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Making Mathematics, Science and Technology Education, Socially and culturally relevant in Africa

Proceedings Editors M. Ogunniyi, O. Amosun, K. Langenhoven, S. Kwofie, S. Dinie

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MESSAGE FROM THE PRESIDENT

It is a great pleasure to welcome you all to the 21st annual SAARMSTE Conference held at the University of the Western Cape. As our 21st birthday, this is an especially significant conference as it marks the successful development of our community to continually mature to this important age. 21 years is indeed a significant milestone and we will be celebrating this milestone at the conference Gala event in the beautiful Kirstenbosch Botanical Gardens. Organising a SAARMSTE conference is an enormous responsibility and takes a large amount of commitment and work and I would like to thank the members of the LOC and many others who have given so generously of their time to organise this event.

I would also like to thank the University of the Western Cape for hosting this conference. The SAARMSTE conference is a key event in the annual calendar of SAARMSTE as it is the largest gathering of our members and as such provides us with a wonderful platform for sharing, learning and networking. We are a strong and growing community and I thank all our members for their on-going participation in our conferences and other SAARMSTE activities.

Our conference theme this year is: Making Mathematics, Science and Technology Education, Socially and Culturally relevant in Africa. Given the dominant crisis discourse that pervades in relation to Mathematics and Science Education in Africa this theme is critical. The theme calls on each of us to find ways to contribute to finding a way forward to the many challenges that face our continent in addressing the challenges of mathematics and science education. Our conferences are a critical point where we stimulate engagement, discussion, debate, learning, leadership and action.

Thank you to all of you for your ongoing commitment to SAARMSTE and to the imperative that as members of SAARMSTE we contribute positively to finding ‘relevant’ pathways of progress in this field.

Finally, I wish to thank our funders who have given so generously in supporting SAARMSTE to achieve its aims and objectives. Without their assistance this conference and this publication would not have been possible.

Enjoy the conference!

Mellony Graven
SAARMSTE President
January 2013
21st ANNUAL SAARMSTE CONFERENCE PAPERS

Review policy of SARMSTE 2013 Conference Papers
University of the Western Cape, Cape Town
Monday 14 - Thursday 17 January 2013.

The purpose of reviewing is to provide constructive comments from other researchers in an effort to promote high-quality papers and presentations. At least two reviewers will look at each long paper and extended abstract. Authors will be required to consider their comments and may be asked to revise their work before submitting their final paper. The review process is “blind” both ways, names of authors and reviewers are not revealed to each other, although reviewers can choose to reveal their names to authors in the interests of further discussion. It is SAARMSTE policy to use the journal reviewers as conference reviewers.

FOREWORD
This SAARMSTE 2013 Conference celebrates the 21st Annual Meeting to be held at the University of the Western Cape. In one sense it is a birthday celebration of Mathematics, Science and Technology Education (MSTE) Research in Africa.

New researchers are particularly welcome. All stages of education are included, and the papers presented cover Early Childhood Development, Foundation Phase, General Education and Training, Further Education and Training and Higher Education and Training levels.

This annual conference maintains its regional, national and international flavour in a way that contributes to the spirit of Ubuntu in Africa and further afield. Researchers add their exploratory voice to the value and relevance that the social and cultural fabric of African society also holds for education.

While looking for connections across subjects and research areas, we also hope to build on strands in previous conferences. As we stand on the threshold of change in our global society, social networks have speeded up access to knowledge on a large scale and presents MSTE education with challenging perspectives in areas requiring relevant curriculum policies and research. The contributions by MSTE researchers are encouraging pointers to support mechanisms for MSTE teaching and learning that occur in a social and cultural context and ultimately stimulating knowledge production on the African continent. The Local Organising Committee welcomes you to a vibrant experience both academically, professionally and socially. The community spirit of SAARMSTE and its visionary mission is a vital support base for successful MSTE through these research initiatives and outcomes.

It is with heartfelt appreciation that I want to thank all the members of the Local Organizing Committee, staff of the School of Science and Mathematics Education at UWC, our external reviewers, the SAARMSTE Executive, our former Director, Meshach Ogunniyi of the Faculty of Education, the Dean of the Faculty of Education and the UWC Executive.

Keith Roy Langenhoven

Chairperson (LOC)
KEYNOTE SPEAKERS

Keynote Speaker 1

Dr Sizwe Mabizela
Deputy Vice-Chancellor: Academic & Student Affairs
Rhodes University

Dr Sizwe Mabizela holds a B Sc, B Sc Honours, and M Sc degrees from the University of Fort Hare. He completed his B.Sc Honours in Mathematics *cum laude* in 1984 and his Masters in Mathematics in 1985. In 1986 he had a brief stint at the University of Zululand as a junior lecturer in the Department of Mathematics.

After completing his PhD he was offered and accepted a lectureship at the University of Cape Town until he became an Associate Professor and deputy Head of the department of Pure and Applied Mathematics. In 2004 he was offered the Chair and Headship of the Department of Mathematics at Rhodes University. In 2008 Dr Mabizela was appointed as Vice-Chancellor: Academic and Student Affairs at Rhodes University. In this capacity, he has executive responsibility for and provides strategic leadership on all academic matters, student affairs and Community Engagement.

He is well-versed in a variety of higher academic education matters, including governance, management and leadership, teaching and learning, quality assurance, academic development, assessment and evaluation. He has served as a member and also as a chairperson of Institutional Audits in South Africa.

Dr Mabizela’s research field is *Abstract Approximation Theory*, a subfield of *Functional Analysis*. He has published widely in his field of research in both national and international journals and has produced three Lecture Notes Series. He has presented numerous scientific papers at national and international conferences, workshops, and seminars in the field of Functional Analysis and Approximation. He has research collaboration with Mathematicians in the USA, Australia, China and Korea. He has spent academic visits in a number of countries. On several occasions he has been asked to present “invited lectures” at conferences. Despite the heavy demands of his current position as Deputy Vice-Chancellor,
Dr Mabizela continues to do research in Mathematics. He is also occasionally invited to serve as a referee for international journals.

Dr Mabizela has lectured at every level – from First Year level to Masters level. He has supervised one Master’s student and co-supervised one PhD student. He is currently supervising one Master’s student.

Dr Mabizela serves (or has recently served) on several provincial, national and international bodies.

- He is a member of the South African Mathematics Olympiad Committee
- He is the Chairperson of UMALUSI Council (Council for Quality Assurance in General and Further Education and Training)
- Until recently, he was the Chairperson of the Rhodes Scholarship selection panel for the Eastern Cape and Free State provinces
- In April 2006 he served as a member of the technical team that accompanied Honourable Deputy Minister Derek Hanekom (Deputy Minister of Science and Technology) for a ministerial visit to Slovakia and Romania.
- In 2005 he served on the Ministerial Committee set up by Honourable Minister Naledi Pandor (Minister of National Education) to advise her on the National Curriculum on Mathematics and Mathematical Literacy
- In 2007 he served on the Ministerial Committee set up by Honourable Minister Naledi Pandor (then Minister of National Education) to investigate Learner Retention in the South African Schooling System.
- In 2011 he served as the Chairperson of the Ministerial Task Team on FET Examinations. This Task Team was set up by the Minister of Higher Education & Training, Dr Blaze Nzimande, to investigate problems experienced with the examination processes and certification of FET College learners.
- In 2012 he serves as the Chairperson of the Ministerial Task Team on Mathematics and Science Foundation Programmes. This Task Team was established by the Minister of Higher Education & Training to propose a workable bridging programme that will make it possible for learners with a potential in Mathematics and Science to improve their performance in these subjects and be able to access higher education learning and training programmes that require solid grounding in Mathematics and Science.
- He is a member of the Eastern Cape Socio-Economic Consultative Council (ECSECC).
Underpinning all of this is Kay’s longstanding interest in human as designers and the importance of nurturing the ‘designerly’ through all phases of education. Kay takes a keen interest in international developments in Technology Education and has been a visiting scholar in Canada, USA, Australia, New Zealand and Sweden. She has over 80 publications, linked to 25 years of TERU research supported by grants totalling approximately £3,090,000.
EDUCATIONAL BACKGROUND

- 2004-2005  Postdoctoral Research, University of the Witwatersrand, South Africa
- 1999-2002  Doctor of Education, University of Leeds, United Kingdom
- 1992-1993  Master of Education, University of Leeds, United Kingdom
- 1991-1992  Advanced Diploma in Educational Studies, University of Leeds, United Kingdom
- 1989-1990  Bachelor of Science (Honors) (Mathematics and Statistics), Chancellor College, University of Malawi.
- 1983-1988  Bachelor of Education (Mathematics), Chancellor College, University of Malawi.

TEACHING AND PROFESSIONAL EXPERIENCE

- June 2010 - to date  Associate Professor of Mathematics Education, Chancellor College, University of Malawi.
- 2006- 2010  Senior Lecturer in Mathematics Education, Chancellor College, University of Malawi.
- 1993 -2006  Lecturer in Mathematics Education, Chancellor College, University of Malawi.
- 1991 - 1993  Assistant Lecturer in Mathematics Education, Chancellor College, University of Malawi.
RESEARCH EXPERIENCE (from last 10 years)

2010 to 2013: Developing more effective school and University partnerships in initial teacher education project. This is a collaborative project of four Universities; University of Ulster (Northern Ireland), University of Malawi (Malawi), Eduardo Mondlane University (Mozambique), and Makerere University (Uganda). I am one of the leading researchers and also the Coordinator for Malawi. The project is funded by DELPHE through the British Council.

2008 to 2012: Project SUSTAIN – I am one of the leading research team members and Coordinator for Malawi chapter for this project which aims at mathematics and science for sustainable development. The project works as a collaboration of five Universities: University of Malawi (Science Education section of CATS), University of Zambia, University of Pretoria, University of KwaZulu Natal and University of Life Sciences in Norway.

2009 to 2011: QUANTUM research project phase 4 (2009-2011) - Member of a research team of five including: J. Adler – University of the Witwatersrand, Z. Davis – University of Caper Town, D. Parker – University of KwaZulu Natal, L. Webb – University of Port Elizabeth, and myself – University of Malawi. Project is funded by the National Research Foundation (NRF) of South Africa.

2009 to 2012: Teaching Mathematics in Multilingual Classrooms – member of an international study group of the International Commission on Mathematical Instruction (ICMI).

2006 to 2008: I was a member of the project team for the QUANTUM project, which was funded by the NRF-South Africa. QUANTUM focuses on Mathematics for teaching and is directed by Prof Jill Adler of the University of the Witwatersrand.

2004 – 2006: Mathematical knowledge for teaching probability in secondary schools. A study carried out as part of my post-doctoral research at the University of the Witwatersrand, South Africa.

2003-2004: Enhancing primary pupils’ participation, interest and understanding of mathematics through cooperative learning. A project funded by the African Forum for Children’s Literacy in Science and Technology (AFCLIST). I am the project director/principal researcher.

2002-2004: Problems of teaching mathematics and science in Malawi primary schools. A project conducted in conjunction with some Zomba urban teachers as part of the Southern African Association for Research in Mathematics, Science and Technology Education (SAARSMTE) – Malawi Chapter.
EDUCATION:

- Ph. D. North Carolina State University, Raleigh  
  (Major: science education; Minor: chemistry)
- M. A. University of North Carolina (Major: organic chemistry) Completed all course work for Ph.D. in physical organic chemistry.
- B. S. Methodist College (now Methodist University), Fayetteville, North Carolina  
  (Major: chemistry) Magna cum laude

RESEARCH INTERESTS: Socio-cultural-political Influences on Science Learning and Teaching, Multicultural Science Education, and Chemical Education

FELLOWSHIPS:

- AERA (American Educational Research Association) Inaugural Fellows  
  (August 18, 2008)
- American Association for the Advancement of Science Fellow (1995)
- Affiliated Fellow of Institute of Behavioral Research, University of Georgia (1994 – present)
- Lilly Teaching Fellowship, 1988. One of nine assistant professors selected for the University of Georgia fellowship in teaching program.
- Danforth Graduate Fellowship, 1979-1980. A graduate fellowship to help finance and nurture graduate students in their doctoral programs in the United States.
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Leatham and Hill (2010, p. 226) define mathematical identity as one’s relationship with mathematics with regard to the way one learns, does, thinks about, retains or chooses to associate with the subject. This paper will focus on the extent that a mathematics module underpinned by an enactivist philosophy and teaching pedagogy enabled preservice teachers to unpack their mathematical identity and the influence it had on their teaching practice.

Enactivism views cognition as a complex co-evolving process of systems interacting and affecting each other to construct meaning (Li, Clark and Winchester, 2010, p.7). This view encompasses five interconnected tenets namely, autonomy, embodiment, sense-making, emergence and experience. All living organisms are autonomous due to their ability to create their own identity which characterises them as a unique entity (Di Paolo, Rohde and De Jaegher, 2011, p.7). This study considered a students’ identity as being characteristic of autonomy. Enactivism maintains that one’s identity is enacted and therefore determined by the interplay between biology, human culture and an individual’s manner of dealing with life’s experiences. This aligns with Davis (2004, p. 210) definition of autonomy which he describes as being structurally determined, since an individual elects how to respond to a perturbation, thus potentially enabling change to take place. Perturbations are actions that trigger new ways of sense making by interrupting established habits of understanding, and thus creating the opportunity for an individual to act according to his/her structure (Davis, 1996, p. 10). As a result, one’s interactions with the world and past experiences will shape and influence the meaning they make of their world (Lozano, 2005). Although embodiment is seen to be a developing process of one’s interaction with the real world, the significant fact that underpins this potential co-emergence between an individual and its environment, is that the system and its environment may interact but they do not necessarily adapt to each other, as Proulx (2004) points out “if we do not ‘see’ the triggers in the environment, we cannot be ‘affected’ by them” (p.119). Thus an individual’s structure determines which environmental perturbations will trigger an action. Owens (2007, p. 1) depicts mathematical identity as incorporating both social identity and being a self regulating learner encompassing both cognitive and affective characteristics. Since self efficacy is one’s belief in one’s ability to attain set goals and certain levels of performance (Bandura, 1994, p. 1) it stands to reason that a student’s self efficacy will impact on how they construct their identity, which in turn will influence how they respond to environmental triggers.

The research project sought to provide students with opportunities that would initially require them to become aware of their mathematical identity by reflecting on the triggers in their mathematical history, that through structural determinism (Varela, Thompson and Rosch, 1991), they had autonomously chosen to respond to in a manner that had constructed their identity thus far. Kilpatrick et al (2001, p. 384) are of the opinion that teachers who exhibit a productive disposition know that “mathematics, their understanding of children’s thinking, and their teaching practices” are interconnected in such a manner as to make sense. Thus students were placed in small mathematical communities and provided with tasks that they were required to teach to their peers. The intention being that through preparing the lessons, teaching the concept and receiving feedback from their peers, students would have the
opportunity to respond to perturbations that would hopefully develop their teaching for proficiency. An aim of the project was to determine and understand the autonomous choices the students made to change and grow their identity and productive disposition relative to their increasing awareness of their identity.

Autonomy relates to the construction of mathematical identity, ways of knowing and self efficacy. It was found that mathematical histories had an impact on autonomy and identity which in turn influenced students’ productive disposition and self efficacy both negatively and positively. This appreciation of their identity resulted in an awareness of the perceived qualities and characteristics a teacher should possess in order to teach mathematics proficiently. Furthermore, it was determined that working in smaller mathematical communities had a positive effect on self efficacy and autonomy as students were often encouraged by the fact that often their peers experienced similar fears or difficulties. Having the support of their mathematical community when teaching tasks to their peers and the feedback they received thereafter, resulted in an improvement of both their teaching practices and productive disposition. Finally, reflecting on and understanding their mathematical identity had created awareness in the students of the need to be in control of their own learning and to research further, if need be, in order to teach a concept proficiently. This culminated in an overall increase in confidence to teach mathematics.

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REFERENCES
Anjum Halai¹; Peter Kajoro¹; Joyce Mgembelo²:

¹Aga Khan University Institute for Educational Development East Africa; ²Faculty of Education Brock University, Canada

anjum.halai@aku.edu; peter.kajoro@aku.edu; jmgembelo@brocku.ca

The paper aims at providing insights into mathematics classrooms in multilingual contexts in Tanzania, and raise questions about prevailing language policy and practice in pre-service teacher education in the country.

It draws from an ongoing project involving five case studies on concerns related to mathematics education in disadvantaged contexts. The case reported here looked at a purposively selected teacher training college, to study practices in pre-service teacher preparation that are sensitive to the relationships between multilingualism, and mathematics teaching and learning. As part of the research syllabi were reviewed, teaching practice classes were observed, and tutors and teacher trainees were interviewed. Employing grounded theory procedures thematic analysis was undertaken of qualitative data to look for emerging patterns (Strauss & Corbin 1998).

The paper argues that the current policy of pre-service teacher education in Tanzania, with Kiswahili as the language of instruction in the early primary classrooms does not adequately take account of the complex linguistic reality of the classroom. Learners especially in early primary classrooms often do not have an adequate command over Kiswahili language, as it is not their first language. Children in the early primary classrooms, where trainees of this teacher training college go for their practice teaching, come to school from at least five different language backgrounds but are expected to learn in Kiswahili. This points to the need for teacher preparation to address the issue of multilingualism in classroom such as including appropriate pedagogic practice and more inclusive curriculum materials. The findings from the research show that teacher preparation assumes monolingual classrooms and does not necessarily take account of multilingualism in the classrooms. Tutors’ and teachers’ awareness of these issues needs to be raised through focussed input on the role of language in learning mathematics. To accommodate multilingualism in teacher education practice would have major implications for the policy and provision of teacher education in Tanzania.

References


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¹ Presenting and corresponding author
A situative perspective approach to examining pre-service mathematics teacher education classrooms

Anthony A. Essien

University of the Witwatersrand, Johannesburg, South Africa
anthony.essien@wits.ac.za

Wenger’s (1998) community of practice (CoP) theory has found applications in different spheres of life and in different organisational and educational settings. Its use to understand and describe mathematics pre-service classrooms is, however, still largely unexplored. In this paper, I propose a methodological approach that can be used in analyzing pre-service multilingual mathematics teacher education (TE) classrooms using Wenger’s notion of CoP as a lens. I contend that this methodological framework can be used to explore the nature of the CoP in research contexts involving the preparation of pre-service multilingual mathematics pre-service teachers and by doing so, to delineate the implications thereof for pre-service teacher professional development. Before delving into the framework, it is expedient to examine briefly Wenger’s CoP theory.

Wenger (1998, p. 5) defines community as “a way of talking about the social configurations in which our enterprises are defined as worth pursuing and our participation is recognizable as competence”. For Wenger, thus, a community of practice is an emergent relationship between people who have come together around a joint enterprise, and is characterised by the existence of mutual engagement in the social practices, and in the process developing a shared repertoire of practices, understandings, routines, activities, common stories, and ways of speaking and acting (Wenger, 1998). For Wenger (1998), therefore, a community of practice has three components: Joint enterprise (what is it about), mutual engagement (how does it function) and shared repertoire (what capability is produced).

Clarke (2008, p. 30) argues that since communities of practice (Wenger, 1998) theory is at once a theory of learning, of identity, of meaning, of community and a theory of practice, CoP “offers considerable potential for thinking about a community of students whose common enterprise is to learn the practices of teaching”. For Wenger, practice does not exist in the abstract but reside in a community of people and the relations of mutual engagement by which they can do whatever they do, hence, membership in a community of practice is a matter of mutual engagement (Wenger, 1998, p. 73). Mutual engagement can, thus, be defined as does Clarke (2008, p. 30) as “participation in an endeavour or practice whose meanings are negotiated among participants”. A joint enterprise is the result of mutual engagement, and “refers to the focus of activity that links members of a community of practice” (Clarke, 2008, p. 31). Wenger explains that an enterprise is joint not in the sense that everyone believes in the same thing or agrees with everything, but “in that it is communally negotiated”. Wenger (1998, p. 83) defines a ‘repertoire’ as “a community’s set of shared resources”, thereby emphasising both the ‘rehearsed character’ and the ‘availability for further engagement in practice’ of a community’s repertoire. Put differently, shared repertoire “refers to the common resources for creating meaning that result from engagement in joint enterprise” (Clarke, 2008, p. 31).
Applying Wenger’s CoP Theory to pre-service multilingual mathematics TE classrooms

But Wenger is not a mathematician or a mathematics educationist and was not theorising specifically for the mathematics classroom. Wenger’s theory, thus, has limitations in terms of providing tools for analysing the (nature of) communities of practice, and there is no ready-made set of tools for analysing interaction within a community of practice. It is, therefore, limiting in providing tools for gaining an entry into the negotiation of meaning process occurring in the CoP. Moreover, mathematical aspects/perspectives of practice are not dealt with by Wenger. The challenge for me as a researcher using Wenger’s notion of CoP was to draw on CoP theory as a theoretical framework, and then using the teacher education communities of practice classrooms in this study, to develop an analytical framework. In so doing, the three dimensions of communities of practice and their associated processes (Wenger, 1998, p. 95) provided the backbone for the development of the analytical framework for the present study.

Each dimension of CoP is subdivided into categories. The categories are then subdivided into sub-categories. Codes are used to for each of the sub-categories and code identification rules are provided for each code. While the dimensions and categories were developed a priori by using Wenger’s CoP theory and other literature, much of the sub-categories/codes and the code identification rules were developed a posteriori from working with data obtained from multilingual teacher education classrooms. The overall analytical framework offers, in my estimation, an integrated and comprehensive approach to understanding and capturing the nature of different communities of practice. It offers a comprehensive approach to characterising the mutual engagement which results in the joint negotiation of the enterprise and the joint negotiation of meaning, and hence, the development of a shared repertoire, all of which are at the heart of Wenger’s CoP theory.

Characterising the Shared repertoire/Mutual Engagement/Joint Enterprise of CoP

For shared repertoire (SR), I use three categories of analysis (and associated sub-categories in each of the categories): mathematical practices (SRMP), norms of practice (SRNP) and pool of shared language and shared representations (SRPSL) that reflect and shape a joint understanding of the community’s SR. To analyse the mathematical practices of each community, the following questions are used: What mathematical practices are in used in the negotiation of meaning and how are these practices made visible (or not) in the mathematics community? The question that enabled the analysis of the norms of practice was: What social, socio-mathematical and mathematics community norms are in use in the communities of practice? The questions that guide the exploration of the pool of shared language of each community are: 1) What are the common discursive repertoire within the communities, and 2) how do they co-construct the community and reflect the different modes of mathematical practices?

The three categories that the author proposes for the analysis of mutual engagement are: 1) Environment/group dynamics; 2) Building identities; 3) pattern of discourse. To analyse the environment/group dynamics, the following questions are used: how does the environment enable or hinder engagement? What helps and what hinders mutuality in the communities? For Building identities, the question are: What type of identity is constructed/developed in each of the communities of practice? And for pattern of discourse, the question to analyse is: How is participation organized? Where does authority stem from (dialogic/authoritative discourse).
Analysis of the joint enterprise would be informed by those dimensions of the community of practice that lend to the appropriation of mathematical knowledge and the associated processes of understanding and tuning the enterprise (Wenger, 1998). Characterising the joint enterprise involves an analysis of the external conditions of each community; the meaning making processes of the communities and the accountability/responsibility structures within the communities of practice. Given that our study was conducted in different classroom communities of practice both in an urban university and in a rural university, the approach thus far, has offered considerable insight into the important role context plays in determining the nature of practices, the norms and the nature of engagement in different classroom CoPs that reflect and shape our assumed joint enterprise in the different CoPs classrooms in our study. Such contexts included the context of teacher education, the context of the individual universities involved in the study, the language infrastructure of the classroom, and who the teacher educator is (that is, whether the TE is monolingual, bilingual/multilingual).

This paper, if accepted for presentation, would include diagrammatical representations (flow charts) that move from the three dimensions of CoP to the categories to the questions in each of the categories to the codes and then to the code identification rules. I will also present how through the use of such a framework, the nature (and implications thereof) of pre-service teacher education communities of practice would become apparent.

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Curriculum Change and Teacher identity: Case studies of three primary Mathematics teachers

Bronwen Wilson-Thompson
Curriculum Division, Wits School of Education
Bronwen.Wilson-Thompson@wits.ac.za

This paper suggests that while much research focuses on mathematics learning and mathematical content in the curriculum, an awareness of the possibilities and constraints related to teachers’ identities can be overlooked. It explores the research question: What is the relationship between changing views of knowledge and of learners in the intended curriculum and intermediate phase teachers’ identities?

The nature of this interaction depends, in part, on the social context of the teacher’s practice. This paper draws on interview data of three mathematics teachers in different school in close proximity to each other. These case studies give insight into how they negotiated their identity in response to on-going curriculum change.

The combination of Wenger’s (1998) notion of identity in practice with aspects of Alexander’s (1992) model of primary practice is used as an analytical framework to explore teacher identity from four perspectives: 1) the nature of teacher’s communities of practice, 2)
identity as a negotiated experience, 3) teacher’s beliefs about learners, their development and learning, and 4) Teachers views of knowledge – both as it has evolved in culture and learners’ ways of knowing. The table below (see fig. 1) shows similarities and differences in the identity development of these three teachers. For example

a) The curriculum in place at the time of the teachers’ training has continued to shape their identity and practice despite subsequent curriculum changes.

b) Each teacher identifies a different type of community as a support in their practice. Each exercises their agency in within their community in a different way. Similarly, each teacher negotiates their own identity and practice by bringing their teaching history, experience, life circumstances and aspirations to the process.

c) Each teacher has a different understanding of the nature of intermediate phase learners which relates to their how they believe learners are motivated to learn.

d) Teachers have different notions of mathematics learning. These notions relate to their perceptions of what learners can and should know.

While there is some coherence within each teacher’s developing identity and practice, there is also unevenness as different aspects of their identity develop. The extent to which teachers align themselves with the ideals of changing curricula is uncertain. Communities of practice, while offering a context in which teachers can engage in ongoing identity development, may either help or hinder the development of practices envisaged by the curriculum.

The variety and richness of the different teachers in this study shows that teachers show a measure of agency in their interaction with the curriculum and in the development of their practice. The coherence and depth of their beliefs means that neither sustainable curriculum change nor meaningful identity development can be easily achieved. Sensitivity towards teachers and an understanding of their ideas, values and beliefs about learners and knowledge, may assist curriculum planners and educators in supporting teachers as they engage in their development and learning.
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**Figure 1: Overview of teachers’ identities**

**References:**


**A METACOGNITIVE INVESTIGATION OF MY PERSONAL MATHEMATICS COGNITION – A COMPARATIVE ANALYSIS**

Catherine Zoghby1 & Pieter van Jaarsveld2

1Wits School of Education, University of the Witwatersrand, Johannesburg, South Africa; 2Wits School of Education, University of the Witwatersrand, Johannesburg, South Africa.
1catzogz@gmail.com; 2Pieter.vanJaarsveld@wits.ac.za

There is recurring feedback regarding the poor mathematics achievement in South Africa, and many researchers have attempted to identify the source of this problem. The students’ lack of understanding, due to inadequate teaching methods, has been the focus of many discussions and much research has been completed in an attempt to find a solution for this
shortcoming. The 2011 report of the South African Department of Basic Education on the National Senior Certificate mathematics examination (DBE, 2011) indicates poor understanding of mathematics content areas and a lack of good mathematical skills and language. The report may imply that these issues are due to the quality of teachers in the classrooms. In order to address these concerns, I intended to go straight to their root – the South African teacher. However in order to make this study realistic, I had to start small with the knowledge and understanding of one teacher – me.

The problem is that I do not know the levels of my understanding or thought processes, for different mathematical objects and concepts. If I were to discover this level and improve it, I would be able to use this ability repeatedly to assess my understanding of any given mathematical object or concept before teaching them in a classroom situation. This would enable me to teach having a better enriched and mathematically proficient understanding of the content. This study is an investigation into my personal mathematics cognition, using metacognition (Wilson & Bai, 2010; Carr & Biddlecomb, 1998) as a tool to discover my level of understanding, in a comparative analysis.

The purpose of this study was to compare and contrast my metacognitive processes to other qualified mathematics teachers (in analysing the same mathematical objects) to ascertain the level of my understanding. I then assessed the new knowledge that I gained in analysing the participants’ responses, and compared them with my own. In order to develop a deeper and richer understanding of the specific mathematical objects and topics, my attention needed to be focused on each object (through the process of metacognition). This purpose made it easy to shape my research questions. 2

i. What is my understanding of a given mathematical object? 
ii. How do I examine and deepen my understanding, through comparing the analysis of my response with others’?

The literature reviewed included mathematical learning theory. The theoretical framework relies on the commonalities of the work of Tall & Vinner (1981), Skemp (1976) and Kilpatrick (2001) elaborated on below. In constantly creating and changing my own thoughts and actively building up knowledge, there was engagement with radical constructivism as learning theory applied to myself (von Glasersfeld, 1990). The theoretical framework was divided into three sections used to analyse the data – concept image/ definition (Tall & Vinner, 1981; von Glasersfeld, 1996; Attorps, 2007), instrumental/ relational understanding (Skemp, 2006) and the five strands of mathematical proficiency (Kilpatrick, 2001 and Suh, 2007). The research looked specifically at how I encounter and define specific mathematical concepts and how (or whether) I link the definition of a concept to its image. My understanding was then analysed and determined to either be instrumental or relational, in comparison with the other participants. Each strand, said to develop mathematical proficiency (conceptual understanding, procedural fluency, strategic competence, adaptive reasoning and productive disposition) was used individually in the analysis process. The presence or absence of these was determined by analysing the responses of the participants.

This study examined and identified the different levels of understanding using an action research approach (Feldman & Minstrell, 2000; McNiff, 2005). As the educator and the researcher, my focus was on the research and aims of the research, which were for improving teaching and learning in the classroom – beginning with my own knowledge and understanding. The study was qualitative in that the analyses were of participants’ written
responses. The sample included three qualified teacher’s with whom I compared my level of understanding. The research instrument was a type of questionnaire of which four mathematical objects were given with a request for doing and talking about each of them in as much detail as possible. The process began with my written response to four mathematical objects. Three participants then responded to the same mathematical objects. All four responses were analysed and a level of understanding discussed for each participant. The varying levels were then compared and conclusions and recommendations reached.

This research study yielded very interesting results. I found a remarkable difference in levels of understanding using the different theoretical frameworks as measures. In comparing my level of understanding to that of the participants, I found so many gaps in my knowledge and that my level of understanding was very superficial. I was very 3 surprised at my low level of understanding. In addition, in order to analyse the participants’ responses accurately, I needed to investigate the mathematical objects – this deepened my level of understanding. The direction of my research changed as I had a discussion with my supervisor (as my sounding board). I realised that while I assumed I understood each object so much better through the research process, I didn’t even think about the possibility of misunderstanding the objects from the very beginning. In reanalysing the data, I saw a number of incorrect assumptions that I had made about each mathematical object, making some of my analyses comments incorrect. The research questions were answered, although not in the way that I expected. I found my level of understanding for the four different mathematical objects, and was able to recognise what I didn’t know. I was able to examine and deepen my understanding through comparing the analysis of my response with others’. I found gaps in my knowledge that I didn’t expect to find, and was able to address and try to understand the missing/ incomplete knowledge. My recommendation would be for more teachers to use the tool of metacognition in order to discover their understanding (or lack thereof) of certain mathematical concepts, in an attempt to deepen that understanding to attain a teaching method that is both knowledgeable and understandable.

References
Using metacognitive exercises to reveal conceptual understanding in Grade 11 trigonometry

Charmaine Price ¹ & Pieter van Jaarsveld ²
¹Wits School of Education, University of the Witwatersrand, South Africa; ²Wits School of Education, University of the Witwatersrand, South Africa.

pricecs65@gmail.com; Pieter.VanJaarsveld@wits.ac.za

I teach Grade 11 and 12 Mathematics and Grades 10 – 12 Physical Science at a small, middle-class, private school in Gauteng which emphasises inclusion. Despite many efforts on my part to encourage conceptual understanding in mathematics, I find that most students do not develop the depth and breadth of conceptual understanding needed to succeed adequately in mathematics. I suspect that a fundamental problem lies with the learners’ quality of thinking.

The research in this paper sought to answer two interrelated questions:
1. To what extent is conceptual understanding revealed by metacognitive tasks requiring learners to search and retrieve from their memory or understanding?
2. To what extent is there a connection between procedural competence and conceptual knowledge?

The aim of this study was to investigate the level of thinking of my learners with regard to their conceptual understanding. I wanted to see if certain exercises, which I considered metacognitive in nature, allowed learners to express their own conceptual understanding of trigonometry. In addition, I wanted to examine if the level of understanding affected the degree of procedural competence.

Four main sources informed my theoretical framework. I used Skemp’s (1976) ideas of mathematical understanding as comprising either “relational” or “instrumental” aspects, with relational understanding being more indicative of conceptual understanding. Sfard’s (1991) distinction between “structural” and “operational” conceptions are similar to Skemp’s, although she sees her categories as a duality and not a dichotomy. Sfard’s (1991) description of learning mathematics as requiring the hierarchy of “condensation”, “interiorisation” and “reification” was also used. The ideas of “concept image” and “concept definition” by Tall and Vinner (1981) were very important. Lastly, I drew upon Flavell’s original idea of metacognition as intelligent storage and retrieval of information in memory (J.H Flavell, as cited in Hacker, 1998).

Working within an action research paradigm by being the teacher/researcher in my own class, I collected data over a five week period during which we were studying trigonometry. My sample was my own Gr. 11 Mathematics class. It is a small class, with 10 learners of varying abilities. Two students are particularly strong in Mathematics, three are quite weak, and the rest are in the middle. The students and parents completed forms giving consent to participate in the research under the conditions of anonymity in my report and that the research would in no way adversely affect the learners’ marks.

I administered three learner response sheets which I called “questionnaires” but were single open questions that asked the learners to reproduce on paper their understanding of sin θ or
to connect the various aspects of trigonometry covered. I considered these exercises metacognitive as they required a conscious effort on the part of the learners to be aware of the contents of their own memories. To echo the dual nature of mathematical knowledge described by Sfard and Skemp, I also administered three different sets of procedural exercises. The questionnaires and exercises were administered at the beginning, middle and end of the trigonometry unit. The questionnaires were coded and rated; the exercises were marked and errors noted. The questionnaires were analysed both qualitatively and quantitatively.

From a quantitative perspective, the following trends were noted:
- The total number of entries per learner per questionnaire increased across the three questionnaires with the third questionnaire showing a significant increase. This may indicate that the learners had a larger “mental stock” to draw from.
- The median number of verbal description entries increased, perhaps showing that more learners began to form an individual concept definition.
- There was a large increase in use of symbolic expressions. This may be evidence of condensation.
- The level of accuracy increased across the three questionnaires. This could possibly be seen as a movement of the learners to be more closely aligned to the formal concept definition.
- There was a positive correlation between evidence of conceptual understanding and procedural competence.

From a qualitative perspective the following trends were seen:
- Each learner had a unique, individual way they conceived something. There was almost a “signature” to their work. This was reflected in the way they wrote, what they included or did not include, the drawings they made, the colours, shapes and weights of writing, precision or imprecision, accuracy or errors. Looking at all three questionnaires together, one could see they all belonged to the same person.
- The learners used a number of ways to reproduce their understanding on a page. They used words, diagrams, formulas/equations and pictures.
- The diagrams displayed in the learners’ responses were important expressions of their concept image. The diagrams showed relational understanding and the development of conceptual knowledge. Drawing a diagram may be a step toward reification if the picture becomes an abstraction of the processes that produced it. It may also be a lower level object that higher order processes can operate on. Thus, the use of diagrams was one of many ways the learners demonstrated their degree of conceptual understanding.
- The development of a strong learner was particularly noteworthy. This learner demonstrated an increase in the depth and accuracy of his conceptual understanding. He showed strong signs of relational understanding and his concept image was very close to the formal concept definition of trigonometric relations.

Conclusion:
I concluded that metacognitive exercises do reveal a learner’s conceptual knowledge. Left to themselves, without any specific prompting, learners articulate what they know in some way, whether through words, symbols, diagrams or a combination of the former. The degree to which their manner of articulation (concept image) matches the concept definition determines the accuracy/depth/relatedness of their conceptual knowledge and this in turn affects the accuracy/depth/relatedness of their procedural competence.
Recommendations for further research:

- Are there different types of metacognitive exercises and would they elicit different responses?
- Do different forms of metacognition require different instruments to measure them?
- The fact that the learners’ responses were so individual makes me wonder if each learner has a sort of “mental template” from which they work, that may be similar but significantly different from other learners. This may be an area for future research.
- I think more study in the area of metacognition could further an understanding of constructivism. Metacognitive exercises have the potential to represent what is in the mind of a learner and could be seen as concrete representations of internal, personal constructions.

References:


Clemence Chikiwa
Department of Education, Rhodes University, South Africa
c.chikiwa@ru.ac.za

The relationship between Mathematics and language has been a source of interest for researchers, educationists and many other various stakeholders in education for many years. Language is a communication tool through which concepts are conceived, meaning negotiated and knowledge conveyed from one individual to another. Durkin (1991; p. 3) states that, “Mathematics education begins in language, it advances and stumbles because of language and its outcome are often assessed in language.”

Across the world in Mathematics education, there is an increasingly growing interest to facilitate students’ epistemological access in Mathematics learning (Mafela, 2009). In many communities, multilingualism is no longer an extra-ordinary phenomenon, for approximately half of the world’s population use more than one language in everyday life (Franceschini, 1998). A variety of languages in the classroom however, presents extensive challenges to the teaching and learning of Mathematics (Setati, 2008). In South Africa, the presence of an increasing variety of pupils with an increasing variety of linguistic backgrounds forces Mathematics teachers to reconsider their teaching and assessment strategies in the classroom.
One of strategies teachers use is code switching, defined by Adler (2001) as the use of more than one language in the same conversation. In schools and classrooms, as Adler (2001) noted, code switching occurs most obviously in bilingual or multilingual settings where learners are learning in an additional language. Thus code switching is between language of learning and teaching (LOLT) and teacher’s and learners’ first language whose Mathematics register may not be sufficiently developed to carry Mathematics. Code switching practices are a feature of many South African classrooms where teachers and learners share a common home language, while the language of learning and teaching is English (Probyn, 2009). The questions that arise are: How consistent is this teacher code switching in the mathematics classroom? What are the code-switching consistencies/inconsistencies exhibited by mathematics teachers in their multilingual classes during teaching? How do these consistencies/ inconsistencies manifests themselves in the assessment of teaching and learning mathematics?

The goal of this research is twofold:

1) to determine code switching consistencies and inconsistencies by teachers as they teach mathematics multilingual classes.

2) to determine how the observed consistencies and inconsistencies manifests themselves in the assessment of learning and teaching of mathematics in these classrooms.

A sample of four secondary school mathematics teachers will be selected for this research. Data will be collected through lesson observations and interviews over four consecutive school terms. Data analysis and data collection will be done concurrently. Data analysis will be done in two phases:- First, the Quantitative Analysis where transcripts will be analysed for frequency and consistency of code switching. Secondly, Qualitative Analysis:- Transcripts of in-depth reflective interviews and corresponding lesson observations will be analysed. Particular attention will be focused on frequently used Xhosa words during the lesson, translations by the teacher from English to Xhosa, meaning of Xhosa words and how much they capture the concept intended, relationship of Xhosa word to mathematics concepts. It will also focus on how and why teachers choose the words they used, and how consistent these chosen words are used across grades and content. School based examination/assessments and administration of formal and informal tests will be observed and analysed.

References:


“I once had this teacher...” mathematics teachers tell their stories

Clyde Felix¹ & Marc Schäfer²

¹ School for Continuing Professional Development, Nelson Mandela Metropolitan University, South Africa; ² FRF Mathematics Education Chair, Rhodes University, South Africa.

¹ clyde.felix@nmmu.ac.za, ² M.Schafer@ru.ac.za

In this short paper the central position is that the professional identities, and consequently the professional practices of mathematics teachers, are continuously being shaped by their personal narratives. What is presented here is a snapshot of significant narratives that the teacher participants in a PhD project shared about their own mathematics teachers, followed by a brief analysis of how these narratives shaped their professional identities and, subsequently, their classroom practices.

This research project is situated within a sociocultural framework (Cobb, 2006; Lerman, 2000; 2001; 2006; Goos, 2008) which accounts for learning by focusing on the processes by which people increase their participation in various cultural practices; hence, embracing the notions of identity (Sfard & Prusak, 2005; Lave & Wenger, 1991; Wenger, 1998), communities of practice (Wenger, 1998), and legitimate peripheral participation (Lave & Wenger, 1991).

Our own position with regard to this theoretical framework can be summarized as follows: Firstly, we reject the essentialist notion of identity as fixed, choosing instead Sfard & Prusak’s (2005) operational definition of identity as “a set of reifying, significant, endorsable stories about a person.” (p.14) This perspective of identity refers to the way in which we story ourselves and how others story us (Sfard & Prusak, 2005; Wenger, 1998; Anderson, 2007; Grootenboer, Smith, & Lowrie, 2006). Secondly, in line with the “sociocultural turn” (e.g., Lerman, 2006) we accept the notion of communities of practice which embraces the shift from an acquisitionist (cognitivist) approach to participationist (socio-cultural) approach to human growth and development (Sfard, 2006); taking the view of “learning as social participation.” (Wenger, 1998, p.4) From this perspective the professional identities of teachers reflect the ways in which they reconcile their multi-membership of various communities of practice into one identity, described by Wenger (1998) as a “nexus of multimembership.” (p. 159) Lastly, we draw on Lave & Wenger’s (1991) notion of legitimate peripheral participation to provide a conceptual bridge between the individual as a person and the community of practice as a collective; taking the view that, as the individual participates in the practices of a community and become more knowledgeable, greater mastery of the practices is gained, and consequently the individual shifts from being a ‘peripheral participant’ to being a ‘full participant’ in the community.

The participants in this study shared their practice of mathematics teaching through their observation of and experiences with their own teachers’ classroom practices. During the narrative inquiry they related these experiences, revealing how the practices of their
mathematics teachers have impacted on their own professional identities and subsequent practices. Some were good experiences, for example, Wellman (pseudo name) described his teacher, who was at that time still a student doing practical work at their school as follows:

when he is also coming into a class we will just go bubbly because he does not restrict us in terms of when he is asking questions. He will say, all right... He will make everybody involved. So that in itself I loved, because at the end of the day that impression that he imprinted in me is still in me because at the end of the day this is what I want the learners to be. (Wellman, Second interview)

At the time there were not sufficient mathematics teachers at the school so Wellman, then a senior learner, was asked to substitute as a teacher for the lower classes. In the absence of any prior training his experiences with the young student teacher has inducted him into the practices of teaching via an apprenticeship model similar to those discussed by Lave and Wenger (1991) in their seminal publication ‘Situated Learning: Legitimate Peripheral Participation’

Not all experiences were positive however, for example, Laverne (pseudo name) explained how she was ignored by the math teacher.

we felt as if the teacher spent more time on the very bright students. And he, he ignored us. You know. And that is the reason why I, I think I had that, because I wasn't... That is the reason why I feel I wasn't as serious as I should be... But nevertheless, we never failed maths... And, and I think the reason why we were not as good as she expected is because she was not spending enough time with us (Laverne, First interview)

Laverne went on from being a marginal mathematics learner at school to become the top mathematics student winning top honours at college. She described her experience of the differences in the teaching practices between the teachers at school and lecturers at college as a turning point for her in terms of her mathematical identity and professional identity. Today, she says, she actively tries to avoid the ‘mistakes’ made by her own teachers in ignoring some of the learners.

This short paper will probe into the way in which narratives of their mathematics teachers and their practices continue to shape the professional identities and subsequent practices of mathematics teachers. Do we always teach as we have been taught? Perhaps not always! Furthermore, this short paper will allude to the appropriateness of a narrative enquiry approach to this type of research.

References


About time: Pre-service secondary maths teachers’ attention to time in financial maths

Craig Pournara
Wits School of Education, University of the Witwatersrand, South Africa. craig.pournara@wits.ac.za

We cannot talk about the mathematics of finance without talking about time. In financial mathematics at school level, where the focus is on discrete payments, learners need to pay attention to whether payments are made at the beginning or at the end of a period. In order to do this, teachers need to help learners become increasingly aware of and explicit about timeframes. This requires that teachers are themselves aware of the importance of paying attention to time, and can mediate in appropriate ways to help learners do the same.

While there is very little research on learning of financial maths, particularly at school level, there is agreement in the literature that the time-value of money is a central concept in the mathematics of finance, yet also one with which students have difficulty (e.g. Eddy & Swanson, 1996; Gardner, 2004; Jalbert, Jalbert, & Chan, 2004)

The study reported here involved forty-two pre-service secondary mathematics teachers who were registered for a semester-long financial mathematics course designed and taught by the author. Drawing on Sfard (1998), I consider learning as both acquisition and participation. I
therefore pay attention to students’ conceptions, their talk, and their use of resources such as timelines. The data is drawn from two separate periods in the course. The first focuses on compound growth, while the second deals with annuities. The data sources include video records of class discussions and tutorial group activity, tutorial group reports, and students’ test responses.

The research questions that frame the presentation are:

- To what extent do students pay attention to time in their talk?
- To what extent do they adopt the conventions of timelines, and with what effects?

In the presentation I shall describe students’ difficulties to reach consensus on timeframes when dealing with compound growth. I shall argue that these difficulties were partly a result of students’ lack of consistent attention to timeframes, with the result that other students struggled to follow their reasoning. I shall show that students were generally more explicit in their references to time when working with annuities later in the course. Nevertheless, there were still many instances of implicit and ambiguous references to timeframes, such as “in February” and “payment for the first month”. Drawing on several instances of students talking about time, I shall argue that while teachers should always be precise in their references to time, it may not always be productive to be explicit about this. Thus talk about time needs to become a transparent resource (Lave & Wenger, 1991) for learning financial maths.

With regard to timelines, I shall problematize the key conventions of timelines and show evidence of typical errors students make in their use of timelines. Despite this I shall show evidence that appropriate use of timelines may not be necessary for obtaining correct answers to annuities problems. In so doing I shall present several examples of students’ “idiosyncratic” use of timelines.

I shall conclude the presentation by linking the focus on time and timelines to the broader study which was concerned with exploring the notion of mathematics-for-teaching (Adler, 2005) in relation to financial maths at school level.

References

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NOTES ON THE USE OF SPREADSHEET ALGEBRA PROGRAMMES IN MATHEMATICS TEACHER EDUCATION
Faaiz Gierdien¹ and Alwyn Olivier²

¹Research Unit for Mathematics Education, University of Stellenbosch (RUMEUS), South Africa; ²Research Unit for Mathematics Education, University of Stellenbosch (RUMEUS), South Africa

¹faaiz@sun.ac.za

In pre- and in-service mathematics teacher education (MTE) we use what we call “spreadsheet algebra programmes” (SAPs). How and why we use SAPs is the issue we address in this paper. We start with a general description of spreadsheets (Excel Microsoft©) followed by a specific example of an SAP. The paper offers theoretical and practical reasons for the use (and design) of SAPs in MTE.

To gain a better sense of how SAPs are used, we first have to ask what is a spreadsheet and what do we mean by spreadsheet algebra? Pea (1985, p. 170) describes “electronic spreadsheets” as an example of a computer technology that can reorganise our thinking. The way that this reorganisation is done entails the use of a spreadsheet. He notes that one can place a number, a calculation or a formula in the formula area of the (electronic) spreadsheet cell, which can subsequently be edited, copied and moved. The most dramatic difference compared to a paper-pencil static spreadsheet is that one can change entries in cells and see the repercussions of that change recalculated with immediate effect throughout the spreadsheet. In other words, one can link different spreadsheet cells through calculations and formulas, i.e. through relationships. It is therefore not surprising that we see several studies during the 1990s in which spreadsheets were used to explore ways of connecting arithmetic and algebra in terms of school mathematics, i.e. establishing a “continuum from arithmetic and algebra” (Ainley, Bills & Wilson, 2005). Leung (2006) argues that spreadsheet use in general, and in school algebra in particular, gives rise to the phenomenon of “spreadsheet algebra” (i.e. the algebra as learned through spreadsheets). In spreadsheet algebra there is an explicit focus on conceptual understanding of the underlying (school) algebra. According to Heid (1995), spreadsheet algebra per se demands new visions of school algebra through a shift in emphasis from symbolic manipulation, as in paper-pencil algebra, towards conceptual understanding, symbol sense and mathematical modelling.

We now look at an example of an SAP and ask what it is and what are ways to use it in MTE. The SAP (see Figure 1) was designed in a way that entails deliberate moves to show links between tabular, symbolic, graphical and numerical representations and flow diagrams associated with two linear functions \( f \) and \( g \).

In the SAP the various cells are linked in ways where the effects of any numerical/arithmetic inputs are displayed immediately in the table and on the graphs. To use Pea’s words, we can think of such effects as repercussions. In theoretical and practical terms, in MTE we can think of the SAP as an example of curriculum materials (Remillard, 1999; 2005) and as a resource (Adler, 2000) for school mathematics teaching.

The SAP in the above Figure was designed to subvert and not to follow the enacted curriculum (Remillard, 2005, p. 217). In the middle grades content such as linear
equations/functions and their graphs are usually considered as separate topics. On its own the SAP is not a resource for thinking about the mathematics content in the intended ways. The SAP only becomes a resource through “mediated use” (Adler, 2000), which requires a reorganisation of thinking about the particular mathematics, i.e. algebra content, equations, identities and impossibilities. Mediated use of the SAP may lead to teachers noticing a continuum from arithmetic to algebra. In other words, in theory there is the possibility of “re-sourcing” (Adler, 2000) the content, e.g. stressing and noticing relationships between arithmetic and algebra such as the graphical representations of the two linear equations and their respective tabular representations. A further possibility of “re-sourcing” (as a verb) exist in prompts such as “Discuss: What does the solution mean in the flow diagrams? In the graph? In the table as in the Figure?”

Figure 1: A ‘page’ from an SAP showing two linear functions $f$ and $g$

In MTE mediated uses of SAPs such the one in the above Figure has to do with exploiting the potential of a spreadsheet as an arithmetico-algebraic tool (Haspekian, 2005). What we have to realise is that (in MTE) we have to contend with dominant paper-pencil algebra knowledge forms that make their way into the Mathematics curriculum. Simultaneously what we have to do is find learning opportunities related to the use (and design) of SAPs for pre- and in-service teachers as well as for us.

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**Contextualizing a second site of learning: Case study of a mathematics mentoring program**

Femi S. Otulaja, Jill Adler

1*Marang Centre for Mathematics and Science Education, Wits Math Connect, School of Education, University of the Witwatersrand, Johannesburg, South Africa.*

Femi.Otulaja@wits.ac.za, Jill.Adler@wits.ac.za

The need to improve mathematics performances through teacher development and learner intervention has been a continuous call of all concerned in South Africa. Provincial, national and international data continue to indicate that learners in public schools are grossly underperforming in mathematics (DoE, 2008; 2010). This condition is worst in township and rural schools with limited resources, overcrowded classrooms, understaffing of educators and larger number of educators with limited content knowledge in mathematics. The Human Sciences Research Council review (HSRC review, 2011) declared,

In a nutshell, the South African schooling system shows the following characteristics: the national mean mathematics scores are low and need to improve. There is a high differentiation of the educational performance of students from different socioeconomic conditions and we can say that we have two systems of education. This means that an estimated 30% of schools perform reasonably well, while 70% of schools are underperforming.

This quote affirms what Shalem and Hoadley (2009), in discussing the duality of the economy of schooling and teacher morale, posited that teacher preparation, learners’ readiness and the provision and management of resources is skewed against learners from poor and under-resourced schools in the country.

It is with this type of knowledge that the learners’ mentoring program (LMP) ran a series of sessions focused on mathematics mentoring. The overall goal of the LMP was to create the structures and functions (socio-cultural fabrics) associated with the home as ‘a second site of learning’, while helping learners improve their mathematics learning by enhancing participation and performance through mentoring. LMP is part of a larger study focused on improving mathematics performance in public secondary schools under the jurisdiction of the Gauteng Department of Education. While LMP focused on learners, the other parts of the larger study focused on improving teachers’ mathematics content knowledge and conceptual understandings. LMP recruited second and third year BSc undergraduate students majoring in mathematics and/or actuarial sciences and second and third year BEd student teachers specializing in mathematics and/or science to act as mentors of grades 9, 10 and 11 mathematics learners in three of the township schools. Mentors were from similar socioeconomic and cultural backgrounds as the learners. We meet on Saturday in one of the
three schools as our mentoring site. We set up the LMP in the notion of a context as a social, cultural, physical, psychological and cognitive setting bounded by the activities and actions taking place in the setting; a place where roles, rules and resources interplay in dynamic triple dialectical relationships to produce outcomes.

Bernstein (1977) purported that in addition to school learning, the homes of learners from middle class families serve as a second site of learning whereas the homes of working class or poor families do not. Using a narrative discourse in the context of mentoring (Lave and Wenger, 1991), we argue that learners’ identity (Wenger, 1998) is structured by their participation in mathematics learning in a set of social relationships different from their home relationships and different from the traditional classroom relationships with their mathematics teachers. Learners’ identities (individual and collective, both of which exist in a dualism and in dialectic relationship, one presupposing the other) are rooted in learners’ and mentors’ perceptions of “self” in relation to one another, on one hand, and learners’ interactions with artefacts that mediated learning of mathematics aided by mentors, on the other hand. These perceptions of “self” are narrated in their weekly written reflections from where such perception of “self” are extracted as data for this paper.

We theorize identity as a narration of “self” in a context. Preliminary findings of LMP indicate that there are aspects of these identities which are constant (stable) ways of thinking and acting (being) while there are others which are shifting ways of thinking and acting (becoming and belonging) as successful mathematics learners; we are exploring these further in an upcoming paper. For this paper, however, we are proposing that the activities and the participation in mathematics activities by learners’ (mentees’) and mentors’, individually and collectively, generate elements of the socio-cultural fabrics that construct the context of mathematics mentoring as a second site of learning; i.e., a location in space and time where mentors and learners (mentees) produce structural resonances (discursive markers) associated with a second site of learning that helps learners want to succeed as mathematics learners. These will be presented at the conference; space limitations prevent this from being done in this short paper.

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References
A geometry test: questions that does not fit the Van Hiele model

Gerrit Stols \(^1\) & Caroline Long \(^2\)

\(^1\) Department of Science, Mathematics and Technology Education, University of Pretoria, South Africa; \(^2\) Centre of Evaluation and Assessment, University of Pretoria, South Africa.

\(^1\) gerrit.stols@up.ac.za \(^2\) caroline.long@up.ac.za

The Van Hiele theory describes how a student develops geometrical proficiency through a sequence of five levels that are discrete. The theory suggests progress through thinking on sequential levels as a result of experience which is dependent on instruction. This theory was used by Stols (2012) the first author in an attempt to investigate the effect of a six month geometry course given to pre-service teachers at the University of Pretoria in particular the effect of dynamic geometry software on cognitive growth. For the purpose of assessing growth the Cognitive Development and Achievement in Secondary School Geometry (CDASSG) Van Hiele Geometry Test was administered. The most problematic areas as identified by the test were the construction of proofs, understanding the role of axioms and definitions, and understanding non-Euclidean systems. The students performed slightly better on the Level 5 questions compared to the Level 4 questions. This was contrary to the Van Hiele model, which suggests that mastery at one level is a prerequisite for mastery at the next level.

There is a continuing discourse regarding the levels of thinking as described by the Van Hiele theory. Several researchers have found some aspects of the theory problematic. The nature of the Van Hiele levels and the assigning of students to a specific level is a major point of discussion and critique. Gutiérrez, Jaime and Fortuny (1991), for example, argue that learners develop several Van Hiele levels simultaneously and have found these levels to be dynamic and continuous rather than discrete.

Purpose of the research
The question that arises is firstly whether the existing ability levels can be identified, and measured with a degree of reliability. The study focusses on one instrument that was used in studies to determine students Van Hiele levels of geometric thinking, the Cognitive Development and Achievement in Secondary School Geometry (CDASSG) test, designed firstly to operationalise the levels and secondly to assess these levels (Usiskin, 1982). The test consisted of 25 items with 5 items identified at each level to match the Van Hiele levels. All the items were of the multiple choice type with 5 options for each question. Usiskin and Senk (1990) reported that they analysed the Van Hiele notes and took care to ensure that each test item corresponded to statements from the notes. However, in spite of the theoretical rigour, the study reports low Kuder-Richardson reliability coefficients. Items limited to five test items for each level may have contributed to the low reliability.
The questions of interest are whether these levels (as operationalized in the test) have been sufficiently theorised and whether the CDASSG test is a reliable measure of these levels. The Rasch model was applied to interactively assess the theory and the test instrument.

**Research design**
A feature of the Rasch model is that the data are required to fit the model. It is only when this requirement has been met that we can regard assessment as measurement in a scientific sense. In the application of the Rasch model we firstly checked the targeting and reliability of the test instrument. Secondly, we investigated to what extent the data fitted the model, and where there were anomalies we attempted to explain these anomalies by reflecting on the theory. Thirdly, we investigated items for differential item functioning (DIF) that is the phenomenon where persons of the same ability as measured on the test, but from different groupings, achieve significantly different estimates on a particular item. The presence of guessing was also investigated; strategies for countering the effect of guessing were implemented. After the resolution of the anomalies the empirical levels as determined for this frame of reference (the cohort of students in this learning environment) were compared with the theoretical levels built into the test design.

**Initial results**
As to be expected the items at easier locations exhibited good fit to the model. At the mid difficulty locations, the items showed over discrimination, which could be interpreted as response dependence. The most difficult items showed under discrimination and evidence of guessing. What was also found interesting at this stage of the analysis is that the order expected from the theory and from the design of the test was somewhat different. Two tables were set up, one showing the items in the order determined by the design of the test; the other the order established empirically from the analysis of the data. In particular Item 14 was more difficult than expected and there was confusion of the levels four and five.

**Conclusion**
The results align in some respects with the critique of the Van Hiele levels in the literature that is that the levels are not found to be discrete, but that proficiency at adjacent levels may be achieved concurrently in response to the educational programme. We cede that the assessment of the levels through a multiple choice paper and pencil test may not be optimal; some of the test items may require revision, especially where the options are very close. However, the administration of the CDASSG test operationalizing the Van Hiele levels, and the application of the Rasch model, provide empirical evidence to take the discussion on the development of geometry proficiency further.

**References**
This paper proposes a framework for teaching secondary school Euclidean Geometry, which is based on the reduced levels of the Van Hiele theory (1986), different types of knowledge (Cangelosi, 2003) and the necessary geometrical skills that Hoffer (1987) identified. Over the years, while educating teachers to teach Geometry, the researcher merged these theories to arrive at a practical, workable framework for planning geometry teaching in the secondary school. Furthermore, the theorems in the Euclidean Geometry curriculum were grouped around topics. These theorem groups play a pivotal role in planning the teaching of geometry. The envisioned outcomes are the development of both the learners’ inductive and deductive reasoning, as well as domain specific problem solving strategies.

Explaining his theory of cognitive levels Van Hiele (1986) postulated five levels namely Level 0: Visualization/Recognition; Level 1: Analysis; Level 2: Explanation and informal deduction (ordering); Level 3: Deduction and Level 4: Rigor. By means of the reduction of levels, van Hiele (1986:53) reached a simplified classification. The first three of these reduced levels are especially suitable to apply in the school environment. Teppo (1991) described these as follows:

Visual level: Students recognise the geometric objects globally (p. 210).
Descriptive level: Students distinguish shapes on the basis of their properties (p. 211)
Theoretical level: Students are able to devise a formal geometric proof and to understand the process employed (p. 211).

Van Hiele (1986) also described five learning phases to progress from one level to the other. However, planning according to these phases requires an in-depth knowledge of the Van Hiele theory and is time-consuming. Therefore these learning phases are not included in this framework.

Cangelosi (2003) described different mathematical knowledge types, of which concepts and relationships are of interest for this framework. In geometry initial intuitive concepts are developed on the visual level and are expanded as the learner progresses through the levels. To facilitate the construction of these concepts and their attributes, teachers need to use concept attainment methods (Gunter, Estes, & Schwab, 1999). Relationships between concepts - as well as the conditions under which they hold - have to be discovered through using inductive reasoning. Learners are now on the descriptive level: they should be able to understand and apply properties of figures and the different relationships that exist. Finally, deductive thinking is purposefully taught to phase in the theoretical level.
To complete the theoretical grounding we have to look at the geometrical skills Hoffer (1981) identified, namely visuals-, drawing-, verbal-, logical- and applied skills. Every skill develops further as the learners progress through the levels. Based on these three theoretical views, this proposed framework divides the teachers’ planning into two parts:

A. Planning for the development of skills as applicable at the different levels.

In the lower grades a great deal of attention should be paid to developing visual skills, including basic skills, but also more advanced visual skills, such as tessellation, visualising rotated objects, visualising nets of 3D shapes, etc. Drawing skills progress from intuitive drawings to accurate constructions and the drawing of intricate figures from verbal descriptions. Verbal skills advance from informal to rigid as the learners progress through the levels. The teacher has to plan on how to facilitate the development of the skills to do investigations using inductive thinking, e.g., detecting common properties, and formulating conjectures. Finally, the skills for the theoretical level are facilitated through the teaching of certain topics in Euclidean geometry as described in the following section.

B. Planning to introduce an Euclidean Geometry topic.

To facilitate planning of the different topics in the curriculum the theorems can be grouped according to certain concepts, e.g. straight lines, triangles, etc. Each of these groups form a cluster of theorems around which teaching revolves.

For each topic teachers firstly have to facilitate the construction of all the concepts in the theorem group, using concept containment teaching methods. Secondly, the discovery of theorems/relationships and their conditions follows by means of investigations - applying inductive reasoning. Thirdly, the theorem groups are used to do theorem analysis and diagram analysis, which enable the learner to proceed with deductive reasoning when solving problems. Formal proofs of theorems can be introduced as problems to be solved instead of worked examples to be memorised.

The initial introduction of deductive reasoning skills can be accomplished by using Theorem group 1 (Straight lines) and Theorem group 2 (Triangles). It includes the very basic skill of writing a statement substantiated by a reason, followed by three fundamental deductive reasoning patterns learners have to master, namely: the patterns of equality (if a=b, b=c, a=c); equal sums (if a+b=K and a+c =K then a+b=a+c and therefore b=c) and substitution (if a+b =K, and a=c then b+c=K). Other domain specific patterns and problem solving strategies emerge when theorems clustered around other concepts are studied.

In conclusion, this two-part framework may be of value to teachers in planning a comprehensive teaching strategy that develops a useful package of learners’ skills, as well as thinking processes to promote understanding and facilitate problem solving, both in transformation geometry and Euclidean geometry. Seen that the framework is based on the van Hiele levels of reasoning, it gives teachers a meta-cognitive understanding of why they teach a specific kind of knowledge or skill, at a specific stage of development of the learner.

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Developing a coding model for analysis of revoicing practices.

Jessica Sherman  
*Mathematics Division, School of Education, University of Witwatersrand, South Africa.*  
jessica.sherman@wits.ac.za

In this paper, I present the derivation of a coding model developed from a broader study that looked at ‘revoicing’ practices within two primary mathematics classrooms. The broader study was situated in a ‘learning as participation’ Lave & Wenger (1991) paradigm, within which appropriation of mathematical discourse is seen as important. My research question explored the nature and range of revoicing practices used by two South African teachers in an effort to open up opportunities for learners to participate in mathematical discourse?

In terms of implications for mathematics teaching, the National Council of Teachers of Mathematics (1989) published standards which require teachers to orchestrate whole class discussions with their learners. This led to a number of researchers focusing on how to orchestrate discussions. O’Connor & Michaels (1993, 1996) introduced the notion of ‘revoicing’ in terms of two categories - repeating and rephrasing – of learner utterances as an alternative to the widely documented ‘Initiate, Respond, Evaluate’ format (Mehan, 1979). This was seen as a way of deepening students’ understanding by supporting their participation in mathematical discourse. Moschkovich (1999) situated the benefits of revoicing within the need to support bilingualism in the classroom, as did Setati & Adler (2001). Brodie (2010), noting the extensive use of the IRE/F format in South Africa, explored the possibilities of improving the type of feedback given to learners within that model.

In Brodie’s (2008, 2010) model, the following categories are presented - Elicit, press, insert, confirm and maintain. As Brodie regards maintain as her only revoicing category, it seemed appropriate to distinguish between revoicing and non-revoicing feedback. These categories laid a foundation for the development of my own coding model.

The study involved videotaped observations of three Grade 6 mathematics lessons across two teachers in two different government primary schools in Gauteng. In addition the teachers were interviewed. Both teachers were selected because initial observation of their lessons suggested an interactive teaching style, and both teachers expressed willingness to participate in a study exploring classroom discourse. As the coding of the data progressed, a disjuncture emerged between the categories drawn from the literature and the types of teacher utterances used by the two teachers. Thus, working in more grounded ways, I developed my own coding model in ways that encompassed the empirical data I was working with. Below are explanations of the revoicing categories I developed during this study, and the sub-descriptions derived from the data for each category.
**Repeating:**

To affirm a learner’s answer or statement. The teacher indicates by repeating the answer or statement that she agrees with the learner.

To give access to all learners. The teacher will repeat her own or a learner’s question or statement. This is done to give learners a chance to think about the question or statement.

**Written revoicing.** The teacher decides to write what is being discussed on the board for extra reinforcement or for better understanding of the concepts.

**Rephrasing:**

Into mathematical language. The teacher will reformulate the learner’s answer into correct mathematical language.

Into correct English. This will be done by the teacher to model the correct language required.

Deconstructing. The teacher skilfully deconstructs a question in order to support learners who are struggling to understand what is expected of them. It is also used after a learner displays that s/he understands the concept, to give access to the rest of the class. If not used in the intended manner, this practice can lead to an unnecessary lowering of the level of discussion and time wastage.

**Funnelling** (Bauersfeld, 1980) indicates a form of elaboration which lowers the level of the task significantly. Funnelling occurs when a teacher is focused on getting the right answer from the class and starts to ask increasingly simplified questions.

My findings show that the two teachers in my study are already using revoicing within the IRE/F format but that the more advanced revoicing practices which fell into the rephrasing categories were used less than the repeating categories. Consequently, the ways in which revoicing practices are used, don’t necessarily develop understanding, as suggested in the literature, or help to move the pedagogical agenda forward. In order to open up participation of learners in mathematical discourse through revoicing practices, careful study of current practices and support for teachers in their attempts to use these practices is required.

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Understanding teachers difficulties in teaching elementary mathematics

Kakoma Luneta
Department of Childhood Education, University of Johannesburg
kluneta@uj.ac.za

Abstract

The problems associated with the teaching of mathematics at primary school have been with the world for a very long time. James (1899) Dewey (1916), Polya (1957) and Cockroft (1982) all reported concerns in mathematics teaching and learning. All these papers and reports suggested solutions to the problems of teaching mathematics at elementary level. It is still unfortunately true that there are still problems in teaching mathematics today as some of them are embedded in the social, cultural and economic contexts. It is also well documented in research that elementary mathematics is the corner stone of children’s attitude and competence in mathematics in future. When well taught learners tend to like mathematics in their upper grades and excel in the subject but when it is not, it creates anxiety and children tend to detest the subject. Research also has revealed that most elementary teachers find mathematics uncomfortable to teach. This study is a culmination of a series of workshops that were conducted for foundation phase teachers. It recounts the difficulties expressed by the teachers as well as the researcher’s observation during the workshops. A questionnaire in the form of a needs analysis was sent out to 58 schools for teachers to list down the topics they wanted the workshops to cover and it turned out all the five learning outcomes (numbers operation and relation, algebra, space and shape, measurement, and data handling) at foundation phase were listed. In total there were 14 workshops conducted involving 52 teachers of grades R to 4. Each work shop was preceded by an exercise. These were 10 grade 7 examination questions on the topic that the workshop hinged on. Less than 30% of the foundation phase teachers could answer all the questions correctly. The workshops revealed that while some of the teachers might have the content knowledge of the mathematics they teach at foundation phase, even they had difficulties expressing that in ways that enabled children to understand it. It was identified that not only did the teachers need comprehensive professional development programmes on the mathematics they teach but effective practical, classroom tested instructional approaches that took cognisance of their contexts as well.
Prospective Mathematics teachers’ knowledge of teaching geometry in a GeoGebra-based environment

Kim Ramatlapana\textsuperscript{1} & Margot Berger\textsuperscript{2}

Marang Centre for Mathematics and Science Education, University of the Witwatersrand,
South Africa
\textsuperscript{1}kim.ramatlapana@wits.ac.za; \textsuperscript{2}margot.berger@wits.ac.za

Mathematics educators are challenged to prepare prospective teachers with the mathematical and critical thinking skills that will enable them to be productive citizens in a technological society. The mandate of most Mathematics Education programs is to deliberately ensure that they provide formal learning situation which prepare prospective teachers to teach school mathematics. Mathematics teacher education programs need to prepare prospective teachers so that they are able to consider the mathematics content, the technology in use and the pedagogical methods employed in teaching the content. In such programs, knowledge of technology should integrate both mathematical knowledge and knowledge about the technology tools. I contend that knowledge is derived from experience for which I conjecture that teacher knowledge is influenced and framed by teacher practical experiences with tools. As mediators of mathematics learning, prospective teachers should experience technology first if they are to incorporate it into classroom mathematics learning. Hence, the courses in these programs should include tasks that prompt mathematics thinking and reasoning as components of teacher learning that addresses both the teacher content knowledge and pedagogical content knowledge.

This study is located within an undergraduate mandatory mathematics methods course at a South African university. The Bachelor of Education (B.Ed) second year mathematics education course is a theoretically and practically oriented mathematics methods course that deals with the teaching and learning of mathematics, develops prospective teachers’ didactical knowledge, and incorporates aspects of mathematics teaching that challenge student’s mathematical thinking (Ramatlapana, 2011). Technology integration in the teaching and learning of classroom mathematics is a module in this course. Technology-rich environment should be examined for their potential in the promotion of the use of technology in mathematics learning to address the school curriculum and in mathematics teacher education programs to develop prospective teachers’ technology pedagogical content knowledge and with a view to promoting teachers’ mathematical knowledge.

The study is guided by the following research question:
How does mathematics prospective teachers’ technological pedagogical content knowledge (TPACK) of teaching circle geometry evolve in a GeoGebra-based environment?

The instrumental approach and the TPACK are lenses engaged to study prospective secondary teachers’ mathematics development as they work on a set of GeoGebra tasks where such tasks are designed to advance both mathematics knowledge and technology knowledge. The instrumental approach developed by Vérillon & Rabardel (1995) has been applied by French mathematics educators such as Artigue (2002) and Drijvers & Trouche (2008) in their research on the integration of technology into the learning of mathematics. The technological pedagogical content knowledge (TPACK) framework is a prerequisite to effective integration of technology in education. Mishra & Koehler (2006) explicate that TPACK is the interaction of these bodies of knowledge, both theoretically and in practice, to produce the types of flexible knowledge needed to successfully integrate technology use into teaching. To understand the kind of knowledge teachers need within computerized environments, it is necessary to understand teachers’ experiences as they relate to technology. I contend that knowledge is derived from experience for which I conjecture that teacher knowledge is influenced and framed by teacher practical experiences with tools.

This paper presents work of an on-going study on prospective teachers’ knowledge of school geometry in a GeoGebra-based environment. The entire study employs the exploratory multiple case study design. The rationale for the design is that mathematics knowledge development within a technology environment is influenced by the different components of TPACK and the use of the GeoGebra tool. Multiple cases within mathematics knowledge development can be examined through the case study approach to seek a range of multiple sources of evidence of development and prospective teachers’ instrumental genesis with GeoGebra through a teaching experiment. A purposive sample of ten (10) participants enrolled in secondary mathematics methodology course was selected based on their performance in the geometry module in the mathematics methods course.

Data were collected through screen recordings and written responses of prospective teachers working on GeoGebra-based geometry tasks and through lesson plans for teaching circle geometry theorems with GeoGebra. This paper will present the preliminary findings of a document analysis of lesson plans developed by prospective teachers specifically for teaching Grade 11 lesson on circle geometry theorems using GeoGebra-based. Prospective teachers use of GeoGebra to explain a given geometry theorem, was closely related to their conceptual understanding of the mathematics behind the technical skills required to mediate the explanation.

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Mathematics, Science and technology are the driving tools for the development of any country. As the percentage of women in Malawi is higher than that of males, the underrepresentation of women in mathematics and science does not threaten the wellbeing of women and their families only but also on the economy of the whole country (Chamdimba, 2008). The purpose of this study was to explore classroom practices which affect girls’ participation and performance in mathematics. The study used a qualitative study approach with a case study design. Data was collected through direct mathematics lessons observation, in-depth focus group and individual interviews. Data analysis was done through framework analysis in which themes were identified, and the relevant and related passages to the research concerns were placed under them (Srivastava and Thomson, 2009). The study found that girls’ low participation and performance is mainly due to the irresponsible behaviour of the girls themselves and partly due to the teachers and boys actions during mathematics lessons. During interviews the girls did acknowledge boys’ support and encouragement but blamed themselves for being lazy to join them when they are practicing mathematics. Girls’ laziness was observed as the main factor that contributes to their low participation and performance during mathematics lessons. The study therefore conclude that although many mathematics education studies attribute girls’ perceptions and low participation and performance in mathematics to social and educational influences, especially classroom socialization (Fennema and Sherman, 1977; Gallagher, 2005) much blame can also be put on the girls themselves.

References


Functions and their representations: An investigation of learners’ mathematical thinking when solving algebraic functions through a discursive analysis of errors.

Lizeka Gcasamba

School of Mathematics Education, University of the Witwatersrand, South Africa.
lgcasamba@vodamail.co.za

In the recent National Diagnostic Report of the learner performance on National Curriculum Statement NCS (Education, 2011) examinations, it was noted that: (a) Questions on Functions and Graphs were generally poorly answered, (b) teachers and learners did not spend enough time discussing different representations of functions and information that can be obtained from the graphs, (c) learners were unable to convert flexibly between verbal, symbolic and graphical representations of the functions. Learner difficulties with functions and their representations are not unique to South Africa. Others have reported learner difficulty in linking graphical and tabular forms of representation to algebraic forms of functions (Brenner, Mayer, Richard & Mosely, 1997). Furthermore, research indicates that these difficulties can lead to errors (Even, 1998). An investigation into learner strategies and related errors then, when dealing with tasks related to functions, can illuminate learner difficulties and their thinking more generally.

This study sets out to investigate Grade 11 learners’ thinking when solving tasks in algebraic functions. All algebraic functions, quadratic, linear, exponential, hyperbola and exponential functions will be investigated. I intend to explore and describe all the errors that learners make when dealing with algebraic functions, and each function family has its own unique errors. Research literature related to errors and mathematical thinking within functions has been reviewed in order to shape and inform the study. The theoretical framework of commognition, developed by Sfard (2008) which defines “thinking as communicating” will be used in the study. Commognition theory defines learning as participating in the mathematical discourse (Sfard 2007). Mathematical discourse is described by certain rules. According to Sfard (2007), these rules involve vocabulary, narratives, visual mediators, and routines.

In order to gain deeper insights into learners’ thinking and sense making with functions, this study will try to answer the following research questions:
1. What common errors in terms of algebraic functions are made by the learners?
2. What discourses do the learners use as they explain their mathematical errors?

This study aims to explore and interpret in detail the learners’ written and spoken responses using a qualitative approach (Creswell, 2012). In other words, I am interested in the mathematical discourse the learners are using when solving tasks on functions. The spoken responses refer to the learners’ comments during the interviews while the written responses refer to written answers to the test.

I am intending to do a case study (Cohen, Manion, & Morrison, 2000) consisting of 50 Grade 11 learners. The study will be conducted in a multilingual² high school situated in a northern suburb in Johannesburg, South Africa. The school was a convenience sample, because I had an access to the school since the school is one of the schools in the Wits Maths Connect project. All the participants in the chosen class will be given a test. All the tests will be investigated and analysed in detail. I will then identify 20 learners based on the kind of

² Multilingual means that learners are learning in language not their mother tongue and learners and teachers are speaking many different languages
common errors that emerge in their answers. Thereafter with the help of the teacher, 10 learners will be purposefully sampled according to their general performance in class, communication skills and willingness to participate in the study. The learners’ abilities will be classified from high to medium performance in solving tasks.

There are two research instruments that are going to be used for this study, the test and interview schedule. The test will be used as a primary source of data for the first question in my study (see table1). The interview schedule will be used to answer the second question of the study.

| 1. What common errors in terms of algebraic functions are made by the learners? | The test |
| 2. What discourses do the learners use as they explain their mathematical errors? | The interview and the test |

Table1: Research instrument per question

To aid in a close examination of the data, I will use multiple analysis tools. These tools will allow me to get close to the data. Table 2 below provides a summary of the data source and corresponding analysis tool.

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Data Collection</th>
<th>Data Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>What common errors in terms of functions are made by the learners?</td>
<td>Tests</td>
<td>Typological and inductive Analysis</td>
</tr>
<tr>
<td>What discourses do the learners use as they explain their mathematical errors?</td>
<td>Tests and Interviews</td>
<td>Typological and inductive Analysis</td>
</tr>
</tbody>
</table>

Table 2: Alignment of Research Questions with Data Collection and Data Analysis Methods

ANALYSIS AND DISCUSSION

The common errors that are evident in the data are:

<table>
<thead>
<tr>
<th>Common Errors</th>
<th>% of learners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linearity</td>
<td>85%</td>
</tr>
<tr>
<td>Gradient</td>
<td>62%</td>
</tr>
<tr>
<td>Classification</td>
<td>62%</td>
</tr>
<tr>
<td>Algebra</td>
<td>54%</td>
</tr>
<tr>
<td>Notation</td>
<td>42%</td>
</tr>
<tr>
<td>Table construction</td>
<td>38%</td>
</tr>
<tr>
<td>Plotting</td>
<td>55%</td>
</tr>
<tr>
<td>Constant functions</td>
<td>44%</td>
</tr>
</tbody>
</table>

So far the investigation is showing that the errors exist, and some are similar to those suggested in the literature. Many reasons why learners are making such errors have been cited (i) the function concept may be limited due to lack of instructional examples, (ii)
learners possessing inaccurate definition of the function concept, (iii) learners tendencies of overgeneralising all functions to linearity (linear functions), (iv) an over emphasis of algebraic calculations. (v) a traditional instruction that emphasizes in plotting the graph from the table of ordered pairs. In these conditions, learners are inclined to use graphs the same way they use table, by looking at pieces of information, ignoring global features of the graphs or representation,(vi) Learners understand that function is a co-variation between two quantities x, y and constant function are seen as ‘monster’ functions, because one variable is missing (vii) notation and concept of variable (Bell & Janvier, 1981; Breidenbach, Dubinsky, Hawks, & Devilyna, 1992; Brenner et al., 1997; Confrey & Smith, 1991; Even, 1990).

Further investigation on how learners are explaining their errors is underway. I am going to be looking at mathematical discourse characteristics that are evident in learners’ explanations, that is: words, routines, endorsed narratives and visual mediators (Sfard, 2008). The research on errors from a commognitive perspective is new and under-developed; hence my reading of the literature refers to the work done from a cognitive perspective. In this study the functions errors will be redescribed in both cognitive and commognitive ways because from a commognitive perspective thinking is a dialogue with oneself, through talking, arguing, asking questions and waiting for your own responses.

References


The role of the teacher in object-level and meta-level learning

Maria Bogdanova
University of the Witwatersrand
maria7p@yahoo.com

The National Curriculum statement, or NCS for short, proposes significant shifts in the way teachers carry out their work. Strategies, such as investigation and collaborative work were promoted as a reform model for effective teaching and learning. Thus, the intention of my research project was to determine how mathematics teachers are implementing the new reform in South Africa.

Based on Sfard’s theory of commognitive development, a theoretical framework was established and the focus specified in the following research questions:
1. How does a teacher mediate instruction during object-level & meta-level learning?
2. What enables and constrains her/his facilitative mediation in the case of Congruency in Grade 9?
3. What can we learn about the practical efficacy of Sfard’s discourse theory?

The Commognitive theory, the most recent theoretical view of learning was chosen for this study because it is engaged with mathematical context. Looking at thinking as communicating with oneself, mathematics as a discourse and learning mathematics as becoming a member of a mathematical community, the basic commognitive tenets is a break-away from the traditional discourse and explores discursive development.

Before describing the findings of the three questions above, I focussed on two types of learning – object-level and meta-level learning. Ben-Zvi and Sfard (2007) recognise object-level learning as a straightforward type of learning; it is a product of logical necessity. Furthermore they state that object-level learning increases the set of “known facts” (Ben-Zvi & Sfard, 2007: 6) about the investigating objects and the goal of this type of learning is to get better acquainted with the object, with the properties of the object and the mathematical narratives. Object-level learning leads simply to the extension of a discourse.

In contrast, meta-level learning is a result in an incommensurable discourse. Sfard (2008:161) considers mathematics as a “multi-layered recursive structure of discourses” meaning that mathematics as a discourse consists of sub-discourses, which relate to each other in various ways: some are isomorphic, and some subsume others, while some are incommensurable. The relationship that we are familiar with is no longer valid in the new discourse (the discourse of rational numbers). The type of learning that results in an incommensurable discourse is meta-level learning and involves changes in rules and endorsed rules and mathematical laws of the old discourse, which may sound contradictory, compared with the rules of the new discourse and may also be mutually exclusive. At the same time meta-level rules are difficult to discover; they are the result of historically sanctioned custom and are thus contingent rather than inevitable.

In order to explore the actual teaching process the research project presented a case study constituted from two teaching practices on one topic, Congruency, at a College in Johannesburg. I, as a researcher, together with two teachers, deliberately designed four lessons on the topic Congruency across these two levels of learning. Using the idea of collaborative learning in the first three lessons the learners had to implement the activity by working in groups. Simultaneously, lessons one and four were designed to contain two
activities; one on object-level and one on meta-level learning. The study implemented two related activities – non-participant observation and semi-structural interviews with teachers. The purpose of observing and interviewing two teachers on the same lessons was to get a greater variety of conversation on object-level and meta-level learning. At the same time analysing their teaching process in-depth created an opportunity to have different possibilities of mediating collaborative learning.

Two main findings can be summarized: Firstly, the way the teacher manages instruction originates from her/his teaching style. The data analysis clearly confirms that mediation of the two teachers on the topic Congruency does not differ according to object-level and meta-level learning, but according to the teachers. The second finding is related with Sfard’s theoretical perspective: on the one hand the Department recommends investigative activities, whilst, on the other hand, Sfard’s theory states that reinvention by the learner is highly unlikely. Therefore the practical efficacy of Sfard’s theory is that in meta-level learning investigative activities are not appropriate and the role of the teacher should be dominant, not necessarily as facilitator.

In conclusion this research study is an empirical proof of the validity of Sfard’s theory and recommends a review of main derivative for teachers’ requirements of the Department of Education.

References:

Understanding the pre-service teachers’ nature of Mathematisation

Mark Winter
Department of Mathematics Education, University of the Witwatersrand, South Africa.
Mark.Winter@wits.ac.za

Abstract
The introduction of Mathematical Literacy (ML) as a subject in the Further Education and Training (Grades 10-12) band within South African schools in 2006 was aimed at developing learners’ numerical skills necessary for citizenship (Department of Education, 2003). The relevance of pushing for a citizenship agenda in schools is evident in the numeracy demands contained in a wide range of real world situations. The need for students to develop their capacity to use mathematics in dealing with situations in their present and future lives has been strongly emphasized in the National Curriculum Statement (NCS) for ML (ibid). Similar intentions have also been expressed in the Curriculum and Assessment Policy Statement (CAPS) for ML (Department of Basic Education, 2011). According to both NCS and CAPS, learners would engage with ‘authentic’ contexts drawn from their experiences as well as their current and future needs to develop the citizenship skills and competences.

The rhetoric in both curriculum statements suggests that ML teachers would be confident and competent in engaging with real-world situations which contain mathematical features. However, a study by Mbekwa (2007) revealed that teachers were drawn from the already
limited pool of mathematics teachers to assist in the implementation of ML in 2006. The report further indicates that some of these mathematics teachers did not undergo any training for ML at all despite evidence showing that mathematics teachers often lack the capacity to both connect their mathematics to real contexts and struggle to see the internal connections between mathematical concepts (Brombacher, 2007; Steen, 2001). The implication is that ML needs to be taught by competent teachers – those capable of connecting their mathematics to real-life contexts. Pre-service teachers in particular need to have ML based competencies developed in order to ensure that ML related identities are formed which are crucial for ML teaching.

This paper explores the nature of pre-service ML teachers’ ways of solving problem situations through a focus on solutions to a range of tasks. These pre-service teachers were enrolled into a new three-year B.Ed ‘concepts and literacy in mathematics’ (CLM) course at a large urban University in South Africa. The CLM course aimed specifically at developing the teachers’ fundamental mathematical knowledge as well as contextual knowledge, which I believe are key components in ML teaching. These course assessment tasks were in the form of assignments, quizzes, tests, and examinations. Since the study focus was on ways how the teachers worked through assessment tasks, I used document analysis to collect solutions to the assessment tasks. The fact that the course offers a new approach to professional teacher development in ML as opposed to the old model where qualified teachers from other subjects were re-skilled, coupled with the need to grow the pool of qualified ML teachers, provide a rationale for conducting this study. The key question which this paper is addressing is; what does the pre-service teachers’ mathematisation of course tasks indicate about their understanding of both mathematics and contexts?

The results presented here are part of an on-going case study involving eight pre-service ML specialists. All the participants were in their second year (2011) of study. This paper draws on data from the first year of a two-year (2011-2012) study where solutions to a range of course tasks were collected. I use the notion of Realistic Mathematics Education (RME) by Freudenthal (1973), especially the idea of horizontal and vertical mathematisation. RME assumes that successful learning of mathematics can be achieved if learners are taught using real-life or ‘realistic’ contexts. In RME terms, the word ‘realistic’ is used to refer to tasks which can trigger imagination in the mind of the learner (van den Heuvel-Panhuizen, 2003). Drawing from the course tasks analysis, I argue that;

1. Teachers in the sample use vertical mathematization more than horizontal mathematization.
2. The teachers’ vertical mathematization is often incorrect, resulting into incorrect solutions.
3. The teachers’ horizontal mathematization, is seen especially when numerical answers are been interpreted in the context of the problem situations, and less so when transforming problem situations into models.
4. Teachers’ competencies relating to horizontal mathematization are more developed than vertical mathematization competencies

The pre-service teachers’ responses to situational problems show a gap in mathematics content understandings as evidenced in their incoherent and incorrect procedures. Although this is an on-going study, the major implication of the results for ML teaching relates to the need for further development of the teachers’ mathematical knowledge.
Some cognitive obstacles faced by ‘A’ Level Mathematics students in understanding Inequalities: A case study of Bindura Urban High schools

Maroni R Nyikahadzoyi; Tichaona Mapuwei; Mirirai Chinyoka
Department of Physics and Mathematics, Bindura University of Science Education, Zimbabwe
nyikahadzoyi@yahoo.com, tichaonamapuwei@yahoo.com, mchinyokai@buse.ac.zw

This paper reports on a study in which Mathematics lecturers and teachers collaborated to determine the cognitive obstacles faced by ‘A’ Level mathematics students in understanding inequalities. The target study group consisted of twelve and eight ‘A’ level students from two urban high schools respectively which are within five kilometres from the university. The data was collected in one afternoon in a lesson where the students were taught inequalities at one of the high schools. The Japanese lesson study process (a teaching improvement and knowledge building process) was considered as the appropriate theoretical framework to capture the ‘A’ level students’ cognitive obstacles when learning inequalities. Using this framework, lecturers and teachers collaboratively planned lesson plans for teaching inequalities which is a key component of the ‘A’ level syllabus. While one member of the research team was teaching the other members were writing detailed observations of students’ activities and written work during the lesson. The lessons were videotaped for future reference and review.

Soon after the lesson was taught the researchers shared their observations about the lesson, such as student written work and the transcribed think-out-loud protocols, searching for patterns that could reveal important insights into cognitive obstacles as students were responding to the following three part task:

(a) On the same axes, sketch the graphs of $y = |x - 1| - 2$ and $y = -|x - 1|$
(b) Solve the equation $|x - 1| - 2 = -|x - 1|$
(c) Hence solve the inequality \(|x - 1| - 2 > -|x - 1|\)

Students’ think-out-loud protocols were used as part of the research instruments since not all the students’ thinking is put down in their written work.

**Results**

The major cognitive obstacles of the ‘A’ level mathematics students in understanding inequalities include: overreliance on deceptive intuitive mathematical knowledge, undue focus on mathematical procedures, compartmentalization of mathematics topics and also the representations of mathematical concepts.

**Overreliance on deceptive intuitive mathematical knowledge**

Students knew that they were supposed to sketch the two functions by transforming the graph of the standard modulus function. However, instead of translating the standard modulus function one unit to the right, some students translated it one unit to the left thereby obtaining the graph of \(y = |x + 1|\) but labelled it as the graph of \(y = |x - 1|\). When asked to justify their behaviour one of the students had this to say … ‘but I always have this feeling that if a number is negative such as this -1 in the function \(y = |x - 1|\) then I should translate the graph of \(y = |x|\) to the left. I would shift to the right if it was positive’.

**Focusing on mathematical procedures and processes**

The study noted situations where students attempted to find either the derivatives or the intercepts of the functions. Obviously this approach was motivated by the students’ knowledge of the procedures they would use in sketching functions differentiable at all points and having stationary points. There were also cases where some students attempted to sketch the function by constructing tables of values thereby showing lack of understanding the general characteristics of modulus functions. When asked to justify the choice of their procedural approaches the students responded by saying that the phrase ‘sketch the graphs of’ demands that they embark on the chosen approaches.

**Compartmentalization of the mathematical ideas**

Students failed to exploit the interrelatedness of the three part task. For example, after sketching the two functions they would proceed to solve the equation algebraically, forgetting that the roots of the equation could be read at the points of intersection of the functions sketched in the first part of the question. In other cases we noticed that after getting the roots of the equation the students would start afresh to solve the inequality by initially squaring both sides of the inequality. The students did not take cognizance of the fact that the answer to the inequality could be obtained by integrating the results of the first two parts of the question.

**Compartmentalization of representations of inequalities**

Compartmentalization of representations of inequalities was evident initially when procedural learners could not read the solution of the inequality from the graph. After having obtained the correct graphical representations of the two functions reading the solution of the inequality was an uphill task for the procedural learners. Poor understanding of the symbolic representation was evident again when students were asked to represent verbal description of the solution set using mathematical symbols.

**Recommendations.**
The findings of the current study show that intuitive knowledge can be inappropriate, inaccurate or deceptive thereby interfering with new understanding. The secret to learning then is to be willing to unlearn the deceptive intuitive understandings, even if the intuitive understandings previously brought success in other topics. Mathematics teachers should teach for conceptual understanding. Learners with a procedural understanding of mathematics have a tendency of compartmentalizing mathematical ideas and their representations and are likely to suffer from cognitive overload leading to eventual failure in further mathematical studies.

References


Accessing prospective early years’ teachers’ knowledge on fractions in order to design tasks for developing teachers’ MKT

C. Miguel Ribeiro¹, Arne Jakobsen² & Ana Caseiro³

¹Research Centre for Spatial and Organizational Dynamics (CIEO), University of Algarve, Portugal; ²Department of Education, University of Stavanger, Norway; ³School of Education of Lisbon, Portugal

¹cmribeiro@ualg.pt, ²arne.jakobsen@uis.no, ³anac@eselx.ipl.pt

Fractions is perhaps one of the most complex and difficult topics pupils explore in the early years of schooling. Difficulties in learning this topic may have its genesis in the fact that fractions comprise a multifaceted construct (Kieren, 1995) or can be conceived as being grounded in the instructional approaches employed to teach fractions (Behr, Harel, Post & Lesh, 1993). Thus, students’ limited understanding might be related to how their teachers understand and interpret fractions — it’s thus related with teachers’ knowledge and practice. Although there is a generalized agreement on teachers’ role on/for students learning, most research on fractions focus on students, leaving aside teachers’ role (and their knowledge on the topic). Thus, teachers’ training has in certain respects been left behind. We still know little about how teachers’ knowledge on fractions influences students’ broader view of mathematics, and its connection and evolution within and along schooling. Aimed at conceptualize ways of improving teachers’ knowledge, training and practices, it’s of fundamental importance to access the areas of knowledge (here conceived as mathematical knowledge for teaching (MKT) (Ball, Thames & Phelps, 2008) in which (prospective) teachers lack.
This paper is part of a broader research project aiming at obtaining a deeper understanding on teachers’ MKT, allowing designing tasks for developing such knowledge. We aim at identify, discuss and reflect upon some mathematical critical situations identified in (prospective) teachers MKT in different mathematical topics (e.g., pictograms, subtraction), as well as concerning transversal abilities (e.g., problem solving, reasoning). Its ultimate aim is to conceptualize specific tasks for improving teachers training. Here we will focus on prospective teachers’ subject matter knowledge on fractions and in particular, on the role of the whole and different kinds of whole. We will address the following research question: What critical aspects of MKT do prospective early years’ teachers reveal about fractions and the role of the whole, and how can such mathematical critical situations be perceived to design tasks to develop teachers’ MKT?

We opted by the MKT conceptualization because it attributes a very specific orientation to teacher’s mathematical knowledge, placing emphasis on the mathematical reasoning they are immersed in during the development of tasks of teaching (Ball et al., 2008). By using this approach, we also aim to identify, discuss and reflect upon some mathematical critical situations, allowing to conceptualise optimal learning opportunities. Design of tasks is one of such approaches. The study in grounded in a set of tasks applied to 60 Portuguese prospective teachers focusing on their MKT on fractions and on their revealed understanding on the role of the whole and the different kinds of whole. Here we will focus only in one part of the first task: if we want to share equally 5 chocolate bars amongst 6 children’s, what amount of chocolate would each children get?? We combine a qualitative methodology with an instrumental case study — and in the analysis we focus mainly on the situations where there was some evidence of gaps in knowledge, as these instances are seen as an opportunity to learn (Ribeiro & Carrillo, 2011). Such an approach intends accessing the critical aspects of (prospective) teachers’ MKT, discussing not only ways of contributing to improve such MKT (were the conceptualization of tasks specifically for teachers training has a major role), but also the content of the MKT domain’s and equate a theoretical refinement of the MKT conceptualization in itself.

While answering the question, the prospective teachers’ revealed knowledge that was at the same level as some of the students they supposedly will be teaching. The majority of them revealed subject matter knowledge, and ways of representing the solution(s), similar to pupils in first grade —including the chosen representations. Examples of such answers are: “each child will get 5 pieces”; “each child gets 2 big squares and one small square (2/3 of 4 chocolate bars and 1/6 of other)”; “each child will get exactly 5/6 of the total amount of chocolate or 5/6 of each chocolate bar”. These revealed difficulties are also our fault, as teacher educators and if such difficulties are not properly overcome, it will be impossible for teachers to prepare and implement tasks allowing their pupils to develop a broader understanding specifically, but not exclusively, on the interpretations and representations of fractions. Teacher education must start paying more attention to, and incorporate in training, the results from research (if it was already effectively incorporated, students’ understanding on fractions would not be as it is). We think focusing on the specialized mathematical knowledge will be most usefull, as we assume it can be effectively taught (Hill & Ball, 2004). We will present, discuss and reflect upon the results from the prospective teachers’ knowledge and the potentialities of accessing such mathematical critical situations and reasoning, for conceptualizing a specific kind of tasks for developing teachers MKT, in particular on fractions. From such results we will discuss also some aspects of the MKT conceptualization, allowing proposing some refinements.
Acknowledgements:
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References

Learner interviews as a pedagogical tool for teacher learning in a professional learning community

Million Chauraya¹ & Karin Brodie²

¹School of Education, University of the Witwatersrand; ²School of Education, University of the Witwatersrand

¹Mchauraya04@yahoo.com, ²Karin.Brodie@wits.ac.za

Contemporary ideas on teacher learning in professional learning communities highlight the use of school-level data as evidence for developing new understandings and trying out new practices. The data serves as a pedagogical tool that supports teachers’ collective inquiry and reflection on knowledge and practices. In a professional learning community the collective interpretation of a wide range of classroom data enables teachers to identify learners' real learning needs and their own learning needs (author ref.). This paper draws from a larger study to highlight how data from learner interviews about errors in mathematics served as a pedagogical tool for teacher learning in a professional learning community. The theoretical ideas which guided the study included situated learning (Lave, 1993) and professional learning community. Situated learning theory regards learning as social practice which is situated in the activities of communities of practice (Lave & Wenger, 1991). A professional learning community refers to a group of teachers “critically interrogating their practice in ongoing, reflective and collaborative ways” (Stoll & Louis, 2007, p. 2). A key feature of teacher learning in a professional learning community is having a shared focus which guides the goals and activities of the community (Katz, Earl, & Jaafar, 2009). In the study five
mathematics teachers in one high school and the researcher worked collaboratively on a series of professional development activities whose focus was on understanding and working with learners’ thinking in mathematics. The researcher acted as a facilitator and ‘critical friend’ in these activities (Earl & Katz, 2005).

This paper is based on the activity of analyzing learners’ errors on two teacher designed mathematics tests. The activity involved collecting data about the errors made by the learners in the tests and collaboratively inquiring into the reasoning behind the observed errors. Collecting data about learners’ errors involved each teacher interviewing at least five learners from his or her class on specific errors they made in the tests. The learners’ descriptions of how they solved particular test items were additional data to the observed test errors and the actual test items. During the error analysis activity the three data sources provided the teachers with rich data to analyse in their quest to understand the learners’ reasoning in making particular errors. Transcripts of the audio-recorded interviews were used in conjunction with the test errors and the test items as evidence for identifying the critical mathematical concepts with which learners had problems. In this paper we present results that show how the learner interviews were critical for the teachers’ understanding of their learners’ learning needs with respect to the concept of rational numbers.

The results from analyzing the learner interviews in the professional learning community highlighted several critical issues with respect to learners’ understanding of rational numbers. In explaining how they had solved the tasks learners focused on the procedures for getting the answer and saw their errors as a result of forgetting certain rules. In tasks that involved addition and subtraction of common fractions learners explained their errors in terms of incorrect application of the procedures such as how to find the lowest common denominator. When asked about the meaning of the lowest common denominator none of the learners could explain what it means. Some learners were not able to explain the differences among common fractions, decimal fractions, and percentages although they showed understanding of the procedures associated with rational numbers. Through such collective analyses of learner interviews it became evident for the teachers that while learners had some procedural understanding of rational numbers they lacked conceptual understanding.

The results show how the voices of the learners enabled the teachers to develop shared understandings of their learners’ learning needs about rational numbers. Such knowledge created a need for the teachers to deepen their own understanding of the conceptual meanings of rational numbers. The learner interviews were an important pedagogical tool for supporting teachers’ deepening of their own understanding of their learners’ learning needs and in turn their own learning needs in the professional learning community. Using these findings we argue that the use of classroom data as evidence for identifying learners’ learning needs in a professional learning community requires attention to the voices of the learners as a pedagogical tool for deepening the teachers’ own understanding.

References
Junior Secondary Learners’ Views on Learning Mathematics that Arises from Newspapers, Radio or Television

Minenhle Ngcobo
Department of Curriculum and Teaching, University of Swaziland.
minenhle@uniswa.sz

This paper reports on learners’ view about learning mathematics that emerge from newspapers, radio and television. The data came from part of a larger study that set out to explore learners’ preferences for contexts to use in learning mathematics. Proponents of contexts in the teaching and learning of mathematics assume that learners perform better when mathematics is presented in the context of practical, real-world situations than when they are presented in traditional school contexts (McNeil, Uttal, Jarvin & Sternberg, 2009). Realistic Mathematics Education (RME) is one theory that has given prominence to contexts in the learning of school mathematics (Ngcobo, 2011). RME by its nature incorporates constructivism and situated learning Lave (1988). Cobb (2000 p.318) lists the following as views central to RME:

- The starting point of instruction sequences should be experientially real to the students in the sense that they can engage immediately in personally meaningful mathematical activity.
- The starting point should be justifiable in terms of the potential end points of the learning sequence.
- Instructional sequences should contain activities in which students create and elaborate symbolic models of their informal activity.

To facilitate the above instructional activities teachers need to be aware of contexts that are meaningful to learners

The use of realistic contexts became the defining character of RME. Realistic is in the intention that learners are offered problem situations which they can imagine (Van den Heuvel-Panhuizen, 2003). These realistic situations do not only include real world but fantasy world as well as the world of formal mathematics which are real in learners’ minds (Van den Heuvel-Panhuizen, 2003). Sparrow (2008) acknowledges that contexts allow learners to see how school mathematics is used outside the classroom. However, he decries educators’ claims to relevance if the situation used is not directly in the world of the learners.

Learners often have an awareness of the social and organisational matters that can affect their learning (Taylor Hawera &Young-Loveridge, 2005). However their perspectives have in most cases been ignored, even though they form the majority in any school community (Ngcobo, 2011). This paper is in search of learners’ views on the use of mathematics from the media.

Cook-Sather (2006, p. 367) says “… if students speak, adults must listen.” True listening involves more than hearing. It comprises capturing the message sender’s voice and responding or taking action on it. The study reported here gives the learners a platform to speak and the analysis of what they say is a way of listening to them. The questions that the paper answers are:
1. What is the frequency of learners in favour of learning mathematics that arises from newspapers, radio or television?
2. What reasons pertaining to mathematics do learners offer in favour of learning mathematics from the media?
3. What reasons pertaining to mathematics do learners offer against learning mathematics from the media?

The study is based on one of the questions in the original Relevance of School Mathematics Education (ROSME) questionnaire. The present paper is based on item C64: “Are you interested in learning something on mathematics related to issues that have been in the newspapers or radio or TV recently?” They had to choose between yes or no and give reasons for their choice. Learners were instructed on how to answer each part of the questionnaire. The participants were 1028 junior secondary school learners doing Form 1 (37.5%), Form 2 (32.6%) and Form 3 (29.9%) from eight public schools in Swaziland.

Quantitative methods used in this study were simple statistics involving percentages. The percentage number choosing ‘yes’ and ‘no’ in item C64 was used to determine learners’ decisions on learning mathematics from media. To analyze the reasons given for choosing or not choosing to learn mathematics from media and in interpretations of the reasons the qualitative approach was used. Learners’ reasons for preferring or not preferring to learn mathematics that arises from the media were coded using a process of open coding. The categories can, therefore, be thought of as emerging from the data, rather than being imposed from outside. ATLAS/ti 4.1 was used to code the reasons that learners stated in favour of or not in favour of learning mathematics that arises from the media. There was at least a 60% agreement in the coders on most categories (Ngcobo, 2011).

The findings showed that 80% of the learners were positive about learning mathematics that arises from the media 19% were opposed to the idea and 1% did not answer the question. The reasons for preferring to learn mathematics that arises from media were screened for reasons that are relevant to mathematics. Reasons for being opposed to the idea were similarly screened. Fifty five percent (55%) of the reasons in favour of the idea emanated from mathematics and 35% of the reasons against the idea originated from mathematics. Each group of reasons were then studied in order to categorise the reasons. Seven categories were found from those in favour of learning mathematics from newspapers radio and television. The category with the highest frequency was: improves the learning of mathematics with a frequency of 46%. Four categories were found from those against learning mathematics from newspapers radio and television. The category with the highest frequency in this group was: negative attitude to mathematics 52%.

It is clear from the results that learners in this study consider learning mathematics from the media important. It seems the learners who were positive about learning mathematics that arises from media saw it improving their learning. This is in line with proponents of the use of contexts in the learning of mathematics as alluded to by (McNeil, Uttal, Jarvin & Sternberg, 2009). In line with Sparrow (2008) and Van den Heuvel-Panhuizen (2003) the learners were able to imagine how the media could be relevant in their learning. Learners that were opposed to the idea seem to be mostly those that were not doing well in mathematics. Thus their view could be coming from their mathematical self identity. These learners did not perceive a relationship between mathematics and the media. This could be due to the programmes that attract them in radio and TV and their perception that reading the paper is an adult’s activity.
In conclusion it can be said that learners in this study were aware of how the media could contribute in their learning of mathematics. They are aware of the presence of mathematics in the media. Learners that were opposed to the idea also acknowledged the presence of mathematics in the media. It is recommended that as educators we become interested in mathematics in the media and actually use it in our teaching. This means we should develop interest in the programmes that learners like to view, read or listen to in order to discover things that we can connect to school mathematics

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Investigating the Relationship between Mathematics Teachers’ Pedagogical Design Capacity and the Mediation of the Object of Learning: Textbook Analysis

Moneoang Leshota

Wits Maths Connect Secondary, Wits School of Education, University of Witwatersrand,
South Africa

Moneoang.Leshota@wits.ac.za

The key problem in my study is to understand the what, the how and the why of mathematics teachers’ use of textbooks, and how such use interacts with the teachers’ mediation of objects of learning (Marton et al, 2004). The notion of pedagogical design capacity (PDC) which Brown (2002, 2009) defines as “teacher’s capacity to perceive and mobilise existing resources in order to craft instructional episodes” is central to the study in order to understand better what decisions teachers make with regard to the use of textbooks and how they make these decisions. The focus of the study is grade 10 functions and the participants are seven teachers from three township schools participating in a wider object focussed research and development project. All three schools use the same textbook as a recommended text at grade 10. While the substantive data for the study will be drawn from three lesson observation videos for each teacher, and follow on reflective interviews, a critical document in this study is the textbook itself. This paper reports on (1) the development of analytical tools for describing the affordances and constraints of the textbook (Wertsch, 1991, 1998), that is, what the textbook makes available for the teacher to utilise, and (2) the initial results of the analysis.

The framework developed is drawn from theoretical resources including socio-cultural theory (Vygotsky, 1978), variation theory (Marton, Runesson, & Tsui, 2004); research on the teacher-text interaction (Remillard, 2011), and the literature on the teaching and learning of functions (Carlson, Jacobs, Coe, Larsen, & Hsu, 2002; Leinhardt, Zaslavsky, & Stein, 1990; Oehrtman, Carlson, & Thompson, 2008). It includes such aspects as: a) the modes of address of the textbook, b) the conception of the notion of function advanced by the textbook, c) the type of example space and its focus, and d) how research-informed the textbook is in the light of available research on the teaching and learning of functions.

The following questions guided the analysis:

1. What actions/competencies are required from the example space in the textbook?
2. What are the foci of the example space? And
3. What are the dimensions of variation in the example space?

Initial results indicate that the dominant conception of function in the textbook is the action-view (Dubinsky & Harel, 1992), and in this regard the textbook affords a wide range of examples and exercises for the teacher comprising a wide space of variation.

How does this analysis of inform the rest of the study? There is an assumption that the textbook is the most important resource for the teacher for the classroom. We foresee problems for a teacher who randomly selects parts of the exercise, if the rationale of the textbook is that the entire exercise has to be done in order to accomplish its objectives. In the same way, we foresee problems for a teacher who offloads all responsibility to the textbook, since there are affordances as well as constraints in the textbook which the teacher

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needs to be aware of. So, what kind of interaction takes place between the teacher and their
textbook? The next step after this will be to explore what the teacher makes use of when
they interact with their textbook.

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Mathematical Literacy teachers’ understanding of the use of functional relationships in
real life contexts

**Mumtaz B Khan**¹ & **Dr Sarah Bansilal**²

¹ Senior Mathematics Educator in a school in Kwazulu-Natal; ² School of Science and
Mathematics Education, University of the Kwazulu-Natal, South Africa.

¹ khanmb786@gmail.com ² bansilals@ukzn.ac.za

Abstract

With the subject Mathematical Literacy (ML) being introduced only five years ago, many
teachers and researchers are still grappling with the subject and trying to understand how the
subject is similar to and different from the subject mathematics. One of issues that is of
interest is how mathematics concepts are used in ML contexts. An important strand of mathematics is functions which is used to represent relationships between two or more variables. Some of the focus of functional relationships in mathematics is on finding general properties of different functions, learning how to sketch these graphs, finding the equation of a function when the curve is given or when it is shifted, finding points of intersection between different graphs. However in real life contexts, graphs are usually used to present crucial information about a particular issue arising in the context, and thus the focus of the graph in ML may be different from that of mathematics. In order to understand these differences and similarities, it is useful to research how people engage with functional relationships in real life contexts.

This study was carried out with a group of 200 ML teachers who were studying towards an Advanced Certificate in Education (ACE). The purpose of this study was to look at practising teachers’ understanding and use of functional relationships in two real life contexts, which were presented as part of the assessment in the module. The first task was based on a car hire scenario, where the teachers were required to sketch graphs of the different cost packages, which was dependant on the number of days that the car was hired for and the number of km that was driven. In the second task the teachers were given a graph and they were asked to come up with a real life situation that could be represented by the graph.

A naturalistic inquiry will be used as it has an emphasis on interpretive dimensions where the goal of the researcher is to understand reality (Cohen, Manion & Morrison, 2000). According to Cohen et al (2000), the interpretive research paradigm assumes that people’s subjective experiences are substantive and worthy of study. The assessment items under scrutiny were part of a module that focused on exploring applications of functional relationships in real life contexts. The analysis of the responses can be viewed as content analysis which throws “additional light on the source of communication, its author, and on its intended recipients, those to whom the message is directed” (Cohen et al, 2000, p. 165). In this case the students’ responses are the source of the communication intended to convey their engagement with the concept. The analysis of the data has not been completed so we cannot report on the findings yet, but we will be able to present them at the conference, should our paper be accepted.

In analyzing the students’ performance we will draw upon Duval’s (2006) framework concerning transformations of semiotic representations. Duval (2006) asserted that two different types of transformations of semiotic representations may occur during any mathematical activity. The first type, called treatments, involves transformations from one semiotic representation to another within the same system. The second type, called conversions, involve changing the system but conserving the reference to the same objects. This resonates strongly with the study of functional relationships in that this strand presents opportunities for mathematical activities where one representation may be converted to another.

Mathematical activities which are conversions involve working with two semiotic representations, each of which preserves the objects under scrutiny. However, the content associated with the objects in each representation is different. Duval (2002) asserts that the content (properties) of a representation of an object depends more on the register of the representation than on the object represented. Duval gives conversions a more central role in understanding mathematics than treatments, and views conversions as a cognitive threshold that is the main cause of learning difficulties in mathematics. He argues that a conversion of
representation (change of register) cannot be reduced to a treatment and conversions thereby account for one of the sources of incomprehension in mathematics. Another factor cited by Duval as affecting the complexity of mathematical activities, is the direction of the conversion. Duval has shown that when the original and destination registers of a conversion are changed, students’ performances vary considerably.

This study provides us with the opportunity to look at how the notions of conversions and treatments influence students’ (who are teachers in this case) engagement with the tasks. Do ML students perform better at treatment-type or conversion-type questions set around functional relationships? What challenges do the students experience when working with concepts embedded in functional relationships? Most importantly, in what ways is the application of these concepts in real life contexts, different from the focus of the concepts in mathematics?

It is hoped that the findings of this study will add to our knowledge of how mathematics concepts are used in ML tasks, as well as adding to knowledge about the understanding of concepts embedded in functional relationships.

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Development of the mathematical language in an environment where the LoLT is the local languages

N. Chitera, D. Kasoka & E. Thomo
University of Malawi
nchitera@yahoo.com

Literature shows that there are many different relationships that can be highlighted between mathematics and language, Pimm (1991). Mathematics has its own register (Halliday, 1975; Pirie, 1998), rules, grammar, syntax, vocabulary, word order, synonyms, negations, conventions, abbreviations, sentence structure, and paragraph structure (Esty & Teppo, 1994, p. 1). Halliday (1975) specifies the notion of register as ‘a set of meanings that is appropriate to a particular function of language, together with the words and structures which express these meanings’. Lee & Fradd (1998) explain that appropriate use of key mathematical terminology is an indicator of the precision and sophistication of understanding. Therefore, part of learning mathematics is gaining control over the mathematics register so that one is able to talk like a mathematician (Pimm, 1991).

Further, Morgan (1998) and Pimm (1991) explains that, while mathematics, when spoken, emerges in a natural language, when written, it makes varied use of a complex, rule-governed writing system mainly separate from that of the natural language into which it can be read. Such mathematical encoding includes symbol order, position, relative size and orientation (Pimm, 1991). Morgan (1998) calls this “writing system” as “mathematical academic
writing” (p. 11). Which means that, teachers in a mathematics classroom have the duty of helping learners to write mathematically that is, using symbols in a correct order.

Therefore, for a student to be mathematically literate, he/she should be able to talk, write, and read like a mathematician. Considering that the language in education policy in Malawi encourages the use of local languages in lower classrooms, the implication is that mathematical language to be learnt is the mathematical language expressed in the local language. The mathematics, which include mathematical terms are carried and expressed in local languages rather than English.

Considering this situation, it means that, for students to be able to write, speak and read mathematically, there is need for a supportive environment/friendly environment that would help the learning and teaching of the mathematics. In this particular case, we are referring to the LoLT, the LiEP, and how the mathematics teachers use the environment to create a conducive environment so that the learning of mathematical language is not endangered.

Therefore this study explores the following research questions:

1. To what extent does the LiEP allow support mechanisms in case of a deficiency in the local languages including use of other local languages in the classroom?

2. To what extent does the learning environment informs/supports the learning of mathematical language?

According to Setati (2001) students have to learn mathematical language from informal mathematical language to formal mathematical language. It is the teacher who mediates this continua process with the students. In this particular process there are a number of activities that come into play apart from the LoLT and the teacher him/herself. These activities include having supportive learning environment. Supportive learning environment may include, kinds of teaching and learning materials are being used, the LiEP, classroom structure. Furthermore, it also matters to know the balancing of informal language and formal language, oral and written, procedural to conceptual discourse through the media of two or more languages and literacies whose linguistic structures vary from known to unknown (similar to un-similar) and to which the developing biliterate individuals exposure varies from simultaneous to successive. Borrowing from Hornberger (2003), the process of developing mathematical language can be considered to be a continua model of biliteracy which depicts the development of biliteracy along intersecting of the points mentioned above.

According to Hornbeger (2003) p. 275, ‘the continua of biliteracy model offers an ecological framework in which to situate research, teaching and language planning, in linguistically diverse settings”. According to Hornberger (2003) all the points on the continuum represents that all points on a particular continuum are interrelated. This ecological framework suggests that the more the learners learning contexts and contexts of use allow learners and users to draw from across the whole of each and every continuum, the greater are the chances for their full biliterate development and expression.

The paragraph above implies that, in a mathematics multilingual classroom, there has not been usually attention to all points and that movement along the continua and across the intersections may well be contested. Thus it is important to check whether the language used in the books is balanced, if both ends of each continuum is associated with equal power or one is powerful than the other.

We want to use the continua model of bi-literacy in exploring ways of developing and trying out, and demonstrating workable strategies for teaching and learning mathematics in multilingual classrooms.
The sample for this study was small, and purposive. Two mathematics teachers from one semi-urban primary school were chosen. These two teachers had three years experience of teaching mathematics in lower primary school where LoLT is the local language. They were also selected on the basis of their willingness to participate in the study.

Data collection was done through pre-observation interviews, classroom observations, and reflective interviews. The interviews were both tape recorded and the classroom observations were video-recorded.

The preliminary findings of this study show that the LiEP allow support mechanisms in case of deficiency in the language being used as the language of learning and teaching. The LiEP in Malawi states that teachers should use the mother tongue language for the first four years of schooling. However, it is the process of implementation which is problematic.

In classrooms, it has been observed that teachers do not mix the local language with English as they are teaching even when they are not able to explain using the local language. The reason behind this according to the teachers is that the LiEP does not say so. This is also reinforced by the Primary Education Advisors when they come to supervise, if they find any teacher in the any of the first four years classroom mixing the local language with English, it is taken as a crime. This means that even though the LiEP is supportive, it does not mean that it is helping when it comes to teaching. The interpretation and the process of implementation need to be clearly stated and teachers have to receive necessarily help in the process of implementation in order to have the maximum benefits.

Also, the findings of this study reveal that the learning environment in the school visited supports the learning of mathematical to the minimal. Chichewa, as a language is not rich in terms of mathematical language. The Chichewa mathematical language is not yet developed. It was observed that most of the things are very difficult to explain in local languages. In addition, most of the examples given in books are not the things that most students are familiar with. Hence, it became evident that teachers struggle to connect what is in the book and concepts that they would like to teach.

This study recommends for a big study in order to document what is really needed in terms of development of mathematical language in the context where language of learning and teaching is the local language. It is envisaged that after the study, ways can be found of how the development of mathematical language in classrooms where language of learning and teaching is the local language can be enhanced.

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Learning to teach primary school mathematics through multiple representations – a case of prospective teachers in Lesotho

Nkosinathi Mpalami

Lesotho College of Education, Department of Pure Science, Lesotho

nkosinathi.mpalami2@mail.dcu.ie

A decade has passed since the introduction of free primary education in the year 2000 in Lesotho. Studies such as the Needs Analysis that were carried out in order to inform the Ministry of Education and Training about progress made in the teaching of core subjects in schools during the decade of free primary education reveal that there are multiple problems associated with the teaching of primary school mathematics. The reality of overcrowded classrooms impede on the effective teaching of mathematics. Overcrowding is a generic problem facing many schools in Lesotho. However other problems are both content and pedagogically orientated.

Learning to teach mathematics is a complex process. It involves among other things, gaining Pedagogical Content Knowledge (PCK) (Shulman, 1986). The purpose of this study was to explore prospective elementary teachers’ understanding and use of mathematical representations. By mathematical representations I refer to instructional resources through which teachers make mathematics comprehensible to learners. The three modes of representations (enactive, iconic, and symbolic) as proposed by Bruner (1966) provide contexts for both learners and their teacher(s) to construct, negotiate, and re-construct meaning for mathematical concepts, procedures, and processes. The choice and use of representations is a key component of teachers’ PCK.

This study was designed in four distinct tiers, spread over three years, to explore the development of understanding and use of mathematical representations for teaching by a group of prospective elementary teachers in Lesotho. The main analytical framework was the Knowledge Quartet (KQ) (Rowland, Huckstep and Thwaites, 2005). The findings indicate that participants’ mathematical knowledge (foundation) influences their choice of representations and their use in instruction. I found that participants with strong mathematical knowledge are able to choose appropriate representations and are also able to use them effectively in teaching. It is recommended that for the improvement of mathematics teaching in Lesotho, the KQ be incorporated into mathematics courses studied by prospective elementary teachers at Lesotho College of Education where this study was situated. The model (KQ) might assist student teachers to learn to plan and teach mathematics topics collaboratively and as such act as a teacher development model. The inclusion of this model in the Diploma in Education Primary (DEP) programme opens doors for further investigation.

References

Learner Errors and Misconceptions in Ratio and Proportion
Phathisizwe Mahlabela¹ & Sarah Bansilal²

University of KZN
¹ phathamahlabela@gmail.com, ² BansilalS@ukzn.ac.za

Ratio and proportion form part of the South African curriculum and curricula of other countries. Proportionality is rooted in these topics. It (proportionality) is believed to be vital for problem solving and reasoning, which are key cognitive domains of mathematics teaching and learning. Studies carried out in UK, Singapore, China, Malaysia and even in South Africa found that while learners can do simple and routine manipulations of ratio and proportion, they struggle to solve problems that involve these concepts. The studies apportion the blame for this to the strategies that learners use to solve the problems. The studies maintain that learners use flawed strategies due to misconceptions that they have on ratio and proportion.

The purpose of the study was to explore learner errors and misconceptions in ratio and proportion. A test that comprised of questions that are appropriate to the National Curriculum Statement (NCS), for General Education and Training (GET) band, was used to collect data. Items in the instrument were selected and adapted from a tool used in Concepts in Secondary Mathematics and Science (CSMS) study. The participants in the study were 30 Grade 9 learners from a rural school in KwaZulu-Natal (KZN).

The study, through a case study, sought to find answers to the following research questions:
- How do learners in the selected school perform in assessment items based on ratio and proportion?
- What errors and misconceptions do these learners commit when they solve problems on ratio and proportion?
- Why do these learners commit the identified errors and misconceptions?

The research draws on a constructivist perspective, within which learners are viewed as actively constructing their own mathematical understanding as they participate in practices and whilst interacting with others (Cobb, Jaworski, & Presmeg, 1996). The theory of constructivism posits that students learn by actively constructing their own knowledge, knowledge is created not passively received, and views learning as a social process (Clements & Battista, 1990; Jaworski, 1994). Furthermore all knowledge is seen to be constructed by individuals rather than transferred directly by an expert, such as a teacher, parent or book, to the learner. This means that learners play the primary role in organising input from outside into meaningful knowledge (Clements & Battista, 1990). They also plays a crucial role in both creating, confronting and ameliorating their own errors and misconceptions. Thus, errors should be viewed “as opportunities for deepening one’s understanding and as important components of learning process”. In fact, “the view of errors as a vehicle for learning, rather than an activity to eradicate, continues to gain momentum in mathematics education” (Lannin, Barker and Townsend, 2007, p. 44).
The study found that about 57 percent of the participants had limited knowledge and understanding of ratio and proportion, hence their performance in items on the topic was poor. In excess of 50 percent of the learners had serious misconceptions of ratio and proportion. They used incorrect ratio notation and incorrect strategies to solve problems on ratio and proportion that produced errors. The errors and misconceptions they exhibited were not different from those observed by studies conducted by Misailidou and Williams in the North West of England; Chunlian in Singapore and China; Md-Nor Malaysia; and Hart UK, to mention a few.

The study recommends a structured focus on ratio and proportion because the topic is fundamental to proportional reasoning. It recommends clarity for teacher trainers, textbook writers and teachers on what learners need to learn on ratio and proportion. It recommends serious exploration of errors and misconceptions on ratio and proportion, and a teaching approach that considers errors and misconceptions as opportunities for learning.

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**Paul Hobden ¹ & Sally Hobden ²**

School of Education, University of KwaZulu-Natal, South Africa

¹hobden@ukzn.ac.za; ²hobdens1@ukzn.ac.za

One of the reasons given for the poor pass rate in the National Senior Certificate (NSC) is that we have large numbers of poorly performing schools. These schools contribute only a small fraction of the university passes in mathematics and physical science, despite entering the majority of learners for the NSC. One of the solutions suggested by private foundations as part of their social responsibility is to find learners with potential in these underperforming schools and provide bursaries to enable them to attend private schools which have historically produced excellent results in these subjects. The basic assumptions underlying this practice is that when removed from schools with a minimum of resources and underperforming teachers and placed in schools with many resources and excellent teachers, learners will have the opportunity to reveal their true potential and improve their achievement particularly in mathematics and science.

However, one of the major issues for donors is how to select learners i.e. how to determine potential to take advantage of a new school and improve academically. How is talent and potential identified? This can be a contentious issue for some. If donors take the highest performers, they are seen as “creaming” i.e. taking the best, and leaving behind a “diluted” pool of learners resulting in even worse public school results as their best learners have left. In most cases the donors, amongst other qualifying criteria such as clear economic disadvantage, use discipline based tests such as mathematics tests to determine future potential. This study investigated the relationship between the selection tests used and the final NSC grade 12 results of such learners.

**Literature informing study**
The theoretical framework underpinning the current study is that ability, as indicated by previous achievement, is a predictor of subsequent school achievement and that this relationship may be sustained over many school grades (Hemmings, 2010). It is generally agreed that academic achievement at any point in a learner’s life is a cumulative function of current and prior family, community, and school experiences. What this implies is that there are many factors that can influence learner achievement such as home background, socio economic status, motivation, attitude, prior achievement etc. This study has as its focus prior achievement as a predictor. While it is accepted that the other factors could be just as important, the focus here is on current practise of using discipline based tests as predictors. Because achievement is influenced strongly by ability and these selection tests measure prior achievement, they can be considered a proxy for ability.

Most of the studies reviewed indicate that prior achievement is a predictor of later performance. For example, Hemmings (2010) reports on studies that show that tests carried out at Grade 7 were significantly correlated with state wide examination results in mathematics and English in Grade 10. These Grade 10 examinations were found to be a very positive and significant predictor of Year 12 examinations accounting for over 60 per cent of the variance in the Grade 12 result. He suggests that in terms of Grade 10 achievement in Mathematics and English, the “die has been cast” many years earlier. It would appear that by implication the same could be said for Grade 12 NSC results?

Does preschool and early development really have such an influence? Research shows that children who bring into their reception year numerical and relational knowledge do appear to be advantaged in terms of their mathematical progress through primary school (Aubrey, 2006). Many of learners in this study do not come with this advantage. They have achieved despite disadvantaged home backgrounds and poor early education. The question is will this continue to act against them in high school even if they have quality teachers and resources? It appears from current research that this could be the case. For example Aubrey (2006) found that children were able to make real progress in early years in terms of mathematical development, but reported that slower progress during these early years was unlikely to be compensated for by faster progress later.

While there are many government reports on the problems in schooling, there does not appear to be much detailed research in which the same group of learners are tracked in the South African schooling context particularly where they change schools and many barriers to learning are lowered. This is not limited to South Africa as Diaz (1998) reported that there was limited research on underachieving talented children from culturally and linguistically diverse backgrounds.

**Findings**

A primary objective of the initial empirical analysis is to obtain estimates of contribution of prior achievement, as measured on the selection tests, to student NSC achievement. Two separate year cohorts of learners were tracked from their selection in grade 9 through to their final Grade 12 NSC examinations. These were economically disadvantaged learners who moved from public schools to high performing private schools. Their marks on independent selection tests in mathematics, science and English were obtained together with independent tests in each grade and their school marks each year. There were over a hundred learners in each year cohort spread across 12 schools. In addition to the achievement data the students were interviewed and completed numerous questionnaires about their experiences over the
three years and were tracked for two years after leaving school. This paper only deals with the quantitative achievement test data.

A brief synopsis of the findings is provided as illustration. Further justification supported with statistical analysis of test and NSC results is provided in the presentation.

- Learners did not change much from their entrance tests. There was a general stability in their achievement. Schools were unable to significantly improve achievement or tap the latent potential that was assumed to be present.
- Analysis by bands of marks gave some interesting results. If the learners score very well on the entrance tests then there is a good chance that they will do well at NSC. If the learners have low score at start, then they generally have a low chance of success. Those in the middle band around 40 to 60% achievement either increase, decrease or stay the same! No pattern or relationship can be predicted.
- There were significant differences in the predicting power of the English, Mathematics, Science and Critical thinking tests. The best predictor of overall success in the NSC was the English selection tests.
- The selection test results needed to be interpreted in relation to the learner background e.g. if from a well-resourced school little change in results over time but if from a disadvantaged school there was more chance of significant change in results, either up or down.

Some possible implications that will be expanded in the full paper presentation.

- Mathematics tests are good predictors of success for high achievers i.e. if doing really well now, the chances are they will do really well later.
- If learner is from disadvantaged background and poor school, then language is better predictor.
- We do not have a predictor of undetected talent and potential. Current tests do not help as they simply confirm what we already know. Time for new tests dealing with self-regulation, attitude and reasoning to be developed and trialled for predictive ability.

References


Investigating the nature of learning within an after-school mathematics club using the ZPD – a case study of four learners

Penehafo Olivia Kaulinge¹, Mellony Graven², Debbie Stott³
South African Numeracy Chair, Rhodes University, South Africa
¹peneha4@gmail.com; ²m.graven@ru.ac.za; ³d.stott@ru.ac.za

In this short paper presentation the first author will present the design of a study to investigate the nature of student learning within a Grade 3 after school mathematics club, drawing in particular on the Zone of Proximal Development (ZPD) as an analytical lens. This study is part of the first author’s Masters research work and is embedded in the broader research and development work of the South African Numeracy Chair, Rhodes University (²nd author). This research is supervised by the latter two authors.

The aim of the study is to better understand how participation in a mathematics club enables learning and thus the following research questions guide this study:

1. How does participation in an after-school mathematics club enable (if at all), mathematics learning of club members?

2. What is the nature of mathematical learning progression (if at all) and how do the SA numeracy Chair assessment instruments enable me to assess this.

The study embraces a socio-cultural perspective as a broader theory of learning, specifically drawing on a social constructivist theory of learning. In particular, the elements of social constructivism that are important to this study are that learning is seen as an interactive and collaborative process and that the Zone of Proximal Development (ZPD) is viewed as a symbolic space (Meira and Lerman, 2001; Goos, 2004). In terms of analysing the mechanism for learning in the club I will draw on Vygotsky’s (1978) notion of the ZPD. The ZPD will be used as a analytical tool for explaining how learning occurs within the after-school mathematic club. This assists in answering question one of the study.

The study takes the form of a case study approach of four learners participating in an after-school maths club over two school terms (Term 2 and 3, 2012). The school at which the club runs is one of those participating in the Chair activities and is located in the township in Grahamstown. The unit of analysis is the individual learner in peer and mentor interactions in the club. The data collection process took place in the second and third term of school for the period of 4 months by the author as a non-participant observer in the clubs (facilitated by the latter two authors). The primary data instruments are audio recordings and video taping of the club sessions and four learners in task based interviews specifically focussing on the interactions between peers and the mentor in the club. Field notes and a reflective journal were also used to record specific events and observable data related to the four learners. Data collected from audio recordings of the four learners was transcribed and analyzed using the ZPD.

Drawing on Lerman’s (2002) paper which indicates how to read and analyze the ZPDs from transcript data we proceed with the analysis of the data following transcriptions of the session recordings. In particular, this will involve searching for events of communication in which learners and mentors ‘catch each other’s thoughts’ (Lerman, 2002, p64). Possible indicators for this may include: trying to establish joint understanding; listening to each other;
considering each other’s utterances; finding common ways for task solving. These will be evidenced by for example, re-voicing, requesting clarification and/or elaboration, providing new suggestions and so forth.

In the presentation the first author will present some of the findings from this analysis relating to the first research question.

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References


Exploring unrealistic solutions to real wor(l)d problem solving

Percy Sepeng

Wits School of Education
Percy.Sepeng@wits.ac.za

This paper explores secondary school learners’ abilities to solve real-life mathematical word problems and the extent to which they consider (or ignore) reality from their solution processes. The study was conducted in a multilingual mathematics classroom context with learners drawn from different linguistic backgrounds. The data collection strategies for the purpose of this study included interviews and audio-visual recordings. The results of this study demonstrate that looking closely into learners’ justifications of their ostensibly unrealistic solutions can inform us of the difficulty in connecting out-of-classroom mathematical (informal) knowledge with the knowledge required to do the mathematics.

Keywords: real-wor(l)d knowledge, unrealistic solutions

Introduction

There has been much recent interest in problem solving and socio-cultural perspectives in mathematics education (Verschaffel, Greer, & Van Dooren, 2009). Such interest reflects an acknowledgement of the complex nature of classroom environments and cultural aspects of learning and teaching mathematics in South African multilingual settings (see Adler, 2000; Setati, 1998; 2005a). Many researchers have studied the tendency of learners providing
unrealistic solutions to real world problems without considering common aspects of reality (Greer, 1997; Verschaffel, De Corte, & Lasur, 1994; Xin & Zhang, 2009).

**Theoretical Perspective**
This study is framed by socio-cultural perspective (Cooper, 1998). The socio-cultural perspective proposes that collective and individual processes are directly related, and students’ unrealistic responses to real world problems reflects the students’ socio-cultural relationship to school mathematics and their willingness to employ the approaches emphasised in school.

**Method**
Data gathering included a test and video recordings. Learners’ responses during group and individual problem solving of the problem-solving task were video-taped and later transcribed in full. These methods of data gathering are appropriate for research designed with a socio-cultural perspective because they allow for the opportunity to examine classroom discourse and interactions.

**Results**
Learners responses (or answers) to the problem-solving task (PS) were coded into three general categories: realistic reaction (RR), no reaction (NR), other reaction (OR), which were adapted from a schema developed by Verschaffel, et al. (1994). As noted earlier in chapter three, RR comprised all cases wherein a learner either gave the most accurate numerical response that also considered real-world aspects and context of the problem, or cases where there was an attempt to consider real-world situations without providing a numerically most correct response. On the other hand, OR were all those responses without real-world considerations, and situationally inaccurate responses with correct computations. NR were all the cases with no numerical responses and mathematically incorrect, without any further written responses that indicated that the learner was not aware of real-life aspects of the problem that made it impossible for him or her to solve the problem.

**Table 1: Problem Solving task 1 (PS1)**
100 children are being transported by minibuses to a summer camp at the sea-side. Each minibus can hold a maximum of 8 children. How many minibuses are needed?

When asked about how they solved this problem in the follow-up interviews, one of the learners responded by saying:
“...when you divided children like that you will count that each minibus will get in 8 children, if you divided them in groups of 8, so that all 100 children can enter in all of the minibuses and you will know that you must have 12 mini buses”.

In solving the PS1 problem, learners’ written and verbal responses were recorded. Table 2 shows examples of learners’ responses to this problem with division with a remainder.

**Table 2: Examples of learners’ responses to PS1 task**

<table>
<thead>
<tr>
<th>Answer</th>
<th>Realistic reactions (RR)</th>
<th>Other reactions (OR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>i. 100÷8=12.5</td>
<td>therefore 13 minibuses are needed (situationally most appropriate answer)</td>
<td>so 12.5 minibuses are needed (mathematically accurate, but numeric answer is situationally inappropriate)</td>
</tr>
<tr>
<td>ii. 100÷8=12; remainder 5</td>
<td>so 12 minibuses are needed (answer that does not consider problem context and situation)</td>
<td>so 12 minibuses are needed and a car for remaining 5 children (mathematically incorrect, other</td>
</tr>
</tbody>
</table>
Problem solving and test order

Learners’ responses to the PS task produced more mathematically correct answers, but generated most situationally appropriate numerical responses in their solution statements. In other words, learners most of the learners could not use their out-of-school (informal) knowledge and experiences to solve PS task, but succeeded more in problem-solving of the same item mechanically.

Discussion

The notion of presenting reality into mathematics classrooms by starting from learners’ everyday-life experiences and situations is fundamental aspect of persuading learners’ thinking and reasoning to connect classroom mathematics to real-life knowledge. As such, the inclusion of application and modelling problems is intended to convince learners to develop in them necessary skills of knowing when and how to apply their classroom mathematics effectively in situations encountered in everyday life. These everyday life situations and learners’ experiential reality should be viewed as a natural extension of teaching and learning formal mathematics. I contend that this extension can only be realised and achieved if learners and teachers can bring mathematics into reality, using available and relevant real-world contexts that are familiar to the learners.

Conclusion

Mathematics classrooms in South Africa reflect different cultural and social classes. As such, individuals in these classrooms are engaged in different kinds of discourses that sometimes overlap and at times are mutually exclusive. Consequently, classroom stakeholders are faced with challenges of choosing discursive practices that are relevant when solving problems, and when presenting arguments in a particular setting. Therefore such overlaps and/or moves between classroom discourses is sometimes complicated, as illustrated by this study about the concept of ‘fair sharing of money’, which I have discussed earlier in this paper. In fact, learners found it very difficult to realise what the logic of the argumentation is and what are useful arguments at a particular point in time.

References


Perceptions and attitudes of student teachers’ towards mathematics and their cognitive-metacognitive awareness: a case of Mufulira College of Education

Peter Mulendema
Copperbelt University
peter.mulendema@cbu.ac.zm

The purpose of this study is to investigate student teachers’ perceptions and attitudes towards mathematics and their cognitive-metacognitive awareness. From a social constructivist epistemological paradigm, the survey research is guided by the following research questions: how do student teachers’ perceptions and attitudes associate with their metacognition?; what teaching approaches do college lecturers employ when teaching student teachers in mathematics content courses?; what perceptions and attitudes do student teachers have towards mathematics and their metacognitive awareness?; what are student teachers’ perceptions on their academic performance and lecturers’ methods of teaching? The study which is currently in progress, has adopted the conceptual framework which includes affective and cognitive-metacognitive epistemological variables. McLeod (1992: 592) defined the affective domain as, “a wide range of beliefs, feelings, and moods that are generally regarded as going beyond the domain of cognition.” The term metacognition was posited by John Flavell in the late 1970’s. But despite metacognition being posited by the 1970’s, the concept of metacognition has not been known or studied by scholars particularly here in Zambia as there are no studies that have been carried out in relation with metacognition. Flavell (1976: 232) defined metacognition as, “one’s knowledge concerning one’s own cognitive processes and outcomes or anything related to them.” Metacognition can be defined in simple terms as ‘thinking about thinking’ or ‘cognition about cognition’ (Brown, 1987).

Therefore, this study is guided by various theoretical frameworks from various researchers in the fields of affective behaviours, metacognition, mathematics learning, understanding and problem solving. Edwards (2008: 19) states that, “A sound conceptual or theoretical framework is critical for any study.” The study aims at providing a synthesis, analysis and description of the interrelation or interplay of student teachers’ affective behaviours and their cognitive-metacognitive skills they engage in mathematics learning and problem solving situations. The researcher’s goal is to provide a meaningful integral of perceptions, attitudes, cognition and metacognition for student teachers and educators. Further, the researcher adopted for this conceptual framework with the reason that, it is a critical aspect to prepare prospective secondary school teachers holistically.

The performances of students at all levels of education in Zambia have kept on falling due to poor teaching approaches. The startling situation is that very little learning of the type expected by society was occurring in Zambia’s schools. Disappointingly, successive reports have generated data portraying the same picture and status of student under-achievement in
many countries (Schoenfeld, 1992, Binde, 2004, and Slavin, 2009). The Examinations Council of Zambia’s (ECZ) ‘Preliminary Figurative analysis of the Grade 9 performance for 2008’ (ECZ, 2009) showed that the number of learners attaining a 20% or less in Mathematics was at 67%. The same results are reported from high schools across the nation; a problem partly attributed to teachers who are properly qualified but have negative attitude towards teaching or could be that they are not well trained to teach Mathematics in secondary schools. This has led to Zambian pupils’ performance being the least in Southern and East Africa, according to the Southern and Eastern Africa Consortium Monitoring Education Quality (SACMEQ, 2011) document Zambian pupils were ranked the worst in Mathematics and reading skills in Southern and East Africa. It appears that students in colleges of teacher training have low levels of autonomy in Mathematics classrooms and often exhibit a dependence on external authority for constant verification of the correct answer or method of solving problems. They fail to serve as their own source of verification and they tend to feel that Mathematical thinking, processes and solutions are validated externally, that is from their lecturers (Schoenfeld, 1992). It is not clear how student teachers perceive Mathematics and their attitude towards it and what kind of cognitive-metacognitive skills and strategies they possess as they graduate from the colleges. Cognitive-metacognitive aware student teachers will go into the schools for practice upon completion of their training with positive perceptions and attitudes towards Mathematics and pupils. For student teachers to be well informed they need to be metacognitive aware of their learning and teaching processes. Much of the research in the resent past in Mathematics education has focused on affect and cognitive-metacognitive awareness among learners and lecturer.

In this research the researcher has adopt two questionnaire designs, which comprise five-point Likert-Scale questions. The two questionnaire designs adopted from Schraw and Dennison (1994) and Ernest (1996) on ‘student Metacognitive Awareness’ and ‘Student perceptions and attitudes towards mathematics’ respectively are being utilized to collect primary data. The Metacognitive Awareness Inventory (MAI) developed by Schraw and Dennison (1994) will measure two main constructs, namely Knowledge of cognition and regulation of cognition. The MAI is a comprehensive scale assessing various facets of metacognition and it has good reliability for metacognitive assessment (Schraw and Dennison (1994). The MAI questionnaire consists of 52-items and respondents will answer on a five-point Likert-type scale. The items will be set into two scales and eight subscales. In the eight subscales, three will be based on ‘knowledge of cognition’ and the remaining five will focus on ‘regulation of cognition’. The questionnaire on students’ perceptions and attitudes towards Mathematics comprises five-point Likert-type and demographic open-ended questions. The Metacognitive Awareness Inventory (MAI) comprises the five-point Likert-type of questions and will be administered to student teachers at the college of education. The Metacognitive Awareness Inventory for Lecturers (MAIL) will be administered to lecturers who teach mathematics content. The MAIL was adopted from Balcikanli (2011) and was developed by Schraw and Dennison (1994). Permission was sort from Balcikanli and a written consent letter was sent to the researcher through the internet. On qualitative data, Focus Group Discussions (FGD) will be conducted with student teachers from the three levels of their study, i.e. first, second and third year levels. In the FGD’s, the researcher will utilize a semi-structured interview schedule. For lecturers, the researcher will conduct Focus Group Discussions (FGDs), with their consent. The respondents will be required to provide concurrent self-reports after solving some questions. Respondent’s self-reports will assess the respondent’s metacognitive awareness together with the MAI. Self-reports will enable the researcher to get rich data about processes that are invisible to other methods. Due to the multiple research methods, the researcher will conduct the research at
the college of education for eight to ten weeks. The multiple research methods have been adopted to enable the researcher to provide a more reliable picture of the phenomena under study.

Data analysis will be conducted using comparative analysis to delineate the responses of student teachers. Further, the chi-square significance test for independence will be utilized to test the association of student teachers’ affect (perceptions and attitudes) and their metacognitive awareness at 5% level of significance. Descriptive statistics will also be utilized. Data from Focus Group Discussions will be analyzed using the Micro-interlocutor Analysis.

References


What do pre-service secondary teachers know about the mathematics they will teach?

Pieter van Jaarsveld
Wits School of Education, University of the Witwatersrand, South Africa
pieter.vanJaarsveld@wits.ac.za

South Africa’s performance in mathematics annually in the National Senior Certificate (NSC) examinations is well below standards desirable for tertiary education, or of a calibre sufficient for developing teachers of mathematics. The annual report of the Department of Basic Education (2011) on the NSC mathematics examination spells out that in several of the mathematics content areas there is a ‘poor understanding of the basics and foundational competencies’, ‘Many candidates struggled with concepts in the curriculum that required deeper conceptual understanding’, ‘learners are exposed to stimulus response methods only…’, (DBE 2011, p199). To move on from this decades-long observation and status quo it would seem that we need to invest in the development of teachers, an investment that should aim to address these learner failings. Instead of repeatedly identifying mathematical deficiencies amongst learners we need to turn our attention to what constitutes an efficient and effective mathematics teacher and how we can bring a quality of sustained mathematical understanding to impact on (South African) classrooms.

As a teacher of prospective secondary teachers and I find that the deficiencies described in the NSC report also accurately describe the acute deficits in the cognitive capacity of my students who are prospective secondary mathematics teachers. What is emerging is that incapacities, all too easily, associated with the socio-economic ontological context of previously disadvantaged cultures, is common to most teachers whom I train, irrespective of ethnicity or language. The lack in cognitive engagement amongst teachers about the mathematics they teach therefore perpetuates epistemological and pedagogical habits that do not address the shortcomings identified in the NSC report on mathematics on learner performance. There is a generic trend of an absence of interrogating mathematical objects cognitively with a view to understanding them by gestalt or immediate context that should contribute to their meaning. The practice of knowing how we know what we know, or being cognitively aware about our own cognitive processing is defined as ‘metacognition’ (Flavell, 1976). It is a self-interrogation, (referred to self-monitoring and regulation in the literature) through habitual cognitive questioning, which I call ‘mathematical soliloquy’ – a personal, private conversation, quite radically constructivist in nature. It is the practice of soliloquy that should direct mathematical teacher and learner mathematical activity and task, either in its preparation, delivery and execution by teachers and/or learners.

As practitioner action research using metacognition as a conceptual framework, this investigation seeks to know the depth of knowledge that student teachers have about the mathematics they do, with a view to modifying teaching practice. The study’s connection to mathematical content knowledge and pedagogical content knowledge as elucidated by Ball et al. (2004) is inevitable. Students responded to five mathematical objects through doing them, and then provided a dense description of the same objects. A coding instrument was designed to analyse the descriptive textual accounts using the following categories: Terminology (appropriate mathematical register), Articulation (fluency of language use), Coherence (the comprehensiveness of the meaning of the description), Procedural or Conceptual (the description of process and/or the awareness of conceptual associations of the object).
Results suggest the ‘doing’ of objects lacks sound and accurate procedure. In descriptive texts there appears to be a paucity of conceptual insight where procedural instruction and description far outweighs conceptual depth associated with cognitive engagement.

References


Relevance and School Mathematics

Mercy Kazima

University of Malawi

mkazima@cc.ac.mw

Abstract

The theme of SAARSMTE 2013 conference is Making Mathematics Science and Technology Socially and Culturally Relevant in Africa. This paper will focus on mathematics and relevance in schools. I will start by discussing briefly the importance of paying attention to cultural relevance and social relevance. Then I will focus on students’ interest as one of the aspects of relevance. I will present findings of a small survey conducted in Malawi which was adapted from a very large cross country project. I argue that relevance for students includes their interests, and therefore should be considered. Interest yields motivation and meaningful learning which mathematics teaching aims for. I conclude by raising more questions than answers for implications to curriculum development, teacher knowledge and teacher education.
Exploring Foundation Phase mathematics teachers’ work with examples and representations in number-related tasks

Samantha Morrison

School of Education, University of the Witwatersrand, South Africa

samantha.morrison@wits.ac.za

The focus of this paper is to report on a study being conducted on Foundation Phase teachers’ use of examples and representations when teaching number in the context of a year long in-service mathematics content knowledge for teaching course. The acquisition of number skills or ‘number sense’ is an essential outcome of mathematics curricula of many countries around the world. Within the South African curriculum the weighting for Numbers, Operations and Relationships in the Foundation Phase has been increased within recent curricular reform from 55% - 50% in Grades 1, 2, and 3 to 65%, 60% and 58% for Grades 1, 2 and 3 respectively (DBE, 2011a). This increase in notional time reflects the increased attention number sense has received within the international mathematics community (The Cockcroft Report, 1982; NCTM, 1989; Reys et al., 1999).

I explore the use of examples and representations across teachers’ course tasks and classroom teaching, as literature shows these to be critical components of instructional explanations in mathematics (Leinhardt, 2001, as cited in Bills et al., 2006), and important for both concept development and good teaching in mathematics (Ball & Bass, 2003; Heize et al, 2009). Teachers’ selection and representation of examples when teaching mathematics has bearing on the features learners take note of, and consequently, on learners’ mathematical understanding (Watson & Mason, 2005). Examples - the ‘raw material’ used in teaching mathematics (Bills et al., 2006) - come in a range of representational forms, viz. concrete – which includes fingers and counters; iconic - including drawings and cartoons; indexical - like dots and tally marks; symbolic number based - like number lines; and symbolic syntactical - like using numerals and mathematical statements (Ensor et al., 2009).

The importance of representations in mathematics teaching and learning has been widely acknowledged. Heize et al. (2009:536) note that: “Among researchers and practitioners it is widely claimed that the facility to use multiple representations (including graphical, tabular, algebraic and verbal ones) is a critical component of the skill of solving mathematical problems”. Heize et al. (2009) argue that those classroom environments wherein learners are exposed to multiple representations of the mathematical concept being taught; and wherein they learn to flexibly shift between these representations prove effective in helping students’ conceptual understanding of the given concept. Haylock and Cockburn (2008) argue that learners’ understanding of number is enhanced as they build meaningful connections between four key mathematical experiences, viz. the use of concrete materials like blocks and rods; the use of symbols like tally marks and numerals; the use of language like number names and word problems; and the use of pictures like number strips, number lines, and tables.

Literature within the South African landscape shows that teachers’ persistent use of concrete representations in the teaching of number inhibits the development of learners’ number concept. The work done by Ensor et al. (2009) shows learners on the Cape Peninsula using
concrete representations when learning number and number operations from Grade 1 to Grade 3. The use of concrete representations involving ‘count all’ strategies is a natural starting point for young children, but over time these should be replaced by more efficient strategies like ‘count on from larger’ and ‘using number facts’ (Carpenter et al., 1999).

Taken together, these findings from literature led me to my research questions:

**Research Questions**

1. What kinds of range, in relation to number operations and number sense more broadly, figure within teachers’ choice of examples?
2. In what ways can teachers’ use of representations be described as showing:
   a) flexible working across multiple representations?
   b) more coherent connections between word, action, diagrammatic and symbolic representations?
   c) progression from concrete to more abstract representations?
3. What conclusions can be drawn from this analysis of teachers’ work with examples and representations?

Two Foundation Phase teachers in one of the schools participating in the Wits Maths Connect Primary Project’s in-service training course make up the purposive sample of this qualitative case-study. My focus on Foundation Phase teachers with a sample selection based on differing levels of content knowledge (CK) was motivated by literature which points to links between CK and pedagogical content knowledge (PCK) and findings of weak CK among South African teachers (SACMEQ III; Carnoy & Chisholm et al., 2008). In this paper, I draw on data based on analysis of the teachers’ use of examples and representations in course- and classroom work within number-related tasks, the former based on written tasks and the latter based on video recorded lesson observations.

**Findings**

Preliminary data analysis of teachers’ course-work point to some confusion in their understanding of progression, i.e. from concrete to more abstract representations. For example, when teachers were asked to show a learner a more efficient strategy for calculating ‘18 + 3’ than the one shown, responses such as the one below were received.

In this response, there are indications of shifts to a more abstract symbolic form in the first instance, with shifts back into more concrete forms in the last step. In the intermediate stages, steps suggest the ability to work with 8 + 3 as a recalled fact, which then raises questions about why 10 + 10 + 1 in the last step needs a concrete diagram representation. A teacher’s choice of examples (worked out examples and learners’ exercises) and use of representations (flexible, connected, progressing from concrete to abstract) reflects their awareness of what builds good number sense and significantly influences what children learn about number.
References

Application of Rasch analysis to mathematical literacy assessment items.

Sarah Bansilal\(^1\) & Caroline Long\(^2\) & Rajan Debba\(^3\)
School of Education, University of the KZN, South Africa; \(^2\)Senior Research Officer, Centre for Evaluation and Assessment (CEA), University of Pretoria; \(^3\)Student, School of Education, University of the KZN, South Africa

\(^1\)Bansilals@ukzn.ac.za; \(^2\)Caroline.long@up.ac.za; \(^3\)rdebba@yahoo.com

The school subject mathematical literacy (ML) was introduced in 2006 in a bid to improve
the numeracy skills of learners who were not studying any mathematics in Grades 10 to 12. The relationship between contexts and mathematics content has proved to be challenging to disentangle. Bowie and Frith (2006) have written that the definition of ML specifies four elements of ML — the content, the contexts, the abilities and behaviours that a mathematically literate person will use. Brombacher (2007) also identified similarly, interplay in ML between the content, context and problem-solving skills. Venkat and Graven (2007) identified a spectrum of ‘agendas’ within the teaching of ML comprising the context driven agenda, the content and context driven agenda, the mainly content driven agenda and the content agenda.

Research about ML suggests that item difficulty in ML assessment tasks may be affected by the actual context used (Debba, 2010), and the amount and complexity of the language used in the task and instructions (Vale, 2011). In addition to the above features the importance of the mathematical structure underlying the problem has been noted by Vergnaud (1988) and further elaborated in Long (2011). It is hoped that this study will identify challenges encountered by learners in responding to ML assessment tasks. This small scale study has been designed to add to the knowledge about factors which influence item difficulty in ML assessment tasks and to extend the debate concerning contexts and language.

The study was carried out with a class of 73 Grade 12 ML learners who wrote a preparatory examination. The examination consisted of questions based on a variety of situations ranging from context-free to authentic contexts. The learners’ written responses were scored and analysed using the Rasch measurement model. Subsequently, ten of the learners were interviewed in order to find out more about the challenges they experienced in responding to the tasks. They were probed about their responses to each item.

The application of Rasch measurement theory provides information about whether the reliable and valid measures have been attained. The idea that the data are required to conform to the requirements of the model is premised on the concept of scientific measurement, where the property of invariance is central (Rasch, 1960/1980; Andrich & Marais, 2008). This property that the data are required to fit the model is a particular requirement of the Rasch measurement model.

The challenge with constructing and applying a test instrument is to establish items that reflect the development of the construct. For example, when designing a test for mathematical literacy the items should ideally reflect more or less of the construct conceptualised as mathematical literacy. Other factors not central to the construct mathematical literacy, as defined by the theory, may interfere with the process. If the data when subjected to a Rasch analysis fit the model, we can be reasonably satisfied that we have measures for a particular frame of reference, that is for a particular cohort tested on the particular instrument. Where items or persons are shown, through application of the analysis, to perform unexpectedly, these anomalies have to be investigated. For example in a case where an easy item is answered incorrectly by learners indicating greater proficiency on the test as a whole, this item should be investigated, and new insights may emerge.

The outcome of the Rasch analysis places both item difficulty and learner ability on the same

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3 Item Response Theory is similar to the Rasch model in some respects, however the 2-parameter and the 3-parameter model differ essentially as other parameters are introduced which may distort or conceal the anomalies that arise which provide insights to improve the instrument and understanding of the construct being measured, in this case mathematical literacy.
scale through applying a log transformation. This feature enabled the targeted analysis of specific items in relation to specific persons. By looking at the overall item difficulty, we were able to reflect on the findings in terms of context, language, and underlying mathematical structure. The interviews enabled understanding of how the three constructs were experienced by the learners in the various items. We hope that the findings of this study will feed into our understanding of the test itself and our overall understanding of assessment in ML and what concepts are involved in ML.

References


Enhancing teacher knowledge through an object focused professional development model

**Shadrack Moalosi**

*Wits School of Education, University of the Witwatersrand, Johannesburg, South Africa.*

shadrack.moalosi@wits.ac.za

The purpose of this paper is to present preliminary results from a study in progress. In the short paper that I will present at the conference, I will report on one aspect of my research which is about teachers learning from professional development. I am interested in what in Marton et. al.’s (2004) terms, is referred to as the ‘lived object of learning’ and particularly what becomes the lived object of learning at the level of the teacher. This question, ‘What
becomes teachers’ lived object of learning after participating in the Wits Maths Connect Secondary (WMC-S) project’s professional development?’ is one question from my larger study that I am going to report on, and one data source that I will analyze to report on teachers’ lived object of learning is in-depth interviews that I conducted with nine of the seventy teachers in the WMC-S project. I am drawing my analytical lenses from both phenomenology and variation theory to look into the datasets. In my data analysis I work both inductively and deductively on the same data to explore teachers’ lived object of learning so as to gain insight into teachers’ professional learning in the context of professional development. Presently I am analyzing interview data. In the following paragraphs I elaborate further on the context of my research.

What is the WMC project, and its model? Wits Maths Connect (WMC-S) is a 5 year longitudinal professional development and research project targeting secondary mathematics teachers from 10 schools in the Johannesburg East District in South Africa’s Gauteng Province with two main development aims: (i) strengthening teachers’ mathematical knowledge for teaching so as to improve teaching quality and (ii) improving learner performance so as to increase the number of learners able to pursue pure mathematics in Further Training and Education (FET) level (Grade 10 – 12), and into tertiary study (J. B. Adler, November, 2010). What is unique about the WMC professional development initiative is its focus on what it refers to as the ‘object of learning’. Interestingly, or strangely, the WMC-S project does not directly copy any of the well known professional development models (e.g. Cognitive Guided Instruction and the Japanese Lesson Study) despite their reported successes. However, aspects of these models are built into the WMC model. For instance, the WMC recognizes and facilitates teacher collaboration, and the importance of engaging teachers with learner thinking is acknowledged.

Why has WMC-S selected to focus on mathematical objects of learning? The choice of focus in any professional development is informed by the nature and context of the problem being addressed. The inequitable and poor quality of teacher preparation in apartheid South Africa is well known, as is the evidence that quality in the post apartheid system is not improving. According to Adler (2009) and Adler and Davis (2006, 2011), there were serious deficiencies in teacher preparation in previously disadvantaged communities in apartheid South Africa. Indeed, the problem of the level and depth of content knowledge of many in South Africa’s secondary teaching corps is well known. Huillet, Adler & Berger (2010) argue that content needs to be at the centre of mathematics teachers’ professional learning. Drawing on teacher education research in Mozambique and South Africa, they show that where there are gaps or limits in teachers’ content knowledge, teachers need opportunity to learn such directly.

What is the focus of the interviews? In the WMC-S project teachers participated in professional development where Functions were in the fore. In particular, teachers engaged with activities where these key features of functions were privileged – multiple representations, intercepts, arbitrariness, univalence, and gradient. In addition a wide variety of resources were made available in PD activities where teachers were participants and additional resources were given to teachers for use in their own classrooms- erasable mobile grids for drawing graphs, readings on functions, geogebra, and card activities. Consequently, the interview focused around key features and resources to generate data for exploring how their participation in PD mediates their mathematical knowledge for teaching (MKT) in the domain of Functions. Variation theory is applied to understand teachers’ capabilities and Variation theory views learning as ‘a change in an individual’s way of experiencing that which is the object of learning’ (Runesson, 1999, p. 1).
Conclusion
This research is expected to contribute to the literature on professional development by providing insight into what and how teachers learn in an object focused professional development (PD). This is a PD where school mathematics content is used to strengthen teachers’ SMK to improve teaching quality and learner achievement. At this point no recommendations are made because the research is still in the analysis stage. However, recommendations will be part of the discussion in the paper I will bring to the conference.

References


Institution and Autonomy in Teacher Professional Development: The Case of Secondary Science and Mathematics Teachers (SESEMAT) Programme in Uganda

Shinichi Ishihara¹ & Takuya Baba²

¹ Graduate School of International Development and Cooperation, Hiroshima University, Japan; ² Graduate School of International Development and Cooperation, Hiroshima University, Japan.

¹ sishi@hiroshima-u.ac.jp, ² takuba@hiroshima-u.ac.jp

Quality improvement of education is the most important issues which most countries have been struggling for. There may be some sporadic successes through the intensive efforts. It is, however, never-ending discussion how effectively the systematic and continuous professional development for all teachers can be established in a sustainable way. Of course, economic and social conditions limit working environment/conditions which may promote or hinder teacher professional development, but more importantly professionalism which promotes it is yet to be developed. We have worked with some teacher professional development projects/programmes within the Strengthening and Mathematics and Science Education, Western and Eastern, Central and Southern Africa (SMASE-WECSA) network,
which is mainly supported by Japan International Cooperation Agency (JICA), to enhance classroom practices. Changing what teachers do in the classroom might be one of the greatest challenges in many African countries. Here we would like to take up the case of Uganda, Secondary Science and Mathematics Teachers (SESEMAT) Programme.

Currently, both developing countries and development agencies being engaged in educational reform and its assistance are required to have explicit outcomes under the pressure of accountability. The education reform, however, should not be transient but rather continuous and systematic. This is not made possible by simply enforcing the law. In Uganda, a cascading training for secondary science and mathematics teachers has been expanded nation-wide since 2010, since then, the government has encouraged the regional based In-service training (INSET) activities by their own initiative. As a result, apart from the regular cascading training, it seems that the number of secondary science and mathematics teachers who are engaged in the INSET activities by school or regional initiative (hereinafter referred to as ‘school/regional initiative’) has been increased. It is assumed that the government of Uganda has tried to apply both the institution focused approach through the cascading training and the collective learning approach through the school/regional initiative which required autonomy at school and regional level.

Therefore we would like to find what kinds of school/regional initiative have been conducted and examine how this school/regional initiative influences their views on teacher professional development. These views might be mutually formed by individual teachers and their group. There are also social and economic factors which may influence on teachers’ views. In this sense, the concept of communities of practice (Wenger 1998) is employed for the analysis. Wenger (2004) points out that the most successful communities have always combined bottom-up enthusiasm and initiative from members with top-down encouragement from the organization. In this paper, we define a cascade training of SESEMAT programme as an institution focused approach, whereas we define a school/regional initiative as autonomy oriented approach. This research aimed at analysing the complexity of teacher professional development from the perspectives of institution and autonomy.

Research Questions:

1. What kinds of school/regional initiative have been implemented?
2. What is the difference between the school/regional initiative group and the non school/regional initiative group in terms of the teachers’ perceptions on application of the teaching methods of SESEMAT in classroom, factors that might make it difficult for them to apply the teaching methods of SESEMAT in classroom and teaching profession?

In order to answer the above research questions, the questionnaires survey for science and mathematics teachers in six SESEMAT regions was carried out during the five days cascading training in January, 2012, and collected 912 responses. The sample interview survey in two SESEMAT regions was also conducted. The data is examined the difference between school/regional initiative group and the non school/regional initiative group in terms of teachers’ perceptions on teacher professional development.

The main findings are as follows:

Question 1: About 30% teachers respond they attended or organized the school/regional initiative mostly in 2010 and 2011. Lesson observation is most popular activity, followed by lesson study.
Question 2: (1) The school/regional initiative group puts higher value on teaching methods, networking and attitude change relatively, (2) The school/regional initiative group pays more attention to educational issues such as syllabus and examination relatively, (3) The school/regional initiative group become more motivated to apply teaching methods of SESEMAT in classroom, (4) There is not much difference between two groups in terms of teachers’ perceptions on allowance issues of a cascading training, working environment /conditions and teaching profession.

Since one third of teachers are involved in the school/regional initiative, and it is also spreading out recently after the encouragement from the government, the autonomy in this kind of movement is neither simply a law enforcement, nor has been naturally created by professional motivation. This autonomy may be a mixture of expectation of financial reward, networking, school/regional leadership and genuine claim for professional development, which also be influenced by the social and economic factors. In future, it might be significant to balance institution and autonomy so that this fragile professional development could grow gradually and continuously.

The data was collected with the support of the SESEMAT programme and JICA. The opinions expressed in the researchers are of the authors.

References


What’s in a mathematics lesson? An exchange or a gift?

Simon Karuku

Aga Khan University, Institute for Educational Development, East Africa, Dar es Salaam Tanzania

In Jacques Derrida’s *Given Time: I. Counterfeit Money* (1992), a distinction is drawn between an exchange and a gift. The former is conditional on receiving something in return, while the latter is given unconditionally, with no expectation of anything in return. One of the emergent questions from the study to be reported in this paper is whether a mathematics lesson is an exchange or a gift. Based on Derrida’s analysis of gift giving, it can be argued, on the one hand, that no gift actually takes place when the teacher gives a lesson to the students, because the teacher gives a lesson in expectation of some thing in return. But on the other hand, it can be argued that a mathematics lesson is a gift insofar as the given may be something that is not intended. For example, during the course of the lesson the teacher...
almost always convey things that they did not intend and thus this fits the notion of a gift as described by Derrida.

The data to be reported in this paper were obtained from a hermeneutic phenomenological study that explored the essence and meaning of helping in the context of mathematics learning from the perspective of mathematics students. The study used a qualitative research design informed by the theoretical framework of hermeneutic phenomenology as described by van Manen (1997). As a research methodology, hermeneutic phenomenology is a way of knowing that is dedicated to rendering explicit the structures of human life as it is lived in all of its contexts from the first-person perspective. It privileges the experiencing subject as the source of all knowledge about a give experience, and seeks to deepen our understanding of what ‘it is like’ to live through the experience (van Manen, 1997).

Participants in the study were senior secondary school mathematics students drawn from seven secondary schools located in the eastern and mid-eastern regions of Tanzania mainland. Data were gathered through in-depth open-ended interviews with individual participants, as well as through participants’ own written accounts of their lived experiences. The participants were asked to recall a salient moment in their experiences of mathematics learning when they either approached or were approached by someone for help with a mathematics problem.

As Spiegelberg (1964) pointed out, no phenomenon is sharply circumscribed by precise contours (p. 327). In other words, the phenomena we encounter in the world are never experienced in isolation. As such, in the course of exploring a particular phenomenon, the researcher will inevitably encounter other related phenomena. Although the aim of this study was to explore and understand how high school mathematics students experience helping and being helped with their mathematics learning, some research participants also shared classroom experiences that were examples of perceived unjust teaching practice. On this, the participants expressed feelings of helplessness from the realization that they were unable to seek help from their teachers. The unequal power relations in the classroom suppressed students’ voices, rendering their attempts at seeking justice futile.

This paper will discuss how students make meaning of their learning experiences as a result of being in a particular classroom learning environment. The paper will draw from the participants’ accounts of their classroom learning experiences to show how students’ decisions to seek help from the teacher may be affected by the students’ perceptions of the teacher’s behaviour and attitudes towards them. In particular, the paper will draw from the participants’ experiences to show how a mathematics lesson may come to be seen by the students as an ‘exchange’ rather than a ‘gift’, and how this perception can alter the teacher-student relationship.

Some of the implications of conceptualizing a mathematics lesson as a gift, on the one hand, and an exchange, on the other, will be considered. For example if a mathematics lesson is considered a gift, then there is a danger that the teacher may be seen to be the holder of the gift who gives the gift to the learner, raising the question of whether or not the teacher could be entrusted with the responsibility of being just to the students (Glaucon aptly observed that “men are inherently unjust and are only restrained from unjust behaviour by the fetters of law and society” [cited in Rousseau, 1782/1992]). Based on the participants’ experiences, the teachers need to be restrained from unjust behaviour. The onus is on the school leadership. The strength of professional school leader lies not in their concessions to injustice but, rather, in their unswerving fidelity to justice in the discharge of their duties.
If the lesson is considered an exchange, then there is the danger of jeopardizing the true meaning of pedagogy (van Manen, 1986). Using the students’ experiences it will be argued that unless the teacher appeals to his or her own moral conscience, any external imposition of ethical responsibility cannot guarantee the authenticity of a pedagogical enterprise. In Buber’s (1923/1970) words, the teacher who wants to help a student to realize his/her best potentialities must “know him not as a mere sum of qualities, aspirations and inhibitions; he must apprehend him and affirm him, as a whole. But this he can only do if he encounters him as a partner. … And to give his influence unity and meaning, he must live through this situation in all its aspects not only from his point of view but also that of his partner.” This paper will examine how this partnership may look like in a mathematics classroom setting, paying attention to the role of school leadership in relation to social justice. Ultimately, it will be argued that the possibilities of justice in the mathematics classroom are enmeshed in the space between exchange and gift.

References

An investigation of the approaches used by mathematics and mathematical literacy learners to solve start-unknown and result-unknown problems

**Sipho Mbonambi** & Sarah Bansilal

1 *M.Ed student-UKZN*; 2 School of Education, University of KwaZulu-Natal, South Africa.

1 mbonambisipho@webmail.co.za, 2 BansilalS@ukzn.ac.za

The focus of Mathematical Literacy (ML) on real life contexts, has led many to assume that learners do not need to know much formal mathematics when learning ML. For example in ML, learners are rarely introduced to any more mathematics beyond what is covered at the Grade 9 level. However when dealing with real life situations, a mathematical gaze may require sophisticated use of basic mathematics. An example which often appears in ML textbooks and assessment is when learners are asked to use a formula such as:

Cost per month = $1, 80 \times \text{no. of units used} + R85.$

In an ML classroom learners are often required to use the formula to calculate costs if a certain number of units are known, or to calculate the electricity or water bill based on a given consumption. Such formulae form part of ML knowledge. Solving these problems...
requires the use of result-unknown strategy (Nathan and Koedinger, 2000) because the value of the variable (number of units) is given and one is being asked to find the cost (or result). However, a question such as “how many units you can get for R300?” requires learners to calculate number of units that correspond to a certain given cost. This question requires a renewed strategy which can be described as a start-unknown type problem (Nathan and Koedinger, 2000), because in this case, the result (cost is given) and the start (number of units) is required. Result-unknown and start-unknown strategies are also described by Groetsch (1999) as direct and inverse problems respectively. A direct problem is one which asks for an output, when given the input and the process. For an inverse problem, the output is given, and the problem could ask for the input or the process that led to the output. Solving problems based on well-known everyday situations such as telephone, water or electricity bills may thus need the use of the start-unknown strategy which is mathematically more demanding than the routine use of a result-unknown or direct strategy.

In order to understand the differences in demand between the two types of problems, we will draw upon Sfard’s (1991) process-object duality theory. According to this theory (Sfard, 1991), mathematical concepts may sometimes be interpreted as process and at other times as an object. Sfard also describes this phenomenon as being conceived both operationally (process conception) and structurally (object conception). However, even though the mathematical construct can be seen operationally and structurally, the two views are complementary. For example, in the expression \((1.8 \times C) + 32\) can be seen as a process, that is take C, multiply it by 1.8 and then add 32 to the results i.e. as a computational process. On the other hand an object conception, according to this theory is when the algebraic representation \((1.8 \times C) + 32\), can be regarded as a whole entity which can be manipulated, or used in further operations or processes, that is, it is conceived as abstract object. Sfard (1991) states that the ability of a learner to see a mathematical concept both as a process and as an object is indispensable for a deep understanding of mathematics. This multifaceted view of the object develops intellectual quality. Intellectual quality is achieved if learners are engaged in higher order thinking, if learning focuses on deep knowledge of the subject, if pedagogy focuses on producing deep understanding, if learners are engaged in substantive communication about the things they are learning (Department of Education, 2003). The purpose of this study is to explore the extent to which ML and mathematics Grade 11 learners are able to recognise the difference between a start unknown and a result-unknown formulation of a problem based on the same equation, and to actually solve the two problems. The learners’ responses to the two types of problems will give us insight into the extent to which these learners are able to access an object understanding of the linear equation that is under scrutiny. This study seeks to answer the following questions:

Can learners identify the differences between start-unknown and result unknown problems in mathematics?

What are the approaches used by mathematics and mathematical literacy Grade 11 learners to solve start-unknown and result-unknown problems in mathematics?

Are there differences in trends of the approaches favoured by the two groups?

The study utilises a naturalistic inquiry and the participants are 132 grade 11 learners, consisting of 30 mathematics and 102 mathematical literacy learners. The two groups were given the same test item to write at the same time. The two questions were based on the formula used to convert from degrees Celcius to degrees Fahrenheit: \(F = (1.8 \times C) + 32\). One
question was a result unknown question requiring the value of F when C was given. The second question was a result–unknown version of the same formula, where F was given and they were asked to calculate C. In addition learners were asked to reflect on the differences that they saw between the two questions. Ten learners (five mathematics and five mathematical literacy) were thereafter interviewed, in order to explore further the approaches they used and their reasoning behind their approach. The analysis is in the initial stages and results are not yet available. The final results from the written responses and the interviews will be presented at the conference, should this paper be accepted.

Maharaj (2010, p.42) writes “A learner does not learn mathematical concepts directly but applies mental structures to make sense of a concept. Learning is facilitated if the individual possesses mental structures appropriate for a given mathematical concept.” This quotation implies that it is imperative for teachers to note and learn from approaches used by learners to solve mathematical problems. Understanding learner approach helps the teacher to guide learners to build appropriate mental structures. It is hoped that this study will add to our knowledge about learners’ facility with start-unknown and result-unknown problems and will therefore help us understand better how we can help learners develop the appropriate mental structures for particular concepts.

References:


Investigating addition and subtraction strategies of Grade 3 learners within the context of a Maths Club

Thulelah Blessing Takane
Marang Centre for Mathematics and Science Education, Wits
thulelahblessing@gmail.com

Abstract

There is evidence of poor performance in primary mathematics from Annual National Assessment (ANA) report Department of Education DBE (2012) and overtime in Foundation Phase (Fleisch, 2008). Within this there is evidence that learners remain highly dependent on concrete strategies (Ensor et al., 2009).

This problem led to an interest to investigate and explore the shifts that can be seen in the addition and subtraction strategies used over the course of a year by a sample of Grade 3 learners within the context of Maths Club set up as a school based pre-service mathematics teacher education methodology course. I focus on addition and subtraction since this aspect has been identified as a topic where a lack of progression to more compressed and abstract strategies (Gray, 1991) disrupts learner progress in mathematics in Intermediate Phase (Ensor et al., 2009; Schollar, 2008). The critical questions that I seek to answer are, a) What addition and subtraction strategies do learners display at the start of maths club?, b) What addition and subtraction strategies does maths club suggest to learners?, c) What shifts in addition and subtraction strategies can be seen during the course of the maths club?

Literature on the learning of early addition and subtraction describes effective strategies and progression thereof through the relation of problem types and counting strategies. My conceptual framework is drawn from the work of Carpenter, Fennema, Franke, and Levi (1999). The framework consists of four basic classes of addition and subtraction problems: Join, Separate, Part-Part-Whole, and Compare. Within each class there are distinct problem types such as Result Unknown, Change Unknown and Start Unknown for Join and Separate Problems. For Part-Part-Whole problems, problem types are distinguished as Whole Unknown and Part Unknown; and for Compare problems as Difference Unknown, Compared Set Unknown, and Referent Unknown. These problem types provide opportunities for learners to apply different strategies which are referred to as Direct Modeling strategies which are: Joining All, Joining To, Separating To, Separating From, and Matching; and Counting Strategies which are Counting On from First, Counting On from Larger, Counting On To, Counting Down, Counting Down To.

With regards to the sample I use for my study, six Grade 3 learners together with 2 student teachers conducting lessons within the Maths club were observed. The lessons and activities carried out in the maths club were the same for all groups, and were discussed with the students in the content course associated with this school-based methodology course. The learners in the group (and parents) led by these students were informed about the study and all gave their informed consent for participation.

Data collected during the sequence of the 13 maths club sessions held across the year formed the dataset for my analysis. Various data sources were used for this study. Observation data through videotaping forms the key data source. Field notes with feedback from the student teachers were also used. Lesson plans and worksheets used within the Maths Club sessions were collected and analysed. However, the focus of this presentation is on the analysis of the first and third critical question stated above.
The results from the initial data analysis revealed that the predominant strategies used by learners for addition and subtraction ―Join‖ and ―Separate‖ problems are direct modelling strategies. These are ―Joining All‖ and ―Joining To‖ where learners rely on concrete objects such as beans, fingers and bead strings. The shifts that seem to appear overtime in the course of their participation in maths club are that in addition strategies mentioned above, learners display more sophisticated strategies of direct modelling such as ―Matching‖ to solve ―Compare‖ problems.

The tentative conclusion is that at the end of Grade 3, there seems to be a combination of use of concrete strategies and more sophisticated strategies rather than a linear progression to the use of more sophisticated strategies.

References


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**A comparison of mathematics teachers’ self-evaluation and their peers’ evaluation of the teachers’ teaching**

Ugorji I. Ogbonnaya¹ & David Mogari²

¹Department of Mathematics, Science and Technology Education, Tshwane University of Technology, South Africa; ²Institute for Science and Technology Education, University of South Africa.

¹ugorjiio@yahoo.com; ogbonnayaui@tut.ac.za, ²mogarld@unisa.ac.za

**Abstract**

The paper reports a study that compares mathematics teachers’ evaluation of their teaching and their peers’ evaluation of the teachers’ teaching. A sample of 31 grade 11 mathematics teachers and their peers took part in the study. The results show that there were generally internal inconsistencies among teachers’ evaluation of their teaching and also among their peers’ evaluation of the teachers teaching. Similarly, there were internal inconsistencies
between teachers’ evaluation of their teaching and their peers’ evaluation of the teachers’ teaching. The implications of the findings are discussed and recommendations made.

**Keywords:** Mathematics teaching, mathematics learning, peer evaluation, self evaluation, teaching effectiveness.

**Background**
To evaluate teachers’ teaching, education researchers sometimes use teachers’ self-evaluation evaluation of their teaching for their peer-evaluation of the teachers’ teaching (for example Ferguson and Womack (1993), or the student-evaluation of their teachers teaching). A teacher’s self-evaluation of his/her teaching is process whereby the teacher carries out self-assessment of his/her practices. It enables the teacher to reflect on his teaching, review his/her performance and rate himself or herself. A teacher’s self-evaluation is an important source of evidence of his/her teaching; it demonstrates the teacher’s knowledge about teaching and perceived effectiveness in the classroom (Cranton, 2001). One main concern about the use of teachers’ self-evaluation is the possible teacher’s biased estimate of their teaching. However, a teacher’s self-evaluation of his/her teaching can provide support for what the teacher does in the classroom and can present a picture of the teacher’s teaching that is unobtainable from any other source (Berk, 2005).

Peer evaluation of teaching is a process by which the quality of a teacher's teaching is evaluated by his/her peers. Peers are used to evaluate their colleagues’ teaching because of the peers’ knowledge of the subject matter and their understanding of the teaching context (French-Lazovik, 1981). Also, the organised review of a teacher’s work by his/her peers makes the work of the teacher evident.

One reason for the use of self-evaluation or peer evaluation to evaluate teachers’ teaching is the relative ease to collect data and the minimal cost of data collection as compared to the use of lesson observation. This paper compares teachers’ self-evaluation of their teaching and their peers’ evaluation of the teachers’ teaching. Hence, the question addressed by this paper is: does teachers’ self-evaluation of their teaching correlate with their peers evaluation the teachers’ teaching?

**Conceptualising the study**
The purpose of teaching is to promote learning. Teaching entails the application of skills and carrying out of appropriate activities to enable students develop and ultimately exhibit the expected learning behaviours. In this paper, effective teaching is conceptualised as the teaching that enables students to achieve their academic learning goals.

For teachers to be effective they need to have sound knowledge of the subject matter, and plan; present and organise their lesson properly. They also need to effectively assess the students learning and motivate them among other things (Adeosun, Oni, Oladipo, Onuoha, & Yakassai, 2009; Tsang & Rowland, 2005). Hence, subject matter knowledge, lesson preparation, organisation and presentation; and student assessment and motivation are used in this study as variables of teaching effectiveness.
Method

A sample of 31 grade 11 mathematics teachers and their peers from one education district in a province in South Africa took part in the study. The study employed survey research design in which two questionnaires (teacher self-evaluation questionnaire and peer evaluation questionnaire) were used to collect data from the teachers and their peers.

Construct validity of the instruments were ascertained by the process of experts rating of the favourability of each item to the construct it was purported to measure and subsequent calculation of the correlations between the experts’ average rating of each item and total score across all items in the construct. Only the items with correlation coefficients greater than or equal to 0.7 (Trochim, 2006) were selected for the instruments.

The reliability (coefficient alpha values) of the instruments were 0.92 and of 0.95 for the teacher self-evaluation questionnaire and peers evaluation questionnaire, respectively. The values implied that the instruments were reliable.

Data analyses involved correlation analyses to determine the patterns of relationship among teachers’ evaluation of their teaching and the peers’ evaluation of the teachers teaching and also between the teachers’ self-evaluation and the peers’ evaluation.

Results

The findings of the study show that contrary to expectation, there were generally internal inconsistencies among teachers’ evaluation of their teaching and also among peers’ evaluation of the teachers’ teaching. Similarly, there were internal inconsistencies between teachers’ self-evaluation of their teaching and their peers’ evaluation of the teachers’ teaching. This implies that teachers’ self-evaluation of their teaching does not correlate significantly with their peers evaluation of the teachers’ teaching.

Conclusion

The findings of this study has a lot of implications for the use of teachers’ self-evaluation of their teaching and peers’ evaluation of teachers’ teaching in educational research. Often, researchers’ are constrained to use surveys as the easiest means of data collection, this urge has to be weighed against the potentials pitfalls of the use of survey data in studying teaching and also against the significance of the study. Information about teaching from teachers or their peers can give an indication of what transpired in the classroom, however, survey studies may not give accurate account of educational practices on which high-stake decisions can be taken. To ensure credibility, high-stake studies should not depend exclusively on survey data but on a triangulation of different data sources and data collection methods.

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Background and objectives
Few would argue that mathematics education in the country has faced a lot of challenges over the years. More often than not mathematics educators have been blamed by the government, school authorities, parents and even students for poor achievement in mathematics at various examinations. While it can be generally agreed that educators have a significant role to play in students’ learning, studies (e.g., Ahmad, 2008; Graham, 2007; Ingvarson, Beavis, Bishop, Peck & Elsworth, 2004) have shown that prevailing circumstances under which educators work contribute to their effectiveness. This research paper aims to highlight some of the challenges mathematics educators at the Further Education and Training (FET) band face in the discharge of their duties. Also, to offer possible solutions to identified challenges.

Conceptualising the study
This study is located within the phenomenological research paradigm (Groenewald, 2004). The purpose of phenomenological research approach is to identify phenomena through how they are perceived by the actors in a situation; it is based on a paradigm of personal knowledge and subjectivity, and emphasises the importance of personal perspective and interpretation (Lester, 1999). The focus of this study was to identify some of the challenges faced by FET mathematics educators, as mathematics educators, from the educators’ perspectives. As such, it is concerned with the lived experiences of the educators in the discharge of their duties. In line with the phenomenological paradigm, this paper aims to describe, rather than explain, the challenges of the educators.

Method
A cohort of 42 mathematics FET educators from one province in the country that attended an in-service content development workshop took part in the study. An open ended questionnaire was used to collect data from the educators. The questionnaire requested educators to reflect on a number of issues about the entire school system. For example, they had to reflect on the education policies, the schools’ management and administration, the learners, the schools’ resources, and the learners.
Results
The challenges faced by FET mathematics educators were varied. These were:
(a) learners not adequately prepared at the lower grades to learn mathematics at the FET level,
(b) learners not committed to schooling,
(c) learners lack of interest in mathematics,
(d) high educator-learners ratio in schools,
(e) schools lacking resources like needed to teach mathematics effectively,(e.g., textbooks, calculators, computers)
(f) few learning facilitators from the department that support educators at schools,
(g) educators lacking content knowledge of some of the topics,
(h) educators being overburdened with too much work load,
(i) constantly changing of the curriculum
(j) schools management encouraging learners to do mathematical literacy instead of mathematics in order to increase the schools’ pass percentage in Matric examination.

Conclusions
The results presented here are a cause for concern and they need urgent attention from stakeholders. For instance, stakeholders in mathematics education should as a matter of urgency look at ways of improving the teaching and learning of mathematics at the GET level. This will hopefully address the concern by FET phase educators that learners are not fully equipped with the requisite mathematical knowledge to continue their studies at this level. Furthermore schools should be equipped with current recommended textbooks and other learning equipment to make the teaching and learning of mathematics easy and interesting. Importantly, FET mathematics educators should be encouraged to attend in-service content training workshops in order to increase their subject matter expertise. Also, more subject facilitators should be employed to regularly visit the schools and provide on-site support to the educators. In addition, ways of addressing the high educator-student ratio should be addressed. This can be accomplished by employing more educators. It is our hope that the policy makers will see the urgency to focus on the issues identified in this study.

References
Tracing the use of Pedagogical Content Knowledge of Grade 6 mathematics educators in Kwazulu-Natal

Viren Ramdhany
virenr@vodamail.co.za

This paper reports back on the results of a study in which I was involved and which formed the basis of my master’s research. The aim of this study was to explore the concept of pedagogical content knowledge, or PCK, and its use in the practice of teaching.

Teacher knowledge is a significant factor in determining learner gains in all school subjects. However, little is known about the role of the different types of knowledge that teachers are supposed to possess in particular in a developing world context. PCK was introduced by Lee Shulman in 1986 and has since been the subject of much research in teacher education. Pedagogical content knowledge is thought to be a highly specialised form of teacher knowledge that intertwines subject matter (content) knowledge and general pedagogic knowledge.

In this study, I examined the PCK of 39 mathematics teachers. My research questions included: how the teachers used PCK in their teaching of mathematics; what determined their PCK; and to what extent their PCK influenced the mathematical achievement of their learners. The primary data collection method that I used was lesson observation of 42 video-recorded grade 6 mathematics lessons from various schools in the greater Umgungundlovu district of Pietermaritzburg in KwaZulu-Natal. I also examined teacher tests, learner tests and some biographical information from teacher questionnaires. The schools were selected through random stratified sampling to participate in a larger regional achievement study, designed to investigate the factors which influence learning in schools.

The theoretical framework used in this study was derived from theories that already exist about teacher knowledge and its resulting effects on teacher preparation and practices. These included the works of Shulman, Ball, Grossman, Sorto and Ma. Shulman pioneered the concept of pedagogical content knowledge (PCK) in 1986 and others have since taken up this idea and re-worked it in ways to make it sensible to them. Grossman (1990) maintained the PCK moniker but expanded on Shulman’s categories. Ball and her colleagues used Shulman’s main points to develop their mathematical knowledge for teaching (MKT), while Ma’s Profound Understanding of Fundamental Mathematics (PUFM) called for teachers to have a deep and broad understanding of mathematics in order to achieve greater understanding among students.

The PCK that teachers possess is thought to equip them with the skills and abilities necessary to transform (mathematical) content knowledge into forms that are accessible to learners; skills that enable teachers to have a greater understanding of how students learn particular concepts or sections in mathematics; to be able to identify the common errors that students make and understand the reasons for these errors; and to have alternative methods at hand to facilitate student learning when difficulties do arise (Shulman, 1986, 1987; Ball, 2000; Ball & Bass, 2000).

It is further believed that teachers accumulate this knowledge as they teach the same sections over and over and begin to see patterns in student learning and error-making. Formal pre-service and in-service content and pedagogical training courses are also believed to have a great influence on a teachers’ PCK development; while informal trial-and-error experiences
in their own classrooms are also thought to contribute (Ma, 1999; Ball, Hill & Bass, 2005; Ball, Thames & Phelps, 2008; Sorto, Marshall, Luschei & Carnoy, 2009).

Using the data from my observations, I developed a PCK instrument and attempted to measure the teachers’ PCK. I then tried to link these PCK ‘scores’ to other variables in my study, which included a teacher’s test and learner tests. I tested the consistency of my instrument and the teachers’ PCK scores appeared fairly consistent across lessons, but that more research is needed to interrogate that.

My initial findings suggested that all teachers possess PCK in some form, though their observed PCK levels were limited. The opportunity to develop proficiency, the use of examples and some engagement with learners’ prior knowledge though mostly in the form of checking homework were the areas most prevalent. The focus was mostly on procedural aspects. Only a minority of the teachers used representations, showed more than one method, displayed longitudinal coherence or engaged in more substantial ways with learner thinking (misconceptions and errors).

Crucially, it emerged that a sound teachers’ knowledge of mathematical content was necessary for a high PCK rating, but there was no significant relationship between teachers’ PCK and learner gains in mathematics. It is likely that there are other factors which have a greater impact on learners’ learning than effective teachers, factors such as the socio-economic backgrounds of the learners. Given the random sampling of the schools in the study, and various attempts to ensure consistency in my coding and analysis, I hoped that these results would be valid for the greater KwaZulu-Natal area. However, because I used mainly the video analysis of lessons, and only a part of the teachers’ test, to determine the teachers’ PCK, it is possible that I may not have been able to get the full picture of the teachers’ PCK as I would have if I had also interviewed them.

In a study of this nature, one is often faced with more questions than answers at the end. I believe it is vital that efforts be made to improve teacher education and training. If teachers enter the classroom armed with the content and pedagogic knowledge they require, then they would teach with the confidence and understanding that is needed to improve learner understanding. Peer and departmental support must also be available to those teachers who require their assistance. If one were to look beyond the more urgent and obvious need for social upliftment of the majority of our learners, and decide that PCK is worthy of a greater investment, then perhaps a closer look at the teacher education programmes offered by higher education institutions is necessary.

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ROUND TABLE DISCUSSIONS
Handing Over the Facilitation of a Mathematics Professional Learning Community from a University Based Facilitator to a School Based Facilitator

Rencia Lourens
Wits School of Education
Rencia.Lourens@wits.ac.za

Introduction
In this round table, I wish to raise some issues relating to my MEd dissertation research. In my research I am looking at the handing over process in a professional learning community from being facilitated by a university-based facilitator to a school based facilitator.

Internationally professional learning communities are increasingly seen as an alternative method for professional development (Brodie, 2011). Mathematics teachers participating in a professional learning community can use their own experiences to identify their needs for professional development. Brodie (2011) argues that the collective nature of professional learning communities is important. Teachers work together and as they learn more about their learners’ needs their practice can be influenced and improved. In a specific research project, initiated by a South African university, teachers meet and work in professional learning communities as well as networked learning communities. The focus of the learning communities in this project is to look at learners’ errors in mathematics.

As part of the project a professional learning community was established amongst mathematics teachers at a high school west of Johannesburg in 2011. Weekly meetings took place with a facilitator from the project. Research (Borko, 2004; Jaworski, 1999) suggests that professional development projects are successful when there is collaboration with researchers from universities. Research has also shown that professional learning communities are hard to sustain (Koellner-Clark & Borko, 2004). The professional learning community at the school was developed in 2011 with tremendous support from the university-based facilitator. In turn the facilitator was supported by a project team at the university. From 2012 onwards a gradual withdrawal of the facilitator is envisaged, without compromising the learning of the community. The aim is to have an independent sustained professional learning community where the facilitator will still be available for support, but not necessarily on a regular basis. The facilitator can rather become a resource when needed.

Research on successful sustained professional learning communities is scarce. My research is looking at this handing over process of the facilitation and the sustainability of the professional learning community.

Research Questions
I am currently (July 2012) working on my proposal and my research questions are:

1. What factors support or inhibit the sustainability of the professional learning community and to what extent?
2. How does the handover process from a university-based facilitator to a school based facilitator work?
3. How does the university-based facilitator gradually shift to a resource for the professional learning community?
4. What is the role of distributed leadership in the sustainability of the professional learning community?

Methodology
The research will be a qualitative case study with two foci of analysis, the potential school based facilitator and the professional learning community. I will interview the individual members of the professional learning community, including the potential school based facilitator. These interviews will be recorded and transcribed. I have recorded all the professional learning community meetings of 2011 and 2012 and will continue to record the professional learning community meetings in 2013. I have also recorded the meetings between myself and the identified school based facilitator. All these recordings will be transcribed. I will analyse the interviews and the professional learning community meetings, looking for indicators of sustainability, indicators of distributed leadership and indicators of the hand over process. It is important that mathematical issues are included as an aspect of all these indicators. Particularly important will be how content knowledge and pedagogical content knowledge are developed and sustained in the community.

Questions to the Roundtable
I request a round table to advise me on the following:

- What can be used as indicator(s) of sustainability in a mathematics professional learning community?
- In what ways might I analyse the hand over process in a mathematics professional learning community?
- What can be used as indicator(s) of distributed leadership in a mathematics professional learning community?

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Metacognitive skills of second year extended and main stream university mathematics
students: a case study

Ruan Moolman

Department of Mathematics, University of Johannesburg, South Africa.
rmoolman@uj.ac.za

South African universities have introduced bridging pre-graduate courses (also referred to as extended, foundation or augmented courses) in order to support students academically, particularly in mathematics and fundamental sciences. I will refer to students following bridging courses as extended degree students. After passing these bridging courses, extended degree students proceed to follow courses in a main stream degree (non-augmented degree) of their choice. Although these bridging courses are fundamental in giving students needed academic support, I believe that some bridging courses mostly focus on content knowledge rather than on explicit training in the use of metacognitive skills in a mathematical context. Metacognitive skills are concerned with the actual regulation, coordination and control of one’s own learning activities and cognitive processes (Focant, Grégoire & Desoete, 2006; Veenman, 2006). These skills are an important aspect in the solving of mathematical tasks (Lucangeli & Cabrele, 2006) and also play an important role in students’ mathematical learning performance (Mevarech & Fridkin, 2006; Mevarech & Kramarski, 2003). A number of South African studies argue that the instruction in and the design of engineering and science related courses need to take into account the training of students in metacognitive skills (Grayson, 2010; Jacobs & de Bruin, 2010; Loji, 2010). Desoete, Roeyers and De Clercq (2003) and Desoete (2007) both argue that metacognitive skills need to be explicitly taught to enhance students’ mathematical learning performance and that such skills do not necessarily develop spontaneously. From my own experience, extended students mostly obtain low grades in mathematics. I hypothesise that extended students may exhibit fewer and/or lower quality of metacognitive skills than compared to that of main stream degree students. It is within this context that I conducted a qualitative case study in order to determine possible differences in the metacognitive skills of extended and main stream degree students during a semester second year calculus course. Above students were explicitly instructed in the use of metacognitive questioning techniques (MQT) as advocated by the IMPROVE method (Kramarski, Mevarech & Arami, 2002; Mevarech & Kramarski, 1997). My research is guided by the following three questions:

1. (a) What metacognitive skills does an extended and mainstream student respectively exhibit, while working together in a pair on mathematical tasks, before explicit instruction in MQT?  
   (b) In particular, are there any differences in the metacognitive skills between that of an extended and main stream degree?

2. (a) After explicit instruction in MQT, what metacognitive skills does an extended and main stream student respectively exhibit while working together as a pair on mathematical tasks?  
   (b) Again, are there any differences in the metacognitive skills between that of an extended and main stream degree student?

3. Is there a relation between a student’s metacognitive skills and his/her mathematical performance over the period of the calculus course?

Students were video recorded while working together in pairs in solving mathematical problems. Each student pair consisted of one main stream and one extended degree student in order to observe possible differences in students’ metacognitive skills. Moreover, each student pair was observed twice before instruction and twice after
instruction of MQT in order to trace possible development and/or variations in individual students’ metacognitive skills. Data is currently being analysed by means of qualitative and quantitative methods in order to address above questions.

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In Search of the Meaning of PCK: Report of an International Summit held in Colorado, USA in October 2012

Marissa Rollnick ¹ and Elizabeth Mavhunga ²
Marang Centre for Mathematics and Science Education, Wits School of Education, Wits University, South Africa
Marissa.rollnick@wits.ac.za; Elizabeth.Mavhunga@wits.ac.za

This Round table will share with the SAARMSTE community the outcomes of a PCK summit held in Colorado in October 2012 and discuss the conclusions reached at the summit, raising further questions for PCK research in Southern Africa. The motivation for the summit was provided by Julie Gess-Newsome, the organiser of the summit: “Pedagogical Content Knowledge (PCK) has generated a lot of interest in the research community. Unfortunately, few commonalities exist in the way we have conceptualized or operationalized the construct in science education. The PCK Summit was designed to allow an international group of experienced PCK researchers the time and space to delve into their collective efforts, uncover assumptions, understand the divergences in approaches internationally, and perhaps agree upon the most fruitful tools that have been found to date in the exploration of teachers’ professional knowledge, including PCK.

The presenters of this round table were fortunate to be invited to this very important summit. The aim of the summit was to allow all those participating, as a research community, to agree upon a few deliberate and purposeful paths on which to focus individual and collective research in the future. The ultimate goal of the summit was to catapult the research on teachers’ professional knowledge on a productive trajectory.

The participants of the summit were purposefully selected to represent a range of conceptions and models of PCK, as well as variation in research methodology and creation and use of tools to document and assess teacher knowledge and skill. Prior to the summit, each research group was asked to write an expanded paper (EP) to provide the PCK Summit participants with a succinct yet comprehensive view of their definition of PCK and their research in this area. The EP, along with the Overview, was posted on a common website, read by participants and was used as the basis of an analysis and synthesis of the field. There is also an expectation of a book and journal articles following the summit.

Outcomes of the PCK Summit will include
- descriptions of current research efforts in science and mathematics education related to PCK and a synthesis of the findings of this research,
- clarity in the model of professional knowledge and the definition and measurement of PCK,
- identification of the most fruitful lines of research, and
- the exploration of a unique method of catapulting the work of a research community toward coordinated future efforts.

In this round table we will present some of the deliberations and findings of the summit and reflect some of the unsolved dilemmas. Participants in the round table will then consider the following questions which were also considered in the EP’s of the summit:

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1. The Nature of PCK: What are your assumptions about PCK as an attribute of teachers? Is it a knowledge base, a skill set, a disposition, or some combination? Is PCK tacit or explicit? Is it an unalterable characteristic or can it be enhanced with experience and/or particular kinds of preparation or professional development? If it can be enhanced, what specific mechanisms exist that might result in differences in PCK?

2. Model of PCK: How did you define the elements that comprise PCK? How is PCK related to the professional knowledge base for teaching? Is it transformative or integrative? How does growth in one area of teacher professional knowledge relate to growth in other areas of professional knowledge, such as PCK?

3. Measurement of PCK: How have you measured PCK? How did your answers about the nature of PCK and your model of PCK inform the development of measurement and analysis tools? What have you found to be the appropriate levels or grain sizes at which to measure PCK? Should it be examined at the topic level (e.g., mechanics) or the domain level (e.g., physics)? Why did you choose this level or grain size?

4. Contexts for Studying PCK: Where should the emphasis of PCK research lie in the future? For example, should it be studied in its own right, in terms of the translation of teacher knowledge to practice, in terms of the relationship between teachers’ level of PCK and student outcomes, or some combination of these ideas? Are there other directions for the research we should consider? What is your rationale for favouring one direction over another?"

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How to Start Developing a Socially Just Mathematics, Science and Technology Education

Maarten Tas 1 & Martin Braund 2

1 School of Education, University of Leicester, UK; 2 Faculty of Education and Social Sciences, Cape peninsula University of Technology, Cape Town, South Africa.

1 mprt1@le.ac.uk, 2 martin.braund@york.ac.uk

Political and economic aspects influence education in our societies. In a study of 15 year-olds in 41 countries it was concluded that overall student performance would increase if governments distributed limited educational resources more equally (Chiu and Khoo, 2005). Chiu and Khoo (2005) also showed that pupils scored higher in reading, mathematics and sciences when there were more resources and less privileged student bias. However, in African countries debates about inequitably distributed resources and student access have tended to squeeze out wider discourse embracing post-colonial, indigenous and cultural considerations of a socially just education (Tikly and Dachi, 2009).

In many countries, especially those seeking to modernise and industrialise, there is a move to improve teaching and learning in Mathematics, Science and Technology (MST) education and to reduce social and cultural barriers through national and regional actions, establishing networks of teachers and other stakeholders, teacher training, campaigns and competitions targeting students and other initiatives (Kearny, 2011). There is a strong bias toward inquiry based learning as the most important curriculum change. However, a debate about changing curriculum policies needs to also include ideas of Bernstein (1996), creative pedagogies (e.g. PCHA, 2011) and ideas for social justice in the mathematics and science classroom, for example as described by Gates and Jorgensen (2009) and Reiss (2003).
Gorard (2010) argues that schools can try to be the precursors of the kind of society that we wish to have and that education can compensate for society if young people in schools learn to trust the people around them, are willing to help others and experience school as fair. His research shows that better studies on what might constitute a socially just education are needed to inform government policy.

The aim of this round table is to develop a vision for what is needed for a socially just education with emphasis on MST education. In the UK and Australia several similar activities to this have taken place at conferences and meetings of teacher educators and academics. The ideas emerging from these activities have been recorded on an independent website (http://edchange12.weebly.com/). Recurrent themes identified so far address: ‘political’, ‘global’, ‘inclusion’ and ‘equal opportunities’ dimensions while recognising that a socially just education should encompass diversity and teachers’ professionalism. Carrying out this exercise at the leading MST conference in Africa is a unique opportunity to widen discussion and compare outcomes that might shape a more socially just MST education in African settings.

A key purpose of the round table discussion is to offer insight on developing equality of opportunity offered in education systems and how this can be utilised to afford individual learners the possibility of achieving their potential in MST. We will engage colleagues in working collaboratively to identify a skeleton for a ‘Manifesto for MST Education’. This skeleton is a framework designed from what the participants of the round table see as principles of MST education for social justice. This may be similar to the framework published by the Social Justice Education in Schools (SJES) project by the University of Massachusetts (Carlisle et al., 2006). The Massachusetts project integrated field-based study and existing research to identify five key principles of social justice education in schools: inclusion and equity, high expectations, reciprocal community relationships, system-wide approach and direct social justice education and intervention. They showed strong commitment to the cultivation of strong partnerships between diverse schools, their communities and the university with the aim of transforming teacher education and to improve student achievement. The successes of similar partnerships for more equitable and inclusive teacher development have been described in South Africa (Ndlovu, 2011).

In the round table we will first collate ideas and opinions, and then decide on headings for grouping these selecting most important headings. These headings will guide the framework/manifesto, which should provide suggestions for intervention strategies, policies, and allocation of school resources for curriculum and teacher development relevant in African and other systems.

This first step in constructing a manifesto aims to encapsulate a clear vision of education for the 21st Century. The next step will be to collaboratively work on statements which can be used generally, in separate fields, or to establish cross-curricular links such as in MST. Participants in the round table may want to run similar events with people within their fields of expertise or for other interested groups and this will help expand the discussion and clarify our understanding supported by relevant literature. Subsequent discussion with a range of other stakeholders in education will focus on developing these visions. These will then be communicated and consulted upon with a wider audience via a range of media including the already established web forum.

We hope an outcome of this round table will be to establish a short list of key principles, expressed succinctly and with clarity, supported with evidence found in academic
publications. An expanded discussion of each principle would be made freely available to a wider public. Engagement with policy makers and politicians could form a part of the discussion that starts here at the SAARMSTE conference. This round table session intends to initiate a democratic process about debating and further developing a socially just MST education with particular focus on education in African countries.

References

MEASURING AND CAPTURING PCK IN SCIENCE EDUCATION

Rene Toerien, Jenni Case, Elizabeth Mavhunga, Phihlo Pitjeng, Marissa Rollnick, Nonkhaniso Vokwana & Bette Davidowitz

1 Marang Centre for Mathematics Science and Technology Education Research, Wits; University, South Africa; 2 Chemical Engineering, University of Cape Town, South Africa; 3 Department of Chemistry, University of Cape Town, South Africa.

The idea of a specialized knowledge unique to teachers has grown to represent cutting edge knowledge of teaching practice. Pedagogical Content Knowledge (PCK), a concept first introduced by Shulman (1986), is now valued as the entity that defines expertise, something that brings to the fore the complexities involved in teaching and therefore the value of teaching (Loughran, Berry, & Mulhall, 2006). In recognition of the extensive research work
done in understanding the nature of PCK in science education, researchers are working towards an agreement on a uniform definition with meaning that is understood by others. Furthermore, there is also growing awareness of the identification of the expertise associated with PCK at different levels of teaching, namely, broader PCK, domain (science) specific PCK and topic specific PCK (Veal, & Makinster, 1999). While there appears to be progress in understanding the nature of PCK as indicated above, ‘seeing’ and capturing PCK at any of the levels is challenging as PCK while is exceptionally elusive. The purpose of this symposium is to unpack the issue of conceptualization of PCK at the different levels of practice and share possible ways of capturing and quantifying its quality.

The running theme connecting all the papers to be presented in the symposium is ‘Capturing and Measuring PCK’. The theme is anchored on a theoretical framework that identifies broader PCK as knowledge located internally in the understanding of the teacher and its presence seen through manifestations. These manifestations may then be captured to portray PCK. In this framework, PCK as an internal knowledge of the teacher is comprised of the teacher’s knowledge of Subject Matter Knowledge (SMK), knowledge of students, knowledge of context and general pedagogical knowledge. As shown in Figure 1 below, the manifestations indicating the presence of PCK suggested in the framework are: (i) Representations, (ii) Assessments, (iii) Curricular Saliency and (iv) Topic Specific Instructional strategies.

![Figure 1: Tailored PCK model from Rollnick et al. (2008)](image)

Four empirical studies that are anchored on this theoretical framework will be presented. While the connecting theme across the four studies, in addition to the framework, is capturing and measuring PCK, the presentations bring a combination of work looking for PCK at different levels of practice and using varied qualitative and quantitative approaches. The first presentation: Capturing and portraying PCK ‘in action’ - what can video data tell us? Rene Toerien and Jenni Case

The paper reports on a study that focused on describing science teacher practices in a township setting located in one of the metropolitan municipal areas. The goal of the study, in line with a call from Berry, Loughran & Van Driel (2008), is to build up cases to describe teacher practice. In this study, the PCK of science teachers as observed in classroom settings was captured using video recording. The recorded series of lessons were then analysed for manifestations of PCK using the theoretical framework described above. The paper’s contribution to the theme of the symposium will be in the conceptualization of broader PCK and the qualitative manner of capturing and portraying its existence. The paper will describe how the manifestations as defined in the framework have been used to describe the broader PCK of the teachers.
The second presentation is entitled: **Measuring Topic Specific PCK in Chemical Equilibrium in Pre-service teachers**. Elizabeth Mavhunga and Marissa Rollnick.

In this presentation the idea of PCK as defined by the theoretical framework described above, has been extended to look at PCK within a topic. The presentation defines PCK within a topic as a different but an integral construct to the broader PCK and referred to as Topic Specific PCK (TSPCK). The concept of TSPCK is built on the teacher’s knowledge of Subject Matter and the capability to transform it into forms that are suitable for teaching. Thus Topic Specific PCK becomes an intermediate step in the theoretical framework described above, see Figure 2 below. Five knowledge components have been identified as resulting in transformation of content when used to reason about its teaching. These are (i) students’ prior knowledge, (ii) curricular saliency, (iii) knowing what is difficult to teach, (iv) representations and (v) conceptual teaching strategies.

![Figure 2: A model of Topic Specific PCK](image)

The presentation reports on a study where Topic Specific PCK within Chemical Equilibrium as a topic was measured and its quality quantified in pre-service teachers using a specially designed tool (Mavhunga and Rollnick, 2011). While anchored on the same framework as the previous paper, the concept of PCK in this paper has been located at a different level, that is, a topic specific level. The capturing of PCK at this level was done through a tool and the analyses of the responses analysed through a quantitative method.

The third presentation is entitled: **Measuring Topic Specific PCK in Particulate Nature of Matter in Novice science teachers** Phihlo Pitjeng and Marissa Rollnick.

The paper reflects on challenges experienced by novice teachers as they embark with their new careers. The study explored these challenges with respect to five areas: the content and discipline of science, learners, instruction, learning environments and professionalism. The aim of the study, in line with reported findings by Luft and her colleagues (2011) about the importance of subject specific support to beginning teachers is to explore the relationship between Topic Specific PCK in Particle Nature of matter as a topic and the underlying beliefs of novice teachers. The paper presents another practical example where the idea of PCK within a topic is captured using a specifically designed Topic Specific Tool (Mavhunga and Rollnick, 2011) and its quality quantified. While the paper is based on the same theoretical framework (figure 2) as in the previous paper, the presentation however highlights the difference and the specificity of PCK within this topic confirming the topic specific nature of PCK.
The fourth paper is entitled: *Developing an instrument to evaluate Topic Specific PCK in organic chemistry*. Nonkhanyiso Vokwana and Bette Davidowitz. This paper presents a study where a topic specific tool was developed to capture and quantify the PCK of practicing teachers in organic chemistry. The developmental stages of the tool from conceptualization to validation are outlined. The tool is based on the five components of Topic Specific PCK captured in the Topic Specific model in figure 2 above. Insight into the quality of Topic specific PCK in organic chemistry of practicing teachers measured in the validation of the tool is shared. A criterion-based rubric reflecting differing categories of Topic Specific PCK was used in the analysis. The paper while sharing the same theoretical framework as the other two papers in the symposium, its unique contribution is the articulation of the process entailed in the development and validation a tool that measures Topic Specific PCK in a different topic.

The symposium will have a discussant who will respond to the presented varying cases on capturing and measuring PCK. It is envisaged that valuable comments and discussions will be made on the conceptualization of PCK and the practical ways of capturing and portraying its presence.

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SNAPSHOTS
Analysing student’s productions as a starting point to improve teachers’ MKT – some examples on data analysis

Miguel Ribeiro

Teachers’ training around the world has undergone a wide range of changes in the last few years. In Portugal, three different approaches were followed. Fort the first, it was defined nationally the amount of credits (ECTS – accordingly with the Bologna Process⁴) that each study program should cover in each one of the core topics. Second, a national program for professional development of primary teachers (teaching from first till six grade) was implemented; and thirdly, a new national curriculum for the first 9 years of schooling was implemented (Ponte, et al., 2007) (one single document which also aims to contribute to allow teachers to envisage students learning as something continuous). In all these different approaches and contexts, the topic of data analysis is one which has emerged as a focus of attention (at least theoretically) – analyzing the national guidelines for kindergarten (DEB, 1997) –, we can find, already, also, some references (although not explicit) to topics included in data analysis (e.g., data gathering, graph elaboration, analysis of information).

From kindergarten, children’s are supposed to have experiences from activities that contribute to the development of (informal) strategies in which the formal learning can be grounded – also contributing to the development of the basis of a statistical literacy. This topic (in parallel with fractions) is, thus, one of the ones which are expected to be approached from kindergarten to secondary schooling.

Aligned with such aims, we conceive the need for teacher’s awareness about the need of exploring such topic with pupils. However, traditionally data analysis is one of the topics in which teacher’s lack training, and thus, it’s one topic that needs more attention in teachers’ training, allowing also for teachers to prepare and implement mathematical challenging tasks (e.g., in the sense of Stein, Smith, Henningsen and Silver (2000)), maintaining a high cognitive level in such implementation. For such (both preparations and implementation of mathematical challenging tasks) the teachers knowledge assumes a critical role (e.g., Charalambous (2008); author_1 and other (2011)). Thus it is of fundamental importance to improve teachers’ training and knowledge on data analysis, allowing them to prepare and implement such kind of tasks, as well as to give sense to students’ productions, reasoning and argumentation. For such, it’s fundamental that (prospective) teachers have a knowledge that allows them to integrate in one, coherently and intertwined way both the mathematical and didactical aspects/dimensions in their practice (actual and/or future). Such knowledge if here perceived as the Mathematical Knowledge for Teaching (MKT) data analysis (e.g., Ball, Thames and Phelps (2008); Burgess (2011)). As mentioned by Batanero (2009) we also consider that research in these dimensions is an important aspect for the development of a sustainable initial and continuous teachers training.

This poster is part of an ampler research project focusing on early years (prospective) teachers’ MKT. Here we will focus on the topic of data analysis (the one which we have just started researching). It aims, amongst others, to identify, discuss and reflect upon the

⁴ An european atempt to normalise Higher Education system through the definition of a common unit of credits ECTS allowing students to navigate easier between countries and universities.
mathematical critical situations on (prospective) teachers’ knowledge (were some kind of lacuna is evidenced – in terms of subject matter knowledge and/or transversal abilities). With such focus we aim, ultimately, to access the mathematical whys and hows which are at the core of such difficulties, allowing us to conceptualise tasks to develop teachers MKT on data analysis. We will present some preliminary results concerning early years’ prospective teachers’ knowledge (mathematical critical situations on the MKT – specifically on two of its domains – common content knowledge and specialized content knowledge) on statistical literacy gathered through their analysis of students’ productions and from those we will discuss some potentialities of such kind of approach for the design of tasks to develop such knowledge and to change the focus and nature of teachers training.

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An ethnographic study of beginner mathematics teachers’ career development in the first two years of their employment: shaping of a professional identity.

Narayanan Ajayagosh
Mathematics Department, Faculty of Education, Rhodes University, Grahamstown, South Africa.
agnarayanan76@yahoo.com

Abstract
This study intends to explore how a beginner mathematics teacher shapes his professional identity during his first two years of teaching in Lesotho. From the day a mathematics teacher joins the school staff, he becomes part of the everyday activities that unfold in the school and its classrooms. From day one, he starts creating meaning to his professional identity. As his professional career begins, he engages with, participates in and prepares to understand the culture, norms, ethics and behavior of the school community he works with. He starts building a personal meaning of the career he has chosen and begins to shape his own professional identity. Within this background, I ask some fundamental questions like:

- What makes a person to be a teacher?
- How does a teacher shape his professional identity?
- What is this identity?

In an attempt to understand their professional identity, I ask some further fundamental questions such as; how do beginner teachers make meaning of themselves as mathematics teachers and how do they shape their ‘professional identity’? Using an ethnographic study that is further narrowed into narrative ethnography, I used the following approaches to investigate how identities evolve through participation and how this influences teaching practices. In this study, I have used classroom observations, interviews and other data collections (lesson plans, schemes, journals etc).

My pilot study concluded that, beginner mathematics teachers possibly complement teaching by providing a range of examples drawn from everyday life. On the other hand, some of them believe in an interactive way of learning mathematics, which is learning as doing. Teacher-identity is thus shaped and re-shaped through interactions within their professional context. In addition, it has also inspired me to gather beginner mathematics teachers’ experience to understand how they shape their professional identity within a community of practice, using ethnographic study over a period of two years in Lesotho schools. The pilot study also helped me to design the broader study within the framework of social and cultural theory of learning and on the theory of practice. It also guided me to see how BTs develop their career by examining and reflecting on their classroom behavior and inspired me to engage with an in-depth study on the shaping of beginner mathematics teachers’ professional identity.

The classroom observation and the interview that I engaged with brought the issue of in-experience of beginner mathematics teachers and their concerns, challenges, tension, hopes, excitements and other emotions that has an impact on their classroom teaching. This could possibly have an impact on their professional identity, as I academically assume. In this regard, the article elaborated the role of beginner mathematics teachers’ professional identity using Wenger’s (1998) social practice perspectives and Lave and Wenger’s (1991) theory of participation. The study so far has observed with an understanding that the professional identity needs an in-depth investigation through exploring the various strands of identities.

Over the two-year period of observing and following the participants (beginner mathematics teachers) in Lesotho schools in 2012 and 2013, it is also expected that the reflexive thoughts and their living through the experience could make a difference in their professional identity. I have identified the trace of progress on the attitude of these research participants throughout their narratives.

Intended approach of presentation: In a power point presentation, I will be narrating the findings from the three classroom observations (of six beginner mathematics teachers in three different terms) as well as the reflective thoughts of these participants. During the snap-shot presentation, I will also use the extracts from their journals and conversations to establish any possible trace of shaping the professional identity of these beginner mathematics teachers.

**References**

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**Metacognitive skills of second year extended and main stream university mathematics students: a case study**

**Ruan Moolman**

*Department of Mathematics, University of Johannesburg, South Africa.*

rmoolman@uj.ac.za

Internationally universities have introduced bridging pre-graduate courses to support students academically in hopefully preventing the decline of graduates in mathematics and fundamental sciences. In South Africa these bridging courses are referred to as extended, foundation, or augmented courses (I will use these terms inter-changeably). I will refer to students following bridging courses as extended degree students. After passing these bridging courses, extended degree students proceed to follow courses in a main stream degree (non-augmented degree) of their choice. Although these bridging courses are fundamental in giving students needed academic support, I believe that some bridging courses mostly focus on content knowledge rather than on explicit training in the use of metacognitive skills in a mathematical context. Such metacognitive skills are concerned with the actual regulation, coordination and control of one’s own learning activities and cognitive processes (Focant, Grégoire & Desoete, 2006; Desoete, 2008; Veenman, 2006). These skills enable one to evaluate and monitor one’s own understanding and cognitive processes (Lucangeli & Cabrele, 2006). Successful students in mathematics are able to apply metacognitive skills (Lucangeli & Cabrele, 2006; Schoenfeld, 1987). These skills are an important aspect in the solving of mathematical tasks (Lucangeli & Cabrele, 2006) and also play an important role in students’ mathematical learning performance (Mevarech & Fridkin, 2006; Mevarech & Kramarski, 2003). A number of South African studies argue that the instruction in and the design of engineering and science related courses need to take into account the training of
students in metacognitive skills (Grayson, 2010; Jacobs & de Bruin, 2010; Loji, 2010). Grayson (1996) argues that it is not students’ lack of content knowledge that is mostly the root of their poor performance, but students’ lack of metacognitive skills. Desoete, Roeyers and De Clercq (2003) and Desoete (2007) both argue that metacognitive skills need to be explicitly taught to enhance students’ mathematical learning performance and that such skills do not necessarily develop spontaneously.

From my own experience, extended students mostly obtain low grades in mathematics. I hypothesise that extended students may exhibit fewer and/or lower quality of metacognitive skills than compared to that of main stream degree students. It is within this context that I conducted a qualitative case study in order to determine possible differences in the metacognitive skills of extended and main stream degree students during a semester second year calculus course. Above students were explicitly instructed in the use of metacognitive questioning techniques (MQT) as advocated by the IMPROVE method (Kramarski, Mevarech & Arami, 2002; Mevarech & Kramarski, 1997). Students were video recorded while working together in pairs in solving mathematical problems. Each student pair consisted of one main stream and one extended degree student in order to observe possible differences in students’ metacognitive skills. Moreover, each student pair was observed twice before instruction and twice after instruction of MQT in order to trace possible development and/or variations in individual students’ metacognitive skills. Data obtained from the above observations is currently being analysed by means of quantitative and qualitative methods. Notions underlying that of Symbolic Interactionism, as well as the concept of socio-mathematical norms are used in order to describe students’ mathematical learning performance and (possible) use of metacognitive skills. Results from the study may give insight in the implementation and use of metacognitive skills of individuals in order to design effective instructional programmes.

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**EXPLORING PEDAGOGICAL CONTENT KNOWLEDGE OF MATHEMATICS LITERACY TEACHERS**

Sarah Bansilal ¹ & Ellamma Pillay ²

School of Science Mathematics and Technology Education, University of the KwaZulu-Natal.

¹bansilals@ukzn.ac.za, ²pampil@webmail.co.za

The main aim of this study is to explore the nature of Pedagogical Content Knowledge (PCK) of Mathematics Literacy teachers in Data Handling so that the construct of PCK is better understood in this field. Mathematics Literacy (ML) entails mathematics taught within real life context and does not require rigorous methods and proofs associated with mathematics but rather application of mathematics in real life contexts. According to DOE (2003) ML is:

a subject driven by life-related applications of mathematics. It enables learners to develop the ability and confidence to think numerically and spatially in order to interpret and critically analyse everyday solutions and to solve problems” (p. 9).

Its main purpose is for learners to do more application of mathematics in real life contexts thereby using mathematics to understand and make sense of the world and not aimed for
learners to do more mathematics. According to Steen (1999) numeracy not calculus is the key to understanding our data drenched society as the age of information is an age of numbers, data, graphs and statistics which both enrich and confuse our lives.

The three main research questions are:

1. What is the nature of Pedagogical Content Knowledge of Mathematics Literacy teachers teaching Data Handling?
   This question explores the types of representations, analogies, illustrations, examples and explanations that ML teachers draw upon when explaining concepts, or designing activities/lesson plans in DH?
2. How do Mathematics Literacy teachers use Pedagogical Content Knowledge in teaching Data Handling?
   This question explores how ML teachers use representations, metaphors, analogies, illustrations, examples, in-class activities, homework assignments and explanations in teaching DH?
3. Why do Mathematics Literacy teachers use Pedagogical Content Knowledge in the way they do?
   Teacher knowledge has become the focus of interest and this study will interrogate, uncover, describe and explore the nature of PCK of ML teachers. The findings of this study will provide a deeper understanding of the nature of PCK in teaching and learning in classroom practice.

Studies aim to conceptualise and measure teacher’s topic-specific knowledge of students (Hill, Ball & Shilling, 2008) which is a domain of PCK, or just measure (Manizade & Mason, 2011) or determine levels (Yusof & Zakaria, 2010) of teachers’ PCK in particular topics. The study by (Hill, Ball & Shilling, 2008) report partial success in conceptualizing and developing measures of teachers combined knowledge of content and students but still remains insufficiently exploited.

The study by Yusof and Zakaria (2010) reveals that teachers lacked conceptual knowledge as it explores, describes and determines the level of PCK of three school teachers relevant to the topic of functions. They suggest that assistance should be provided for teachers through in-service trainings and courses to improve teachers’ PCK. In-service trainings and courses will only be able to contribute to enhancing teachers’ PCK once the construct of PCK is clearly understood. Mirel (2011) provides a strong argument that PCK can be taught to prospective and practicing teachers.

According to Ball, Thames and Phelps (2008) “few studies have tested whether there are, indeed, distinct bodies of identifiable content knowledge that matter for teaching” (p. 389). Thus this practice-based theory of content knowledge for teaching (Ball, Thames and Phelps, 2008) is ideal and will be used as theoretical framework for this study as the focus is on the work of teaching and the kinds of mathematical knowledge and skill needed by teachers as they teach. This theory is built on Shulman’s (1986) notion of Pedagogical Content Knowledge and is an elaboration of the construct of PCK.

This study engages the tenets of qualitative research approach. According to Merriam (2000) document analysis, observations and interviews are three major sources of data for qualitative research study. This study uses all three sources of data as these sources of data will yield rich information to answer the research questions. The teacher’s responses to the assignment task, their responses to examination questions and teacher’s research project will be used for the data production as it contains tasks requiring Content Knowledge, Pedagogic
Knowledge and Pedagogic Content Knowledge. The fourth document will be the in-class activity on real contexts used in teaching Data Handling. The analysis of these documents will provide insight and deep understanding of the nature of ML teacher’s PCK. The observation of 8 teachers teaching in classroom will be undertaken under naturalistic conditions and semi-structured interviews will be conducted with these teachers after each lesson. This study is in progress.

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The Local Curriculum in Pedagogical University: epistemological and methodological-didactic strategies of their implementation

**Capece, J.**

jocapece@yahoo.com.br

*Universidade Pedagogica, Faculdade de Ciencias Naturais e Matematica, Departamento de Fisica, Maputo-Mozambique*

The Pedagogical University has embarked on a multidisciplinary and multifaceted movement around the Local Curriculum. Are examples of this, recent events that the Pedagogical University organized, such as a workshop that culminated with the memorandum of understanding between our institution with the artist Renata, known by her work with traditional art, and the International Conference on the local knowledge. That is, we need to take a step forward, without neglecting the epistemological aspects relating to Local Curriculum,. That is, we need to find elements of Local Curriculum in local communities that underlie and redeem them for the official knowledge. To do so, we need to introduce a new paradigm shift in the approach of the Local Curriculum, this paradigm that prioritizes also and especially aspects of character of didactics and methodology that take the educator to
"prospecting ", looking for local knowledge communities, so that it is able to "seize" what is universal in local knowledge, converting it into school knowledge.

Our ultimate purpose is to systematize these practices and move forward to a level that allows us to present concrete platforms, under viewpoint of epistemology, didactics and pedagogy, in order to rescue the local knowledge and "making them" on the official knowledge.

To pursue these objectives, we create three focal points of our University, one in the North, the other in the Center and the third in the South of the country. In each of these regions it is intended to have a coordinating body, composed of at least two colleagues. We also aim to involve the Ministry of education and culture, with a particular focus on ZIP5.; teachers and researchers who have pursued this theme in Pedagogical University and other researchers who although not belonging to the above groups, have shown relevant knowledge in this area will also be involved.

It is expected that this "prospecting" and "systemization" which will give the local knowledge a possibility to be included in school curriculum knowledge must be rooted in epistemological bases that can ensure a didactics and methodology that provide an adequate and correct implementation of local knowledge. So, we will be privilege ethnomethodology, as a mean to data collection.

We will question:
Why and how aspects of particular character of a given collective culture are represented in schools as factual knowledge objective?
As a concrete situation of the teaching and learning process, the official ideological knowledge represents the settings of dominant interests in society?
Are the schools giving legitimacy to these limited standards and knowledge as partial finished truths?

In this survey, results are expected:
Produce a potential return to local communities that are the subject of this research, through lectures, seminars, cultural events whose subject sits in key aspects of research;
The results of this research are a collection that can be used for bibliographic query and not only;
Creation of an institutional vision more or less rough on the Local Curriculum and the scope of its applicability under the epistemological and methodological-didactic point;
Produce publications that systematize all around this project.

Key words: Local curriculum, local knowledge, epistemology, ethnomethodology.

Learning science and the selection of apt representations: an example from physics

Tobias Fredlund
Department of Physics and Astronomy, Uppsala University
tobias.fredlund@physics.uu.se

Introduction

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*ZIP, means, Pedagogical Influence Zone.*
Meaning making in science is dependent on an appropriate choice of different kinds of representations (cf. Kress, Jewitt, Ogborn, & Tsatsarelis, 2001; Lemke, 1998), such as “spoken and written language, mathematics, gesture, images (including pictures, graphs and diagrams)” (Airey & Linder, 2009, p. 27). Furthermore, as has been shown by research, interactively engaging students in class enhances learning (Hake, 1998; Mazur, 2009; Van Heuvelen & Etkina, 2006), although there are some indications that the quality of the interactive engagement is important for successful outcomes (Prather, Rudolph, Brissenden, & Schlingman, 2009). Further research regarding the role of the representations that are used and referenced in interactive engagement among peers is therefore important for an understanding of how the quality of interactive engagement can be enhanced. The theoretical framework we use to engage with this task is social semiotics (cf. Halliday, 1978; and Hodge & Kress, 1988). In particular, we are drawing on Lemke’s (1990) thematic patterns. Thematic patterns can be abstracted from spoken language, and show “patterns of semantic relationships” as they are realised in discourse. Drawing on Tang, Tan and Yeo (2011) we extend these thematic patterns to also take into account semantic content provided by representations other than spoken language.

**Research Question**

Our research question is thus: In what ways can different representations be seen to provide access to different aspects of disciplinary knowledge in interactive engagement?

**Method**

Using physics as an example, and in particular the phenomenon of refraction, we analyse a discussion among three third year undergraduate physics students where they attempt to explain why the refraction of light takes place. We use Lemke’s (1990) thematic patterns as an analytical tool to point to semantic relationships realised in the students’ discussion, and point at how these relationships are realised by different representations.

**Results**

Following Fredlund, Airey and Linder (2012) we use the term disciplinary affordance to denote the inherent potential of a representation “to provide access to disciplinary knowledge”. Thus, our results show some of the disciplinary affordances of the different representations that are used by the students in their discussion. For example, a wave front diagram referenced and used by the students appears to be particularly important for the outcome of the student discussion. We highlight the possibility that other semiotic resources may also be used to realise the same thematic pattern. An important outcome is that persistent representations (such as drawings, written text/mathematical notation) and non-persistent representations (for example, spoken language and gestures) play different roles in the discussion, and how representations from both of these categories are co-employed in the meaning making process.

**Discussion**

We conclude by positing that a core task in optimising the possibility of learning in physics is to identify and distil those aspects of the content that are critical for the situation at hand, and that is also important to become able to realise these critical aspects, and their appropriate relationships, through apt choices of representations. These are vital aspects of achieving an appropriate and coherent experience of the content area at hand. We suggest that an area for further research is to investigate whether student learning may be enhanced when teachers
explicitly encourage students, and make it possible for them, to make persistent
representations in class interactive engagement.

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Investigating Cell phones as Viable Alternatives to Traditional type Clickers in Large
University Classrooms

Ilse Rootman-le Grange ¹ & Marietjie Lutz ²

¹¹ Department of Chemistry and Polymer Science, University of Stellenbosch, South Africa.
¹ ilser@sun.ac.za, ² mlutz@sun.ac.za

Clickers, also known as student response systems, audience response systems or electronic
voting systems, are small hand-held devices that use either radio frequency or infra-red to
communicate with a central computer system (Barber & Njus, 2007). These devices are used
as a tool to assist formative assessment and collaborative teaching methods in the classroom
(MacArthur & Jones, 2008). A number of studies have been conducted on such instances
especially in science education classrooms at a tertiary level. The studies mostly focus on the
experience of students when using clickers, but also on the impact that the combination of
clickers with collaborative teaching methods have on students’ academic achievement and
understanding of specific concepts (Knight & Wood, 2005). The most interesting findings of
these studies are that the use of clickers leads to an increase in participation during lectures,
which is contributed to the fact that students can respond anonymously to the questions that are posed by the lecturer (Brewer, 2004; Julian, 1995; Skiba, 2006). Furthermore, the technology facilitates immediate feedback to the students on their responses, which presumably contributes to the students generally achieving better grades in the courses where this intervention was employed (King & Joshi, 2007).

We’ve identified the valuable contribution that clickers make to students’ learning processes in combination with collaborative teaching methods and have become interested in adopting the technology in our first-year chemistry lectures. However, this required each of the nearly 350 students in our classes to have access to clickers. Considering the financial implications of realising such an activity we decided to investigate the use of the students’ personal cell phones as an alternative to traditional clickers in these lectures. Therefore, the following research questions were asked:

Are cell phones a viable alternative to traditional clickers in large university classrooms?

What are students’ attitudes towards using cell phones as a teaching tool in lectures?
What are the advantages and disadvantages of using cell phones instead of traditional clickers, as a teaching tool in tertiary education?

This report forms part of a larger on-going study that focus on the integration of technology and teaching methods in introductory chemistry courses. The aim of the study is to improve first-year chemistry students’ understanding of difficult core concepts. The sample group consists of ±350 first year chemistry students from Stellenbosch University. The study is situated within a post-positivist paradigm and is framed by the social constructivist theory of Vygotsky (1978). The main assumption taken from this theory is that learning does not happen in isolation; instead, learners construct knowledge through interaction with their peers and their teachers.

The study uses an action based approach combining both quantitative and qualitative research methods. The quantitative data was gathered in three different ways. First, a survey was conducted at the start of the course to determine how many students own cell phones and whether or not these devices are internet enabled. Second, the students’ electronic responses to questions that were posed during the course were analysed in order to evaluate their usage patterns. Third, the students completed a questionnaire at the end of the course. This questionnaire aimed to investigate the students’ experience of using their personal cell phones as clickers during the course. In response to this questionnaire we also conducted semi-structured interviews with random sample groups in order to probe some of the trends that came out of the quantitative analysis of the questionnaire. These interviews took place at the beginning of the second semester of 2012.

The study reveals that some of the key advantages to using cell phones over traditional clickers are that these devices can be used outside of the classroom in order to prepare for upcoming lectures and that the students already have cell phones available. On the other hand some technical difficulties were experienced during the initial implementation of the technology. However, these issues are currently being addressed. Furthermore, analysis of the quantitative data shows a similar increase in student participation during lectures as was seen with the introduction of traditional clickers in classrooms. Students also indicate the intervention as a positive experience which contributes to an enhanced learning environment.

This experience and the implication it has on the students learning processes were explored during a more detailed analysis of the focus group interviews.

References

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**The Effect of Alternative Assessments in Natural Science on Attitudes towards science in Grade 8 girls**

Nicole Wallace ¹ & Annemarie Hattingh ²

¹ School of Education, University of Cape Town, South Africa; ² School of Education, University of Cape Town, South Africa.

¹ nickiewallace@gmail.com, ² annemarie.hattingh@uct.ac.za

This study is investigating the effect that alternative assessments in Natural Sciences can have on the attitudes towards science in Grade 8 girls in a privileged, single-sex school environment. A case study of the attitudes of girls in Grade 8 towards science at a private, all-girls school in Cape Town was conducted both before and after a specific alternative assessment was completed.

It is important to consider the attitudes of students towards science, technology, engineering and mathematics (STEM) courses. In order to develop, a nation needs to increase the number of jobs in these sectors through innovation, research and development. These jobs are traditionally higher paying, longer term jobs with more scope for economic opportunities (Kinyondo & Mabugu, 2009). President Jacob Zuma has called for innovation and job creation within the STEM sectors of the South African economy within the last two State of the Union addresses (GCIS, 2011; GCIS, 2012).

Female single-headed households are on the rise in South Africa (Ellis & Adams, 2009). Yet, women are still at a disadvantage when competing for jobs (Kinyondo & Mabugu, 2009; Lopez-Claros & Zahidi, 2005), even when equally qualified. Therefore they will accept lower-paying, lower skilled jobs just to try and make ends meet. They may even take more than one job or work in dangerous conditions. Lopez-Claros & Zahidi (2005) called education the “most fundamental pre-requisite for empowering women” (p. 5); therefore, it is important to examine the education of girls to determine when and where they are choosing to “exit the pipeline” (Aschbacher, Li & Roth, 2010). To this end, a case study of the
attitudes of girls in Grade 8 towards science at a private, all-girls school in Cape Town would be studied both before and after certain alternative assessments were completed.

Assessment reform is not a recent concept, but the kinds of alternative assessments which are evolving today are very different from the pen and paper kinds of assessment of the past. Alternative assessments have been characterized by Herman, Aschbacher & Winters (1992). These types of assessments have 5 basic characteristics in common. They are the following:

(1) asking students to perform, create, pro-duce, or do something; (2) tapping higher-level thinking and problem-solving skills; (3) using tasks that represent meaningful instructional activities; (4) involving real world applications; and (5) using human judgment to do the scoring.

(as quoted in Corcoran, Dershimer, & Tichenor, 2004, p. 213).

Alongside these five characteristics, there has also been a focus on 21st century skills within the teaching and learning environment (P21, 2011). Since the world of work is evolving, it is important to help students learn not only subject matter, but skills that will help them stay relevant in a quickly changing workplace.

Data was collected in four parts throughout the school year. At the beginning of the school year, the Grade 8 girls were asked to write an open-ended reflection before any teaching took place. There were two questions asked in this reflection – the hardest part of Natural Science and their favourite part of Natural Science. The girls were asked to respond openly and honestly to the questions based on their experiences in Natural Science in previous grades. This information was collated and classified into skills and topics for analysis purposes. Data was then summarized into graphs reporting on the percentage of students who mentioned topics or skills and which topics or skills.

Drawing on these skills and the characteristics listed above, an alternative assessment on sustainable energy and its use in the community was drawn up. It was peer-reviewed by other teachers of the same grades and subject. The assessment consisted of four parts – designing a survey, collecting data, collating and reporting on the data, and creating an educational movie with regards to the topic. The first three sections were completed in groups chosen by the teachers and the last part was done either independently or in pairs chosen by the students. These tasks were all marked by the teachers using the rubrics created with the task which were peer-reviewed. The second phase of data collection occurred during the actual assessment week. The girls were asked to write open-ended reflections of their experiences. There were no guiding questions for this reflection, but students were again asked to be open and honest about their experiences during the activities of the week. A simple coding strategy was determined for all of these and responses were categorized and analysed.

The third phase of data collection was during the June examination period. The girls responded to 5 of 11 questions from the Relevance of Science Education (ROSE) questionnaire. This questionnaire was developed by Schreiner & Sjoberg (2004) and originally used in conjunction with a number of other countries to assess the attitudes of 15 year olds towards science. After communicating with Sjoberg (personal communication, April 10, 2012), it was determined that the questions within ROSE could stand alone and therefore the girls could answer the 5 chosen topics – my future job, me and the environment, my science classes, science and technology, and if I were a scientist. Four of the five
questions consisted of statements that students ranked for importance on two different Likert scales – “Not Important to Very Important” or “Agree to Disagree”. The final question was an open-ended response to the statement “If I were a scientist, I would study…because…” This was done electronically in a school computer laboratory at their own pace.

The final phase of data collection will take place during the November examination period. The girls will respond to the final, open-ended question from the ROSE questionnaire again. The second half of the year focussed on different kinds of assessments from the first half of the year, and over very different topics. These results will be compared to the June answers as well as the initial questions as in January.

With regards to the reflections done at the beginning of the year, there is an even split between topics and skills for both the hardest and favourite parts of Natural Science. The favourite skill was by far experimentation, whereas there was a mix of hard skills – memorizing, organizing, and writing. Interestingly, Chemistry and Astronomy were both the hardest and favourite topics. When the open-ended question was analysed, Astronomy was still one of the most common things to study, even though the topic had not been introduced in this academic year. There was an increase in the desire to study biological sciences (which included nature, animals and plants). There were still quite a number of responses classified as “physics” but when reviewed, these tended to be concentrated in the energy sector and mainly about finding or discovering new forms of sustainable electrical energy, which may have been influenced by the alternative assessment topic. This question will be asked again at the end of the academic year to determine if the girls still feel the same about the subject matter they would study.

From the reflections during the assessment, one can see that the girls found the form of the assessment useful, helpful and fun. They felt that they learned new concepts, reviewed old concepts, and engaged with the activity in a positive manner. This led to generally higher results on the marked work from the assessment. Out of 44 results surveyed, 30 students (68%) scored higher marks on this assessment than their Term 2 Final Mark.

With regards to the attitudes of the students towards science, there was a consensus that science and technology is important for humans and society, but there was a scepticism that it is without its problems and drawbacks. Girls agreed that people should be more concerned with the environment and were positive that they had a chance to be an influence in the solutions instead of leaving this up to the experts or rich countries. Although they found their science classes very interesting (90%), less than 20% saw themselves having a career in science or technology. Most importantly, the girls felt that a job in which they could do meaningful work which fell in line with their personal attitudes and values and in which they could continue to develop and learn was the most important characteristic about their future job. Interestingly, they also want to be able to make their own decisions and make time for their family too.

Analysis of this study is currently on going with the hope that insight into attitudes towards science within a high-functioning school will be able to help inform some best practices for increasing the number of girls who are entering the STEM pipeline in South Africa.

**References**

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Workshops
Researching performance based assessment: exploring ways of developing dynamic portfolio based assessments as a way of understanding learning in a range of curriculum contexts

Kay Stables

Technology Education Research Unit, Department of Design, Goldsmiths, University of London

This workshop will explore ways in which dynamic portfolio-based assessment can be adapted and customized to reveal evidence of learning in any process-based curriculum context. The workshop will allow those attending to explore this idea in the curriculum and research settings in which they operate. It will provide opportunities for in-depth discussion of the model of the ‘unpickled portfolio’ (Stables and Kimbell, 2000; Kimbell and Stables, 2007, how this can be used create an authentic assessment setting where the tasks given to the learners allow productive engagement whilst generating valid, tangible evidence of capability.

The workshop will facilitate ‘hands-on’ development of assessment tasks that integrate a range of assessment sub-tasks into a short activity. Opportunities will be provided to explore the challenges of creating ‘constructive alignment’ (Biggs, 2003) between learning objectives and assessment objectives. The workshop will also facilitate exploration of approaches to making assessment decisions and consider the affordances and constraints of holistic and atomized judgements. If time allows, there will also be a discussion of the increased potential from both an assessment and research viewpoint of utilizing a range of digital tools and ways of providing surrogates for these when budgets prevent the use of such resources.

References

Relevance and contexts in school mathematics

Mercy Kazima

University of Malawi

mkazima@cc.ac.za

The aim of this workshop is to suggest ways of adding relevance to the teaching of mathematics in schools through careful selection of contexts for word problems. In the workshop, we will look at examples of mathematics word problems taken from school mathematics text books and discuss their suitability to different groups of learners. Participants will work in groups to (i) analyse problems with the tasks for each of the different groups of learners, (ii) modify the tasks to suit each group of learners while maintaining the mathematical objectives of the tasks, and finally (iii) suggest the extra-mathematics that could be learnt from the tasks. We will use Palm (2007) ideas of authenticity of mathematical tasks.
Reference

Rasch theory workshop

Caroline Long¹ & Marietjie Potgieter²

¹Centre for Evaluation and Assessment (CEA), University of Pretoria, ²Department of Chemistry, University of Pretoria

¹caroline.long@up.ac.za ²marietjie.potgieter@up.ac.za

“The assessment revolution that has passed England by: Rasch measurement” is the title of an article that refers to the fact that for thirty years not a single journal article on Rasch measurement theory was published in the British Journal of Educational Research (Panayides et al., 2009). In South Africa and neighbouring countries pockets of expertise in Rasch theory have emerged over the past ten years. Rasch theory challenges the notion that the statistical model is chosen to fit the data. This theory has presented something of a paradigm shift where the data are required to conform to the model. The Rasch model is a probabilistic model which estimates item difficulty and person proficiency, for a particular frame of reference, building on the notion of a latent construct that can in some manner be ascertained. Rasch theory is premised on the idea that for any item, persons of higher ability should be more likely to answer correctly than persons of lower ability. Likewise, for any person, easier items should be easier to answer correctly than more difficult items. Where serious anomalies occur, that is where either items or persons function unexpectedly, these items and persons need to be investigated.

While in research, the preparatory theoretical work for instrument development, surveys, questionnaires and tests, is critical, application of the Rasch model will highlight where the theoretical work may be underdeveloped, and where errors have occurred. In the interest of fairness and social justice, interrogation of the instruments used and the data that is generated is necessary. This quality assurance mechanism is particularly important in research but also in the frequent systemic tests that are used to identify schools where interventions may be required.

In this workshop we present some essential Rasch theory that provides the context for the analysis process. The theory is then followed by some activities which illustrate some of the critical concepts. You will be given the opportunity to do preliminary analysis of one of two data sets, one of which is attitude data from a questionnaire given to first year chemistry students, the other is performance data generated by a geometry test given to teacher education students. The software RUMM 2030 will be provided for the workshop.

Both presenters have worked with Rasch theory and applications of the model for a number of years, and have recently completed both the introductory and advanced course in Rasch Measurement of Modern Test Theory through the University of Western Australia.

The workshop will be limited to 15 participants.

**Insights from working with assessment instruments in primary mathematics Grades 1-4**

**Hamsa Venkat** ¹ & **Mellony Graven** ²

¹Wits School of Education, University of the Witwatersrand, South Africa; ²Rhodes University, South Africa.

¹hamsa.venkatakrishnan@wits.ac.za, ²m.graven@ru.ac.za

In this workshop, the focus is on gaining insights from presentations from 4-5 research groups across South Africa that have developed, adapted and used assessment instruments for use across Grades 1-4. We focus on the early grades specifically because evidence points to difficulties of gaining reliable information from traditional written assignments (Department for Basic Education, 2011) in these settings. Across our respective SA Numeracy Chair projects, we have both drawn on the diagnostic oral interview Learning Framework in Number assessments developed by Wright et al (2006), supplemented by the use of some orally administered written answer tests using the same format as the Annual National Assessments. Other research/development projects in the South African context have used a range of other assessment instruments and formats. The research workshop aims to provide a forum that allows for the sharing of insights and findings drawn from the administration and results from a range of assessments. The research workshop is set in the context of the increasing prominence of the Annual National Assessments as policy tools with multiple goals: documenting learner performance, highlighting stronger and weaker performance at school and district levels, providing information for formative feedback into teaching, assessing the impact of curriculum reform (DBE, 2011). The validity of such assessments needs to be interrogated against the possibility of alternative forms and means of assessment for young learners. In particular we will bring to this workshop our experiences of drawing on orally administered instruments available from Wright; Martland & Stafford (2006); Askew, Brown, Rhodes, Stafford and Williams (1997), instruments adapted from USAID made available by Brombacher and Associates, and those being used by Henning’s team, drawn from ------.

**Our aim** in the session is to focus on some central issues driven both by our own findings, and research in the broader context pointing to problems with progression to more abstract number concepts (Ensor, et al., 2009; Schollar, 2008). The key issues we focus on are:

- Children’s responses to oral interview based instruments (mathematical and extra-mathematical considerations) (Graven’s research team; Venkat’s research team)
- Children’s performance on number – insights from responses from a range of assessment instruments (Venkat/Graven/Brombacher/Henning/Chetty)
- Language issues within early grade mathematics assessment (Henning’s research team)
- Comparing the scope and level of different assessment instruments (all teams, in discussion)

**Key outcomes** of the session are to support the development of improved understandings of the range of instruments and formats available for assessing primary mathematics, with awareness of the scope of items and the issues arising within administration. Going forward, an important further outcome is to build research-based development of assessments for
primary mathematics that can contribute to the broader project of improving mathematics teaching and learning across the early grades.

Outline of the research workshop, including time allocations

<table>
<thead>
<tr>
<th>Time Allocation</th>
<th>Presentations</th>
<th>Discussion</th>
<th>Questions and Answers</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 x 10 minute presentations</td>
<td>Venkat’s team&lt;br&gt;Graven’s team&lt;br&gt;Henning’s team&lt;br&gt;Brombacher’s team&lt;br&gt;Chetty – National Department – ANA focused input</td>
<td>Discussion focused on the key issues raised above across the teams (25 minutes)</td>
<td>Time for questions and answers (15 minutes)</td>
</tr>
</tbody>
</table>

We anticipate that a group of 9-10 participants will be involved in the presentations within this session. Given the growing interest in primary mathematics at the level of policy, research and development, we expect to attract a group of about 25 academics and postgraduate students as observers who may wish to contribute the Question/Answer section that we have incorporated.

The SA Numeracy Chair projects are generously funded by the FirstRand Foundation, Anglo American, Rand Merchant Bank, the Department of Science and Technology and is administered by the NRF - National Research Foundation.

References


The Copper Project
Indigenous Mining and Metallurgy of Copper in Africa and a Science School Project about Copper

Shadreck Chirikure 1 & Dieter Arnold 2

1 Department of Archaeology at the University of Cape Town; 2 High School Teacher and Senior Science Advisor, Germany

1 Shadreck.Chirikure@uct.ac.za, 2 LCD.Arnold@t-online.de

The intention of this workshop is to show an experimental way to extract and process copper in science lessons at school level. I am doing this in co-operation with Shadreck Chirikure who in his lecture will be presenting the history of indigenous mining and metallurgy in Africa using the example of copper. School curriculums around the world include the extraction, processing, properties and uses of metals. Particularly in Grade 9 CAPS emphasises the teaching of the topic metals. Due to the lack of equipment in school laboratories dealing with this important issue is often not possible. However, the historical process of copper extraction from malachite can easily be demonstrated in the school laboratory as a simple experimental way to extract copper from copper ore. In this way pupils can learn from history and about the properties of copper, it’s processing and electroplating with silver.

In addition to the historical and the technical aspects of copper, my experience from teaching in schools for many years made me realise that pupils’ interest in the topic is awakened if they are allowed to make their own rings according to Tolkien’s novel “Lord of the Rings”.

Introduction
The following experimental approach shows how malachite can be analysed as copper carbonate and afterwards reduced to copper in a simple reaction with charcoal in a test tube. Once a copper ring has been treated mechanically it can be electroplated by means of a silver salt solution to symbolise the power of Tolkien’s “The Ring of the Rings”.

Experiments and [Results]

<table>
<thead>
<tr>
<th>Experiment 1: Analysis of Malachite</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 Flame colouring: Crush some malachite and hold a sample with a wet wooden spoon into the flame of a gas burner.</td>
</tr>
<tr>
<td>[Result: You will see immediately a bluish-green colour which is a proof of copper]</td>
</tr>
<tr>
<td>1.2 Test for carbonate: Add some drops of hydrochloric acid (10%) to some malachite.</td>
</tr>
<tr>
<td>[Result: A gas is evolved which can be collected and proofed with lime water as carbon dioxide]</td>
</tr>
<tr>
<td>CuCO₃ + 2 HCl → CuCl₂ + 2 H₂O + CO₂</td>
</tr>
<tr>
<td>CO₂ + Ca(OH)₂ → CaCO₃</td>
</tr>
<tr>
<td>1.3 Hypothesis: Malachite consists of copper carbonate</td>
</tr>
</tbody>
</table>

From the historical way of copper smelting the pupils should be able to develop an experimental procedure to convert copper carbonate into copper:

It will help to tell them the story of people who are using green stones at the same fire place for some time. Firstly the green stones changed after a while to black stones and a bluish-green colour could be seen. The black stones could easily be crushed into black powder
which, mixed with charcoal, turned into small red grains after some days in the fire.

**Experiment 2: Conversion of copper carbonate into copper**

1.1 Crushed copper carbonate (malachite) is heated in a test tube with a gas burner till the colour turns from greenish to black. The gas evolved can be tested with lime water.

\[
\text{CuCO}_3 \rightarrow \text{CuO} + \text{CO}_2 \\
\text{CO}_2 + \text{Ca(OH)}_2 \rightarrow \text{CaCO}_3
\]

[Result: Copper carbonate is converted into copper oxide and carbon dioxide]

1.2 Mix some copper oxide with crushed charcoal (ratio 1:4) and heat it up in a heat resistant test tube for about two minutes. Take a sample of the gas evolved and test it with lime water. Pour the content of the test tube on an oven-proof pad.

\[
\text{CuO} + \text{CO} \rightarrow \text{Cu} + \text{CO}_2
\]

[Result: Carbon reacts with oxygen to form carbon monoxide. The carbon monoxide reduces the copper oxide to copper and carbon dioxide is formed. You will find small copper grains and the gas evolved proofs to be carbon dioxide]

**Experiment 3: Properties and application of copper**

With some samples of copper the pupils should be able to find out the important properties of copper and combine these properties in a table with examples for the use of copper for domestic and technical applications:

<table>
<thead>
<tr>
<th>Property of copper</th>
<th>Application for</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric conductivity</td>
<td></td>
</tr>
<tr>
<td>Thermal conductivity</td>
<td></td>
</tr>
<tr>
<td>Corrosion resistance</td>
<td></td>
</tr>
<tr>
<td>Ductility</td>
<td></td>
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<tr>
<td>Antibacterial</td>
<td></td>
</tr>
</tbody>
</table>

**Experiment 4: Deburring, polishing, engraving a copper ring**

Rings can be cut from copper tube which should be available in a hardware store. By means of sand paper, iron wool and an engraver the technical ring can be converted into a personal ring.

**Experiment 5: Electroplating a copper ring with silver**

After cleaning the ring with ethylated spirits it can be electroplated by means of a 9 Volt battery and a silver salt solution:

One has to connect the ring to the negative pole and a piece of silver to the positive pole in a silver salt solution for about one minute.

The silver salt solution can be made of silver nitrate, diluted ammonia solution and citric acid solution:

Add one tip of a spatula of silver nitrate to 10 ml of distilled water. After the salt is dissolved add ammonia solution drop by drop to the silver solution until a brown solution results. Continue adding ammonia till the brown solution turns clear again. Now you add a spatula of citric acid to the clear solution. The solution is now ready for electroplating.

Once the electroplating has been concluded, the ring must be rinsed in distilled water and dried and polished with paper towels.
[Result: Copper will be electroplated immediately with silver at the negative pole and the positive pole will release silver ions from the silver electrode into the solution.]

(Minus pole: \( 2 \text{Ag}^+ + 2e \rightarrow 2 \text{Ag} \)) \hspace{1cm} (Positive pole: \( 2 \text{Ag} \rightarrow 2 \text{Ag}^+ + 2e \))

You will get best results using a professional silver salt solution that you can buy from a jeweller.

Workshop: Reviewing manuscripts submitted to journals of research in mathematics, science and technology education (MSTE)

Fred Lubben¹

¹University of York

¹fred.lubben@york.ac.uk

Note: A sample manuscript will be distributed to workshop participants the previous day with the expectation that participants have skimmed through this manuscript before the workshop.

Key outcomes of the workshop

This workshop intends to:

(i) Strengthen participants’ understanding of the review criteria of MSTE journals, including the African Journal of Research in Mathematics, Science and Technology Education (AJRMSTE);

(ii) Develop participants’ skills in applying these review criteria to a sample manuscript;

(iii) Increase participants’ ability to strengthen their own articles in the light of the review criteria.

Outline of the workshop

The workshop consists of three phases, and most of its structure follows the principles of learning in a community of practice (Lave & Wenger, 1991). The workshop will be supported by at least four editorial team members.

During phase 1 (about 15 minutes) participants will work in pairs comparing review guidelines of various academic MSTE journals, and establish common features and differences. Criteria for a ‘good’ paper which are (a) journal specific and/or (b) common across several journals will be consolidated.

During phase 2, participants are familiarised with key issues in the Guidelines for Reviewers for AJRMSTE (10 minutes). In small groups of mixed experience with manuscript reviewing, participants will then use these Guidelines for Reviewers for commenting on specific aspects of an actual journal submission (20 minutes). Some pairs will judge the global features such as consistency and novelty, whereas other pairs will comment on componential features such as introduction/justification; theoretical framework and literature review; methodology, findings, discussion and conclusion. The assumption is that participants will have skimmed this manuscript before the workshop. Pair reviews will be shared (20 minutes), and the diversity of the review tasks will allow the discussion to examine the parts and the whole simultaneously. The pair reviews will be reflected against
an independent expert review. In addition, the group reviews will be consolidated and distributed electronically to all participants after the workshop, together with the Guidelines for Reviewers, the submission and the expert review.

During phase 3 of the workshop (20 minutes) provides practice of the review skills on a familiar manuscript: participants will work in pairs on their own personal manuscripts. Each participant identifies aspects of their own paper they like their partner to review using the AJRMSTE Guidelines for Reviewers. Specific review feedback is provided on paper, which will be discussed between partners.

A consolidation phase (5 minutes) will allow participants to raise any issues that have not been resolved.

References
SYMPOSIUM
Describing school mathematics discourses

Presenters: Jill Adler¹, Vasen Pillay¹, Craig Pournara¹, Regina Essack¹

Discussant: Professor Jeremy Hodgen²

¹Wits Maths Connect-Secondary Project, School of Education, University of the Witwatersrand, South Africa; ²Department of Education and Professional Studies, King’s College London

In this symposium we discuss research in the Wits Maths Connect-Secondary (WMCS) project that engages the key problem of widespread misrecognition of algebraic and functional forms by secondary school mathematics learners in eleven project schools in Gauteng, and the practices implicated in this production. WMCS regards knowledge of algebra and functions as ‘powerful knowledge’ (Young, 2008). Access to algebraic and functional knowledge for secondary learners is a matter of equity, and critical for the strengthening of the pipeline in the secondary school, and between school and tertiary study.

Research in the project includes studies that are varyingly focused on characterising learner responses to diagnostic assessments (both in test and interview settings), and to more open algebraic and/or functions tasks. A range of theoretical and methodological resources have been recruited for this work, and will be elaborated in each of the three presentations below. Together the three studies we discuss here illuminate aspects of school mathematics discourse and open up discussion about epistemic access (Morrow, 2007) in our schools, as well as the state’s response to enduring ‘poor performance’ in school mathematics in South Africa. The symposium will be introduced by the Chair (Jill Adler), locating each of the presentations in the wider project, its problems, methods and progress. To facilitate and stimulate discussion in the symposium, Professor Jeremy Hodgen from King’s College London has been invited to engage critically with the research presented.

Presentation 1. Analysing error and describing ‘levels’ of algebraic reasoning

Jill Adler & Vasen Pillay

The ICCAMs - Improving Confidence and Competence in Algebra and Multiplicative Reasoning study (Hodgen, Küchemann, Brown, & Coe, 2008) - Algebra test is a diagnostic test focused on working with letters as ‘unknowns’ and ‘variables’, within a symbolic system. The test has items categorised empirically into four levels of increasing difficulty, thus enabling a view of progression within and across learners; as well as an analysis of error as this has emerged in testing in the UK. We are using this test in WMCS as we track participation and performance over grades and across schools. In this presentation we will describe the various levels of items, how learners in the WMCS schools have responded to these, and the measures we have constructed for reporting. We will then discuss how we piloted and then administered the test and coded the results. We will also discuss the error analysis we have done to work with the profound misrecognition displayed by a proliferation and dispersion of error in our data. We interpret learners’ productions in the tests both as a window into the school mathematics discourses in which they participate (Sfard, 2008), notwithstanding how the test itself is implicated in learner responses. This orientation, together with reflection on similar analyses in the UK throws light on what appear to be arbitrary and idiosyncratic symbolic actions of many learners, and their exclusion from ‘powerful knowledge’.

Presentation 2: Exploring levels of algebraic thinking through learner interviews
Craig Pournara and Shadrack Moalosi

In 2011 and 2012, WMCS conducted eleven small scale studies exploring learner thinking and error with respect to selected ICCAMs items. Error in these studies is regarded as part of the process of developing algebraic thinking. All studies involved analysis of learners’ written responses to test items, and individual task-based interviews. In this presentation we focus on learners’ interview responses which illuminate the interesting ways in which learners justify their thinking with respect to algebraic problems and symbolic forms. We relate these to the international literature on algebra and error in mathematics education, and discuss what and how these add important depth and critique to the more quantitative results on these items, and reported in presentation 1.

Presentation 3: Learner discourses in the context of tasks on functions

Regina Essack

An analysis of Grade 12 NSC Mathematics scripts in three of the schools in the WMCS project revealed extensive error and absence in questions related to both algebra and functions. A study is underway that aims to reread and so understand differently this production through engaging Grade 11 learners on tasks related to functions. Located in the discursive turn in mathematics education, this presentation will draw on theoretical and analytic tools offered by Sfard (2008) to characterise learner mathematical discourse. In this presentation, key aspects of functions, and learner discourses related to these will be illustrated, together with the methodology used to describe these.

Discussant: Professor Jeremy Hodgen

References

Acknowledgement
This work is based upon the research of the Wits Mathematics Connect Project at the University of the Witwatersrand, supported by the FirstRand Foundation Mathematics Education Chairs Initiative of the FirstRand Foundation the Department of Science and Technology and the National Research Foundation (NRF). Any opinion, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the FRF, DST or NRF.

The organisation of the symposium
Introduction by the Chair (Adler) – 5 minutes; 3 talks of 15 minutes each
Discussant: 10 Minutes; 30 mins discussion
Comparison of teaching orientations of an experienced and novice lecturer in first year molecular and cell biology
Kriel, Maritjie Potgieter

First year Molecular and Cell Biology (MLB111) students at the University of Pretoria tend to struggle to understand and explain photosynthesis. The question arises whether the process itself is conceptually challenging or whether understanding is hampered by the way the lecturer explains the concept. We have decided to investigate the situation from three different angles: student prior knowledge, misconceptions that first year students may have and difference in teaching styles of lecturers explaining the concept. Grade 12 Life Sciences is not a prerequisite for Molecular and Cell Biology as a first year subject. Photosynthesis is included in Grade 10 Life Sciences which means that some of the students have substantial background knowledge while others were merely introduced to photosynthesis in primary school, and only encountered the equation of photosynthesis in words in Grade 8. The different teaching approaches of an experienced and a novice lecturer may also affect learning differently.

Literature Review

According to Yip (1998) teaching experience plays a major role in explaining difficult concepts on a level that learners will understand, since inexperienced teachers tend to use terminology incorrectly. Teachers teaching for two years do not show more experience in teaching difficult concepts compared to teachers with no teaching experience (Friedrichsen, Abell, Pareja, Brown, Lankford, & Volkmann, 2008). Through the literature it becomes evident that there is more than one reason that the first year students have misconceptions that causes them to struggle. One misconception that originates from primary school is where students interpret photosynthesis with the sun as a source of food and they totally miss the concept of energy transfer (Ahopelto, Mikkilä-Erdmann, Anto, & Penttinen, 2011). In South Africa the misconception is not corrected in grade 8 when learners only learn the word equation of photosynthesis. None of the reactions or concepts is explained to the learners, they are only expected to memorise the equation in order to reproduce it in the exam. For some of the first year students this is the extent of their pre-knowledge when they start the first year course. Learners who chose Life Sciences as a subject did photosynthesis again in Grade 10. This time it was done in a bit more detail but they are still not expected to understand the process. Some of the concepts are touched on but the students still have to only memorise the process and write it down in the exam.

Research Questions

The following research questions were asked:

- What is the relationship between the teaching orientation of lecturers with different levels of experience and the academic performance and understanding of first year students with specific reference to the concepts in photosynthesis?

- How does pre-knowledge of first year students influence their understanding of the concepts in photosynthesis?

The analysis of teaching orientations of lecturers will be informed by theory on pedagogical content knowledge (PCK) because classroom instructional design is expected to reveal the different domains of teacher knowledge and it manifestation as described in this theoretical framework (Rollnick, Bennett, Rhemtula, Dharsey, & Nlovu, 2008). The study is situated
within the constructivist paradigm in recognition of the fact that students have to integrate new knowledge into existing schema in order to construct their own meaning (Fosnot, Tworney, & Ed, 1996), a process which is complicated by the presence of scientifically unacceptable alternative conceptions, also called misconceptions.

A stratified sampling method will be used as follows: The first step will be to divide the students in two groups with Life Sciences as school subject as the criterion. A weighted average of the student’s Mathematics and Physical Sciences marks will be calculated with Mathematics mark contributing 60%. Students will then be randomly chosen from every symbol band in both groups. We will compare their results on this specific topic throughout the semester, analysed according to question type.

An experienced and a novice lecturer volunteered to be part of the study. A comparison will be drawn between the way they introduce and explain photosynthesis to the first year students. It is suggested in the literature that experienced lecturers tend to take it for granted that students have very good pre-knowledge of certain concepts. We would like to test this suggestion. Video footage will be collected (3 lecture groups, 5 lectures each). In-dept interviews will be conducted with lecturers before the class to determine the way they planned the lesson and their planned outcomes and after each lecture to analyse the lesson to see if they met their own criteria. If necessary we will also conduct interviews with some of the students.

The answer the question of which teaching style and orientation will best assist students in understanding the process of photosynthesis and the concepts associated with it, the students will write a pre a post test to see if there were any improvement in their understanding of photosynthesis. The questions will be set in such a way to test insight in the process and concepts. Comparison of pre-post performance data will give an indication of which teaching style was most effective in making the concepts of photosynthesis accessible to students. Analysis of video data will enable a rich description of the different teaching orientations and may result in the identification of both the support for concept formation and impediments resulting from each approach.

Bibliography


SHORT PAPER ABSTRACT - SCIENCE
Researching performance based assessment: authenticity in assessment activities and processes to support the development of learner capabilities

Kay Stables
Technology Education Research Unit, Department of Design, Goldsmiths, University of London

Keynote Abstract
Over the last 25 years, researchers in the Technology Education Research Unit at Goldsmiths have been investigating ways of assessing learner capability, initially Design and Technological capability and latterly across a broader curriculum base. The focus of the research has been to find ways of understanding learners’ abilities in procedural settings and so has focused on creating authentic assessment activities that generate authentic evidence of capability. A considerable amount of this research has been in the context of high stakes summative assessment, developing valid, reliable and manageable assessment activities that can be used in the context of national assessments. An underlying model has been established - the ‘unpickled portfolio’ (Stables & Kimbell, 2000; Kimbell & Stables 2007) that structures short assessment tasks (between one and six hours) that generate portfolio-based responses in addressing problem/challenge based scenarios. Initially paper based and more recently digitally captured, these assessment tasks have been used with primary and secondary aged learners, across a range of curriculum areas and in contrasting national settings (including, in 1999, in South Africa; Stables et al., 1999, Stables & Kimbell, 2001).

This presentation will take a journey through a series of the research projects, from the first in the late 1980s where the initial approach was developed, creating dynamic, iterative assessment portfolios on paper, to the current projects that use mobile technologies to capture evidence of capability directly from learners as they convey their ideas and thinking through audio, video, text and image based tools. The journey will provide insights into the fundamental concepts behind the structure of the assessment tasks and portfolios – holistic performance, procedural capability, the iteration of active and reflective sub-tasks, authenticity in tasks and evidence. A framework illustrating how learning intentions can be mirrored with assessment intentions will show how constructive alignment (Biggs, 2003) can be achieved. Case studies from research projects will illustrate how the model has developed to be effective in formative, diagnostic, summative and evaluative settings. The case studies will also show how the model supports Problem Based Learning, enables collaboration and team work within an assessment setting, facilitates peer and self assessment by learners and enables a range of learning styles to be taken into account in collecting assessment evidence. It will also reveal how teachers and learners became involved in a radical approach to making assessment decisions – Adaptive Comparative Judgements (Pollitt, 2012; Seery et al, 2012).

Finally, the presentation will attempt, through an exploration using validity, reliability and manageability as lenses, to comment on possible challenges and potential of drawing on the model in a Southern African context, particularly with regard to the theme of the conference and its focus on cultural and social relevance.

References
Complicated conversations: Science and culture in Australian, New Zealand and South African national science curricula

Brendan Briggs

Faculty of Education, University of Canberra, Australia.

brendan.briggs@canberra.edu.au

As a practiced and theorised discipline, science is influenced by culture. The exact nature of the relationship, however, is extremely complex and rigorously contested across multiple disciplines. For curriculum writers, representing this relationship to students, teachers and communities is a difficult and highly political exercise.

This paper examines the ways in which Commonwealth members Australia, New Zealand and South Africa have represented the relationship between science and culture, contemporarily and historically, in their written national curricula for compulsory science education. As visionary texts, written curriculum documents make important symbolic statements about the relationship between science and society. These national statements are practised, promoted and accessed by government ministers, policy makers, educators and community members.

In line with previous comparative studies which establish similarities between Australian, New Zealand and South African education systems (e.g. Commonwealth membership, large outcomes-based education systems, national curriculum documents), this study asserts that despite existing similarities, each country’s unique socio-political context influences curriculum development and educational policy in different ways.

Consequently, the key research questions for this paper are:

a) How do Australia, New Zealand and South Africa currently represent the relationship between science and culture in their written national curricula for compulsory science education? Why?

b) How have Australia, New Zealand and South Africa historically represented the relationship between science and culture in their written national curricula for compulsory science education? Why?
To answer these questions, this research utilises a qualitative approach to curriculum analysis and draws on the theoretical frameworks of Alan Chalmers’ (1999) ‘scientific realism’, Roger Bybee’s (1997) ‘scientific literacy’ and William Pinar’s (2004) ‘curriculum as complicated conversation’. With themes developed from critical literature review, this paper uses content analysis to examine the ‘nature of science’ (NoS) and approach to ‘scientific literacy’ (i.e. the relationship between students, science and culture) prevalent in each country’s present and immediate past national curriculum documents for compulsory science education. Results for each country are recorded on a matrix and compared and contrasted historically for each nation and with the other two countries. Specific attention is given to analysing each document’s rationale statement and ‘science as a human endeavour’ / ‘philosophy of science’ strand(s). Critical discourse analysis (CDA) is then used to link findings from the content analysis of curriculum to the broader political contexts that have influenced the prioritisation and shape of teaching and learning about the relationship between science and culture in each country.

The main findings of this study suggest that while each country’s curriculum regards ‘science’ as a discipline and practice effected and affected by ‘culture’ and culture as an essential human quality brought to scientific method / endeavour, precise definitions of and references to culture vary by country. Analysis of curriculum documents suggests that New Zealand’s and South Africa’s national curricula for science currently place a higher symbolic priority on teaching and learning about the influence of culture on science than Australia. Furthermore, while all three countries currently recognise positive interactions between science and culture, South Africa is the only country to explicitly acknowledge negative interactions between the two in its curriculum. This paper asserts that it is South Africa’s unique political context, in which public-sphere culture-knowledge debates are frequent, that enables South African [government] curriculum writers to currently approach the relationship between science and culture more comprehensively than curriculum writers in New Zealand, and, particularly, in Australia.

Implications of this study suggest that attempts by curriculum writers to represent the relationship between science and culture (i.e. as potentially both positive and negative) is enabled and constrained by national and international political contexts. Additionally, that, particularly for Australia, frequent, explicit and meaningful knowledge-culture debates in the public sphere is a pre-requisite to comprehensive representations of the relationship between science and culture.

This study concludes that, despite the importance of recognising science curriculum as ‘praxis’ (i.e. both vision and practice), it is still a critically important and worthwhile exercise to examine representations of science and culture in ‘written’ / symbolic curriculum, situated within socio-political contexts. Moreover, while global understandings of the complex interplay between science and culture become more liberal, conservative micro-cycles in national and local politics can inhibit the articulation of these understandings during the curriculum writing process. In some cases, this inhibition forces national science curriculum writers to represent the relationship between science and culture less accurately and ambitiously than their historical predecessors and/or international counterparts.

Consequently, this paper recommends that science educators, policy writers, academics and citizens focus on maintaining a considered balance between critique and nurture of ideas in representing the relationship between science and culture. Furthermore, this paper asserts that by tracing their country’s historical representations of science and culture and by examining representations of science and culture by international counterparts, science
educators can better position, understand, defend and/or reform articulations of science and culture in their current curriculum documents.

Evaluation of an instrument to assess grade 12 teachers’ topic specific PCK in organic chemistry

Bette Davidowitz$^1$ & Nonkanyiso Vokwana$^2$

$^1$Chemistry Department, University of Cape Town, South Africa; $^2$Chemistry Department, University of Cape Town, South Africa.

1 Bette.Davidowitz@uct.ac.za, 2 Nonkanyiso.Vokwana@uct.ac.za

Introduction
Organic chemistry has long been regarded as a difficult topic in the chemistry curriculum at both secondary and tertiary levels. This study, which focuses on organic chemistry, is part of a larger research project on Pedagogical Content Knowledge, PCK, to investigate how teachers’ knowledge of their subject matter affects the way they teach across several different contexts.

Aim of the study
This study aims to evaluate the transformation of subject matter knowledge, SMK, for teaching organic chemistry at Grade 12 level. The research questions to be answered are:
- Is it possible to design a tool that is suitable for evaluating Topic Specific PCK of organic chemistry teachers at Grade 12 level?
- What role do teaching experience and SMK play in developing a practising teacher into an expert?

Theoretical framework
Shulman (1986), described pedagogical content knowledge as knowledge used for the transformation of subject matter knowledge into various forms that students can understand. He emphasised the importance of subject matter per se to a point where it becomes subject matter knowledge for effective teaching. Cochran et al.’s (1993) model of PCK defined teacher preparation as teachers’ integrated understanding of four components namely students’ knowledge, contexts, subject matter knowledge and pedagogical knowledge. Geddis and Wood (1997) “see a variety of different kinds of knowledge as relevant from which subject matter transformations emerge.” (p 612). Using these models of PCK, Mavhunga (2012) developed the construct, “Topic Specific PCK” which is also related to Ball et al.’s (2008) specialised content knowledge for teaching in mathematics. Topic specific PCK includes:
- Learners’ Prior Knowledge
- Curriculum Saliency (deciding what is important for teaching & sequencing)
- What makes a topic easy or difficult to teach
- Representations including powerful examples and analogies
- Conceptual Teaching Strategies

Methodology and sample
The instrument for this study consists of two questionnaires. The first questionnaire, designed to evaluate teachers’ SMK, is based on the Big Ideas which were distilled from the grade 12 chemistry curriculum by a group of expert teachers. The questionnaire to evaluate the teachers’ PCK was based on the categories of Topic Specific PCK captured in the Mavhunga
The design of the questionnaires went through several iterations. The first version, piloted with a group of 16 teachers who were attending a teachers’ conference, revealed that the design of PCK questionnaire was somewhat superficial. Strengthening this area was the main focus for the second version of the instrument. Valuable feedback on the second version of the instrument was obtained from a small group of expert teachers (N = 3) at local high schools. The final version of the questionnaire was administered to a sample of teachers (N = 44) from diverse schools. A rubric constructed for another topic, namely chemical equilibrium, has been adapted for the Topic Specific PCK tool for organic chemistry. Scores corresponding to the categories with each being rated on a four point scale, from 1 (‘Limited’) to 4 (‘Exemplary’) were peer validated by independent raters. An agreement rate of 85% was obtained. The raw scores for both instruments will be analysed using Rasch analysis (Bond & Fox, 2007) to obtain evidence for the construct validity of the SMK questionnaire, to provide a trustworthy estimate of its internal consistency and to convert raw score performance data to interval measures for comparison with PCK proficiencies.

**Findings**

While data analysis is still underway some general trends have been noted:

- 68% of teachers achieved over 75% for the SMK questionnaire.
- There is no correlation between the scores for SMK and years of teaching.
- Low levels of SMK translate into low levels of PCK.
- High scores on SMK do not necessarily translate into high levels of PCK.
- Two teachers exhibit exemplary PCK despite a having studied chemistry only at A level or first year university.
- Teachers with 25 years of teaching experience and high levels of CK do not necessarily develop high levels of PCK.

The SMK and PCK instruments have the potential to provide baseline data for a large cohort of teachers as well as to evaluate any targeted interventions on teachers’ PCK. The data gathered to date provide a snapshot for the sample of teachers who participated in the study. Rasch analysis of both questionnaires will be useful in refining the instrument for use in large scale testing of teachers should this be required. Instruments such as the one developed to evaluate teachers’ Topic Specific PCK in organic chemistry are useful in that they can be administered to large groups of teachers to inform teacher training programmes at all levels.

**References**


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Challenges in Engineering Higher Education: Understanding Student Retention as a Multilevel Complex Phenomenon

Jonas Forsman¹, Maartje Van den Bogaard², Cedric Linder¹, Duncan Fraser³, Alexander Verbraeck², & Staffan Andersson¹

¹ Division of Physics and Astronomy, Uppsala University, Sweden. ² Faculty of Technology, Policy and Management, Delft University of Technology, Netherlands. ³ Department of Chemical Engineering, University of Cape Town, South Africa.

jonas.forsman@physics.uu.se; cedric.linder@physics.uu.se; staffan.andersson@physics.uu.se² m.e.d.vandenbogaard@tudelft.nl; a.verbraeck@tudelft.nl³ duncan.fraser@uct.ac.za

The issue of effectively enhancing the retention of engineering students has become critically important in many parts of the world. This is because the demand for competent engineers has been exceeding availability for some time now (Committee on Science, Engineering, and Public Policy, 2007; European Commission, 2004). The framing for most of the work done in student retention has been the Student Integration Model, SIM (Tinto, 1975; 1987) and the Student Attrition Model, SAM (Bean 1980; 1982. These two models have become paradigmatic for almost all student retention research. Following Morrison (2005), Davis and Sumara (2006), and Lemke (2010) we argue that there is a weakness here, because neither of these models explicitly incorporates derivatives of complexity thinking into the understandings that they present (Forsman, et al. 2012), and we propose and illustrate a complexity thinking point of departure for future research.

This point of departure holds the explicit treatment of student retention as a multilevel complex phenomenon, which requires modeling using network theory (Freeman, 1978) coupled with appropriate applications of complexity thinking (Davis & Sumara, 2006). Also, since Hausknecht, et al. (2011) have argued that going directly to the collective level is not the optimal approach to use for this kind of work, we decided to explore another level of analysis, namely the level of ‘sub-collectives’. These are sub-sets of the entire collective of students that do not necessarily have the specific social bonds or academic attachments suggested by other studies. For our purposes these sub-collectives act as a proxy for a range of social and academic sub-groups that exist within, for example, year groups, disciplines, and curricula.

Our point is that studying interdependencies between the concepts and constructs across sub-collectives will facilitate exploration of the extent to which the concepts and constructs are persistent across the level of sub-collectives within the complex system of engineering student retention. Thus, the research question follows as:

Is it possible to effectively detect what interdependencies are persistent across sub-collectives using a multilevel approach in student retention research?

Our illustrative data was collected in the fall of 2010 at a highly regarded European Union university that offers 3-year bachelor programmes in 13 areas of engineering and science. We studied two cohorts of first-year engineering student cohorts using an online questionnaire was given to the participating students. This questionnaire was built up from the literature on student retention, largely based on the SIM and SAM models (Van den Bogaard, 2012). The questionnaire also included aspects which interviews with a selection of first year students at the same university had brought out (Van den Bogaard, 2011).
To create the model of sub-collective component interdependencies, we used multilayer minimum spanning tree analysis -- MMST (Grönlund, Bhalerao, & Karlsson, 2008). Our implementation of MMST analysis vividly illustrates how to simulate a range of possible sub-collectives of the students surveyed while not “forcing” them into any particular group constellations or group size.
Our use of MMST also shows how identification of the interdependence of the concepts measured in the survey questionnaire can be established within and across sub-collectives.

Two separate MMSTs were created, one for each of the cohorts surveyed. These MMSTs were analyzed for the distributions of the components’ interconnectedness and topological diversity (Eagle, Macy, & Claxton, 2010). The persistence of a structure is then based on the distribution and strength of connections within the structure. The structures in the MMSTs show a range of persistence; some are stable and are reproduced in most sub-collectives, others are particular and have a low frequency of connections with a many other components. Further, we analyzed the persistent structures between the cohorts to identify what structures tend towards being more persistent in time. The results of this provide a tentative characterization of persistence in time of interdependent component structures in the complex system of student retention. Also, the topological diversity serves as a basis to discuss how our identified persistent structures share similarities with the more ‘stable’ outcomes from previous research (Beekhoven, 2002)

Our analysis goes on to illustrate how only a few structures may be persistent across sub-collectives. This result leads us to propose that if transformation of the engineering education experience of students is to be successful, actions targeted towards ‘one-size-fits-all’ interventions would have limited potential. Our study indicates that the space of possible actions is constrained. This is because there are only a few persistent structures that represent reasonably predictable effects when considering the entire student population. Our results also illustrate how some persistent structures can be seen to be more persistent over time as well as across levels of the system.

References
Using EJS to Create Simulations that Teach

Spencer Wheaton

University of Cape Town

spencer.wheaton@uct.ac.za

Students generally find the ideas presented in undergraduate thermal physics courses difficult to grasp. What is more, many traditional textbooks present the material in an extremely abstract fashion, following the chronological order in which the field developed (e.g. using cyclic processes to introduce entropy). However, several authors, e.g. Baierlein (1994), and Moore and Schroeder (1997), favour a focus on the microscopic world in order to explain the behaviour of macroscopic systems. Within such an approach, the main ideas of thermal physics are developed through application of a handful of simplified models (e.g. the ideal gas model, Einstein solid model and two-state paramagnet model). Aside from making the abstract ideas of thermal physics more concrete, such an approach also benefits from all of the advantages of explicit reference to models and modelling in the instruction (see, for example, Wells, Hestenes, and Swackhamer (1995)).
undergraduate thermal physics course and adapted the course material and his mode of instruction to enhance student learning. The first major change was the adoption of a textbook (Schroeder, 2000) that follows the microscopic approach. Apart from the obvious changes necessitated by a new prescribed textbook, a set of computer simulations was developed to illustrate the major concepts introduced in the course. These simulations were written using the Easy Java Simulations (EJS) Java authoring package introduced in Christian and Esquenbre (2007).

Early simulations developed by the author for the thermal physics course were designed for use as lecture demonstrations. The mode of instruction for the course comprised five traditional lectures (with minimal student participation other than occasional questions by the instructor) and one tutorial session (focussing on problem solving) each week. It was soon discovered that using simulations simply as lecture demonstrations in traditional lectures led to minimal learning. Students were often not able to make sense of what they were watching within the very limited time set aside in class for the showing of simulations. Furthermore, they seemed unimpressed by the simulations and were unable to recall the major features of a simulation even a week later.

As stressed in the literature, simulations work best when employed as agents of guided inquiry learning (Wieman, Adams & Perkins, 2008). This led to a major redesign of the materials in 2011. Use was made of the insights of the PhET group to design simulations that engage students and invite them to interact (Adams et al., 2008). Some of the features of EJS that facilitate student learning through interaction include the immediate effect that user input has on the simulation, as well as the extensive graphical options that lend themselves to developing simulations that aid visualisation and multi-representation skills.

Mindful of the need for a simulation to be intuitive and clear in its representations, a series of “talk out loud” interviews were conducted with students as they interacted with the simulations. The results led to further refinement of the simulations and provided useful ideas for guided inquiry worksheets to accompany the simulations. The intention is to use these improved materials in the 2013 thermal physics course during several guided inquiry sessions that will replace some of the traditional lectures.

Although the work presented is focussed on the teaching of a senior undergraduate physics course, the observations made apply equally well to introductory physics courses: simulations used as lecture demonstrations are limited in their impact. In order to create simulations that teach, they should be designed for use in guided inquiry activities.

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References
The Integration of Socio-Scientific Issues into the Grade 11 Biology Curriculum in South Africa

Eugenie Rudolph\(^1\) & Lindelani Mnguni\(^2\)

\(^1\)Department of Science, Mathematics and Technology Education, University of Pretoria, South Africa; \(^2\)Department of Science, Mathematics and Technology Education, University of Pretoria, South Africa

\(^1\)genierudi@gmail.com, \(^2\)lindelani@up.ac.za

The integration of socio-scientific issues into Biology education remains a priority for academic institutions who believe that education should be used as a tool to empower societies. However, Dewey, a popular advocate of the use of education to empower societies has been criticised for failing to “resolve the dualism between the school and society that he fought to overcome because he failed to account for the many institutions in society which provide education” (Zuga, 1992: 5). The argument is that school is not the only agent of socialization and in order for education to effectively address socio-scientific issues, there has to be a synergy between the curriculum and everyday life. Integrating socio-scientific issues into a curriculum however remains a challenge for scholars. For example Ekborg (2010) indicates that if the scientific component of the formal curriculum goes against a normative system of values which students subscribe to, their affect-based responses may be hindered, jeopardizing even their critical reasoning. As a result students may revert back to defending socio-cultural views instead of the socio-scientific ones. Nevertheless Klop, Severiens, Knippels, van Mil, Marc, Ten and Geert (2010: 1128) argue that science subjects such as Biology could incorporate “scientific literate competences that students need to be able to live and participate with reasonable comfort, confidence, and responsibility in a society that is deeply influenced and shaped by the applications, ideas and values of science.”

In the current study therefore the researchers aimed to explore the integration of socio-scientific issues into the Grade 11 Biology curriculum. Of particular interest was the incorporation of HIV/AIDS and green economy content into Biology. The main research question that was asked was “how does the Grade 11 Biology curriculum integrate HIV/AIDS and green economy content knowledge?”
In this qualitative study an inductive curriculum analysis approach was used to determine the integration of socio-scientific issues into the Grade 11 Curriculum and Assessment Policy Statement (CAPS) Biology (Department of Basic Education, 2010). In this method the researchers, using a previously validated instrument, examined sections of the Biology curriculum document in order to identify specific emerging themes and subthemes which relate to HIV/AIDS and green economy education.

In the process of examining sections of the Biology curriculum, as suggested by Schiro (2008: 7), the researcher probed for “the specific concepts that the curriculum is concerned with and the nature of this kind of knowledge” in relation to HIV/AIDS and green economy education. The instrument used consists open-ended questions which according to Nicholls (2003) and Evans and Davies (2000) may be formulated by the researcher prior to document analysis based on the objectives and the research question of the study. In the current study these questions were adopted from Schiro’s (2008) previously validated standard inventory for curriculum analysis. Responses were then formulated inductively by the researchers using verbatim and narrated extract from the document being analysed. The formulated responses were then used to make inferences regarding the integration of socio-scientific issues in the Biology curriculum.

Data show that there are prescribed scientific concepts that are taught to students in relation to HIV/AIDS and green economy. These include tissues, cells and molecular studies; structures and control of processes in basic life systems; environmental studies; and diversity, change and continuity. HIV/AIDS forms part of the tissues, cells and molecular studies knowledge area, while green economy content is part of the environmental studies section. It was observed that the content integrated may not be applicable to everyday life and also lacks scientific depth. The emphasis of the Biology curriculum in this regard is on ensuring that students develop specific skills and construct content knowledge which is discipline-specific. To this end, the learning outcomes and assessment strategies do not relate to empowering students with skills for everyday life even though application of knowledge is listed as a learning outcome. In fact, there is no indication as to how should students apply knowledge and how this will be assessed. Overall it appears that content knowledge of HIV/AIDS and green economy is integrated into Biology as extra content and the subject is not dedicated exclusively on these areas.

The strategy for integration of HIV/AIDS and green economy content into Biology is in line with recommendations for interdisciplinary collaboration in teaching about socio-scientific issues (UNESCO, 2006). Mnguni (2011) and Van Laren (2008) however indicate that incorporating content knowledge as extra content may limit the effectiveness of this knowledge since superficial context-specific detail is incorporated. UNESCO (2006) also supports this view in that because there is already a certain degree of content within the subject, which carries a particular level of priority, content added as extra content will potentially receive lesser coverage and attention. Consequently the researchers argue that the HIV/AIDS and green economy content incorporated in the Biology curriculum will probably not lead to student empowerment for everyday life.

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Teaching Chemical Equilibrium at Further Education and Training (FET) Band: Problems and Prospects

Marumure Godfrey ¹ & Ochonogor, Chukunove Enunuwe²

Institute for Science and Technology Education, University of South Africa, Pretoria

pgmarum@yahoo.com ¹; Ochonec@unisa.ac.za ²

Several misconceptions manifest as learners answer questions on Chemical Equilibrium during examinations. This study explored the problems and prospects of teaching Chemical Equilibrium. The main problem of the study was to identify problems of teaching the topic of chemical equilibrium at FET band; explore why these problems exists; and identify improve ways of teaching Chemical Equilibrium in order to improve the quality of teaching and learners’ performance in Chemistry. The concept of chemical equilibrium is well linked with other topics like electrochemical reactions and industrial processes in Chemical system therefore it contributes more than the indicated 13.3%. During examinations learners demonstrate a lot of misconceptions on chemical equilibrium. For example using the following chemical equation of a chemical reaction at equilibrium:

\[ 3H_2 (g) + N_2 (g) \leftrightarrow 2NH_3 (g) \quad \Delta H < 0 \]

Many learners are quick to say

- ‘If we increase the number of ammonia the number of hydrogen gas will increase’.
‘Apply more pressure to the reactants and equilibrium will shift’.

A descriptive exploratory survey was conducted in Thohoyandou Cluster among Physical Science (Chemistry) at the Further Education and Training (FET) band Educators in South Africa. A Clustered sample of 40 educators including five ‘well experienced’ educators who have been producing ‘good’ results at Grade 12 National School Certificate (NSC) examinations and two Physical Sciences subject advisers were used. Research instruments used in the study are questionnaire and interview schedule. Questionnaire designing was done in three stages with adjustments made following recommendations at each stage by experts used for validation. The reliability of instruments tested through the Spearman Brown Split-Half statistical method giving a 0.891 coefficient. Chemical equilibrium directly contributes 13.3% of the 150 total marks of the National Senior Certificate (NSC) Chemistry Examination (NSC Chemistry Preparatory Examinations and November Examinations for 2008 and 2009; NSC March Examination for 2009 and 2010).

The study answered the following research questions: How is chemical equilibrium as a topic being taught? Which teaching strategies are employed by different educators that many learners end up with many misconceptions? What are the problems of teaching the concepts of chemical equilibrium? Why do these alternative conceptions exist? What are the prospective improved ways of teaching these concepts? Codes used to identify schools and educators to reduce bias towards particular schools and hence introduce anonymity. The questionnaires were distributed and collected in envelopes addressed to the school principals through the five Circuit Offices. Codes were used on the questionnaires to assist in controlling their high rate of return that was registered. Interview schedule was made available to the interviewees before interview date. A variety of teaching methods and strategies are being used in the teaching of chemical equilibrium. These include the lecture method, constructivist approach, inquiry based methods which entails process oriented instruction (POI), prediction, observation and explanation (POE), problem-solving, word webbing, mind mapping, modelling, analogies and the context based approach.

The results show lack or underutilization of laboratory equipment and facilities, poor teaching strategies, rote learning, educators’ deficiency in topic content knowledge and pedagogical skills among others by the educators. Educators do not have the necessary skills to implement the strategies which promote conceptual change and understanding and so the teaching of Chemical Equilibrium haphazard. The South African policy on Education recommends a ratio of one educator for every 30 learners at the FET band. The average number of learners per class in the area of this study is 50.43. Class size is almost double of Sub-Saharan Africa which is 25.8 whiles the world’s class size average stands at 18.0 (UNESCO Institute for Statistics, Data Centre, 2008). Inadequate acquisition of building blocks of basic scientific concepts at General Education and Training (GET) band which are applied at FET level conspicuously stood out as one of the major problems identified by educators and the curriculum advisers (CA). Also learners have a problem in Mathematics which is carrying out simple calculations. Educators demonstrated several alternative conceptions on explaining the basic concepts of chemical equilibrium. The deficiency in topic content knowledge is identified as a major problem to the teaching of the topic. The educators’ major problems of teaching lie in the understanding, explaining and demonstrating the basic concept of Chemical Equilibrium which are incompleteness of reaction, reaction reversibility, chemical (molecular) dynamics and equilibrium constant.
The prospective ways to improve the teaching and learning of Chemical equilibrium and hence a greater achievement for the learners at matric examinations were determined from the respondents of this study. Educators consider professional development through re-training and workshops on subject content matter and teaching strategies with emphasis on topic specific PCK and problem-solving strategy as the way forward. The key terms relating the basic concepts of Chemical Equilibrium using the problem-solving approach should form part of the professional development training and re-training programmes. They strongly advocated for In-Service training on teaching strategies for particular topics. Developing topic specific PCK is viewed as a way assisting those educators who are struggling in teaching the basic concepts. Laboratory equipment and facilities should be provided to schools and skills development on how and when to use the equipment and facilities should be given to the educators on regular basis. Prediction, Observation and Explanation (POE) strategy has been recommended for experimental demonstrations. A set of experiments are recommended for specific concepts. The experiments should be chosen on the basis of simplicity and ‘clear’ parameters of observation for the elements of Chemical Equilibrium. Educators should endeavour to conduct all recommended experiments and improvise materials where the real equipment and facilities are not available for use during training and in their classes.

Keywords: Chemical Equilibrium, Content Knowledge, Dynamic Equilibrium, FET Band, Pedagogical Content Knowledge (PCK), Pedagogical knowledge, Problem Solving, Teaching Strategy, Reversible Reaction.

**Reflections on the Science and Indigenous Knowledge Systems Project: Voices of the Participants**

Emilia Afonso Nhalevilo\(^1\) & Meshach Ogunniyi\(^2\)

\(^1\)Centro de Estudos Moçambicanos e de Etnociencia, Universidade Pedagogica

\(^2\)School of Science and Mathematics Education, University of the Western Cape, South Africa

emiliafonso@gmail.com, mogunniyi@uwc.ac.za

Extended Abstract

The end of colonialism and apartheid systems has brought transformations in the system of education in many countries. One of the transformations has been in terms of language of instruction as many countries that used in the past to have only the language of the colonizer as the medium of instruction have moved in the direction to include local languages too. The experience has proven that the issue is of high complexity and a plethora of studies are taking place looking for effective and positive ways to accommodate this innovation. Another transformation has been in the content itself. Knowledge such as local medicinal plants, local ways of protecting the environment, local ways of interpreting experience, local truths about the earth, the moon and local ways of producing food are being included in science curriculum. The inclusion of such knowledge implies however, the creation of new pedagogies and philosophies to teach and to learn. It implies also new set of axiological perspectives. In fact, most of local knowledge was once regarded as superstitious, non-official and this designation carried much of preconceptions and disrespect that built a hostile environment for this form of knowledge. Ideologically a huge transformation is demanded to address the new pedagogies and philosophies of our schools. This ideology implies a more hybrid approach to deal with knowledge, an approach that would acknowledge the co-
existence in our mind and culture of two or more systems of knowledge. The Science and Indigenous Knowledge Systems Project (SIKSP), located in an African University, has since its inception in 2004 been training pre-service and practising teachers how to implement an inclusive science-Indigenous Knowledge (IK) curriculum which calls on teachers to integrate IK with science in their classrooms. The methodology of the project consists of a series of workshops and plenary sessions as part of the program for postgraduate degrees and for Bachelor and Honours in Science and Mathematics Education. Most of the students are teachers at high school, few are primary school teachers or principals and a few are prospective teachers. Currently the project has 35 collaborators from various countries e.g. Japan, USA, U.K., Mozambique, Zimbabwe, Swaziland, Ghana, Nigeria, and Botswana. The project exposes teachers to a series of plenary sessions and hands-on-workshops on the Nature of IKS (NOIKS) and the Nature of Science (NOS), experiences of including IK worldwide and material development. Further, the project adopts a mixed mode method involving a pre-post-test quasi experimental design, questionnaires, interviews and classroom observation to evaluate the impact of the workshops on the students’ conceptual understanding as well as worldviews about diverse phenomena indicated in the natural science curriculum. This paper, based on interviews, presents some of the participants’ reflections, sentiments and feelings about SIKSP- their voices. It does not aim to evaluate the impact of the project on participants’ knowledge; instead it seeks to understand the feelings of the participants. Thus, rather than using the pre and post tests as in most of the papers produced from the project, we opted for interviews which included questions not about the knowledge of the content but on how participants experienced and what were their judgements in relation to the project.

We choose the interpretive and the critical paradigm to make sense of the lived experiences of the participants in the project. Interviews were conducted to generate data needed for closer analysis. The questions for the interviews were outlined according to themes: expectations, challenges, perceptions, achievements and disappointments. Criteria for quality in the methodological procedure are derived from Guba and Lincoln (1989) (i) authenticity-fairness, ontological authenticity, catalytic authenticity, tactic authenticity (ii) transferability- the degree it may be transferable to other contexts and from Saukko (2005) (iii) reflexivity - the ‘real’ implications our research has for the reality we are studying” (Saukko, 2005, p. 352).

The results from the interview suggest that stability of the group is an important factor for productivity and connectedness of the participants. This implies that strategies to keep motivation and to raise participants’ commitments should be sought. Perhaps time and space should be found to allow participants each of them to narrate their experience and to share their fears and reservations. One way could possible be to integrate personal narratives where participants could write confessional tales (Van Maanen, 1988) about their feelings in relation to the group and their expectations and challenges. This could perhaps help also in relation to their expectations. Participants should share their expectations to ensure that the gap from the project’s goals and their expectations is narrowed.

The results also suggest that differences in cultural and religious beliefs may constitute challenges to integrate IKS in schools. Although the revised curriculum in question states that students must appreciate different cultures and worldviews that make the country a united country, ethical dilemma may arise and teachers have to find strategies to deal with accordingly to the context. There is no one size fits all thus, teachers will have to make practical moral judgments – Prhonesia. Finally we can also infer from the interviews that
associations with schools and the Department of Education and other sectors in education may play a vital role. This could motivate teachers not only to remain in the project but to play a critical and catalytic role in curriculum transformation.

Reference

Problematising Disciplinary Literacy in a Multilingual Society: The Case of University Physics in South Africa

**John Airey**, **Anne Linder**, **Nokhanyo Mayaba**, & **Paul Webb**

1 Department of Physics and Astronomy, Uppsala University, Sweden; 2 Centre for Educational Research, Technology and Innovation, Nelson Mandela Metropolitan University, South Africa; 3 School of Languages and Literature, Linnaeus University, Sweden

john.airey@physics.uu.se, anne.linder@physics.uu.se, nokhanyo.mayaba@nmmu.ac.za, paul.webb@nmmu.ac.za

Over a decade has passed since Northedge (2002) convincingly argued that the role of the university lecturer should be viewed as one of leading students on excursions into the specialist discourse of their field. In his view, disciplinary discourses have come into being in order to create and share disciplinary knowledge that could not otherwise be appropriately construed in everyday discourse. Thus, Northedge’s conclusion is that in order for disciplinary learning to occur, students will need explicit guidance in accessing and using the specialist discourse of their chosen field. Building on this work, Airey (in press) argues that all university lecturers are, at least to some extent, teachers of language—even in monolingual settings. A radical approach to this claim has been suggested by Wickman and Östman (2002) who insist that learning itself be treated as a form of discourse change.

In an attempt to operationalise Wickman and Östman’s assertion, Airey (2011b) suggests that the goals of any undergraduate degree programme may be framed in terms of the development of disciplinary literacy. Here, disciplinary literacy is defined as *the ability to appropriately participate in the communicative practices of a discipline*. Further, in his subsequent work, Airey (2011a) claims that all disciplines attempt to meet the needs of three specific sites: *the academy, the workplace and society*. He argues that the relative emphasis placed on teaching for these three sites will be different from discipline to discipline and will indeed vary within a discipline depending on the setting. In the South African setting two questions arise from this assertion. The first is: *For any given discipline, what particular balance between teaching for the academy, the workplace and society is desirable and/or practicable?* The second question follows on from the first: *Having pragmatically decided on the teaching balance between the academy, workplace and society, what consequences does the decision have for the language(s) that lecturers should be helping their students to interpret and use?* In order to address these two questions we conducted an interview-based case study of the disciplinary literacy goals of South African university lecturers in one particular discipline (physics). Thus, our overarching research question is as follows: *How do
South African physics lecturers problematise the development of disciplinary literacy in their students?

The data collected forms part of a larger international comparative study of the disciplinary literacy goals of physics lecturers in Sweden and South Africa. A disciplinary literacy discussion matrix (Airey, 2011a) was employed as the starting point for conducting in-depth, semi-structured interviews with 20 physics lecturers from five South African universities. The choice of these five universities was purposeful—their student cohorts encompassing a range of different first languages and cultural backgrounds. The interviews were conducted in English, lasted between 30 and 60 minutes, and were later transcribed verbatim. The transcripts were then analysed qualitatively. This involved “working with data, organizing it, breaking it into manageable units, synthesizing it, searching for patterns, discovering what is important and what is to be learned, and deciding what you will tell others” (Bogdan & Biklen, 1992:145).

The main finding of this study is that all the lecturers mentioned language as being problematic in some way. However, there were a number of important differences in the ways the lecturers problematise the development of disciplinary literacy both across and within the different university physics departments. These differences can be seen to involve on the one hand, the lecturers’ own self-image in terms of whether they are comfortable with viewing themselves as language teachers/literacy developers, and on the other hand, their recognition of the diverse linguistic and cultural backgrounds of their students. The differences will be illustrated and discussed using transcript excerpts. These findings are in contrast to parallel data collected in Sweden. In that particular (bilingual) setting, language was viewed as unproblematic, and the most striking characteristic was the very similarity of the responses of physics lecturers (Airey, in press). It is thus suggested that the differences in findings between Sweden and South Africa are a product of the latter’s diverse multilingual and multicultural environment. One pedagogical conclusion is that, given the differences in approach we find, inter- and intra faculty discussions about undergraduate disciplinary literacy goals would appear to have the distinct potential for reforming undergraduate physics. Similarly, an administrative conclusion is that a one-size-fits-all language policy for universities does not appear to be meaningful in such a diverse multilingual/multicultural environment.

Finally, it should be mentioned that our choice of physics as an exemplar in this study has important implications for the interpretation of the findings. Drawing on Bernstein (1999), Martin (2011) suggests that disciplines have predominantly horizontal or hierarchical knowledge structures. Here it is claimed that physics has the most hierarchical knowledge structure of all disciplines. Thus, the findings presented here should be taken as illustrative of the situation in disciplines with more hierarchical knowledge structures (such as the natural and applied sciences). Other and Author (in review) find that the issue of the language of instruction in such disciplines is viewed as much less problematic than in disciplines with more horizontal knowledge structures (such as the arts, humanities and, to some extent, social sciences). See Bennett (2010) for a provocative discussion of language use in such disciplines.

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**Quantum Theory: A Cradle of Multiscience or the Unfolding of Complex Nature of Reality? An Epic Journey Towards a Mozambican Scientific Literacy’s More Inclusive Curriculum**

Amós Veremachi, Peter Taylor

*Department of Physics, Pedagogical University of Mozambique Science and Mathematics Education Center, Curtin University of WA. Australia*

**ABSTRACT**

One of the most dominant features of Science, in Science Education, is its hegemony in different cultures. In fact, this dominance is rooted in the assumption that Science is universal, standing beyond all cultures. As a consequence ways of knowing, perceiving and interpreting the World around us other than western scientific epistemologies have been excluded in Science teaching and learning. Currently, however, there is an increasing awareness about the nature and purpose of science in different stages of our lives. In particular, there is a concern about how science learners in non-western societies can learn science in a meaningful way and benefit from it.

In this paper I argue that one of the pathways in order to ensure science education for accultural scientific literacy may be to recognize the worth and value of the socio-cultural based epistemologies and practices in science classroom and curriculum. For this purpose, I
draw an analogy with Quantum Theory where a pluralistic and non-deterministic perspective is held as a way of turning science and science education a suitable and common place for all.

Through the usage of narrative inquiry, fictive story writing and Mozambican government documents analysis I adopt strategies of reflecting about and communicating my experience in learning and teaching Physics science in Mozambique that is intended to invoke in the readers pedagogical thoughtfulness and thereby stimulate changing practices among science teachers and science teacher educators in Mozambique towards socio-cultural context-based approaches in teaching Physics science. Furthermore, I seek to motivate science teachers and science teacher educators in order to make Physics science classes more culturally sensitive.

INTRODUCTION
Science teaching and science education processes, besides focusing on the careful explanation of scientific concepts, must connect science to everyday life; failure to recognize the need for genuine cultural sensitivity leads to an alienating effect of science (Cobern, 1998). This connection aims to help science learners to construct their own meaning of science concepts based on their socio-cultural realities. In fact, by understanding profoundly how our lives are refined by social and cultural determinants it is possible to develop a critical-reflective awareness about our professional practices and transform ourselves into agents of democratic reforms within educational settings (Taylor & Settelmair, 2003). Thus, there is a need to promote a socio-cultural contextualization that leads to the process of an autonomous acculturation (Taylor & Cobern, 1998). Through conduction of an extensive literature review in different categories, policy documents analysis and narrative inquiry, in this paper I argue in favor of the adoption of socio-cultural context-based approach to teach and learn science as a way of helping science learners to achieve their goals and agendas. I explored the non-deterministic nature and multi-perspective character of Quantum Theory and discussed hypothetical pathways for a more inclusive science education. In addition, I discussed the extent to which the School Physics curriculum was adequate for the development of the much-needed scientific literacy as defined by Hudson (2003) while looking to the particular reality of Mozambican society and by envisioning an isomorphism of multiple perspectives by analogy with Quantum Theory.

METHODOLOGY
The study was based on the interpretive and post-modern research paradigms in the sense that I intend to understand phenomena, whether social or natural, in terms of their meanings (to me, to my students and to society in general). The preference to these paradigms is their usage of relativist ontologies and relativist interpretive epistemologies, which a characterized by the acceptance of multiple constructed realities and conceptions (Denzin & Lincoln, 2000; Lincoln & Guba, 2000). To fulfill the purpose of this study, I conducted an extensive review on Quantum Theory and philosophy textbooks and related literature in science education. In addition, I looked at the Mozambican government’s policy documents – School Physics curriculum and strategy for Teacher Training (2004-2015) – a proposal of policies in order to appreciate the extent to which the promotion of scientific literacy is supported.

This procedure was complemented by fictional story writing in order to portray my experience as a Quantum Theory learner and as a science teacher, besides envisioning difficulties and endeavors in teaching physics by including hypothetical critical events. The
usefulness of narratives resides on their power to provide the reader with a deeper view of life in well known contexts; it can act as an operator which role is to transform one entity into another. Thus, fictional writing of educational experiences provide to the researchers the occasion to bring pieces of information from different real events in order to speak the realm of social consciousness (Clough, 2002).

**QUANTUM THEORY AND MULTIPLE PERSPECTIVE**
Classical Physics, based on the principles of determinism and causality, seems to have helped to develop a narrow view of the world through rejection of views other than the scientific view. In fact, through the laws of classical Physics, science learners were exposed to practices that seem to promote the supremacy of the scientific world by rejecting students’ socio-cultural embedded views of perceiving the world around us and labeling them as being anti-science and superstition-based interpretations.

Being aware of the strong impact that socio-cultural ways of perceiving reality may have on students’ understanding of science content, there is a need to adopt practices that enable to create a science classroom environment that supports the elicitation of alternative views and lets them to interact with scientifically acceptable views of the world.

Quantum Mechanics seems to fit, to some extent post-modernist paradigms, in particular the epistemology of ambiguity.

Quantum Theory presents multiple perspectives and therefore a broader perspective about the nature of reality! In fact, Serway et al. (2005, p.94) recognize this richness:

``Quantum Theory gives light a more flexible nature by implying that different experimental conditions elicit either the wave properties or particle properties of light. In fact both views are necessary and complementary. Neither model can be used exclusively to describe electromagnetic radiation adequately. A complete understanding is obtained only if the two models are combined in a complementary manner``.

How can this view of complementarity can be used in science education in order to conceive empowering models?

How can this view influence curriculum designers to develop a more inclusive, holistic science curriculum in which the so-called non-scientific views become part of classroom discussions, at least in local contexts; not necessarily as a formal knowledge system but as a way of making learners more aware of different worldviews and hence rescue us from the monopolized view of the existing science curriculum?

It seems that a richer picture may result from the consideration of different worldviews. We might have a more complete understanding of the world if science becomes more inclusive in terms of its accountability for other views especially in science teaching; and for this purpose I argue that Quantum Theory seems to offer some windows of opportunity and I draw support from Gergen & Gergen (2000) who deny the existence of any means of celebrating the supremacy of one worldview over another on the basis of match between word and world.

Quantum Theory seems to open opportunities to consider alternative explanations of phenomena, turning science into a more culturally and socially inclusive discipline and broadening or loosening its borders in order to be more comprehensive and allow a pluralism of worldviews. Learning or teaching science through purely mathematical formalisms, although elegant, may promote an unduly narrow understanding. It may confine us to focus
solely on the evidences supporting the theory, laws and mathematical formulae; while the consideration of controversial issues about science content, its generation and validation are something worth being considered by their potential to rise awareness of the implications and reaching beyond those formulae. The complex nature of current problems requires that, for their solutions all stakeholders and the way they interact with each other and with the members of society and with nature, their ways of knowing and solving problems be considered instead of being ignored: Jegede & Aikenhead (1999) argue for culture sensitive science education in order to truly fulfil the purposes of globalization; where modern scientific and local cultural beliefs, values and practices are equally accommodated.

Mozambique, as well as other countries, trusts to the educational settings the task of preparing generation of citizens with abilities and skills to face problems (directly related to human health, economic ones, social environment and natural environment, to name a few.) and decide what actions must be taken in order to face them or at least to minimize their impact.

Due to its complexity nature, the treatment of a certain problem may not be the responsibility of a single science; it may need a wider vision of the issues and might well be faced if multi-disciplinary endeavors and views are settled. In fact, this is not an advocacy neither of a naïve inclusion of local practices nor of the rejection of “western modern science”. The intention is to advocate the establishment of a selective criterion that enables to take what is good and useful from either western view or local ways of perceiving and interpreting the world in order to achieve our goals. Thus, I am advocating the establishment and development of “autonomous acculturation” which is “the process of intercultural borrowing or adaptation in which one culture borrows or adapts attractive content or aspects of another culture…and involves a critical view of the cultural nature of modern science” (Taylor & Cobern, 1998, p.205).

Current practices not only fail to provide science learners with elements that stimulate perceptual change but also fail to connect students´ learning to their real-life experiences or their socio-cultural contexts. Indeed, aspirations, needs and interests of local societies must be reflected in the school science curriculum, thereby preparing a future generation connected with and committed to their societies rather than alienated from them. Through documents used in the inquiry, there is no explicit position on the accountability for students´ traditional socio-cultural values, contexts, traditional ways of knowing and prior knowledge in the classroom as a way of promoting equality, emancipation and valuing our own culture. Indeed, although the policy documents argue about the adoption of revolutionary approaches to teaching and learning science, they do not seem to offer clues concerning the inclusion of socio-cultural factors in science classes, in teaching and learning materials or in science curriculum.

For School Physics program the message was clear “to fight against anti-scientific conceptions”. This metaphor, presumes that there is a need to extinguish them. This seems to be a clear reference to information that learners bring to the science classroom, much of which are informed by socio-cultural based knowledge. However, research on alternative conceptions, and traditional culture or indigenous worldviews has shown that cultural factors, which some consider to be a barrier for effective learning of science (Ogawa, 1999), are difficult to eliminate (Wenning, 2008). This realization led to questions of how to incorporate these socio-cultural factors in the science classroom? What are the appropriate classroom
activities that can ensure their accountability? How can some of them be integrated into classroom discussion, science curriculum and guarantee effective learning of science?

In my opinion, the position of fighting against anti-scientific conceptions and the silence about different sensitive issues (e.g. acculturation between science and socio-cultural based epistemologies) seems to be inconsistent with the recognition of the need to adopt a learner-centered method of teaching as expressed within School Physics program. It also seems to be in sharp contrast with current endeavors in different parts of the world and current demands in science and science education and in environmental science education where there is a trend towards incorporating socio-cultural and community based practices into global endeavors to preserve our environment thereby making our planet a better place for all living beings to live.

The silence and the position of fighting against anti-scientific conceptions seems to not completely fit into the notion of an accultural scientific literacy framework, because this notion entails the recognition of the value and usefulness of local epistemologies and practices as a way of ensuring that the solutions we adopt are suitable to and serve the interests of local societies and communities in the first place. To achieve this level, however, there is a need for the establishment of a research into our socio-cultural and traditional ways of knowing and seek which ones can be incorporated in classroom discussions.

REMARKS
The inclusion of socio-cultural based epistemologies and practices in science classes has a potential to enable the process of learning for accultural scientific literacy. Moreover, the consideration of controversial aspects of science in classroom seems to be a more powerful procedure because it would raise awareness of the epistemological and ontological issues that surround many theories but yet seem hidden to science learners.

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Scaffolding Teachers' Ability to Enhance Students' Understandings of Inquiry

Judith S. Lederman, Selina L. Bartels, Norman G. Lederman
ledermanj@iit.edu, sbartels@iit.edu, ledermann@iit.edu

Scientific inquiry is a perennial focus of science instruction and learning in the United States (NRC, 2000) and throughout the world. Within the U.S. content standards for “science as inquiry” it is stated that; students grades K-12 should develop: 1) Abilities necessary to do inquiry and 2) Understandings about scientific inquiry (NRC, 2000). The objective most often implemented in the classroom and researched is objective one, leaving objective two neither explored nor implemented in most classrooms (Schwartz, Lederman, & Lederman, 2008). Inquiry for grades K-12 as defined by the National Research Council (NRC) (2000) will be used for this investigation, and knowledge of inquiry (KOI), will follow the Schwartz, Lederman, & Lederman (2008) delineation as; 1) Scientific investigations all begin with a question, but do not necessarily test a hypothesis, 2) There is no single set and sequence of steps followed in all scientific investigations, 3) Inquiry procedures are guided by the question asked, 4) All scientists performing the same procedures may not get the same results, 5) Inquiry procedures can influence the results, 6) Research conclusions must be consistent with the data collected, 7) Scientific data are not the same as scientific evidence, 8) Explanations are developed from a combination of collected data and what is already known. Inquiry is most often measured by students conducting labs or students writing about labs. Students’ actual knowledge and understanding of inquiry is not often measured in the classroom. Consequently, this study focused on students’ understandings of inquiry and looks to answer the question, if teachers are explicit and reflective during their grade eight science inquiry lab experiences how will students’ understandings of inquiry change?

Design
The sample was three eighth grade life science teachers. The teachers taught in a Chicago Public Charter School in its fourth year, located on the south side of Chicago. One section of each of the teacher’s course load was studied during this research. The sample class size was between 21-25 students per class. This study took place over the course of two school years. One teacher was part of the study for two consecutive years and the other two teachers were only involved for one year. In effect, this investigation was a continuation of the study of one teacher during year one, and then using the findings with an additional two teachers. One of the researchers met with the teachers on a weekly basis to plan inquiry labs. It was determined through the literature that the most effective way to teach students about KOI was through inquiry labs. The teachers and researcher met to convert “verification” labs to inquiry-oriented investigations and use these labs as a vehicle to explicitly and reflectively teach KOI (Lederman, 1998). The explicit/reflective approach to learning intentionally draws the learners’ attention to aspects of KOI throughout the lesson, through discussion,
instruction and questioning. Aspects of KOI were planned for, taught, and assessed. At each meeting the teachers explained to the researcher what content was taught in the past unit and the group determined the objectives for the inquiry lab addressing both KOI and traditional subject matter. The researcher and teachers brainstormed ideas for carrying out the lab, design of the lab handout, pre-lab discussions, and student presentations. The teachers wrote lesson plans, found readings, wrote assessment rubrics and constructed lab handouts. The group consulted via email to arrive at a final set of lessons plans that were implemented at the end of each unit. The essential features of classroom inquiry and the variations were taken from the National Science Education Standards (NRC, 2000).

Data Sources

Data were collected during the 2010-2012 school year. The student’s understanding of inquiry was measured at both the start and end of the research project. The instrument used to assess students understanding of inquiry is called Views about Scientific Inquiry (VASI). This instrument was adapted from the original Views of Scientific Inquiry (VOSI) by two of the original authors, and additional graduate students, of the VOSI (Schwartz, Lederman, & Lederman, 2008). The VASI is a paper and pencil test that has six open ended questions that address all aspects of KOI, reliability and validity of the instrument was established by the design team. The students were not graded on their response to the VASI, only on its completion. The VASI was given at the start and end of each year.

The teachers’ lessons were recorded, transcribed, and coded to insure that they were authentic inquiry lessons. After each inquiry lab lesson the researcher met with the teachers to debrief the lessons and plan for the next inquiry lab. The teachers and the researcher reflected on the lessons taught, determined if the objectives of the lesson were met, analyzed student work, and discussed what changes could be made to better explicitly teach KOI. Great attention was given to the teachers’ instruction of KOI to make sure that all students were exposed to explicit/reflective inquiry instruction. This study measures students’ understanding of KOI but that can only be changed if explicit/reflective instruction is given.

Intra-rater reliability was used to ensure that the lessons were coded appropriately and consistently across time. The quality of inquiry instruction was measured pre and post using EQUIP (Marshall, Smart, & Horton, 2010). One month after the lesson was taught the researcher listened to the audio tapes again and completed second EQUIP. The previous and recent EQUIP was compared to the coding collected during the lesson to insure reliability (>80%), this was done for each lesson observed. The pre and post VaSIs were collected and coded. The VaSI responses were reviewed by two additional science PhD graduate assistants. All of the VaSI coding was compared and inter-rater reliability was calculated (>80%). Categorical data were used to code the VaSI. Students were given a Naïve, Transitional or Informed score based on their responses.

Results

The results from this study show that students will make significant gains in their understanding of inquiry through teachers’ explicit teaching of these aspects. Students moved up at least one level of understanding (naïve, transitional and informed) for each aspect of inquiry. The data clearly indicate that students’ exposure to explicit instruction on knowledge of inquiry increases their understanding of inquiry.

Conclusions/Implications. Similar to the findings of Schwartz et al. (2002), students showed gains in all aspects of knowledge of inquiry. Another finding that emerged from the study is that careful planning of authentic inquiry lessons increases students’ understanding of
inquiry. This finding was also shown in the Schwartz, Lederman, & Thompson study (2001). When the researcher and the teachers worked together to develop inquiry labs and students explicitly talked with their teachers about inquiry, over time, students’ knowledge of inquiry increased. This study is transferable to Southern Africa because the students in this study have similar circumstances to education situations in Southern Africa, the sample is diverse in both culture and languages. They attend public schools in low income urban environments. Much like the US Southern Africa is paying close attention to students’ understandings about Scientific Inquiry.

References
Representation of moon phases: a textbook analysis and case study of grade eight learners understanding.

Lubabalo Albert Bhulana, Anthony Lelliott

1,2 Marang Centre for Mathematics and Science Education, University of Witwatersrand, Johannesburg

1bhulanal@yahoo.com, 2Tony.Lelliott@wits.ac.za

Introduction

The aim of the study was to investigate the quality of diagrams and explanations of moon phases in grade 6 to 8 Natural Science textbooks; to establish whether the textbooks provide scientifically correct content information for learners and teachers and to investigate whether the textbooks used for teaching are effective conceptual development tools for grade 8 learners, specifically when exploring moon phases. The research consisted of two phases, where the first phase investigated the quality of textbooks, and the second phase investigating learners’ ideas about moon phases. Only the first phase is reported in this paper.

For the present study, constructivism comprehension will be employed as a theoretical framework for the first phase of the research, that being the analysis of grade 6 – 8 Natural Science textbooks. Constructivism is defined as “the process of learning, as the gradual re-crafting of existing knowledge that, despite many intermediate difficulties, is eventually successful” (Smith, DiSessa & Roschelle, 1993: 123). This suggests that the previous knowledge of the learner is important: this previous knowledge is developed, as more complex structures of knowledge are constructed from simpler ones. Hence, constructivism provides a philosophical and theoretical framework for understanding the processes learners encounter in learning, and how this learning process can be facilitated. Therefore, textbook analysis can use constructivism as a theoretical framework to determine whether or not textbooks aid conceptual change in learners through the text and diagrams used.

Research Methodology

The research is that of a qualitative nature, and the methodological approach used to guide the study is that of a case study nature. A case study is not easily definable as there are many research methods texts available with different meanings attached to what a case study is; examples of theorist who attempt to define what a case study is include (Adelman, Kemmis & Jenkins, 1980; Yin, 1984; Fry, Ketteridge & Marhall 1999; Lamnek, 2005) to name but a few. With the varying descriptions of what constitutes a case study, there is little agreement in defining a universal description of what a case study is (Lincoln & Guba, 1985; in Bassey, 1999, p. 22).

For the purpose of my research, the direction taken as to what a case study is, is from Opie (2004), where he describes a case study as “an in-depth study of interactions of a single instance in an enclosed system” (Opie, 2004, p. 74). The study concentrated on a group of 15 learners from one class, and an in depth analysis was done about their understanding of the moon phases after using an education tool which was a textbook. The case in this context is the students and the textbook used for their advancement in learning about the topic. This approach helps in understanding why the learners answered the way they did during interviews, which then may assist in what needs to be unpacked for future research Wilson (2009). The case study involved numerous procedures: the procedures taken were that of conducting videotaped interviews, where at a later stage, the interviews were analysed in great detail for interpretation purposes.
There has been much criticism about the use of a case study for research purposes. One most common criticisms is that a case study cannot be generalised to a larger population (Denscombe 2007, Wilson 2009, Bassey 1999). This conception also questions the validity of the research itself. But a case study though involves the use of multiple methods of collecting data (Golafshani, 2003), and this data may be used in a process known as triangulation to establish validity. Yin (1994) also advocates that to counteract the issue of validity, one of the remedies is the use of multiple sources of evidence. In relation to the issue around generalisation, a case study may not generalise over a large population, but may give us an idea of what might be the thinking behind a problem in other populations; in the context of my research, it might, to elaborate more on the example, give us an idea on what other students in other schools may think about the cause of moon phases, and what might the cause of these learners thinking may be.

I therefore chose the case study approach for my research as it was a suitable methodology to help me explore in greater detail on what the contributing factor might be in the thinking of learners about the cause of the moon phases. The case study approach as well was a suitable methodology to help answer my research questions, and see the relation that exists between the research questions.

**Results and Discussions**

Six textbooks were analysed, with varying results. The two grade 6 textbooks analysed introduced cultural stories in an attempt to show how stories were used to help people understand moon phases. The cultural stories looking at scientific application, only achieved to explain the waxing and waning process the moon undergoes. Those stories however failed to explain correctly the cause of the moon phases. The diagrams presented in the textbook are misleading, as either the moon phase sequences are incorrect, or wrong moon diagrams are put for a particular phase. The activities though must be complimented, as they are good activities that would help learners understand the cause of moon phases a bit better. The remainder of the four textbooks, two grades 7 and two grades 8 did not include cultural stories. In terms of content accuracy, it was analysed that the correctness increases the higher the textbook grade is.

**Implications**

More emphasis in providing the correct content therefore should be paid to the textbooks in the lower grades, so that learners from the onset have the correct scientific view of what causes the moon phases. This may help learners as they go through higher school grades to have fewer misconceptions about the cause of moon phases. Teachers need to also be aware on the limitations of a textbook. The one way that teachers can be aware of the limitations is by teachers possessing correct content knowledge, and an increased level of pedagogical content knowledge. This can be achieved by teachers visiting museums like the Planetarium to advance their knowledge. Teachers could at the same time take learners out on educational outings, so that learners may have a chance to experience content that they are taught in a practical way. Having such educational outings would contribute to the development of correct scientific knowledge that a textbook may fail to provide.
Conclusion
Textbooks provide more correct scientific content the higher the grade. Even though the content can be misleading, especially with the two great six textbooks, the activities provided though for the learners to do are good to help learners develop an understanding on what causes the moon phase.

References
Buckingham; Philadelphia


Teaching approach and student success in examinations

Martin Braund1 and Gill Main2

1 Faculty of Education and Social Sciences, Cape Peninsula University of Technology, Cape Town, South Africa.
2 University of York, UK

1 martin.braund@york.ac.uk; 2 gm544@york.ac.uk

Context-based/STS (Science-Technology-Society) approaches to learning science have been promoted in many countries to address learner disengagement and improve recruitment to further learning and careers in science by promoting use of locally and nationally relevant applications of science and debates of contemporary issues (Bennett, Hogarth and Lubben, 2003). In African countries, context-based science is seen as equipping students with participatory skills to address local and global problems such as disease, environmental degradation, climate change and poverty (Kyle, 2006). Kasanda et al. (2005) see contextualising science empowering learners to be productive thinkers, benefiting both themselves and society. A systematic review of effects of context-based teaching concluded these approaches appear to motivate pupils in lessons (Bennett, Hogarth and Lubben, 2003). Bennett et al. found conflicting evidence that context-based approaches affect pupils’

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understanding of scientific ideas but the reliability of studies in this area has been challenged as different methods have been used to measure conceptual change for different sets of student experiences.

Gilbert theorised four models for context-based courses in science subjects based on the extent to which contexts lead, or are subservient to concept learning and the centrality of applications of science, involvement of students and social dimensions. In 2005 an innovative context-based course in Biology at Advanced level (A-level) was introduced called Salters Nuffield Advanced Biology (SNAB). This course, examined by the EDEXCEL examination board, included activities designed to provide high levels of student involvement, contact with cutting edge modern biology, high use of interactive collaborative learning, a wide range of out-of-school learning and interactive ICT, all linked to context embedded storylines in which the biological story leads acquisition of concepts on a ‘need-to-know basis’ (Reiss, 2006). The course therefore follows Gilbert’s model 2, in that context is presented as ‘reciprocity between concepts and applications’ (Gilbert 2006: 961). From 2005 to 2008 this course was offered alongside a separate one covering the same content but taught through a traditional concept-based approach. These two courses were examined separately and so impacts of the different teaching approaches could not be reliably compared. In 2008 EDEXCEL set a common syllabus and examination effectively offering options of teaching advanced biology through, a context-SNAB, concept-traditional, or a mixture of these approaches. Research questions addressed by the study were:

RQ1: Is there a difference in attainment and grade distribution of biology students taught by different teaching approaches; context-focussed, concept-focussed or a mixture of these two approaches?

RQ2: What in-school factors explain differences in student performance in advanced-level biology?

Methods

A multi-method approach was used that, first, analysed results from 344 schools (7563 students) for the 2010 examination, where a teaching approach could be identified. This was carried out at three levels; for the whole examination, to analyse and compare performance on examination components and for one contextualised question. Qualitative data were collected by questionnaires from 106 teachers and in-depth telephone interviews were conducted with 16 of those responding.

Findings

Analysis (bi-variate tests and ANOVA), at the whole examination level, showed no differences between the context-SNAB approach and the traditional concept-based one. Students who had been taught using these two approaches gained as many top grades and each performance quintile (based on previous public examination results at age 16) performed similarly. However, students following a mixed approach where teachers frequently drew on both concept and context-based learning performed better than students following either of the other two approaches. The effect size of this difference in favour of a mixed approach was +0.27 meaning that it is worth at least half of one grade in the final examination. At the component level, similar findings were noted except for two components in which teachers had an input and some degree of control over the assessment. In a component where students reported a visit or issue in biology and one where they reported an
in-depth investigation, SNAB-context approach students had some advantages over those taught using a concept approach (effect sizes: 0.14 and 0.24 respectively).

Questionnaire returns and interviews with teachers revealed; having experienced teaching teams, high use of interactive teaching, effective ICT resources and drawing on a wide range out-of-school learning were considered to have major impact on student success in A-level biology.

Conclusions and implications
Contextualising science does not disadvantage students. Being exposed to the possibilities of using different approaches to teaching A-level biology has created a professional space in which teachers have been able to take advantage of these approaches to diversify their teaching. A mixed economy teaching approach had a clear advantage in this study. As context-based courses are growing in number across the world, the findings have wider importance. In the South African situation, where learning is increasingly controlled by curriculum dictate and textbooks are homogenised as a result of the centralised approval system, findings show that policy may be in the wrong direction. There are clear implications for teachers’ initial training and professional development. Exposure to a diversity of resources and approaches and giving teachers the skills to critically review and select from these could lead to better examination successes for students in many countries.

References
Black Male Science Education Scholars in the Academy: An Analysis of Their Perspectives and Experiences

Malcolm B. Butler 1, Mary Atwater2, Eileen Parsons 3, & Tonjua Freeman 4

1 School of Teaching, Learning and Leadership, University of Central Florida, USA.
2 College of Education, University of Georgia, USA; 3 College of Education, University of North Carolina Chapel Hill, USA.
4 Malcolm.Butler@ucf.edu, matwater@uga.edu, parsons@unc.edu, tbf@uga.edu

Purpose of Study
The underrepresentation of Black faculty continues to be a persistent problem in U. S. higher education (Allen, et al., 2000). Many researchers have found that Black faculty members are less often tenured, earn less, work at less prestigious institutions, have lower academic rank, and have less academic stature compared to their White counterparts (Allen, et al., 2000; Patitu & Hinton, 2003). Allen-Castellitto and Maillard (2001) found that Black faculty members in traditionally White universities (TWU) in the United States, make up only 5.2% and 3.3% of the associate professors and professors, respectively.

Allen-Castellitto and Maillard (2001) found that Black faculty members in TWUs struggle for decent teaching assignments, research support, tenure, and recognition. They believe they experience more stress than their White counterparts for the level of institutional support received and level of engagement in and time on their research (Smith, 1992). Insufficient time to keep abreast with current developments in their fields, preparation of manuscripts for publication consideration, and obtainment of funds for financial support for their research were among the top 11 high stress items identified by the entire sample of Black faculty in Smith’s study (1992). They also believed they experienced more stress than their White counterparts regarding competition with colleagues and the self-imposition of high expectations in performance and career progress.

Black males have reduced chances for success due to the “absence of proper socialization and mentoring” (Rowley, 2000, p. 91). Jones (2000) asserts that these Black male scholars must choose a route that does the most good and least amount of harm to Black people and themselves. Williams and Williams (2006) found that the participants in their study perceived there was a lack of respect for (a) research and scholarship beyond the mainstream, (b) the use of non-conventional research techniques to better address their research questions, and (c) publication in outlets beyond the traditional top-tier journals in their fields. It is necessary to convince senior scholars that this kind of scholarship is legitimate, especially if the research focuses on the lives of marginalized people.

In 2012, there are only 35 science education faculty members of African ancestry in the US professoriate in science education: 7 assistant professors, 20 associate professors, 4 professors, and 4 clinical faculty or research associates. Most are on the faculty of predominantly White universities (32) with a remaining few at Historically Black Colleges and Universities (HBCUs). Many of them are publishing in a variety of academic settings, with several of them having difficulty publishing their work in the premiere scholarly science education journals, which is typically required for promotion and/or tenure.

Since this work began in 2008, some Black faculty members have left the academy and only two have entered the academy. Others have been promoted, but are still relatively few Black science educators teaching and conducting research in the United States. The goal of this
The research study was to understand the teaching and research experiences of Black male science education faculty members in colleges and universities in the US. The seven male participants in this study were chosen from a larger group of 20 participants that included female participants, which has been reported on elsewhere (Atwater, et al., 2012; Johnson, et al., 2012).

This area of research is important to science education because there continues to be a need for Blacks as faculty members in research intensive universities in the US to provide a different perspective in science education teaching and research. Since Black students make up 30% or more of the school population in some states in the US, and are the majority in rural and urban school systems, it is imperative that there are Black science educators to prepare and work with teachers and conduct relevant research so that all students can experience high quality science learning and teaching.

**Theoretical Framework**

Social constructivism is about understanding human knowledge and meaning-making that is created through historically situated social exchange (Au, 1998). Social constructivism as an epistemology is very relevant when it comes to understanding the experiences of Black faculty members. Constructed meanings about their experiences, especially with respect to their interactions in universities and colleges are important in understanding the influence of race and gender in the development of Black male faculty members, especially as science teacher educators and researchers. Using social constructivism, we sought answers to the following research questions:

1. What were the participants’ goals and responsibilities related to teaching and research at their institution and how did race and impact these aspects of their work?
2. What were the challenges and how did the participants address those challenges as a result of their race and gender?

**Methodology**

This study used the case study approach to investigate the experiences of the seven Black male faculty members in order to provide rich descriptions of the participants and their experiences so that themes can be revealed related to the individuality and uniqueness of each case (Hays, 2004; Stake, 1994). Pseudonyms were created for the seven participants to maintain their anonymity. Four forms of data were gathered and used for this study: a demographic questionnaire, scores on the Cross Social Attitude Scale (Vandiver et al., 2002) and the Social Outlook Questionnaire (Boykin, et al., 1997) (see Appendix), and interview transcripts. The interview data were coded by “starting with predetermined categories” (Schumacher & McMillan, 1993, p. 486) such as the participants’ responsibilities, short and long term goals, challenges, and the meeting of these challenges. These categories were based on the research questions. Categorical aggregation (Creswell, 1998) was used as the researchers read through the data set looking for responses to these questions. In organizing the responses, categories were developed for each research question and themes emerged. As the themes emerged, conclusions were drawn. The scores on the Cross Social Attitude Scale (CSAS) and the Social Outlook Questionnaire (SOQ) are provided to better illuminate the participants’ experiences and thoughts.

**Findings**

The seven participants’ scores on the CSAS and SOQ are reported in Table 1. Scores on the CSAS ranged from 78 to 104, with the six subscales having variability across the constructs.
On the SOQ, scores ranged from 180-204, also indicating some participant variability. Connecting these scores to participant interviews led to multiple themes related to participants’ goals and achievements in the academy, as well as their challenges.

Charles and Grant had the lowest scores on both the CSAS and SOQ. Xavier ranked fifth on both instruments. Brad and Ken were fairly consistent in that there scores were comparable on both instruments. Orien and Patrick had the largest variability in scores, interchangeably ranking fourth on one instrument and first on the other.

In their interviews, all seven men mentioned the attempts to clearly delineate teaching, research and service, while also attempting to meld the three areas together in a synergistic manner. For example, Brad stated: “Most successful…if I was doing what I know the university rewards and I spend all of my time, or the bulk of my time, publishing. I actually like to write which would work. However, I actually also like to teach. Actually, I spend quite a bit of time, a lot of time, preparing my class materials. I’m successful in that in the sense that my students say: they learn things, the class is valuable, we learn a lot, thank you. So it’s successful in that respect. It’s not successful in the sense of I cannot rely on that if I wish to make full professor. It won’t happen.” This conundrum is not unique to Black Science Education scholars, but can be exacerbated because of race.

Two other themes that spring from the participant interviews are balance of family and work and overburdened with administrative tasks. Several participants commented on the challenges they faced with family understanding the tenure-track, sometimes leading to strains on relationships. Working on weekends instead of spending time with family was mentioned often. For administration, scholars cited the unwritten expectation to assist the university/school/department with those tasks that are aligned with service, but are also seen as evidence of being a “good university citizen”.

Table 1
Scores on Instruments

<table>
<thead>
<tr>
<th>Name</th>
<th>Total CSAS&lt;sup&gt;a&lt;/sup&gt;</th>
<th>PA&lt;sup&gt;1&lt;/sup&gt;</th>
<th>PM&lt;sup&gt;2&lt;/sup&gt;</th>
<th>PSH&lt;sup&gt;3&lt;/sup&gt;</th>
<th>IEAW&lt;sup&gt;4&lt;/sup&gt;</th>
<th>IA&lt;sup&gt;5&lt;/sup&gt;</th>
<th>IMC&lt;sup&gt;6&lt;/sup&gt;</th>
<th>SOQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brad</td>
<td>90</td>
<td>15</td>
<td>25</td>
<td>5</td>
<td>5</td>
<td>20</td>
<td>20</td>
<td>189</td>
</tr>
<tr>
<td>Charles</td>
<td>78</td>
<td>5</td>
<td>25</td>
<td>5</td>
<td>9</td>
<td>11</td>
<td>23</td>
<td>180</td>
</tr>
<tr>
<td>Grant</td>
<td>78</td>
<td>8</td>
<td>9</td>
<td>16</td>
<td>5</td>
<td>15</td>
<td>25</td>
<td>165</td>
</tr>
<tr>
<td>Ken</td>
<td>86</td>
<td>10</td>
<td>9</td>
<td>5</td>
<td>5</td>
<td>22</td>
<td>35</td>
<td>194</td>
</tr>
<tr>
<td>Orien</td>
<td>104</td>
<td>24</td>
<td>18</td>
<td>12</td>
<td>5</td>
<td>12</td>
<td>33</td>
<td>188</td>
</tr>
<tr>
<td>Patrick</td>
<td>85</td>
<td>12</td>
<td>10</td>
<td>5</td>
<td>5</td>
<td>23</td>
<td>30</td>
<td>204</td>
</tr>
<tr>
<td>Xavier</td>
<td>79</td>
<td>9</td>
<td>11</td>
<td>5</td>
<td>8</td>
<td>26</td>
<td>20</td>
<td>187</td>
</tr>
</tbody>
</table>

<sup>a</sup>Total Score on the Cross Social Attitude Scale (CSAS)
<sup>1</sup>Pre-encounter Assimilation
<sup>2</sup>Pre-encounter Miseducation
<sup>3</sup>Pre-encounter Self-Hatred
<sup>4</sup>Immersion-Emersion Anti-White
<sup>5</sup>Internalization- Afrocentricity
<sup>6</sup>Internalization Multiculturalist Inclusive
SOQ- Score on the Social Outlook Questionnaire
Implications for Research on Science Teaching and Learning

O‘Connor, Lewis, and Mueller (2007) maintain that “education researchers must explore how contemporary social forces nourish the racial knowledge, structures, and practices that sustain and reward everyday racism” (pg. 547). However, we would advocate for science education researchers to investigate how contemporary cultural and social forces feed the knowledge, structures, and practices that maintain the poor quality of science learning and teaching found in US schools. We need research that uses an analytical lens for uncovering the meso- and macro-level forces that legitimize and institutionalize the systematic denial of the access and the privilege of high quality science learning. Such concerns are universal in nature, reaching from America to Africa and beyond.

References


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Appendix
Name: ________________________ (Code) _______________

**CROSS SOCIAL ATTITUDE SCALE**
B.J. Vandiver, W.E. Cross, Jr., P.E. Fhagen-Smith, F.C. Worrell, J.K. Swim, & L.D. Caldwell

**Section 1**
1. Male ___(1)___ Female ___(2)___
2. Age _____________
3. Please indicate your ethnic background by circling the answer that applies to you. Choose only one.

| African (1) | African American (5) |
| Black (2) | European American (6) |
| West Indian/Caribbean Black (3) | Latino (7) |
| Latino Black (4) | Asian/Asian American (8) |

4. If you are currently a faculty member, do you teach ___(1)___ undergraduate ___(2)___ graduates, ___(3)___ both
5. Name of University: _____________________________ 5b. City/State of location of University: ____________
6. What is the ethnic composition of the school listed in #5? Please circle: Mostly Black (1) Mixed (2) Mostly White (3)
7. If you are no longer a faculty member, what is your current occupation? _____________________________
8. What religious affiliation do you hold? State “none” if none. _____________________________
9. How often do you attend religious services? Please circle: Seldom(1) Sometimes(2) Often(3)
10. How important is your religion to you? Please circle: Not Important(1) Somewhat Important(2) Very Important(3)
11. What is the best estimate of your/yearly income before taxes? Circle “Y” for yours and “F” for family.

| Less than $10,000 (1) | Between $30,000 and $40,000 (4) |
| Y F | Y F |
| Between $10,000 and $20,000 (2) | Between $40,000 and $60,000 (5) |
12. How would you describe the primary community in which you were raised? Please circle:
   Rural (1) Suburban (2) Urban (3) Other (4) (provide information) ___(OTHER COMM)___

13. What is the racial composition of the community listed in #12? Please circle: Mostly Black (1) Mixed (2) Mostly White (3)

14. Please check. Are you a United States citizen (1) or a permanent resident of the US (2) or other (4) (provide information) ______ (3) ______?

15. How many ethnic organizations do you belong to? 12 3 4 5 5+

16. What is the highest education level obtained by your mother (or female guardian) and father (or male guardian)? For mother, circle the “M” in the appropriate box; for father, circle the “F”.

<table>
<thead>
<tr>
<th>Education Level</th>
<th>M</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elementary school</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Some high school</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High school diploma or equivalent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Business or trade school</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Some college</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Associate or two-year degree</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bachelor’s or four-year degree</td>
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<tr>
<td>Some graduate or professional school</td>
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</tr>
<tr>
<td>Graduate or professional degree</td>
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</table>

17. How would you describe your family’s socioeconomic status? Please circle
   Poor(1) Working Class(2) Middle Class(3)
   Upper Middle(4) Wealthy(5)

18. How would you describe your current physical health? Please circle.
   Very Poor(1) Poor(2) Fair(3) Good(4)
   Very Good(5)

19. How would you describe your current mental health? Please circle.
   Very Poor(1) Poor(2) Fair(3) Good(4)
   Very Good(5)

Section II
Instructions: Read each item and indicate to what degree it reflects your own thoughts and feelings, using the 7-point scale below. There are no right or wrong answers. Base your responses on your opinion at the present time. To ensure that your answers can be used, please respond to the statements as written, and place your numerical response on the line provided to the left of each question. (No coding; entered as written)

<table>
<thead>
<tr>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Somewhat disagree</th>
<th>Neither</th>
<th>Somewhat agree</th>
<th>Disagree</th>
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<tbody>
<tr>
<td>1</td>
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<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
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169
1. As an African American, life in America is good for me.
2. I think of myself primarily as an American, and seldom as a member of a racial group.
3. Too many Blacks “glamorize” the drug trade and fail to see opportunities that don’t involve crime.
4. I go through periods when I am down on myself because I am Black.
5. As a multiculturalist, I am connected to many groups (Hispanic, Asian-Americans, White, Jews, gays & lesbians, etc.).
6. I have a strong feeling of hatred and disdain for all White people.
7. I see and think about things from an Afrocentric perspective.

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<th>1</th>
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<th>4</th>
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<tbody>
<tr>
<td>Strongly</td>
<td>Disagree</td>
<td>Neither</td>
<td>Somewhat</td>
<td>Agree</td>
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<tr>
<td>Agree</td>
<td>Strongly</td>
<td>agree nor</td>
<td>agree</td>
<td>disagree</td>
<td></td>
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</table>

8. When I walk into a room, I always take note of the racial make-up of the people around me.
9. I am not so much a member of a racial group, as I am an American.
10. I sometimes struggle with negative feelings about being Black.
11. My relationship with God plays an important role in my life.
12. Blacks place more emphasis on having a good time than on hard work.
13. I believe that only those Black people who accept an Afrocentric perspective can truly solve the race problem in America.
14. I hate the White community and all that it represents.
15. When I have a chance to make a new friend, issues of race and ethnicity seldom play a role in who that person might be.
16. I believe it is important to have both a Black identity and a multicultural perspective, which is inclusive of everyone (e.g., Asians, Latinos, gays & lesbians, Jews, Whites, etc.).
17. When I look in the mirror at my Black image, sometimes I do not feel good about what I see.
18. If I had to put a label on my identity, it would be “American” and not African American.
19. When I read the newspaper or a magazine, I always look for articles and stories that deal with race and ethnic issues.
20. Many African Americans are too lazy to see opportunities that are right in front of them.
21. As far as I am concerned, affirmative action will be needed for a long time.
22. Black people cannot truly be free until our daily lives are guided by Afrocentric values and principles.
23. White people should be destroyed.
24. I embrace my own Black identity, but I also respect and celebrate the cultural identities of other groups (e.g., Native Americans, Whites, Latinos, Jews, Asian Americans, gays & lesbians, etc.)
Teacher Perceptions about School, Family and Community Relationships in Relation to Primary School Science Achievement

Malcolm B. Butler1 & John Settlage2

1 School of Teaching, Learning and Leadership, University of Central Florida, USA.
2 Neag School of Education, University of Connecticut, USA.
1 Malcolm.Butler@ucf.edu, 2 John.Settlage@uconn.edu

Purpose of Study
Teachers’ perceptions about the role communities play in the success of students’ formal schooling has been well documented, with several studies in South Africa highlighting such connections (e.g., Bantwini, 2012; Johnson et al., 2000). In addition, researchers have sought to address issues of equity across the various types of schools in the Africa (Ramnarain, 2011) and the US (Lynch, 2001). This study reports on findings associated with the development of an instrument to measure teachers’ perceptions about school, family and community relationships and their relation to student achievement in primary science.
Conceptual Framework
This study was framed by Tony Bryk’s considerable line of research on urban school organization and the associated influences on student achievement (Bryk, Sebring, Allensworth, Luppescu & Easton, 2010). While we align our project with his interests in leadership influences and relational trust, this study concentrates on one of the lesser-studied elements of his larger model: School/Community Ties. Just as was true when Bryk and associates studied Chicago schools, our project is guided and influenced by social capital theory (Coleman, 1988). In brief, individuals and organizations have the potential to develop wealth in the form of networks of support, relational trust, and norms of interaction (Dika & Singh, 2002). Such investments can be “cashed in” to create new opportunities and generate more wealth. Social capital offers a way to study relationships as more than simply the links between individuals. The connections are imbued with social significance and echo the combined power of “form + function” (Smylie & Hart, 1999). Social networks can connect a person within a group as well as across boundaries: we interact with fellow researchers but also have opportunities to step outside our circle as we communicate with school administrators, classroom teachers and policy-shapers. The two forms of networking have been labelled, respectively, as bonding and bridging (Larsen, et al. 2004) and can be represented as the contrast between intra- and inter-group community connections.

Methods
Taking a lead from Bryk and his colleagues (Bryk, et al. 2010), we developed a 200+ item survey developed and provided it to a panel of teachers and principals for validation. The content validation process allowed us to reduce the size of the online survey to 98 items. These items were then piloted in a single school district. From the 130 respondents, our factor analysis revealed reasonable reliability (Cronbach’s alpha ranging from .70 to .91). However, what we had anticipated to be distinct factors began collapsing into unexpected groupings. Less surprising was that several factors were not especially strong. Consequently, we further refined the survey to 80 items using the hypothesized categories shown in Figure 1.

Figure 1. Relationship Items: Constructs and Definitions from the Pilot Study
PROFESSIONAL CAPACITY (13 items)
Professional Development. Influences of professional development on teacher’s sense of competence.
Deprivatized Teaching Practices. Substantive collaborations among teachers about their instruction.
Teacher Commitments to the School. Satisfaction with school as workplace and likelihood of remaining.

SCHOOL/FAMILY/COMMUNITY TIES (9 items)
Teacher Direct Agency. Teacher efforts to connect with families.
Teacher Proxy Agency. Teacher perceptions of family efforts to support education.
Teacher Collective Agency. Teacher use of community as educational resource.
Community Support Services. Teacher awareness of social agency supports for families in need.

SCHOOL CLIMATE (7 items)
School Emphasis on Academics. Attention given to student academic progress.
School Safety and Order. Sense of the emotional atmosphere within the school.

The data source was a convenience sample of teachers within a single school system. Science test scores and student demographic data were also available. Using responses for teachers
from “Upper” schools (e.g., science achievement, after accounting for the proportion of low income students, was in the top third of all participants), we compared their responses to “Lower” schools (e.g., science test performance, after factoring percent of students qualifying for free school lunches, placed them in the bottom third). The emphasis of this paper will be on the nine items associated with School/Family/Community Ties. The other eight factors are being analysed for discussion and dissemination elsewhere in other scholarly venues.

Findings Linked to “School, Family and Community Relationships”
Factor analysis of the 80-item questionnaire produced 9 distinct factors explaining 63% of the variance in responses. Two of the factors seem to focus on relationships between schools, families, and communities. Thus, these two factors will be considered further.

Factor 4. These four items had a reliability of 0.92 and are what we call "Social Services Knowledge." (See Table 1.). Statistically these four items are related and conceptually, they do too. Interestingly, there were no statistically significant differences even though teachers in the Lower third of schools (recall, by science performance after accounting for low income students) ALWAYS rated their knowledge higher than the more science successful schools. Also interesting is that on a Likert scale of 1 to 5, most teachers were right at the midpoint in both the Upper and Lower schools.

Table 1. Factor 4

<table>
<thead>
<tr>
<th>Item</th>
<th>Upper</th>
<th>Lower</th>
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<tbody>
<tr>
<td>78. I know who to contact if the family of one of our students requires assistance with housing.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>75. I know what to recommend to a student’s family that is in need of food.</td>
<td></td>
<td></td>
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<tr>
<td>72. I know how to advise families about finding assistance to deal with the costs of home utilities.</td>
<td></td>
<td></td>
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<tr>
<td>69. I know where to send a student’s family if they are struggling to pay medical expenses.</td>
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Factor 5 – Teacher Direct, Proxy and Collective Agency – also falls within the purview of this report on school/family/community ties. Lost in much of the research arising from Bandura’s self-efficacy theory has been the notion of agency (Lasky, 2005). Bryk et al. (2010) represented this construct as Parent-Community Ties with indications that Epstein’s work on partnerships was especially valuable (e.g., Epstein & Sanders, 2000). Bandura (2002) differentiated among types of agency. Personal (or direct) agency is represented by the work of an individual, proxy agency represents the capacity to influence others to labour on one’s behalf, and collective agency describes a group working together toward a shared outcome. Captured in this combination is more than just individual and/or collective belief; agency also draws from action and self-determination (Deci & Ryan, 2000). However, the theoretical differences among the forms of agency were distilled from teacher responses into what has become Factor #5 in our study.
Clearly, these five items center on Parents and Families, and no other "family" items fell outside of this factor. One item was significantly different between Upper and Lower schools (71. My students' parents and families are committed to supporting education outside of the regular school day.), and another item was very close to being significant (68. Many parents and families at our school have difficulty supporting the science learning of their child.). The patterns are as we might expect: Upper schools felt parents were more committed (#71) whereas teachers from Lower schools perceived parents having difficulty supporting their kids' science learning. And the reliability of items in Factor 5 was solid: alpha = .80.

Table 2. Factor 5

<table>
<thead>
<tr>
<th>Item</th>
<th>Upper</th>
<th>Lower</th>
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<tbody>
<tr>
<td>68. Many parents and families at our school have difficulty supporting the science learning of their child.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>77. Many families of my students have asked what they can do at home to deepen their child's science knowledge.</td>
<td></td>
<td></td>
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<tr>
<td>74. Most families at this school would rather have the school teach their child without any supplemental efforts at home.</td>
<td></td>
<td></td>
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<tr>
<td>80. The majority of families at our school recognize that their efforts at home will reinforce the educational progress of their children.</td>
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<td></td>
</tr>
<tr>
<td>* 71. My students' parents and families are committed to supporting education outside of the regular school day. *</td>
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Discussion and Conclusion

In the summer of 2012, we subcontracted with a commercial company that administered the questionnaire to a nationally representative pool of 500 elementary school teachers across the United States. Analysis of these data will assist us in further refining our online survey in preparation for administration to US primary teachers in the first part of 2013. Qualitative data will also be collected in the forms of teacher and principal interview and focus groups with key community members. We hope to triangulate the multiple data sources to be able to communicate rich stories about our participating schools and their connections to their communities.

Extensive research has been conducted and reported on the general concept of school, family and community ties (e.g., see Gordon & Louis, 2009; Jeynes, 2005), as well as studies focused on other primary school subject areas such as mathematics (Sheldon, Epstein, & Galindo, 2010) and matters such as homework (Voorhis, 2011). However, the research is much less plentiful in accurately describing the connections between this concept and science achievement. We hope that our research will address this knowledge gap for scholars across the world. For the accurate identification of teachers’ perceptions of school, family and community relationships could be a significant step toward addressing the equity and excellence issues in primary science achievement in schools in southern Africa, the US and indeed around the world.
References


***This project is funded by the National Science Foundation of the USA via Grant Numbers 1119349 and 1119359. However, any opinions, findings and conclusions or
recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation (NSF).

**Capturing, understanding and Developing Science Teachers’ Pedagogical Content Knowledge for teaching Concepts of the Nature of Science.**

Andrew Chikochi\(^1\) & Elaosi Vhurumuku \(^2\)

\(^1,2\) Wits School of Education, University of the Witwatersrand, Johannesburg, South Africa.  
\(^1\)mailto:Andrew.Chikochi@wits.ac.za;  \(^2\)mailto:Elaosi.Vhurumuku@wits.ac.za

The processes and practices of science (nature of science) have had an implicit role in science curricular across the world. Teaching and learning about the nature of science (NOS) has become far more explicit, including in the South African school science curricular. The need for explicit teaching has sharpened efforts to understand what knowledge and skills teachers need in order to engage learners in effective learning (Ratcliffe, 2008). I think this is of paramount importance for effectiveness in the teaching and learning process. The construct “nature of science” (NOS) has been advocated as an important goal for students studying science for approximately 100 years (Lederman, 2007). Most recently, NOS has been advocated as a critical educational outcome by various science education reform documents worldwide (e.g., Australia, Canada, United Kingdom, United States and South Africa). The observation that NOS has been a perennial goal of science education, and is now receiving increased emphasis, can be construed to mean that high school graduates, and the general citizenry, do not possess adequate views of NOS (Lederman, 2007). This assertion points out that PCK for teaching NOS and general view of NOS is relatively new and needs further investigation. This may require adequate and correct teacher training on aspects of NOS. Teachers need to be adequately skilled and knowledgeable in order to be able to interpret and deliver the science curricular of any nation. It is from this premise that explicit rather, than implicit, teaching of aspects of the processes and practices of science is now expected in science curricular (variously labeled as ‘how science works’, ideas about science’, ‘nature of science’) presenting challenges in classroom practice (Ratcliffe, 2008).

The researcher believes that explicit teaching of concepts of the nature of science is an important aspect of a rich science curricular. This may be possible if teachers also have adequate subject matter knowledge and well developed pedagogical content knowledge (PCK) for teaching concepts of the nature of science.

Arguments for teacher development have emanated from the perspective that a good knowledge of the nature of science is a pre-requisite and that many science teachers have an unrefined understanding (Lederman, 1992). In this way developmental work has focused on teachers’ understanding (Schwartz, Lederman & Crawford, 2004). However, some research work have shown that there may be links between engaging students effectively and specific teaching approaches rather than just teachers’ understanding of the subject (Bartholomew, Osborne & Ratcliffe, 2004). Such research goes some way to commence to articulate the pedagogical content knowledge (PCK) for teaching the nature of science.

In this research the following questions will be investigated:

1. What pedagogical content knowledge (PCK) and skills do teachers need in order to teach concepts of the nature of science?
2. If PCK can be represented for key science concepts, can it be established for aspects of the nature of science?
3. What tool or instrument can be developed for capturing teachers PCK for teaching nature of science (NOS)?

The following sub-questions will also be explored:

- What constitutes PCK for teaching the nature of science (NOS)?
- What is the influence of one’s worldview on conceptions of nature of science?
- What understandings do teachers need in order to teach about NOS?
- How do teachers develop PCK for the nature of science? Is it related to their knowledge structures for traditional science content?
- How do science teachers teach concepts of NOS?
- Does knowledge of the nature of science improve students’ learning of other science subject matter?

One of the most vexing issues for researching on the teaching and learning of NOS is that NOS can be a moving target. Perceptions of NOS are as tentative, if not more so, than scientific knowledge itself. In this way NOS is analogous to scientific knowledge (Lederman, 2007). The recognition that our views of NOS have changed and will continue to change is not a justification for ceasing to research on this construct until total agreement is reached, or for avoiding recommendations or identifying what is thought student need to know about NOS.

Theoretical Framework

Shulman (1987) first introduced the notion of PCK as a fundamental component of the knowledge base for teaching. PCK, according to Shulman, is what makes possible the transformation of disciplinary content into forms that are accessible and attainable by students. Shulman’s model has been elaborated upon and extended by other scholars (e.g., Grossman, 1990; Magnusson, Krajcik, and Borko, 1999). In this study, we will tap on the transformative model of PCK of Magnusson et al. (1999) that includes interactive components.

Within the various domains of teacher knowledge, understanding of NOS can be considered part of teachers’ subject matter knowledge (SMK) – more specifically, their syntactic knowledge of science, which includes knowledge of the source and justification of scientific knowledge. According to the model of Magnusson et al, SMK influences PCK; however, as Lederman points out, “the relationship between one’s views of NOS, subject matter, and pedagogy remains uncertain” (Lederman, 2007, p. 870).

Methods

It is envisaged that both qualitative and quantitative methodology will be adopted. The aims and research questions outlined may not be usefully addressed by way of either the qualitative or quantitative traditions alone. A mixed method approach may be necessary coupled with some of the most innovative research strategies this approach can offer.

Bibliography:


Indigenous copper smelting as a vehicle for teaching science and technology in Africa

Shadreck Chirikure ¹ & Dieter Arnold ²

¹ Department of Archaeology at the University of Cape Town; ² High School Teacher and Senior Science Advisor, Germany

¹ Shadreck.Chirikure@uct.ac.za, ² LCD.Arnold@t-online.de

One commonly held misconception in the African educational sphere is that there was no science on the continent before colonialism and the associated introduction of the western education system. Thus in the scientific realm, pre-colonial Africa is often not highly regarded because it lacked innovations and notable industries. Unfortunately, this misconception has been extended into the classroom where it is wrongly believed that Africa did not possess any technology that can contribute towards learning the modern concepts of science and technology. In fact, little merit is given to the potential of indigenous technologies as illustrative aids in making science learning easier and more accessible to learners on the continent. And yet, the African past is replete with technological and industrial processes which exhibit the processes of science in action. One such example is provided by the little known process of indigenous copper production which sustained communities for close to two thousand years before the onset of modern mining and metallurgy. The production chain of indigenous copper working is full of scientific principles such as thermodynamics, reduction, oxidation and so on and so on. Furthermore, studying indigenous copper production provides information on resource management strategies and even concepts such as sustainability and sound environmental stewardship. This discussion argues that exploring the process of indigenous smelting is a useful aid in class which helps students to better understand science while appreciating the cultural achievements of their ancestors.
Introduction
Although, the process of mining has a very long history in Africa, in southern Africa, the intentional application of heat to gain metal from copper rich ores only began early in the first millennium AD (Miller and van der Merwe 1994; Killick 2004; Chirikure 2010). A study of the history of technology in Africa shows that human beings started using iron rich ores for bodily decoration as far back as 120 000 years ago. The evidence from localities such as Blombos Cave and Pinnacle Point in the southern Cape amply supports this thinking (Brooks and McBrearty 2000; Hensilhood et al 2002; Marean et al. 2009). About 40 000 years ago, our ancestors were extracting specular hematite using underground methods from the Bomvu ridge in Swaziland. This still remains one of the earliest dated mines in the world.

The archaeological record indicates that despite this very long history of encounters with mining, the earliest intentional reduction of copper ores to produce metal only began around 6000 BC in the Middle East and adjacent regions of Europe. In southern Africa, the advent of copper smelting is associated with the first appearance of black agriculturalists early in the first millennium AD (Phillipson 2003; Pwiti 1996). These ancestral Bantu folks not only kept big and small stock but they cultivated crops such as millet and sorghum. More importantly, these pioneer farmers had the capacity to smelt ores of iron and copper. Not surprisingly, this period is known as the Iron Age. There is however a marked distinction in the way copper and iron were used (Miller 2002). Based on their differences in terms of physical qualities such as hardness, ductility, malleability and the so forth, iron was used for utilitarian chores while copper was largely used for making objects personal adornment such as beads and bangles. Some of the earliest known copper objects were recovered from places such as Broederstroom near Johannesburg in South Africa, Mabveni in central Zimbabwe and Divuyu in Botswana (Miller and van der Merwe 1994).

The technology of pre-colonial copper production was remarkably different from that which is practiced today (Craddock 1995, Bisson 2000; Hauptman 2000). Modern day copper smelting involves acquiring suitable raw materials such as fossil fuel, copper rich ore (sulphide or oxide), the flux (limestone) and air (oxygen). These ingredients are charged into a high temperature blast or reverberatory furnace whose walls are lined with highly refractory materials usually made of clay. During the reduction process, the burners provide exothermic heat that melts the copper ore. After reduction, the slag floats on top of the metal and is tapped away. The copper which varies in levels of purity but is often around 65 wt % purity is also tapped and transferred to a converter furnace.

In pre-colonial times, raw materials such as the copper ore (mainly oxide ores), fuel (charcoal), and air (supplied by bellows) were charged into comparatively small charcoal driven furnaces. The firing of the furnace initiated redox reactions which resulted in a puddle of metal forming at the bottom while the slag floated on top. Because the copper had occluded charcoal and other impurities, it was processed in crucibles and cast into ingots of different varieties (Bisson 2000). The ingots were then processed to produce the desired objects. After the process of smelting, the remains from the production chain included slag, remnant furnaces, broken tuyeres and even finished products. Because they are products from high temperature processes, these remains contain partial histories of the processes which they have undergone. Not surprisingly, they form the staple of a sub-discipline of archaeology known as archaeometallurgy.


Indigenous copper smelting in Africa

When compared to metals such as iron (Fe) which are abundant in the Earth’s crust, the geological distribution of copper is fairly limited (Chirikure 2010). As such, unlike iron reduction which was widespread in the Iron Age (last two thousand years), the smelting of copper was mostly restricted to few only those areas with economically exploitable ore mineralization. Some of the most common examples of pre-colonial copper working include the Phalaborwa and Musina areas of South Africa (Miller et al 2001), the Tati area of Botswana, the Hurungwe area of Zimbabwe and the Copper belt region of central Africa. In West Africa there is evidence of indigenous copper working in Niger, Nigeria and Mauretania (Killick 2004). The available evidence points to the fact that pre-colonial southern African copper smelters mostly exploited oxide ores such as malachite and azurite (Miller 2002). There is very little evidence that sulphide ores such as chalcopyrite and pyrite were exploited in the sub-continent. The exploitation of sulphide ores usually required a stepped up process in which the ore was heated in an oxidizing atmosphere (roasting) (Craddock 1995). This produced a material known as matte. This matte was then reduced in furnaces (Hauptman 2000). Occasionally, some copper smelters in central Africa roasted the ores before smelting (Bisson 2000). Elemental analyses of copper objects from southern Africa have indicated that they contain very little sulphur as an impurity (Miller 2002).

Indigenous copper smelting: raw materials

The raw materials essential for pre-colonial copper production comprised of the ore, carbonaceous material (charcoal), and clay for making furnaces and blow pipes and bellows for pumping the air that sustained combustion. Geologically, most copper bodies started as copper-iron sulphide materials (Bisson 2000). These were leached and converted into copper carbonates and iron oxides at the Earth’s surface. It is these carbonate ores such as malachite (CuCO3.Cu(OH)2) which were exploited at localities such as Lolwe Hill at Phalaborwa. Charcoal was typically obtained from hard woods which generated a lot of heat and less in terms of ash. The clay was important for building the combustion chambers for reduction. The furnaces that were used to smelt in pre-colonial Africa differed from area to area and region to region.

The most common furnace types are bowl furnaces which consisted of a hole cut into the ground and shaft furnaces which had a tall column standing on the ground. The bowl furnaces seem to be used in areas adjacent to those where shaft furnaces were used. Thus those who used them were aware of their advantages for example, it seems that it takes a short amount of time to produce metal in them. Bowl furnaces were used at Thakadu in north eastern Botswana, while the Venda who lived nearby in modern South Africa used low shaft types (Chirikure 2010). This mixture of furnace types in a single region has also been recorded in central Africa, where neighbouring groups used different furnace types for copper reduction (Bisson 2000). As copper was generally not smelted in natural draft furnaces, bag and pot bellows were very important in copper smelting.

Copper reduction in pre-colonial furnaces

When all the ingredients were collected, the process of copper smelting began. Conditions at the top of the furnace were more oxidizing, when compared to the reducing atmosphere at the bottom of the furnace (Craddock 1995).

Chemistry of copper smelting

The air was introduced at the bottom of the furnace. This was also the hottest zone. Continual combustion raised temperatures to about 800 °C, while the reaction between oxygen from the
bellows and the burning charcoal, produced carbon monoxide through the following chemical reaction:

\[ 2C + O_2 \rightarrow 2CO \]

As the charge consisting of ore and charcoal drifted down the furnace, the carbonate ore reacted with carbon monoxide. Metallic copper and carbon dioxide were produced. This is explained in the following equation:

\[ \text{CuCO}_3 \text{Cu(OH)}_2 + 2 \text{CO} \rightarrow 2\text{Cu} + 3\text{CO}_2 + \text{H}_2\text{O} \]

Another oxidizing reaction combined the gangue material in the ore with part of the copper to form a slag. Often, a flux such as iron oxide was added to help in mopping away the impurities (Miller et al 2001). The slag consisted of the impurities in the ore, the melting furnace wall, the fuel ash and part of the ore (Bachmann 1982). As the slag was lighter than the metal, it floated on top. The slag also formed a cushion which prevented the re-oxidation of the metal. The slag was removed in two ways. The first involved the scooping of the slag from the furnace using a side opening while the second involved the draining or tapping of a viscous slag from the furnace using a tapping hole (Bisson 2000). The molten metal formed a pool at the bottom and upon solidification, assumed the shape of the bottom of the furnace (see Figure).

Because the metal from the furnace was not hundred percent pure, it was refined in crucibles. Charcoal and lumps of metal were charged into a crucible which resembled domestic pottery. Air was introduced through the bellows. As the heat continued to increase, the copper became molten and settled at the bottom while the slag floated on top (Miller 2002). The slag was then skimmed off leaving the pure metal. Although copper could become liquid under furnace conditions in pre-colonial times, it was rarely cast into usable objects. Often, small pieces of metallic copper were molten in crucibles and poured into ingot moulds to produce different types of ingots. The ingot moulds ranged from permanent templates which were inscribed in the ground to portable moulds. For example, permanent templates were used by the Venda of South Africa and the Bushongo of Congo (Chirikure 2010). Portable moulds which were either carved in stone or molded with clay were also common across Africa (Cline 1937). The Kaonde of Zambia made their moulds using wet ash while clay ones were used by the Nupe of Nigeria. The Shona of Zimbabwe used steatite to make x-shaped ingot moulds such as those recovered at Great Zimbabwe.

With casting, smiths could make an object with very little effort, through pouring the metal into the mould and allowing it to become solid. Typical cast objects include bangle blanks, x-shaped ingots, and musuku and lerale ingots. The musuku and lerale ingots which were made by the ancestors of the Venda and Ba-Phalaborwa people in modern day South Africa were very valuable and could be exchanged for cattle or wives in bridewealth transactions.

**Case studies of copper smelting in Africa**

There are so many farming communities that reduced copper ores to gain metal from them. Copper was in most cases used for making objects for personal adornment. At times it was alloyed with tin to produce bronze. According to Herbert (1984), copper’s reddish color meant that it was valued more locally when compared to gold. This significance was almost universally applicable from the Venda of South Africa to the Kaonde of central Africa and even beyond.
Copper smelting among the Venda of South Africa

According to van Warmelo (1940), the Venda people who occupied part of what is today the Limpopo Province of South Africa were well known copper smelters. The fingerprints of their copper working activities are widely distributed on the landscape and range from ancient mines to collapsed furnaces and piles of slag (Miller and van der Merwe 1994). The Venda copper smelting process began with collecting the malachite copper ore which was sourced around Musina and other places (Stayt 1931). Subsequently, the smelters then collected the clay for building low shaft furnaces. Charcoal was obtained from the dry distillation of hardwoods such as the combretum species. The process of furnace construction involved digging a shallow 45 centimeters wide hole into the ground. The hole was lined with clay and ashes. Subsequently, a half metre high shaft was constructed. This superstructure was occasionally strengthened with stones. An inlet was left at the bottom of the furnace to insert a single tuyere. When enough raw materials were gathered, the process of smelting was initiated. The incomplete combustion of carbon produced carbon monoxide which reduced the ores to metal while the impurities combined to form slag. For reduction to proceed to completion, bellows were pumped continuously over a sufficient duration. After about two to three hours of smelting, a puddle of metal settled at the base of the furnace and was removed for the process of refining. The slag from the furnace was scooped outside. Sometimes, the copper ores contained some iron oxides which were also reduced together with the copper. This produced an unusable alloy of iron and copper known locally by the Venda as Musina. Thus the process of successful smelting required knowledge of the geology and how to separate the iron oxides from the copper carbonates. Failure to achieve this result in the production of an unusable iron-copper alloy (Miller et al 2001).

The Venda process of refining copper was fairly simple. Lumps of copper were re-melted in a 20-centimetre diameter crucible which was in the form of a domestic pot. The bellows provided the blast of air. The Venda made their ingot moulds by pressing thin sticks into the soil. These sticks were one or two centimetres in diameter. At one end of the mould, they carved a small hollow to make a small head. This sometimes had short arms sticking out of it. They then poured molten metal from the crucible into the mould. This created the lerale ingots, which were shaped like golf clubs. In some situations, the Venda pressed the end of a large stick into the sand to make a pattern. This created a cylindrical hole with a flat bottom. Then they pressed the ends of smaller sticks into the bottom of this hole to form a pattern of smaller holes, which were usually parallel lines. When it was overfull with copper, the mould produced musuku ingots, which looked like the top of a hat (see Figure). Musuku ingots are short cylinders with studs on the one end and an irregular flange or surface, where the copper had spilled out of the top of the mould. These ingots were highly valuable such that they could be exchanged for cattle, wives and exotic commodities such as glass beads (Stayt 1931).

Copper smelting among the Sanga, Luba and Yeke of the Democratic People’s Republic of Congo

The Sanga people, who lived in what is now the Democratic People’s Republic of Congo, smelted malachite ores in a shaft furnace that was one and three quarter metres tall and was one metre wide at the base (Bisson 2000). The furnaces had a shallow dip at the bottom where the metal was collected. Drum bellows supplied the air into the furnaces while charcoal was used as a fuel. At the beginning of the process, the furnace was charged with charcoal and malachite. At the end, the rake channel was opened and the metal was taken off without destroying the furnace walls. The copper metal from the smelt was refined in a
refinery which was the same size as the smelting furnace. The refinery was built on sloping ground and laid with carefully compacted wood ash. Four pairs of bellows provided the air blast and at the end of the process, the clay lining on the refinery was broken down. This helped the metal to flow down the slope into cross-shaped ingot moulds which had been lined with ash. The ingots weighed from just over ten kilograms to as much as 50 kilograms.

The copper smelting practiced by the Luba of the Democratic People’s Republic of Congo is an interesting process. Molten metal from the smelting furnace was tapped directly into ingot moulds, to produce ingots which then needed to be refined further. Luba furnaces were built out of moulded clay and were almost 0.5 metres high with an inner diameter of between 30 and 40 centimetres. The furnace had two vents with tuyeres. Furnaces were built on sloping ground because they were designed so that metal could be cast as soon as it was reduced. They also had channels which were connected to numerous but shallow x-shaped moulds made of wood ashes. To begin with, the malachite copper ore was heated to remove moisture outside the furnace. This is a process known as roasting. While it was still hot, the ore was charged into the furnace. As the smelting continued, the changes in the colour of the exhaust fumes helped the master smelters to decide when to open the channel. This was done so that the reduced metal could be tapped into the ingot moulds. After each mould was filled, the smelting assistants changed the position of the furnace channel until all the moulds were filled with metal. Subsequently, the process was started all over again. This semi continuous process resulted in the production of a large number of crosses which were traded over wide distances (Chirikure 2010).

The Yeke people of central Africa live along the borders of both what is now the Democratic People’s Republic of Congo and northern Zambia. European travellers who visited the area between the late 19th and early 20th centuries were surprised by the great skill and professionalism the Yeke people used to work copper (Bisson 2000). Their copper smithing, however, was only done during certain seasons when they did not need workers for important activities such as agriculture. The Yeke copper smithing forge looked very much like the smelting furnace. The only difference was that it was smaller than a furnace. The forge was just less than 0.5 metres high and a quarter of a metre wide. A single pair of bellows provided the air essential for combustion. A crucible, which was lined with ash, was put at the bottom of the forge. It was filled with charcoal to the top. Close to five kilograms of charcoal were loaded onto the forge. After 1.5 hours of constantly pumping the bellows, the copper started to drip into the crucible. In the last stage of the process, smiths broke down the forge and poured the molten metal into an ingot mould. Each ingot weighed on average between two and three kilograms.

The Sanga, Luba, Yeke and Kaonde peoples occupied territory in the world famous Copper belt area and Katanga region of Zambia and DRC respectively. They traded their metal with regions afar. For example, characteristic x-shaped ingots that were likely made in central Africa were recovered at Great Zimbabwe demonstrating possible connections between these areas in the past.

Ingombe Ilede: the case of an archaeological site rich in copper
Because finished copper objects were used and re-used, it is not always possible to find finished objects in the archaeological record. The archaeological site of Ingombe Ilede which is located in Zambia on the margins of the Zambezi River is a very illuminating example. Ingombe Ilede was discovered during the impact assessment for the soon to be constructed Kariba Dam in the early 1960s (Fagan et al 1969). The site consists of several burials
mounds, with incredible examples of a collection of funeral objects. The most outstanding discoveries were those of finished copper objects and copper smithing tools. For example, the Ingombe Illede burials had a range of copper smithing objects including a complete set of wire drawing equipment – the plates, pincers and tongs. The most amazing discovery was copper objects, which showed all the stages in the wire drawing process. For example, there were lumps of unused x-shaped copper ingots, lumps of copper metal, a wire draw plate and a copper bar. These formed part of the first stages of the wire drawing process. Finished copper wire, which was part of funeral objects, was also found. This discovery has helped researchers to understand the kinds of tools which copper smiths used.

The x-shaped copper ingots from Ingombe Illede are similar to those made in central Africa by the Sanga, Yeke and Luba communities, among others. As mentioned already, these ingots have been found as far south as Great Zimbabwe. This shows that a huge area was linked through a complicated system of trade and exchange. Wire draw plates, similar to those of Ingombe Illede, were also recovered in the Great Enclosure at Great Zimbabwe. This is further evidence to support the idea that wire drawing was used through most of eastern and southern Africa.

**Discussion: bringing indigenous copper smelting into science and technology education**

From the foregoing discussion, it is clear that indigenous technologies such as copper working are a reservoir for illustrative aids with a huge potential in teaching science and technology in Africa. The process of modern copper production is in many cases similar to that practiced in the past. The only difference appears in the scale of metalworking. The reduction of copper in the past just as in the present is based on similar thermodynamic and reduction principles. It therefore means that one can use indigenous copper smelting to discuss these concepts in classrooms. One good opportunity is on the chemical equations that illustrate the reduction of ores to make metal and oxidation of gangue materials to form slag. These reactions are all thermodynamic activities which is at the heart of metallurgy and materials processing.

Furthermore, the process of raw material acquisition, particularly the ores requires prospecting. This prospecting demands good knowledge of the local environment. In the past, metalworkers used the presence of certain soils and tree types to identify sources of ore. Interestingly, most modern copper mines that are in operation in Africa are sited on pre-colonial mines. A good example is the open cast mine at Phalaborwa which at one time was the largest open pit mine in the world. Lolwe Hill which has since been mined out was an important source of copper in pre-industrial times. Indeed, the archaeologists who studied Lolwe Hill before it was destroyed by modern mining encountered ancient galleries and adits which demonstrated the presence of underground and open cast mining. Even today, underground and open cast methods of mining are still in use. This demonstrates the fact that examples of indigenous technologies such as copper working can be used in teaching modern science and technology.

More importantly, the process of smelting involved not just the reduction and oxidation principles but also the transformation of matter from one stage to another. Thus ores, which are rocks and solids were charged into a furnace and through thermal reactions transformed into liquid metal and a viscous slag. The elemental was separated from the other materials through reduction which also ‘breaks’ the chemical bonds. The elemental metal will be highly reactive such that if it gets into contact with oxygen, corrosion will take place. The changes in state of matter from solid to liquid and solid can also be plotted on simple phase
A diagram which will also indicate the temperatures at which certain phases form. All these are important scientific principles that can be taught using the case of indigenous copper.

Furthermore, the process of smelting required charcoal to be made from trees. Pre-colonial miners and smelters were very knowledgeable about the need to conserve the environment. Not every tree species was exploited, but only those that had the necessary qualities. This prevented deforestation in places such as Musina where large scale copper production was practiced.

**Conclusion**
A number of case studies reveal that Africa had the capacity to process metals such as copper before the onset of modern industrial methods. The process of raw material acquisition required a detailed knowledge of the landscape and resource distribution for it to be successful. That most modern copper mines are sited on pre-industrial copper smelters does indicate the success of pre-colonial industries. The most important observation is that the principles of redox and exothermic reactions that took place in pre-industrial furnaces are the same as those that take place in modern furnaces. Thus indigenous copper smelting can be an important aid in teaching science and technology in schools.

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**Differential Science Performance of South African Learners in TIMSS 2003**

**Mee-Ok Cho, Vanessa Scherman & Estelle Gaigher**

*Faculty of Education, University of Pretoria, South Africa*

meeokcho@yahoo.com; vanessa.scherman@up.ac.za; estelle.gaigher@up.ac.za

South Africa has been frustrated by its poor performance in consecutive administrations of TIMSS, for both mathematics and science (Reddy, 2006). Specifically for science, South Africa was ranked last amongst 49 participating countries in TIMSS 2003, scoring 244 (6.7) compared to the international average of 474 (0.6) (Martin, Mullis, Gonzalez & Chrostowski, 2004). The poor performance of developing countries has often been attributed to poor infrastructure and teacher quality (Reddy, 2006). This is particularly true for South Africa, as the legacy of the Apartheid system has resulted in unequal distribution of resources (Howie, Scherman & Venter, 2008). In the current paper, we report on secondary analysis of the rich contextual data captured by TIMSS to obtain a broader view of the effectiveness of science.
education in the country. The following question is addressed: Which factors influenced differential performance in South Africa’s TIMSS 2003 results for science?

A model for the effectiveness of science education was used as conceptual framework. This model was developed previously in a larger study (Cho, 2010) by refining existing school effectiveness models and including factors related to science achievement. The refined model is based mainly on Creemers’ model (Creemers & Kyriakides, 2006) with the key concepts time, opportunity and quality. Some organizational characteristics in Scheerens’ model (1997), such as resources as input or climate are also included.

The data was explored to identify factors that may affect achievement in science in South Africa according to those described by the conceptual framework and the TIMSS questionnaires. To reflect the hierarchical structure of the data influencing student achievement, a multilevel approach was adopted. In the analysis, school and classroom levels were combined, creating in a two level model to reflect factors at student level and at class/school level. Data from the student (n=8952), teacher (n=255) and school questionnaires (n=255) were analysed in conjunction with achievement data by means of factor, reliability, correlation and multilevel analysis. A total of 27 variables were identified for the multilevel modelling: nine variables at the student level, 10 variables at the class level, and eight variables at the school level. The MLwiN software was employed, resulting in an intercept of the null model at 245 (7.223), which is almost equivalent to the science achievement in TIMSS 2003. Factors at class/school level influenced performance more than student level factors, with 59% of the total variance in science achievement occurring at class/school level, and 41% at student level. This is the opposite of what is observed in the developed world (O’Dwyer, 2005) and consistent with previous research on mathematics performance in South Africa (Howie, 2002).

At student level the strongest predictor of science achievement is attitudes towards science. This result is in agreement with previous findings reported in the literature (Chang & Cheng, 2008). Results indicated that a student who is extremely self confident in science may score 74 points higher than a student with low self confidence. As regards social context, it was revealed that factors concerning ethnicity, such as ‘born-in country’ and ‘language at home’, had an influence on science achievement. Factors like ‘watch TV or video after school’ and ‘home possession’ also turned out significant.

At classroom/school level, the strongest predictor of performance was safety in school. A student who thinks that he attends a school where less bullying occurs may perform better by 130 points. Other climate-related variables such as ‘percentage of disadvantaged students’ and ‘severity of low morale’ were also significant. With regard to resource variables, ‘physical resource for science’ and ‘number of students in class’ turned out to have significant effects. A science curriculum variable, ‘textbook use’, was statistically significant. Among the teacher background variables, there were two variables that were statistically significant, namely ‘completion of the first degree’ and ‘teacher age’. Regarding school principals, there were two variables contributing to student achievement with statistical significance, namely ‘administrative duty’ and ‘supervising or evaluating teachers’.

In conclusion, the large impact of schools and small influence of student background on achievement found in the current study is in agreement with the trend in developing countries (Heyneman & Loxley, 1983). Furthermore, the study emphasizes the urgent need to improve
material resources, school climate, and teacher background to improve science performance in South Africa.


**Limitation of effective formative assessment in primary science lessons**

*Margaret Cornelius¹, Audrey Msimanga², Anthony Lelliott³*

¹Department of Education, Gauteng Province; ²&³ School of Education, University of Witwatersrand, Johannesburg.

**Introduction**

Language is one of the major challenges to South Africa’s vision for quality education for all. Most South African classrooms are multi-lingual with teachers teaching learners from diverse language backgrounds in a language that is neither the teachers’ nor the learners’. In this context, formative assessment could be used in creative ways that may be beneficial to both teachers and learners, in combating the alienation of learning from teaching that sometimes happens in multi-lingual situations. Teaching and learning are entwined with language, this implies that both the educator and the learner need to communicate and understand each other. Formative assessment allows the teacher reflect on the effectiveness of their teaching and how to modify teaching for effective learning. Black and William (1998, p10) define formative assessment as “all those activities undertaken by teachers, and/or by their students, which provide information to be used to modify teaching and
learning activities in which they are engaged”. According to Boaler and Brodie (2004), formative assessment makes both educators and learners accountable in the learning process.

Formative assessment is an active process that takes place during the lesson as the educator questions learners to assess their understanding (Boaler & Brodie, 2004). The feedback teachers receive from the learners indicates whether the teaching process is appropriate for learner understanding of the content. This paper highlights some language issues relating to formative assessment in multi-lingual Grade 5 Natural Sciences classrooms. We present an analysis of teachers’ responses to a questionnaire on the questions they used for formative assessment and why they used them.

Research Methodology
In the initial research a mixed methods approach was used to obtain some quantitative data through a questionnaire designed to gather teachers’ perceptions of formative assessment. From the thirty-three teachers who responded to the questionnaire two volunteered to have classroom observations conducted in their classrooms. The qualitative data was collected as audio recordings of six lessons, three for each teacher. The audio recordings were transcribed and analysed using Anderson’s Bloom Taxonomy (Anderson 2005) to categorise the questions in terms of knowledge types targeted as well as the cognitive level of the question. The results are reported in relation to trends obtained from the questionnaires and the teachers’ practices of formative assessment.

Results and Discussions
Of the thirty-three respondents to the questionnaire, eighteen teachers reported that they used English as the only method of communication. The other teachers used English in conjunction with other languages such as Setswana, Afrikaans, Sepedi and Northern Sotho. This is in contrast to the fact that the learners spoke more than the five languages reported. Learner languages included Setswana, Sepedi, Isizulu, XiTsonga, South Sotho, Pedi, Venda, Ndebele, English, Afrikaans, Swati and other languages like Portuguese and French. In the classrooms where lesson observations were conducted, both teachers taught in English, which was not their primary language.

In response to the question about factors that influenced their questioning, teachers indicated that the language of Science, the introduction of English in Grade 4 instead of Grade 1, the language of learning and teaching (LoLT) (differing from home language), the poor reading and writing skills of learners and the lack of requisite vocabulary all influenced their questioning negatively. Teachers indicated that language was a limitation to effective formative assessment in their classrooms. They said that they used lower order questions because their learners were not proficient in English; the language of instruction.

We also draw evidence from classroom observations in two of the teachers’ classrooms. The transcripts of the lessons indicate that very little code switching was used to explain concepts during the lessons and teachers insisted that learners should respond in English. As the teachers realised that the learners were not able to express themselves in English they responded by asking simpler questions that allowed learners to answer according to their language competency. Often learners passively chorused answers to questions of low cognitive demand. Teacher questioning elicited mostly one word or short answers from learners and usually after teachers had to repeat or rephrase the question. In order to accommodate their poor English skills teachers sacrificed quality of questioning and posed mostly lower cognitive level questions in the lessons. One teacher made an interesting
comment that using different types of questions would only be effective if the questions were posed in the learners’ mother tongue. Because of the language challenge few learners asked questions and the lessons tended to be teacher centred. Further research is implicated into the role of language in formative assessment and how to equip teachers with creative questioning strategies for formative assessment in multi-lingual classrooms.

Conclusion
Teachers in our study predominantly used the English language in formative assessment, which seemed to defeat the purpose of formative assessment, which seeks to determine how learners learn and how to modify teaching to improve teaching. Learners were unable to express themselves and teachers had difficulty assessing learning. Within the constraints of using a second language for instruction, teachers need to be equipped with diverse strategies for assessing the learning of Natural Sciences.

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References

Towards a characterization of Southern African Indigenous knowledge: The production of indigenous knowledge in Mozambique and South Africa

Alberto Cupane
Physics Department, Pedagogical University, Maputo – Mozambique.
acupane@hotmail.com

This paper based on a study called “systematic review and documentation of IKS research in Mozambique and South Africa” focuses on the process and results that are being produced through a research questions: (1) Is there a IKS produced in Mozambique and South Africa (2) What IKS and how much have been produced in Mozambique and South Africa. The focus of the study is to do a systematic analysis of IKS articles written only in relation to South Africa and Mozambique. The database compilation includes only articles related to IKS produced in and from South Africa and Mozambique. Articles from neighbouring countries (Zimbabwe, Namibia, Lesotho) and from all over the world that provide background for the IKS body of knowledge are referred as links to the database. The emergent research question in this paper comes from my background in which I do question how fair is to (i) distinguish IKS from the general body of knowledge and (ii) discriminate indigenous as special people (Cupane 2007) that even have an international day.
The fact that, in general, each of us do not consider him/herself as belonging to indigenous community is also shown by the message of UN secretary General this year. Indigenous voices are recounting compelling stories of how they are combating centuries of injustice and discrimination, and advocating for the resources and rights that will preserve their cultures, languages, spirituality and traditions. They offer an alternative perspective on development models that exclude the indigenous experience. They promote the mutual respect and intercultural understanding that is a precondition for a society without poverty and prejudice. (27 July 2012, UNIC/PRESS RELEASE/093-2012)

Hence my main aim in this paper is to answer the emergent question: How do we (indigenous) promote ourselves when we do distinguish ourselves from the others? What I have been learning through participating in “systematic review and documentation of IKS research in Mozambique and South Africa”

I have argued that the terms “indigenous” and “local-knowledge” are not so helpful because everyone in the planet share a knowledge in given place and this does not mean that knowledge belong to the place but as always to the people. My suggestion was to use local-indigenous knowledge, the term that I am using to answer my driving research questions.

Promotion can be understood as reinforcement of the progress, evolution, or reception of something; maintenance. Regarding to this understanding there is no doubt that we do need to distinguish local-indigenous knowledge for its promotion. My main problem is that local-indigenous knowledge is not disconnected to other forms or ways of knowing and by putting in evidence what are our aims?

The fact that local-indigenous knowledge cannot be separated by other forms of knowing is also showing by part of data that we collecting in our project.

<table>
<thead>
<tr>
<th>SIKS SYSTEMATIC REVIEW – MOZ-RSA</th>
<th>Title</th>
<th>Aim</th>
<th>Method</th>
<th>Findings</th>
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<tbody>
<tr>
<td>An assessment of two Carpobrotus species extracts as potential antimicrobial agents</td>
<td>Shows antibacterial activities of the two species</td>
<td>Quantitative methods</td>
<td>Antibacterial activities of the two species is confirmed</td>
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<td>The perception of traditional healers of cervical cancer care at ga mothapo village in Limpopo province</td>
<td>Explores and describes the perceptions of traditional healers of cervical cancer care</td>
<td>Qualitative - interviews</td>
<td>It provides a strong evidence of traditional healers quality care on patients with cervical cancer</td>
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<tr>
<td>South African primary school teachers scientific and indigenous conceptions of the Earth-Moon-Sun system</td>
<td>Understanding primary school teacher’s scientific and indigenous conceptions of astronomy-Earth-Moon-Sun system</td>
<td>Qualitative -phenomenographic approach</td>
<td>Teachers hold indigenous conceptions of E-M-S system related to African traditional agricultural practices.</td>
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<td>Is primitivism indigenous to Africa?</td>
<td>Discuss the merits and the challenges facing the ongoing debate about demarcation and exclusion</td>
<td>Qualitative -literature review</td>
<td>Argues about the need of an integrative approach, and how the indigenous language development is</td>
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The data shows that local-indigenous knowledge is the knowledge that it distinguishes itself by the word “indigenous”

**The incorporation of the United States ‘Science Made Sensible’ program in South African primary schools: a collaborative partnership**

Rian de Villiers¹, Tiffany Plantan² & Michael Gaines³

¹ Deptment of Science, Mathematics and Technology Education, Faculty of Education, University of Pretoria, Pretoria, South Africa; ² Department of Biology, University of Miami, Florida, United State; ³ Department of Biology, University of Miami, Florida, United States

¹ rian.devilliers@up.ac.za, ² tiffany@bio.miami.edu, ³ mgaines@bio.miami.edu

**Introduction**

The Science Made Sensible (SMS) program began as a partnership between the University of Miami (UM), Florida, USA, and some public schools in Miami. In this program, postgraduate students from UM work with primary school science teachers to engage learners in science through the use of inquiry-based, hands-on activities. Due to the success of the SMS program in Miami, it was extended to South Africa.

The goal of SMS in South Africa was to learn about South Africa’s educational system, to develop inquiry-based natural sciences lesson plans in collaboration with South African primary school teachers that could be used in both Miami and South Africa classrooms, and to share pedagogical techniques used in the classroom.

In August 2011, the SMS program director, two SMS postgraduates, and two SMS primary school science teachers participated in SMS in South Africa. The team collaborated with Grade 6 and 7 natural sciences teachers at two public primary schools in Pretoria, Gauteng Province. The teachers worked together to create and implement inquiry-based, hands-on lesson plans in the classroom. At the end of the program, participating learners, postgraduates, and teachers were evaluated. The SMS program is based on a hands-on/minds-on learning model (Haury & Rillero, 1994). The premise of the model is that students who are physically involved in science are more likely to be mentally engaged. The purpose of this study is to determine how successful the team was in reaching the SMS goals in South African schools. In addition to reporting the learners’, teachers’, and postgraduate students’ views regarding the SMS program, similarities and differences between USA and South African teaching techniques in the classroom are discussed.

**Research questions**

The following are the research questions that guided the data collection and research methods:

- Was the USA team successful in reaching the SMS goals in South African schools?
- What were the most successful, and least successful, elements of the program as evaluated by the learners, teachers, and postgraduate students?
• What were the benefits of the SMS team’s inquiry-based approaches in the natural sciences classrooms?
• What are the similarities and differences between USA and South Africa’s teaching techniques in the natural sciences classroom?

Research methodology
One-hundred ninety-five learners at two primary, public schools in Pretoria, Gauteng Province, South Africa participated in this study. Three Pretoria Grade 6/7 natural sciences teachers were involved in the study: three teachers at School A and two teachers at School B. The SMS teams in Schools A and B consisted each of one Miami Grade 6/7 science teacher and one UM postgraduate student. The USA SMS team developed various lesson plans in collaboration with the South African teachers and shared pedagogical techniques used in the natural sciences classrooms.

The learners’, teachers’, and postgraduate students’ questionnaires (written in English) contained both open-ended and closed-ended questions. Ethical clearance was approved by the Faculty of Education Research Ethical Committee. The responses yielded demographic data as well as information on the learners’, teachers’, and postgraduate students’ personal experiences of the SMS South African program. In the case of qualitative analysis, open-ended questions were analyzed by means of open-coding. The responses to the closed-ended questions were analysed using frequency counts. The questionnaires’ content validity was validated by two experts in the field of sciences, who are competent to judge whether the questionnaire reflects the content domain of the study. The reliability of the learners’ questionnaire was tested using Cronbach’s alpha coefficient.

Findings and discussion
From the results, it appears that the learners generally are in favour of linking the SMS team in their educational environment. The majority of the learners of both schools responded positively concerning the involvement of the SMS team in their schools.

The South African teachers agree that having Miami postgraduate students and teachers in their classes was a constructive experience. They contended that they gained knowledge of the educational system in the USA by interacting with the SMS team. Furthermore, they said that they will be able to incorporate some of the SMS activities into their classroom. The Miami teachers were in agreement that their experiences teaching with South African teachers were positive. The Miami teachers agreed that their teaching experience in South Africa gave them new insight into how to make science more sensible in Miami. Furthermore, both teachers felt they benefited professionally from teaching in the South African science classrooms. The Miami teachers observed numerous differences between the school systems that were enlightening and provided great learning opportunities for them as teachers. They were most impressed by the differences in the sense of community, curriculum, and methodology between the Miami-Dade County Public Schools (MDCPS) and the South African schools.

The postgraduate students were in agreement that their collaboration with South African teachers was a fruitful learning experience. Although they are not professional teachers, they agreed that their teaching experience gave them a greater appreciation for the common challenges in teaching in Pretoria and Miami schools.

Another observed difference was the educational curriculum, or the documents that outline exactly what the students are to be taught. In MDCPS, the curricula are very structured and
specific, and the expectations of what teachers are meant to teach are very clear. Those documents are made by the school board and distributed to all public schools in America. The curriculum in South Africa was vaguer.

Lastly, the methodology between science instruction in Miami and South Africa is very different. The curriculum used to deliver instruction in South Africa relied heavily on memorization. In Miami the instruction is much more process-based. Miami teachers require learners to think analytically, and the goal is for learners to understand systems of science.

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Quality Educational Assessment in a Changing world: Trends and Challenges

Dr. Betty T. Dlamini,
Faculty of Education, University of Swaziland, Swaziland.
betty@uniswa.sz

Introduction
Education, both nationally and globally is under unprecedented pressure to respond to changes in all areas of life. Factors having an impact on education changes and circumstances that have an impact on education are mainly global in nature. These have been described as the Globalisation phenomenon. Globalisation is defined by Zhao (2009) as reality that eliminates geographic, economic, cultural, political, social and educational distance between and among individuals, corporations, institutions or nations of the world. Similarly Litz (2011) say it is about harmonisation of the same issues. Meanwhile Altbach, Reisberg and Rumbley (2009) describe Globalisation as a reality that is shaped by this harmonised structure for nations across the world and is propelled by the increased development in technology. According to Marx (2006), it not possible to know what the future holds for education. It is therefore critical that learners today be given skill they will need in twenty, thirty or fifty years-time (Rotherham and Willingham, 2009). This alone calls for re-thinking of education and thus a new definition of quality in education. Bezuidenhout and Alt, (2011) say that quality assessment is necessary to determine the quality of education.

This study attempts to analyse quality of education from the perspective of impact of these global factors on education which result in rapid changes in the system. It analyses the assessment of learners in the Swaziland national examinations.

Statement of the Problem
Quality of education is measured both qualitatively and quantitatively. The literature e.g. Pudi, (2010) indicate that though governments make attempts to increase provision for education in a bid to improve the quality of education they have not entirely had adequate success. Similarly, Bezuidenhout and Alt, (2011) suggests that quality assessment is an effective tool for ensuring quality education thus improving the assessment system is desirable. However no concrete evidence that either the assessment or the provision has been studied adequately in Swaziland despite the succession of educational innovation in science education. Therefore this study begins by comparing the rate of passes in the Swaziland
science examinations and the quality of answers given in examinations. It also analyse question paper to determine their value in preparing citizens of an unknown future.

**Research questions**
The study aims to answer the following questions

1. How have learners performance in science national examination developed over five years?
2. What is the quality of learner answers o examination questions?
3. How have examination aligned to future requisite skills?

**Conceptual Framework**
Quality has been described both quantitatively as the provision for the system and the number of learners who pass through the system) as well as qualitatively as the enduring outcomes such as the characteristic of the product of the education system. The issue of quality in education is complex and the quest for quality span from time immemorial. Research in this area is abound and has yielded mixed results. Some writers e.g. (McBay and Davidson, 1993) report marked advancement in attaining quality particularly in view of provision and access to education. In this context provision of well tested and established programme, qualified teaching, resources, infrastructure and effective assessment system count as quality. Meanwhile others such as Pudi (2010) report that the road is still long and that quality is a function of complex factors some of which are beyond the education fraternity.

Innovations that have been sweeping education systems have characteristically not yielded the desired quality thus the succession of reforms have been witnessed. Pudi (2010) uses the multidimensional factors that impact on the quality of education to explain this failure. Similarly, Rotherham and Willingham suggest that quality can only be attained as the system responds to in the contextual changes. In education, that means preparing learners for the unknown.

**Methodology**
This is a descriptive study which combines quantitative analysis of learner performance and qualitative analysis of question papers and learner responses. The sample consists of Science question papers from the years 2007 to 2011 at primary and junior secondary school levels, statistical records of learner performance in those years and a sample of 20 marked examination scripts for the 2011 primary and junior secondary national examinations (a total of 40 scripts) from ten centres representing the four regions of Swaziland for response analysis.

**Findings**
Finding show a surprising consistency in learner performance which peaks at the 40% range (E grade) at both levels for the five years. However, the passes at grades C or better are consistently around 20% mark while A grades range below 5% pass rates at both levels. The quality of learner responses varies. Some show problems of language, misconceptions and incompleteness while others give full answers. Evidence for future skills is almost non-existent.

**Conclusion**
Good in examination at the two levels are few, which explain the deficit of students traditionally opt for science. In order for the examinations to contribute positively to the
quality of education, they need strengthening of content and skills that help learner adapt to changes.

References


Awareness of the three dimensional structure of the Universe

Urban Eriksson1,2, Cedric Linder2, John Airey2, Andreas Redfors1
1 LISMA Group, School of Education and Environment, Kristianstad University, Sweden.
2 Division of Physics Education Research, Uppsala University, Sweden.
1 urban.eriksson@physics.uu.se, 2 cedric.linder@physics.uu.se, 3 john.airey@physics.uu.se, 4 andreas.redfors@hkr.se.

Learning astronomy can be difficult for students at all levels due to the highly diverse, conceptual and theoretical thinking used in the discipline. A variety of disciplinary-specific representations are normally employed to help students learn about the Universe. Some of the most common representations are two-dimensional (2D) such as diagrams, plots, or images. In astronomy education there is an implicit assumption that students will be able to conceptually extrapolate three-dimensional (3D) representations from these 2D images (e.g., of nebulae); however, this is often not the case (Hansen, Barnett, MaKinster, & Keating, 2004a, 2004b; Molina, Redondo, Bravo, & Ortega, 2004; N.R.C, 2006; Williamson & Abraham, 1995).
Simulation videos are often called on to dynamically introduce students to the structure and complexity of the Universe. We therefore chose to investigate, drawing on a range of educational experience, the nature of the reflective awareness evoked by being exposed to an array of 3D representations taken from a well-used simulation video in astronomy education. A key concept for this work is the notion of *disciplinary affordances*. Fredlund, Airey, and Linder (2012, p. 658) define the disciplinary affordances of a given representation as “the inherent potential of that representation to provide access to disciplinary knowledge”. Recent reviews indicate that most of the work done in astronomy education has taken place at a pre-university level and that none has focused on disciplinary affordance vis-à-vis 3D representation (Bailey, 2011; Bailey & Slater, 2003; Bretones & Neto, 2011; Lelliott & Rollnick, 2010). The work reported here addresses both these shortcomings.

The simulation video used in our study was originally created by Brent Tully. After a pilot study a section of the video was selected to be cut into 7 clips (about 15s each). These clips formed the framing of a web survey that asked participants to write down their reflective awareness following after viewing of each video clip, for e.g. what comes to mind, things noticed, new realizations, etc.

A total of 137 participants from university physics and astronomy settings in Europe (42), North America (76), South Africa (3) and Australia (16) took part in the web survey (79 men and 58 women). The reflective descriptions from the survey were coded and used to construct categories, using a hermeneutic constant comparison approach (cf. Gibbs, 2002; Strauss & Corbin, 1998).

A limited number of categories emerged and were grouped under the overarching theme we decided to call *Parallax*. This was because *Parallax* captured all the statements reflecting awareness of the structural and positional affordances offered by the 3D-video. The analysis showed qualitative differences between the categories, where *3D* refers to the highest level of awareness and *Speed, travel or motion* refers to the lowest level. There are also sub-categories, for e.g., for *Speed, travel or motion* there are two main ways of experiencing, either the observers or the observed objects, are described in terms of moving in a relative way.

Many of the novice participants expressed poor prior awareness of the 3D structure of the universe and surprise by the extent of the grand scale of the (local) Universe. In contrast, those participants who rated themselves as astronomy experts had already developed a 3D awareness of the universe. They used much more complex descriptions and to some extent commented on structures and phenomena omitted from the simulation, such as HI-regions and infrared radiation from HII-regions, although these are invisible to the naked eye.

The results show that these kinds of vividly visual and engaging simulations have the potential to provide new disciplinary knowledge for reflective learners in the field of astronomy. Such learning can be characterized as attaining a better appreciation of the disciplinary affordances of the representations used in the simulation. As a conclusion we will discuss how such engagement could open the way for astronomy students to learn more meaningfully about the structure and complexity of the Universe.

References


**Strategies adopted by undergraduate physics students when making sense of hands-on tasks**

Jeff Fearon¹

¹University of Cape Town

¹Jeff.fearon@uct.ac.za

The explicit teaching of the modelling process might be appropriate to facilitate the comprehension of physics (Greca & Moreira, 2002) and practical work in physics education may serve to strengthen experimental skills (Abrahams & Millar, 2008). Further, Portides (2005, p. 68) argues that “not enough attention has been given to the actual ways by which scientific models are constructed, how they function and how they relate to the theory that initiates the construction.” This study focuses on the use of hands-on tasks in developing conceptual understanding of modelling at undergraduate level.

In order to make conceptual sense of the experiences of hands-on tasks, it is necessary to link the real world of the experiment with physics theory to form a physical model which may be expressed as any number of conceptual models. The model-based view of physics (Figure 1) proposed by Buffler *et al.* (2008) forms the framework for the study.
Figure 1. A model-based view of physics.

The framework shows five key activities within the modelling process; particularisation & application (the link to theory), idealisation & approximation (the link to real world) and realisation (the expression of the model).

The research questions in this study investigated, 1) what strategies students adopt when required to approximate and idealise observations they have made of real world phenomena and 2) why do they adopted those strategies? 3) What strategies students adopt when required to particularise and apply physics theory in the process of realising a physical model and 4) why do they adopted those strategies?

Methodology

Seven hands-on tasks, referred to as ‘minilabs’, were undertaken by students over a full academic year with each task relating to the section of the curriculum being covered in lectures at that time. Four tasks covered Mechanics and three Electricity & Magnetism.

Data – in three different formats - were collected throughout the year from a class of 65 University of Cape Town first year physics majors, all of whom participated voluntarily in the study. The data formats were a) students’ written responses to open and structured questionnaire items which focussed on the five key modelling activities, b) video recordings that were taken of 30 student groups as they engaged in the minilabs, and c) interviews that were conducted with 24 selected students at the end of the academic year.

The unit of study is the individual student. The written, group video, and interview data of this grounded study were initially coded separately, using elements of a systematic design. Then those categories and ‘strategy themes’ that were identified in the initial stage of the analysis were used in an emerging ‘zigzag’ design using a constant comparison procedure to develop the findings of the study.

Findings and Implications

Preliminary findings show that strategies adopted by students can be described in terms of general and specific strategies. General strategies lie on a continuum ranging from ‘modelling by association with another, similar problem’ to the direct ‘transforming of the actual observations (or particularised theories) into a new model’. Specific strategies are those in which the student focusses on using a specific, identified formula or a specific, identified textbook or similar example in order to develop the necessary model.

An example of a resulting strategy theme is given in Table 1. The strategy theme considers how students dealt with observed friction when having to measure the angular speed of a wheel that was slowing down.

Table 1. Example of a strategy theme emerging from a constant incidence comparison.
The example given in Table 1 shows that although friction was recognised as a relevant factor in the problem, the strategy for dealing with it was to idealise its effect to zero. Further probing showed that the primary reason for adopting this strategy was one of association, because in all the work they had done to date, “friction was always ignored”.

Findings show similar responses to each of the five key activities within the modelling framework adopted for this study. These findings imply that the knowledge of these strategies may be used to guide the structuring of the hands-on tasks in order to improve their effectiveness.

References:


De-Westernizing Indigenous Knowledge System Research and Reporting Methodology and Conceptualization

Femi S. Otulaja¹, Emmanuel Mushayikwa¹, Moyra Keane² & Vongai Mpofu¹

¹Marang Centre for Mathematics and Science Education, School of Education, University of the Witwatersrand, Johannesburg, South Africa; ²Centre for Learning, Teaching & Development, University of the Witwatersrand, Johannesburg, South Africa.

¹Femi.Otulaja@wits.ac.za, ¹mushaykwa@hotmail.com, ²Moyra.Keane@wits.ac.za, ¹vongai.mpofu@yahoo.com

The prevailing methodology and conceptualization of indigenous knowledge systems (IKS) research and the way IKS is reported in research and journal articles is still predominantly Western in ontology, epistemology, axiology and model. In assuming the nature of reality (ontology), the Western paradigm is much more reductionistic and quantitative. The take of WS researchers on IKS is often that if it cannot be quantified, it cannot be subjected to testing, validity and reliability. Epistemology, which is how one comes to know the reality one knows,
of IKS must be centered on the indigenous way of knowing; in Africa for instance, our IKS need to be grounded and premised on the African ways of knowing. Hence IKS methodology and conceptualization need to depart from the Western practices of attaining knowledge about IKS. The need for IKS researchers to find ways to divorce themselves from the scientific method approach, rooted in positivistic Newtonian, Baconian and Cartesian ideologies, practices and delineation through hypothesis-driven, data gathering, analysis and reporting, is much more urgent, salient and paramount than ever before, especially as many indigenous nations are implementing IKS policies and calling for IKS inclusion in their curriculum.

For IKS not to remain marginalized as a subset of WS, in this paper we call for a paradigmatic and ontological shift in the ways IKS are being conceptualized, researched and reported in the literature (Dei, 2011; Smith, 1999; Chinn, 2007; and Kovach, 2010). The roles of the values and ethics (axiology) associated with IKS research need to change. The traditional scientific method made us believe that science was value-free, objective and unbiased (Cederblom and Paulsen, 2001). We have since come to recognize that there is no value-free, unbiased or objective research (Creswell, 1994). The fact that IKS and WS are two separate worldviews (Ogawa, 1995; Michie, 1998; Ogunniyi, Jegede, Ogawa, Yandila & Oladele, 1995) and are based on distinctive paradigms (Mpofu, Mushayikwa and Otulaja, in review), makes the conceptualization and research of indigenous phenomena using WS paradigm conventionally problematic. The indigenous way of knowing – African way of knowing and worldview - is more holistic and not compartmentalized and reductionistic as WS. Hence we join other indigenous researchers, in calling for de-Westernizing of IKS paradigms.

We propose the use and/or adaptation of Guba and Lincoln’s (1989) four authenticity criteria, which are ontological authenticity, educative authenticity, catalytic authenticity and tactical authenticity. This, according to Otulaja (2010), provides a methodology of conducting research in which research “subjects” are considered participants with agency (power to act) to benefit from the research in which they participate. Ontological authenticity addresses the extent to which participants’ own emic/etic (insider/outsider) perspectives have been improved, matured, expanded and elaborated as a result of their participation in IKS research and by possessing more (deeper) information, have become sophisticated in the use of their IKS as a result of the research study conducted with them. It relates to improvement in participants’ conscious and unconscious experiences of indigenous social life. According to Kenneth Pike (1954), emic perspectives address the intrinsic cultural distinctions which provide meaning to members of a particular society, for instance, the distinction between the natural worldview and the supernatural worldview of that society. For Pike, etic perspectives address the issues of extrinsic understanding of outsiders coming in to conduct IKS studies. Educative authenticity represents the extent to which individual participant’s understandings and appreciations of the constructions of others outside their stakeholders group are enhanced. Catalytic authenticity is the extent to which participants’ actions are stimulated and enhanced to catalyze positive changes as a result of being part of IKS research. By enhancing individual participant’s agency and access to appropriate resources, individual well-being and collective successes can be catalyzed. Lastly, tactical authenticity relates to the extent to which participation in IKS afford participants sufficient agency to effect positive changes in their communities and other fields of indigenous social life. Guba and Lincoln’s authenticity criteria are driven by humanness and fairness. In addition to using these non-positivistic, fairness-laden paradigms, it is important for IKS researchers to include indigenous people’s voices through polyphonic and polysemic interpretations and reporting of research results. By so doing, researchers will not need to speak for participants or tell their stories for them, but will allow participants in a research the agency to speak for themselves and enrich the elucidation of the study.
References

Evaluating Grade10 Physical Sciences teachers’ opinions in the Western Cape on the implementation of the new Curriculum Assessment Policy Statement (CAPS)

Lynn Goodman¹; Phillip van der Linde²
University of the Western Cape
lynnleegoodman63@gmail.com; pcvdlinde@telkomlsa.net

This is the first of a series of studies to evaluate science educators opinions and comments on the introduction of the new Curriculum Assessment Policy Statement (CAPS). Problems were experienced with the implementation of Outcomes –Based Education and the various curriculum policy changes that followed. It is essential for any new program to undergo an evaluation process in order to determine its effectiveness and whether it will achieve its objectives. Any new change, as a result of the introduction of curriculum changes, is in many cases accompanied by problems (Stenhouse, 1975; Serason,1990; Bennie,1998; Newstead,1998; Tan, 2006). Curriculum planners may have a good idea of the outcomes
they want to achieve, but on the ground it is the teachers that must implement and try to make it work. During the first 6-8 months of 2012 many teachers were experiencing some challenges in the implementation of CAPS in grade 10. According to the teachers, the demands of the CAPS have put more stress on those delivering the content. They, for example, found it difficult to keep pace with the times allocated for the various topics. They experienced problems with the depth of the content. Caps presuppose that many learners had a good understanding of certain scientific concepts as they move from grade 9 to ten. Teachers have for example to go into depth on the development of the periodic table or concepts around mixtures. So instead of delivering the CAPS content much time was spent on explaining concepts that CAPS assumed the learners know. With this is the lack of material and equipment to perform laboratory experiments. Many teachers complained that they did not have a single thermometer, glassbeaker or Bunsen burner to practically demonstrate the heating and cooling curves of water.

Further to the problems experienced by teachers, it is good to evaluate CAPS and to determine its effectiveness in preparing learners for university and in preparing a scientific literate society. This paper describes the findings of a qualitative and quantitative case study focussing on the views and attitudes of teachers of the Cape Metropolitan area in the Western Cape, South Africa participating in the delivering of the new CAPS document. One of the authors is directly involved with the teachers to ensure that the CAPS policy is implemented as the National Education system requires. According to the Department of Basic Education (DBE,2011), the CAPS document is a single document that consist of a combination of the two National Curriculum statements, for Grades R-9 and Grades 10-12. It is simply known as the National Curriculum Statement grades R-12 that is still build on the previous curriculum with the updating of aims in order to provide a clearer specification of what is to be taught and learnt on a term-by-term basis. There seems to be general acceptance of the CAPS (not that teachers have a choice really). Although teachers do approve of the CAPS, many concerns arise that can be obstacles to the success of CAPS. The lack of knowledge of IKS, the lack of training in it, shortage or lack of resource material and the relevance of it, are some of the concerns. Another concern is the “overload” or amount of work that must be covered. Lack of equipment and resources and the inability to do the informal assessment tasks, are real problems and hence challenges to efficient implementation.

The purpose of the study was to elicit information regarding the Grade 10 Physical Sciences teachers’ views regarding their experiences in implementing the grade 10 CAPS document. It is aimed that this study would make Curriculum Planners aware of implementation problems grade 10 Physical Sciences teachers may experience in the implementation of CAPS.

This study was conducted amongst the grade 10 Physical Sciences teachers at high schools around the Metropole in the Cape Town area, Western Cape. A questionnaire was developed for this study and validated by a number of curriculum advisors, experienced science educators and senior university staff. The questionnaire was e-mailed and physically distributed to the science educators at the different high schools around the Western Cape, but only the schools around the Metropole area of Cape Town responded. Those that were returned (more than 30) were analysed using both quantitative and qualitative descriptive methods. It would obviously lend more credibility to the results if more teachers responded to the instrument. The instrument was designed to fathom what educators think of CAPS (note at this point it was only 6-8 months after educators started working with CAPS), but also to illicit their understanding of socio-scientific issues, indigenous knowledge practices.
and the relevance of it in science education. So, for example, the varied responses to question 11 indicate areas that could hinder the value of effective CAPS implementation.

The study revealed obstacles that relates to organisational arrangements, content overload, rigid scheduling of time, reporting systems, and enough administrational support. This shows that CAPS is having its share of implementation problems. Many of the respondents to this questionnaire have seen the problems that were experienced with the outcomes-based curriculum changes since 1996. The many positive results of the study indicated that the teachers who are the implementers of CAPS believed that this is definitely an improvement in curriculum change. No complaints were offered as to possible lack of training or support as with previous curricula changes. Although there is some agreement that the content is an improvement, the study reveals that teachers believe that it is too much. Many stated that they were unable to complete the content for the first five months.

According to Altrichter, H (2005), a new curriculum may be described as an attempt to change teaching and learning practices which will also include the transformation of some of the beliefs and understandings hitherto existent in the setting to be changed. It is usually strong on the material side by providing a written curriculum, text books, recommendations for teaching strategies, working material for students, and probably also new artefacts for learning (e.g. in science education or in Montessori classrooms). This agrees with the finding of this study that certain parts of CAPS may be easily handled by the respondents, but other not. The responses to questions 8-10 on the inclusion of IKS, confirm that many teachers are not comfortable with the new IKS requirements in the documents. Some clearly reject the notion of IKS while others recognise there may be a need for it. This is an area that is indeed in need to be addressed by the education authorities. Many respondents made it clear that they may cope with formal assessments, but that no justice is done if the informal assessments cannot be done due to time constraints and lack of equipment or facilities.

The authors hope to continue to evaluate the progress of CAPS and evaluate areas that may cause concern.

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Sarason, S.B. (1990). The Predictable Failure of Educational
Attachment 1
Questionnaire on CAPS for grade 10
Please provide your opinion on the following questions. Do not just state yes or no!!

1) Do you think the current Grade 10 curriculum is an improvement on the previous one? Try and explain.
2) Do you think the content covered will prepare the learners for university and the workplace?
3) Will the new content create a society with more scientific knowledge?
4) Should more socio-scientific issues be addressed in the curriculum?
5) Do you think the content is such that many more learners should do sciences in at least grade 10
6) Do you think the order of the topics as presented in most textbooks will provide for adequate time to comprehensively cover the work?
7) In your opinion does the content as presented suffice in giving learners a good grounding in Physical Sciences?
8) Do you as an educator think more stress should be placed on Indigenous knowledge Systems (IKS)?
9) Do you think enough recognition is given to Indigenous knowledge systems in the CAPS content?
10) Will the subject matter help learners to recognise that knowing more about Indigenous practices, will give them a better appreciation for IKS and help them to recognise that it should be on par with sciences?
11) What concern you most about the implementation of the curriculum assessment policy document in Physical Sciences and why?

Masters science students' perceptions, views and conceptual change of indigenous knowledge-science and technology development in pre-and post-colonized Africa-an analysis via TAP and CAT frameworks

Govender Nadaraj
School of Education, University of KwaZulu-Natal, South Africa.
govendern37@ukzn.ac.za

Introduction
Studies in Africa (Maathai, 2010; Meredith, 2006; Rodney, 1973) support the view that historically Africa was rich in science, astronomy, cosmology and technology and collectively framed as indigenous knowledges. However, these contributions by Africa remained absent in the curriculum and there exist a notion that an indigenous scientific or technological community did not exists in traditional African societies. Students perceive that it is of no value to the current science and technology era to go ‘backwards’ and find out what African past knowledge accrued. The paper explores Masters Science Education students’ perception, views and conceptual change of Africa’s historical contributions to science and technology development in pre- and post-colonization periods. The students engaged in an argumentation-based discourse module African Studies in Science Education underpinned by Toulmins’ Argumentation Pattern (TAP) and Ogunniyi’s Contiguity Argumentation Theory (CAT). Argumentation is not widely used in science classes in SA and very few teachers are explicitly aware of its role in science education (Bricker & Bell, 2008) hence the significance of this study. Issues of the current value of Africa’s indigenous knowledge and science and technology development connected with the past are raised in the
course through archaeological evidence, research papers, debates etc. via Ogunniyi’s Practical Argumentation Course (PAC) design.

**Literature Study**

Argumentation is a useful rhetorical tool for engaging oneself in any meaningful discourse. Argumentation is a statement or constellation of statements advanced by an individual or a group to justify or refute a claim in order to attain the approval of an audience (van Eemeren, Grootendorst, & Henkemans, 2002) or to reach consensus on a controversial subject matters. Argumentation was a common rhetorical tool used by early Greek philosophers as well as by succeeding generations of scholars up to the present-day scientists in their attempts to unravel the nature of matter and the universe as a whole (Popper, 1959). Toulmin (1958) cautions us to be wary of universality of an argument in that it ignores human shortcomings and changing contexts. It is importance to take into account the context in which argumentation is occurring (Billig, 1987). The issues of criticism and justification are central to argumentation. Perelman (1979) notes that both processes occur in social contexts and, therefore, are “always ‘situated’ (p. 33)” (p. 117).

Researchers (Bricker & Bell, 2008; Erduran, Simon, & Osborne, 2004) observe that argumentation is increasingly viewed as a leading instructional approach and educational goal for science education. One way of engaging science education students with scientific processes is providing them access to that process through argumentation (Duschl & Osborne, 2002). Students discussing and arguing in a group contribute to developing their argument skills further as opportunities to propose claims and defend via warrants are necessary to convince others in the group of the ‘reasonableness’ of the argument. In Erduran’s et al. (2004) study, preliminary results indicate that collective reasoning is influenced strongly by the nature of teaching and how teachers mediated the argumentation-rebuttal process. Research has shown that a curriculum that encourages discussion, argumentation, dialogue, and reflection is more effective for promoting understanding scientific issues such as the Nature of Science (NOS), IKS, Western science versus other sciences and other systems of thought and promote critical thinking rather than one that excludes such instructional strategies (Aikenhead, 2005; Erduran et al., 2004; Ogunniyi, 2007).

**Theoretical Framework**

Toulmins’ Argumentation Pattern (TAP) (1958) illustrates the structure of an argument and a process of analyzing an argument as an interconnected set of a claim, data that supports the claim, warrants that provide the links between data and claim; backings that strengthen the warrants and, rebuttals which points to situations where the claim would not be true. In practice, however, it is often difficult to distinguish between data and warrant using this functional distinction (Van Eemeren, Grootendorst, & Kruiger, 1987) as there are multiple notions and types of warrants. What we term data or bits and pieces of empirical evidence supporting a claim are theory laden and may change in meaning as the context changes (Ogunini, 2007, p. 967).

The Contiguity Argumentation Theory (CAT) by Ogunniyi (1997) was applied to the field of science education. CAT explains possible ways in which conflicts arising from clashing ideas or cosmologies such as science and IKS are resolved through the process of accommodation, integrative reconciliation and adaptation. CAT assumes that ideas that come together will interact, overlap, or conflict with each other. One way of integrating such conceptions is by finding a larger, synergistic conception (Ogunniyi, 1997). This leads to a higher form of
awareness and a consequent deeper level of understanding than was previously possible. CAT also recognizes five cognitive categories into which ideas can move within a students’ mind when discussing issues of different thought systems such as African IKS and science. These are: dominant; suppressed; assimilated; emergent; and equipollent. These five cognitive categories exist in a dynamic state of flux in a person’s mind. The context of the discourse plays an important role in the amount or intensity of emotional arousal experienced by the participants in the argument. In other words the arousal contributes to the fate of the clashing ideas. A greater detail of these cognitive categories with examples have been published in Ogunniyi (2007).

TAP works well in a logical situations and in single thought system while CAT, on the other hand, shows categories that are contextually-based and as it can be applied to a two or more thought systems.

Methodology
In order to implement a critical discourse in the module, the paper examines the issues raised through argumentation as extended by Ogunniyi (2006) via Practical Argumentation Course (PAC) research design. Students in the course analyzed the historical development of science and technology in Africa including the last 50 years and examined the present situation in Africa through research papers published in science and technology education. The study analysed the change in students’ argumentation using Toulmin’s structure of TAP and Ogunniyi’s CAT. Six MEd students were engaged in the module of a semester’s duration and a full week (48 hours) of discussions and seminars took place, followed by a review session (4 hours) of the module. Twenty (20) research papers served as a primary course-pack resource for engaging in argumentation discourse in class. The students were free to ask and raise questions, argue, dispute and express their views at any time. Students were asked questions about their perceptions of science education in Africa initially and these were recorded. During their course students wrote summaries of discussions of the day. Their summaries were analyzed to account for their views and their major assignment were analyzed to reveal likely conceptual changes of their knowledge of Africa’s indigenous contributions to science education.

Analysis and Discussion
Students’ classroom discussions were analyzed and narratives are recorded, early and later in the course. Their change of perceptions was also monitored through the evidence of the arguments in the narratives via TAP and CAT categories obtained from their major assignments. These are discussed.

Conclusion
The analysis of data indicates that students have a more nuanced understanding of Africa’s contribution to science and science education through critical discourse pedagogy. They indicated that their own approach and teaching to their school science curriculum will be influenced by these contributions. The use of argumentation as a strategy for raising issues, presenting discussion supports the view that students did undergo conceptual change through this process. Students indicated that even the argumentation methodology will be explored in their classroom teaching.

References


A model for africanising higher education curriculum: A quest for educational relevance

Mishack Thiza, Gumbo
Office of Graduate Studies & Research, College of Education, University of South Africa (Unisa), South Africa
gumbomt@unisa.ac.za

This is a literature study-based paper the purpose of which is to explore internationally and Africa-based existing models, strategies or efforts by scholars, tertiary institutions or states to africanise curriculum to provide guidelines to produce a model for the higher education curriculum in South Africa. African universities’ student population is predominantly indigenous. Ironically, these universities’ curricula are still dominated by Western epistemologies and knowledge systems. African universities are thus faced with the challenge to africanise or indigenize their curricula in order to better and relevantly service indigenous African students. But they do not know where and how to start with the process of africanisation. Thus, to fill this gap, the exploration referred to above will be undertaken in order to recommend a model of africanising the higher education curriculum. The exploration of existing models, strategies or efforts is intended to abase the recommended model. Makgoba (in Viljoen & Van der Walt, 2003) perceives africanisation as the process or vehicle for defining, interpreting, promoting, and transmitting African thought, philosophy, identity and culture (also see Msila, 2009). Africanisation also entails a serious quest for a radical and veritable change of paradigm so that the African may enter into genuine and critical dialogical encounter with other pyramids of knowledge (Banda, 2002). Africanisation resonates with indigenisation due to the African masses being indigenes to Africa whose education is contested in this paper. Therefore, I use the terms Africanisation and indigenisation interchangeably in this paper.

Contesting the Western canons by educational terms is at stake in this paper. Thus, I will undertake this inquiry to confront the status-quo that seems hegemonic in tertiary education – the Western dominance to curriculum that further disadvantages indigenous African students and advantages non-indigenous students. A Western curriculum approach does a disservice to indigenous African students by pushing for a positivist notion that claims that only the Western knowledge systems can be justified as part of the curriculum. It excludes other forms of knowledge systems. According to Michie (1999), government policies in the Western countries may have no longer been assimilationist, when curriculum has certainly not followed suit.

Curriculum transformation can only be realised if indigenised standpoints are put at the centre of the curriculum (MLCek, 2009). Furthermore, transformation can be achieved only if there is attitudinal change to recognise indigenous culture as a positive resource (MLCek, 2009) rather than a stumbling block or curriculum overload. The definition of curriculum that I prefer for the engagements in this chapter is Marsh’s and Willis’ (2003), which states that curriculum is the questioning of authority and the searching for complex views of human situations. It follows that this paper concerns itself with curriculum inquiry because the issues that I raise hit squarely on the curriculum that higher education institutions purport to offer. In the context of the above definition, the stance that I take in this paper is that of questioning...
colonial approaches to curriculum, which do greater disservice to indigenous African students, and recommend a model solution towards transforming higher education curriculum. Higher education institutions are aware of the “what” question, i.e. they know that something is definitely wrong about the relevance of their curriculum to the indigenous masses in Africa, and that it is inevitable that they transform it. The “how” question is what many institutions do not know yet. The recommended model will answer the “how” question.

The route that this paper takes is to first explain the theoretical parameters guiding the line of thought. This will be ensued by condemning the non-relevance of colonial approach to education, consideration of indigenous knowledge as an alternative to Western knowledge, and the role that higher education institutions can play in the promotion and advancement of indigenous knowledge systems. Then I will proceed by exploring models, strategies or efforts on indigenising curriculum existent in Africa and those outside of Africa. A close study of these models, strategies or efforts will ultimately enable me to recommend a comprehensive model for africanising curriculum (MAC).

References
Teacher Satisfaction and Science Content Learning During Professional Development at an Informal Science Institution

Gary M. Holliday, Judith S. Lederman, Norman G. Lederman

Department of Curricular and Instructional Studies, The University of Akron, USA. gholliday@uakron.edu; Department of Mathematics and Science Education, Illinois Institute of Technology, USA. ledermanj@iit.edu, ledermann@iit.edu

This study looked at a life science course that was offered at and taught by education staff of a large Informal Science Institution (ISI) located in the Midwest USA. The curriculum, materials, and agendas for the course were developed by education staff and complemented the permanent life science exhibition. The researcher developed a content test based on the course instructional objectives and lessons provided by education staff. In addition, all participating elementary and middle school teachers (n = 62) were asked to complete an evaluation at the end of each day’s session. This included several questions that required participants to reflect upon the content presented throughout the course of the day, focusing on their satisfaction and effectiveness of instruction. Overall, teacher responses on the daily and final evaluations for both courses were extremely positive. However, after participating in the ISI course, teachers’ gains in science content knowledge were not as strong as they had perceived. The findings described here can assist developers of informal science professional development for elementary and middle school teachers that desire to incorporate inquiry, pedagogy, and science content into their teacher learning experiences.

Background/Rationale
For the general visitor, Informal Science Institutions (ISIs) are quite invested in measuring leisure satisfaction (Falk, 2009). Visitors often are satisfied with their experiences even when, in actuality, there were negative aspects to the visit. They would “tend to excuse away these experiences as insignificant in the grand scheme of things” (Falk, 2009, p. 120). In their 2006 study, Astor-Jack, Balcerzak, and McCallie also noted that ISI professional development (PD) providers hoped teachers would gain confidence in teaching science and that “they won’t feel like they have to know everything” (pg. 75). As a result, teachers have expressed enhanced self-confidence and self-efficacy in their science teaching abilities and strategies (Anderson, Lawon, & Mayer-Smith, 2006; Ferry, 1993, 1995; Jung &Tonso, 2006; Kelly, 2000). However, it was not clear whether explicit connections were being made to academic science content and whether classroom teachers actually learned science content as a result of participating in ISI professional development. Therefore the question guiding this study is: During ISI professional development for elementary and middle school classroom science teachers, how are learning of science content and satisfaction with the course related?

Methodology
This study looked at a life science course that was offered at and taught by education staff of a large ISI located in the Midwest USA. The course was aligned with the state’s learning standards for science and designed according to the National Science Education Standards (NRC, 1996). The curriculum, materials, and agendas for the course were developed by education staff and complemented a permanent life science exhibition. The topics for each of the meeting dates included an introduction to the course; cells, tissues, and organs; body
systems; Deoxyribonucleic acid (DNA), genetics, and evolution; health and wellness; and forensics. The exhibition itself was primarily used to address course content and consisted of eight themes about the human mind, body, and spirit: aging, conception and birth, agility, diet, the heart, the mind, health, and innovations in medicine.

Course participants provided a sample of convenience for this study and were 4-8th grade classroom teachers who spent 80-100% of their time working directly with students, with up to 30 years of teaching experience (\(\bar{x} = 7.5\) years) and were from public, private, urban and suburban schools. Two courses were included in the study with a total of 62 participating teachers. In compliance with the Institutional Review Board (IRB) protocol, all participants were asked to complete a consent form during the first meeting of each course.

Data Sources
The researcher developed a content test based on the course instructional objectives and lessons provided by education staff. In order to establish face and content validity for the content test, four museum educators and two science educators were asked to evaluate the items. Items were only used if there was 100% agreement among all experts. The initial versions of the content tests were piloted with 2 groups for the course (\(n = 67\)) and the items were revised again if they were poorly aligned with the covered curriculum. As a measure for reliability, an estimate of internal consistency (Cronbach’s alpha) was run for the items on the final tests and it was found have an acceptable reliability coefficient of .754. The final content test was given to teachers as a pre-test on the first day of the courses and a post-test on the last day (after all science content had been presented to the participants). To determine statistical differences between pre- and post-test scores within the courses, Analysis of Covariance (ANCOVA) was used (\(\alpha = .05\)) controlling for initial pre-test differences. In addition, all teachers were asked to complete an evaluation at the end of each day’s session. This included several questions that required participants to reflect upon the content presented throughout the course of the day. Frequencies were produced for scaled items on the daily and final evaluations and the open-ended responses were analyzed for trends.

Results and Implications
Overall, teacher responses on the daily and final evaluations for both courses were extremely positive. Since the same questions were asked daily, all of the responses were combined. The following are selected questions:

- “On a scale of 1 – 10, how satisfied were you with today’s/this week’s workshops?” (1 = completely unsatisfied, 10 = completely satisfied).
  - 225 of the 319 responses indicated complete satisfaction (giving a rating of 10) with the courses.
- “Overall, how well did today’s/the workshops meet your expectations?”
  - Many of the teachers responded that education staff met (30%) or exceeded (70%) their expectations throughout the courses.
- “On a scale of 1 – 10, how effective were the workshops in preparing you to do the following: teach {the content presented that day} to your students, use science journals in your teaching, use the inquiry wheel in your classroom, and use the museum as a resource (the exhibits and website)” (1 = completely not effective, 10 = completely effective).
  - Participants rated each component of the question separately. When focusing on the course’s effectiveness in preparing teachers to teach the content
presented in the course, around 97% of teachers gave a rating of 8 or above, with 55% of teachers giving a rating of 10.

The open-ended questions connected to the above ratings included very positive comments as well, with teachers stating that the materials, activities, educators and exhibits were “great”, “awesome”, “excellent”, “fun”, “useful”, and “engaging”. However, when focusing on teachers’ science content acquisition, an Analysis of Covariance (ANCOVA) was conducted and resulted in a statistically significant outcome, $F(1, 45) = 159.70$, $p = .00$, for the content test. However, this result needs to be considered with the understanding that pre-test scores were very low and, while there was improvement seen on the post-test, the scores remained quite low by the end of the course (pre-test: $\bar{x} = 35$ out of 100, post-test: 57), which would indicate that teachers gains in science content knowledge were not as strong as initially perceived.

Conclusions and Implications
When considering teachers’ understanding of the presented science content, most teachers reported that they learned a lot of science content, felt more confident in teaching science, and were very satisfied with the content and materials presented in the life science content course. These findings mirror what has been previously described in the literature (Chesebrough, 1994; Chin, 2004; Jung & Tonso, 2006; Kelly, 2000; Melber & Cox-Peterson, 2005; Neathery, 1998), however, such statements were not supported by the assessments aligned to the content presented or instructional objectives of the course. Meanwhile, assessments produced by ISI education staff primarily relied on measures of affect.

The findings presented here are troubling and it is felt that there were many missed opportunities during the observed courses. Especially when considering that many elementary and middle school teachers are turning to ISIs for their science content needs and, due to a number of factors described above, ISI PD providers are not fulfilling their obligation to them as effective teacher educators. In order to move beyond just preparing science teachers for field trips, measuring affect, and to allow for creative uses of the resources informal science settings provide, it will be important to further understand how ISIs and their educational staff can play a role in developing teachers’ science content knowledge. The findings described here can assist developers of informal science professional development for elementary and middle school teachers that desire to incorporate inquiry, pedagogy, and science content into their teacher learning experiences.

REFERENCES
Understanding the 8th grade students on the circulatory system: An exploration of some conceptual development strategies

**Faira Amade Ibrahimo**
Universidade Pedagógica, Mozambique
faira.ibrahimo@hotmail.com

**Abstract**
The present research study constitutes part of a research program undertook for the master in science education. A range of studies has examined the views of students on some concepts, including respiration and circulatory system. It has been found that there are many misconceptions related to these topics, however many teachers and students are not aware of its existence. For the teaching-learning process be successful, it is necessary that the limitations of these misconceptions be discussed in the classroom. The present work aims: (1) diagnose and document the misconceptions and other learning difficulties of the circulatory system, the students of grade 8 of an urban school in Maputo city hold, (2) suggest new teaching strategies, learning in teaching materials to enhance students' understanding related to the circulatory system and (3) evaluate the contribution of some strategies to build conceptual development and understanding of the circulatory system of the human body.

The following constituted research questions of the study
(i) What kinds of difficulties are presented by the students of grade 8 in understanding the concepts of the circulatory system on: (a) Constitution of the blood and its function, (b) Constitution of the heart and its function, (c) Blood circulation and (d) Relationship between the circulatory system and other systems?
(ii) In the case of students who present difficulties on understanding the concepts mentioned, what kind of methods / strategies can be used to improve understanding of the circulatory system? The study employed qualitative and quantitative methods. To gather data under the quantitative method pre and post test were administered to grade 8 students. Statistical analysis where performed using SPSS package. The qualitative method consisted of interviews with teachers and students and analysis of documents (curriculum, textbooks and exercise books). This study allowed the following conclusions:

Analysing the documents we found that there are gaps between objectives and methodological recommendation in the programs and that there are also some insufficiency or incorrect information in the programs in regard the content. Results from the pre and post tests a show that grade 8 students improved their performance after the intervention with new strategies and methodologies. During the intervention were included strategies / teaching
techniques such as analogies, cognitive conflict, concept maps and group work which enabled a better understanding of the system under study. The main difficulties faced by students are related to the identification of the blood and their functions, components and function of the heart, blood circulation and the circulatory system relate to other systems. Implications from this study are that there is a need to improve the formulations in programs with regard to the objectives and methodological guidelines, review the sections of content and quizzes in school textbooks, to combine several methods and teaching strategies during the class for the consolidation of understanding of the circulatory system.
Keywords: strategies for developing conceptual analogies, cognitive conflict, concept maps and group work.

Why some science teachers’ professional development activities make a difference and others fail to do so. Study in Rwandan secondary schools.

1Casimir Mutabazi Karasira & 2Paul Hobden
1Kigali Institute of Education, Rwanda; 2University of KwaZulu-Natal, South Africa
karasirafr@yahoo.fr & hobden@ukzn.ac.za

The paper explores the challenges encountered by Rwandan secondary school science teachers to transfer the newly gained skills, newly acquired knowledge and new practice in the classroom environment despite efforts made by all stakeholders in education to help teachers improve professionally.

Changes in the political, social, economic and educational landscape in the post genocide Rwanda have brought about needs for various reforms especially in the educational sector. After the 1994 genocide, the education sector, as well as other sectors of the Rwandan national life, went through an emergency phase followed by a development phase during which the main objectives were to reshape and restart the education system which has broken down and to provide a new orientation for the educational system as well as designing a new curriculum.

However, despite noticeable made efforts to improve its educational system, Rwanda is still facing a crisis. Firstly it continues to have a shortage of qualified and experienced teachers especially in the field of science. The low rate of skilled and experienced teachers is reported both by international organizations as well as by the Rwandan government. African Development Fund study reports that “in this central African country, only 47 percent of secondary school teachers are qualified to teach science and technology and efforts are to be made to increase the proportion of teachers trained in science and technology” (ADF, 2006, p. 9). Furthermore, the Ministry of Education recognises this through its declaration concerning teachers’ qualifications. It found that only 18% of the teachers had a bachelor degree and 3% a master’s degree. In addition a high percentage of teachers were found to be poorly qualified with limited content knowledge and pedagogical content knowledge (Ministry of Education, 2006).

Sparks and Hirsh (2001) argue that “States cannot improve schools through mandating high standards and tough tests unless they give teachers the tools, support, and training to help them change their practice”. However, very little is known, in the Rwandan context, about why some professional development activities bring about teachers change and others fail to
do so. In this perspective, this research study aims at finding out why are some professional development activities more effective in bringing about the desired changes in teachers practice and others are not?

The major theory underpinning this research is the change theory borrowed from Lewin’s work (1947). Additional to Lewin’s theory of change this research referred also to the science teachers’ change theory as seen by Guskey (2002). When it comes to understanding teachers learning then this was understood from the constructivism perspective.

The issue that this study intended to explore determined the choice of the pragmatic perspective shaped by a sequential exploratory mixed method design. The design included an inductive qualitative phase and a deductive quantitative phase which used respectively an interview and a questionnaire to generate the data.

It emerged that many factors prevent science teachers to transfer the newly gained knowledge and skills in the classroom environment and some were internal factors, linked to the teacher and others were external factors connected to the school environment, the luck of support and follow up and the top down decision making on the way professional development activities were planned and offered.

Use of ICT by Science Teachers in Maputo city

Kátia Marina da Glória Mário Marques Monteiro
Universidade Pedagógica, Mozambique
Katiamarques2006@hotmail.com

Abstract
This paper reports a major study that constituted a Master thesis. Currently, the increasing development of information and communication technologies (ICT) imposes on teachers and the community at large, the challenge of integrating them in their everyday lives. Over the past few years, in Mozambique and in the whole world, has been the effort to provide the educational community ICT usage. It is in this perspective that the present investigation intending to provide data about the use of ICT by science teachers, specifically the computer connected to the Internet. It is a descriptive research whose sample was constituted by teachers of biology, chemistry and physics of general secondary education in the city of Maputo, in Mozambique. the research was carried out in 23 schools selected at random, while the selection of teachers was for convenience, that is, in each selected school respondents were teachers who were present at the time of delivery of questionários55 (37) teachers belonging to private schools and 94 (63) teachers from public schools, which corresponds to more than 30 of the population.

Whereas the use of ICT in the teaching-learning process is a process quite complex, with many obstacles and questions, this study aims to provide a further contribution to the use of technologies in the teaching of science and also for future research in this area. Thus arise the present study with the following problem: what use that science teachers of Maputo city are ICT, as a resource to the teaching process learning?

To respond to the problem of the study, we stated the following objectives:
-Draw an updated picture the use of ICT by science teachers in Maputo;
-Identify constraints to use of ICT in the teaching-learning process;
-Describe the attitudes of teachers regarding the use of ICT;
-Provide guidelines for future training of science teachers in ICT.

Therefore, whether the science teachers in Mozambique, particularly in the city of Maputo, use ICT in the educational context and, in the case of use, how they do it and what are the factors that may affect their use. Questionnaires were applied with the purpose of obtaining information that would characterize teachers with regard to the use of ICT in the educational context, their attitudes and difficulties, in order to draw a picture of the use of ICT in the educational context.

The analysis of the results showed that the younger teachers, male, with less time in the profession, whose initial training was done in university education and belong to the urban district No. 1 have greater tendency towards the use of ICT. It was noted that ICT aroused positive attitudes in teachers such as: 97.3% of teachers declared that they would like to know more about ICT; 54.4% considers that increased their dependency of ICT is in his professional practice, and 88.4% agree that ICT are valuable in promoting the learning of students. There were also negative attitudes namely: 39.5% of the teachers considered that ICTs do not affect your way of teaching; 23.8% argue that there is no relationship between the use of ICT and the learning of their students and 19% do not want to use ICT in their classes.

Teachers’ responses pointed out several factors conditioning the use of ICT which stressed the lack of technical means (equipment, rooms, etc.), lack of human resources (computer technicians) and lack of training and knowledge for the use of ICT with students. The research also indicated that there are teachers who don't feel the need to use ICT in their classes apparently due to lack of knowledge about ICT.

Arising out of research results, suggestions for use of the Internet computer in the teaching-learning process and a proposal for a workshop entitled "use of ICT in the teaching of biology", with the aim of contributing to the future actions of in-service training of teachers in ICT. There are further the following suggestions:
-Invest simultaneously in equipping schools and the continuous training of teachers in ICT.
-Include the educational component in the in-service training of teachers in ICT.
-Actively involving teachers, collaborative and reflective in the exploitation of ICT and in the production of didactic materials with ICT, providing them with the necessary skills to use with your students.

Keywords: science teachers of Maputo city, role of ICT, science education.

Students’ difficulties in sectional drawing: a case of student teachers in the Eastern Cape.

Sammy Khoza ¹ & Moses Makgato ²

¹ Department of technical Education, Walter Sisulu University, South Africa
² Department of educational Studies, Tshwane University of Technology, South Africa
Engineering Graphics and Design (EGD) is the medium of communication. It relates between theory and the picture of reality. EGD provides an accurate and complete picture for every object in terms of shape and size in the technology related fields. EGD consists of three concepts with sectional drawing being one of them. This paper presents part of the study which investigates difficulties that the BEDTEE 2nd and 3rd year students in the Eastern Cape University have in sectional drawing. The participants of the study were sixteen (16) students in their 2nd and 3rd years who were purposefully selected, and the study used both the qualitative and the quantitative research methods approach. Questionnaire, group interviews as well as the Purdue Spatial Visualization Test of Rotations (PSVT) were used to collect data. Questionnaire data was analyzed using SPSS frequencies distribution, and focus group interviews data were transcribed after each interview and coded to obtain categories of themes. Findings of the study revealed that students do not know the relationship of other EGD components that come before sectional drawing, and they showed poor skills in spatial abilities, they also do not have course outlines in their possession. It was also found that students come to enrol for BEDTEE programme with a shallow knowledge in spatial abilities. The study also revealed that there are no sectional drawing models and students find learning more abstract.

Introduction

In the engineering world, Engineering Graphics and Design (EGD) is the medium of communication. It relates between theory and the picture of reality. EGD provides an accurate and complete picture for every object in terms of shape and size in the technology related fields (Widad & Adnan, 2000: 3). The EGD emphasis is focused on the correct use of tools and equipment, drafting media, sketching, lettering, alphabet of lines, geometric construction, fundamentals of Computer Aided Draughting (CAD) and multiview drawings (Widad, Rio & Lee, 2006: 1). According to Santos, Yee & Petreche (1998: 1), students who learn EGD need spatial visualization skills to understand its concepts. Sorby (2001: 4) suggested that those who enroll in the EGD course need to have attended some courses related to spatial visualization skills. In the meantime spatial visualization ability has been recognized as a predictor of success in many technology related fields, EGD included (Strong & Smith, 2002: 2). The EGD content in an Eastern Cape university, where this study is being undertaken, consists of concepts tailor-made for student teachers. The sectional drawing is one of them. This paper therefore intended to identify the students’ teachers’ difficulties in sectional drawing.

Since sectional drawing is the main foundation to other drawing concepts in EGD, student teachers in the teacher education programme at the university in the Eastern Cape find it difficult to draw the correct sectional drawings. Their reproduction of the missing views, the application of line-types and the identification of the cutting plane lead them to getting the sectional drawing wrong. This paper reports on the difficulties that students have in sectional drawing. The problem statement in this study is well phrase in the critical question as follows: The critical question in study is phrased as follows: “What difficulties do the student teachers at the University at Eastern Cape have when drawing ‘sectional drawing’?”

Sectional drawing

According to Brink, Gibbons and Theron (1997: 164), a sectional view in Drawing subjects is a view where you imagine that part of the object is removed to reveal hidden detail which
in reality, nothing has been removed. On the other hand, the main purpose of sectional drawing is to reveal the hidden details in a drawing (Moolman & Brink, 2010: 196). The revelation of the hidden details in a drawing will assist the students/draughtsman/engineers in identifying underlying components in a drawing when designing technical projects. This will enable an engineer to be able to assemble or dismantle components in a drawing for further machining purposes in industries.

The revelation of underlying or hidden components in a drawing is done through reading and understanding various line types that are used in EGD. According to Moolman & Brink (2010:12-14), there are ten different types of lines which are used in the entire EGD curriculum which also applies in schools. Out of these ten line types, seven of them are so profound to EGD concepts with the other three mainly being the applications of some of the other types. A sectional drawing question on the other hand could contain all the seven line types depending on its degree of complexity. Therefore for the students to understand the sectional drawing and draw properly in EGD subject, they need to understand line-types which are the core-determiners to the understanding of EGD. This is because for students to understand and visualize a drawing, they need to know the meaning and uses of various line types that reflect in a drawing. This will enable them to communicate ideas graphically in their Engineering career.

However, EGD has the following aims (Prieto & Velasco, 2002: 101):

- **To enhance visualization**: this means that before the draughtsman can make/machine an object, he must be able to visualize the object from the drawing placed in front of him. This visualization needs a good understanding of line work because with that, one can be able to describe the underlying components in a drawing, with a sectional drawing as a prime example. This can only be achieved by a good visualization also called spatial visualization.

- **To enhance perception**: this enables one to discover the basic concepts of shape perception through self-investigation (Prieto & Velasco, 2002: 102). The above refers to the fact that when various line types are reflected in a drawing, one needs to be able to visualize what the drawing looks like guided by the said various line-types. The visualization process will therefore be accompanied by perception also called spatial ability. The perception process will merely be applied for one to twist and turn the drawing in their mind when they imagine how the drawing is cut/sectioned. What happens in ones mind is an attempt to have a clear perception on the nature of the drawing and it cannot happen successfully when the interpretation of line types is none.

From the above assertion, it is apparent that visualization and perception, work hand in hand. These two concepts form the integral skill in the success of producing a sectional drawing object. Figure 1.1 below is the prime example of sectional drawing that the BEDTEE student has to answer in assessment activities. The errors that they commit are more of the “principle mistakes” which are the mistakes that clearly show that their completion of sectional drawing is technically wrong. They do not follow the basic rules and principles of sectional drawing.

The instruction for the figure above comes in the form: *Draw a full sectional front view of a Spoke*. “This can easily be translated as: draw a front view of a Spoke when it is cut”. Therefore what students need to do is to first know from which side should the drawing of a Spoke be looked at, and in this case, it should be looked at from side B. They also ought to imagine the inner features of the drawing. The imagining process is basically a synonym of
visualization. When the students visualize how the drawing looks like when it’s cut/sectioned, they will then have a “perception” of what the cutting object do to the drawing during the cutting process (Sternberg, 1990: 9). The success of students in applying the two concepts of spatial visualization and perception will assist in the production of a correct solution. According to Abrahams (2003: 17), sectional drawing has got the following three principles; profile remain the same, inside changes and hatching lines will cancel out all type A and type F lines. These principles are the steps towards completing sectional drawing successfully with the aid of line-work application.

Figure 1 Picture and sectional drawing of a Spoke (Source: Benade and Heever (1994:26)

Figure 2 below is a representation of a single component sectional drawing task that a student submitted. It contains errors that include amongst others; poor spatial abilities and or poor representation of line-work. This addendum shows one of many errors that students commit in sectional drawing. Looking at the way the student answered a question, each errors highlighted shows what the researcher is trying to investigate as to what could really be students’ difficulty when they commit such errors. Error 1 shows poor application of line work. A student has drawn sectional lines over an outline (type A line), which is a principle mistake on its own (Moolman & Brink, 2010: 15). This is because a sectional line must not run over a type A line because a sectional line shows the inside of an object whereas an outline shows the outside of an object, which is contradictory.

Error 2 on the same drawing shows a student having shown a type F line (hidden detail) on a sectional drawing solution. This is because a sectional drawing solution must not be contain a type F line because a solution reveals the inside whereas the type F line still says to the reader that there is still hidden details (Moolman & Brink, 2010: 15). Error 3 on the other hand shows poor application of spatial abilities. A student failed to apply spatial visualization correctly which would have assisted them in imagining how the object will look like when cut/sectioned from cutting plane A-A as shown on the front view (FV). The purpose of the
cutting plane is to assist one to see how and where the object is cut (Brink et al, 1997: 18). Therefore the student misinterpreted or failed to understand the where the cutting plane runs. And that caused them to commit more than one error on one drawing. That is, the student failed to visualize how the object will look after being cut and also failed to imagine the top part being removed so as to come up with the correct solution. Error 3 shown also shows that a student sectioned a plane that was not supposed to be sectioned, which is an application of spatial visualization (McGee, 1979: 6).

Figure 2 Typical students errors in sectional drawing

Theoretical framework
The study was informed by Piaget’s perception and imagery theory (Piaget, 1971), Vygotsky theory of Zone of Proximal Development (ZPD) (Vygotsky, 1978). The employment of Piaget’s perception and imagery theory assisted the study in ascertaining how the students developed in EGD concepts. Vygotsky’s ZPD theory confirms that when students are found studying together in study groups, they had the opportunity to work more independently with fellow age groups (1978: 61). These theories were coupled with the application of the Purdue Spatial Visualization Test (PSVT) which was used as a data collection instrument. The PSVT (Purdue Spatial Visualization Test) test contains three sections; developments, views and rotations each containing 12 questions; that is there were 36 questions in total. However, the development section was not part of the study because it is irrelevant to sectional drawing. Spatial visualization tests have been commonly used by educators as pre-test and post-test assessments to diagnose and improve students’ visualization skills in graphics and Computer Aided Draughting (CAD) courses (Sorby, 2003: 11). Therefore the PSVT was used as a pre and post-test to determine the students’ spatial abilities in EGD and sectional drawing in particular.
Methodology
Purposive sampling method was used to obtain 16 BEDTEE students doing EGD to participate in the study. Therefore data was collected from sixteen (16) BEDTEE students, that is, ten (10) 2nd years and six (6) 3rd years. All of the sixteen (16) students do sectional drawing which is a concept within machine drawing in the BEDTEE curriculum. The trustworthiness of the study was enhanced by the use of a multiple-method approach. Both quantitative and qualitative approaches/methods were used. The validity of the study was informed by the relevance of the questions which mainly were directed at investigating the difficulties that students have in sectional drawing whereas the reliability of the study was informed by the piloting of the study.

Data collection and instruments
Data collection was done by means of focus group interviews, the writing of PSVT test and the completion of questionnaires with EGD students. Questionnaires were administered as quantitative approach and focus group interviews as well as the Purdue Spatial Visualisation Test of Rotations (PSVT) were used as qualitative approaches. According to Makgato (2012: 1), the purpose of interviews is to obtain in-depth information and the quality around a particular activity. EGD students were provided with uniform questionnaires to complete. The questionnaire was used to answer the Research Question about the general students’ difficulties when drawing sectional drawing. The focus group interviews on the other hand contained structured questions pertaining difficulties in learning sectional drawing whereas the PSVT test was addressing the students’ level of spatial abilities.

Data analysis
The questionnaire data was analyzed using statistical frequency technique, while interview data was analysed descriptively. Interviews data were transcribed after each interview and typed verbatim by the researcher (Van Wyk, 1996: 164).

Results

Students’ PSVT Test responses

Table 1 Spatial ability skills (N = 12)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Number of drawing questions</th>
<th>Students’ response versus correct</th>
<th>Number passed versus Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotations’ questions</td>
<td>12</td>
<td>12 (8)</td>
<td>6 (67)</td>
</tr>
<tr>
<td>Views’ questions</td>
<td>12</td>
<td>12 (9)</td>
<td>3 (30)</td>
</tr>
</tbody>
</table>

Students were asked to complete a PSVT test on isometric representation of a three dimensional object and presents a type of rotation to which correlate to a different three-dimensional model. This test has three main parts each with 12 questions. These parts are spatial developments, rotations, and isometric views. However the study used only PSVT on spatial rotations and isometric views. Table 1.1 above shows that half of the students are good in rotating views. They obtained a total of 67% of the twelve (12) drawing questions on the PSVT Test. In the meantime 30% of the same students managed to get the views’
questions correct, thus, obtaining nine (9) questions correct out of the twelve (12) that are on the PSVT Test.

**Focus group interviews data responses**

Students were interviewed in order to obtain in-depth information about how they learn sectional drawing. Below are their responses:

_Interviewer:_ How often do you study EGD with fellow classmates?

Most students (83%) said they are not used in group studying and they cited various reasons based on that. One student was recorded as saying:

_Samuel:_ “I normally understand EGD concepts much better when I join my classmates in class but often we are told that whenever we are in groups we raise the noise level, so we are discouraged to do so”. In the meantime another student said “we often study EGD a day before we write a test because that’s the only time when our lecturer gives us enough exercises to do”. On the other hand one student responded by saying:

_Zukile:_ “I don’t like studying in groups really sir because what I experienced previously is that we gather in groups and be clueless still and I feel like I have wasted my time for another subject”.

_Interviewer:_ Do you think you were better qualified to enrol for BEDTEE course?

67% of the students agreed that they thought they had all that it takes to enrol for the BEDTEE programme with EGD as one of their major subject until they met sectional drawing. One of them responded by saying: “I since studied EGD from Grade 10 in secondary level, so enrolling for EGD in tertiary level is never a problem for me except that here we do a lot of new challenging topics”. In the meantime one fellow classmate said

_Mokgadi_ “I actually enrolled for this course because my results were poor for me to enrol for Building Engineering, so I opted for technology education and the reason I continued till level 3 is that there are opportunities for bursaries in this field”. However, her classmate said the following in response to the same question:

_Alude:_ “I did do drawing in secondary but it is my first time I meet sectional drawing here in the university and this shows me that I can here not having mastered drawing from where I started it”

_Interviewer:_ Since you battle in learning the concept sectional drawing, do you associate that with the Grade 12 EGD results and why?

83% of the students agreed in one voice that their Grade 12 background contributes to their poor performance in sectional drawing in tertiary level. One of the students said:

_Selaelo:_ “Absolutely yes, because in secondary we were never explained line work in details, I only know the bold line (type A) and a construction line (type B) and maybe that’s why I am battling. Our lecturer here is very strict in line work and I find it difficult to learn line work and infuse it in a drawing at the same time”. However another fellow student said the following in addition: “In my Matric I used to get around 50% in assembly drawing and I did not know why I was unable to get 70% and above, it is only now that I realize that I do not know the application of line work which resulted in poor understanding of sectional drawing, a building block to assembly drawing”.

_Siyasanga_ said the following in responding to the above question: “After my Grade 11 teacher passed away, we spent the entire year without a teacher and when we got a new one
in Grade 12, there was a gap left already from Grade 11, so this resulted in me coming here with a poor EGD background”.

**Students’ questionnaire responses**

Table 2 Sectional drawing challenges (n = 16)

<table>
<thead>
<tr>
<th>SECTIONAL CHALLENGES</th>
<th>FREQUENCIES AND PERCENTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>I do have challenges in completing sectional drawing successfully</td>
<td>1 (6)</td>
</tr>
<tr>
<td>I know the relationship between sectional drawing and 2D/ 3D drawing</td>
<td>6 (38)</td>
</tr>
<tr>
<td>I understand sectional drawing principles</td>
<td>7 (44)</td>
</tr>
<tr>
<td>Drawing models at our disposal are relevant to sectional drawing</td>
<td>14 (88)</td>
</tr>
<tr>
<td>I am familiar with ALL the line types that are used in the EGD curriculum.</td>
<td>6 (38)</td>
</tr>
<tr>
<td></td>
<td>10 (62)</td>
</tr>
</tbody>
</table>

Table 2 indicates that most students (94%) agree that they have difficulties in producing a sectional drawing successfully. On the other hand even though 38% of them strongly agree that they know the relationship of sectional drawing and other concepts, 56% of them strongly disagree that they understand the sectional drawing principles. When it comes to the availability of sectional drawing models, 88% of the students disagree that the drawing models that are at their disposal are so much irrelevant to sectional drawing. In the meantime, 62% of the same students are not familiar with the EGD line types in their BEDTEE curriculum.

**Discussions and conclusions**

From the PSVT Test, it really shows that students’ spatial ability skills are poor. This could be the leading factor towards their difficulties in sectional drawing since it is stated that spatial ability skills is a predictor to the success of any EGD concept (Strong & Smith, 2002: 5). The difficulty in understanding and learning the technical drawing is proven by the failure rate in a University in Patras, Greece, which is about 20% (Kabouridis (2010: 4). Similar or greater failure rates have been reported by other researchers (Garmendia, Guisasola & Sierra, 2007: 11). On the other hand, the students’ questionnaire response showed that most of the students do not know the application of sectional drawing principles therefore this could also have an effect in their success in sectional drawing.

This is also supported by Abrahams (2003: 17) that the three sectional drawing principles work hand in hand and are the main foundations to obtaining successful sectional drawing sketches. And since these sectional drawing principles do emphasize line work application, lack of students’ knowledge in using these principles might as well be effected by the fact that they also do not know line-work which forms the base for any EGD concept as mentioned by Benade and Heever (1994: 16). However, the sentiments that Vygotsky (1978) share in his theory that the external stimulation influence students’ development, lack of relevant sectional drawing models play a major role in learning.
The findings above show that students really come to enrol for BEDTEE programme with a shallow knowledge in spatial abilities. This was revealed by their dismal performance in the rotations and views’ section of the PSVT test. Their dismal performance also is affected by the fact that students do not know line-work application and sectional drawing principles. When students’ line-work application is poor, a completion of any EGD concept is unlikely. They also find it difficult to learn sectional drawing because of lack of drawing models that are relevant to sectional drawing. Based on these findings it is important that teachers use appropriated teaching strategy to improve spatial ability of learners, hence their performance in the EGD course.

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An investigation of TRAC practical activities to address Grade 11 learners’ conceptual difficulties in Electricity and Magnetism

Beauty Kotela 1 & Nazeem Edwards 2

1 TRAC SA, Stellenbosch University, South Africa; 2 Curriculum Studies, Stellenbosch University, South Africa.

Practical work in science has been widely acknowledged as important to develop students’ skills, knowledge and understanding while also stimulating their interest and appreciation of the subject. In South Africa, our learners have performed poorly in Physical Sciences and various interventions have been instituted to address the problems. Most of these have focused on improving learners’ theoretical understanding of concepts. TRAC uses practical activities based on the school curriculum to complement the theory through the utilisation of data logging equipment linked to a computer.

Millar (2004: 2) has defined practical work as any teaching and learning activity which involves the students in observing or manipulating real objects and materials. He also emphasised its role in the teaching and learning of science content is to help students make links between the domain of real objects and the domain of ideas. Abrahams and Millar (2008: 1965) also alluded to the absence of these links during the practical activity and suggest that overt scaffolding should take place. Hodson and Bencze (1998: 686) argued that the excessive use of algorithm recipes leads students to believe that there is a method of science and the ‘success’ of these ‘experiments’ reinforces the illusion of certainty. SCORE (2008:6) also concluded that there is no clear consensus that the broader science education community agrees on the aims and purposes of practical work in science.

This study investigates the conceptual difficulties that Grade 11 learners experience in Electricity and Magnetism (E&M) and how these can be addressed through the use of a practical activities-based approach using the TRAC equipment. The quantitative data reported here form part of a wider study. In particular the following research questions are addressed:

1. What are the conceptual difficulties experienced by Grade 11 learners in the module E&M?
2. How does the use of practical activities address these conceptual difficulties?
3. Do the learners exhibit some of the commonly known misconceptions experienced by learners in the module E&M and has the practical activities-based approach addressed them?

The participants in this study are a group of black Grade 11 learners (n=47) from a township school in the province of the Western Cape, South Africa. Their ages range from 16 to 21 with isiXhosa the home language of most of them. The pre-testing, practical intervention, and then the post-test process were repeated six times to cover the different concepts in the E&M module. Null hypotheses were formulated for the six concepts and t-tests were used to find any statistically significant difference between the pre- and post-test.
We report on two of these to illustrate some findings:

1. **H₀**: there is no significant difference between the pre- and post-test scores of Grade 11 learners’ understanding of magnetic field associated with current. A paired t-test was performed to determine if the practical activities based intervention was effective in improving learner understanding of the magnetic field associated with current. The mean difference in test scores (M= 9.17, SD = 14.62, N=24) was significantly different than 0, t = 3.07 (df =23) and p = 0.005389 (two-tailed). This provides evidence that the intervention is effective in improving grade 11 learners understanding of the magnetic field associated with current. The 95% confidence interval about mean test score differences implies that the test score gain could range from 2.99 to 15.34.

Learners were unable to apply the RH rule and the cross-dot notation. Their knowledge of electromagnets was also poor. The gains after the practical interventions, although statistically significant, could be improved if better scaffolding takes place during the practical activity.

2. **H₀**: there is no significant difference between the pre- and post-test scores of Grade 11 learners’ understanding of current associated with a magnetic field. A paired t-test was performed to determine if the practical activities based intervention was effective in improving learner understanding of the current associated with a magnetic field. The mean difference in test scores (M= 26.63, SD = 11.65, N=23) was significantly different than 0, t = 10.96 (df=22) and p = 2.209E-10 (two-tailed). This provides evidence that the intervention is effective in improving grade 11 learners understanding of this topic. The 95% confidence interval about mean test score differences implies that the test score gain could range from 21.59 to 31.67.

In conclusion, the analysis of the data has shown that a practical activities-based intervention can significantly improve learners’ understanding of concepts in E&M. In order for them to make the connection between the domains of observables and ideas, careful scaffolding should be done during the practical activity.

References
The impact of computer simulations on the performance of grade 11 learners in electromagnetism

Jonas Kwadzo Kotoka¹ and Jeanne Kriek ²

¹ Institute for Science and Technology Education, University of South Africa; ² Institute for Science and Technology Education, University of South Africa

¹kotokajk@gmail.com, ²kriekj@unisa.ac.za

This study examines the impact of computer simulations on the performance of 65 grade 11 learners in electromagnetism in a South African high school in the Mgwenya circuit in the Mpumalanga province. The study followed a non-equivalent control group design. The performances of participants in the control group (N = 35) and experimental group (N = 30) were used to determine the impact of computer simulations on the performance of grade 11 learners in electromagnetism. The t-test for independent samples showed that the experimental group achieved significantly higher scores on the post-test than the control group. In the analysis of the short-answered written questions, the experimental group outperformed the control group. Average normalized gain, (g), introduced by Hake on conceptual learning was calculated as 0.18 for the control group which is consistent with Hake’s low g course and 0.32 for the experimental group which is consistent with Hake’s medium g course. It was concluded that computer simulations influenced the higher performance of the learners in the experimental group.

Background
Science teachers nowadays have access to choose a range of computer simulations and some of these simulations are available at free-access internet sites, commercial internet sites, and resident commercial software producers (Trundle & Bell, 2010). According to Wieman, Adams, and Perkins, (2008) research shows that, learners learn better, when they construct their own understanding of scientific ideas within the framework of their existing knowledge. To accomplish this process, learners must be motivated to actively engage with the content and must be able to learn from that engagement. Interactive computer simulations can meet both of these needs. It is hoped therefore that interactive computer simulation usage may hold the key to learner’s visualization of the abstract concepts in electromagnetism.

Aim of research
This research therefore seeks to answer the question, what is the impact of computer simulations on the performance of Grade 11 learners in electromagnetism?

Theoretical framework
The major theoretical perspectives which support Computer-Based Instruction (CBI) as a means of enhancing student learning are constructivism, and situated learning or situated cognition (Thomas & Emereole, 2002). A critical component of theories of constructivism is the concept of the zone of proximal development (ZPD), based on the work of Vygotsky (1978), which posits that learning takes place by the learner completing tasks for which support (scaffolding) is initially required.

Research design
The study followed a non-equivalent control group design. The performances of participants in the control group(x₂) and an experimental group (x₁) were used as basis to establish and
explain the impact of computer simulations on the performance of grade 11 learners in electromagnetism.

Participants
The 65 participants of the study came from two intact grade 11 physical science classes that were randomly constituted at the beginning of the year in a high school in Mgwenya Circuit of Mpumalanga Province of South Africa. There were 35 learners in the control group and 30 learners in the experimental group. To verify the equivalence of the two classes, the achievement of the June Exams was compared using a t-test. The results indicated that there was no statistically significant difference ($t = 0.906$, $df = 101$, $p = 0.3672$) between the classes. This implied that the learners were of the same academic ability before the treatment.

Methodology
The same test was written by both groups as a pre and post test. The control group was taught electromagnetism using traditional teaching methods, demonstrations and real laboratory experiments. Simultaneously the experimental group was also taught electromagnetism using traditional teaching methods, demonstrations and computer simulations using PhET simulations and simulations from the Plato learning centre. Both the real laboratory experiments and computer simulations were offered during a special arranged class with duration of approximately 2.5 hours during the period of intervention.

Instrument
The test consisted of twenty multiple choice questions and five short-answered written questions. The questions in the test were adapted and slightly modified from three sources namely South Africans matriculation past physical science (physics) examination papers; commonly used South Africans physical science textbooks and Modelling teachers question banks CD2 Part 1. Reliability and validity of the instrument was ensured.

Findings
There was no statistically significant difference in the achievement of the two classes in the pre-test: $t$ statistics $= 0.390$, $df = 63$, $P = 0.05$, $t$-critical two tail $= 1.998$ which is approximately 2.00, since the $t$-critical (2.00) is greater than the $t$-statistics (0.906) at $P > 0.05$. However, a statistically significant difference between the post test scores was found: $t$ statistic $= 3.582$, $df = 56$, $p<0.05$ and $t$ critical two tail $= 2.00$; since the $t$ critical two tail $= 2.00$, is less than $t$ statistics (3.582). In the analysis of the short-answered written questions, the experimental group outperformed the control group except on questions on transformers in which calculations had to be used. Furthermore, the average normalized gain gives an index that helps to compare the extent to which the treatment is effective (Hake, 2007). The average normalized gain, $<g>$ was calculated as 0.18 for the control group which is consistent with Hake’s low $<g>$ course and 0.32 for the experimental group which is consistent with Hake’s medium $<g>$ course.

Conclusion
This study investigated the impact of computer simulations on the performance of grade 11 learners in electromagnetism and found that the simulations significantly influenced the performance of learners in the experimental group when compared to the control group.

References
Classroom discussion is a critical component of teaching and learning (Driver, Asoko, Leach, Mortimer & Scott, 1994). Shemwell and Furtak (2010) highlight the importance of student discussions in that “discussion engages students in the constructive process of explaining, reflecting upon, and defending their thinking at the critical juncture between new ideas and the prior knowledge needed to make sense of them” (p.223). It is this juncture, the linking of prior knowledge to new ideas and making sense of them in the context of problem-solving that is central to this study. Identifying when these connections occur and what factors may influence the opportunity to make such connections is important to understand so teachers may provide the optimal learning environment to cultivate such discussions. Unfortunately, some have found that discussion is rare in science and mathematics classrooms (e.g., Newton, Driver & Osborne, 1999, Pirie & Schwarzenberger, 1988). To foster an environment conducive to class discussions, students must have the time, guidance, and opportunity to converse with their peers. Working in groups is one strategy to facilitate such activity though the role of the teacher is still instrumental; what prompts the teacher makes, connections to previous discussions, and providing context for the conversation are key to successfully facilitating class discussion (McNeill & Pimentel, 2010). If science and mathematics classrooms are falling short in adequately providing for such discussion, the question remains as to where and how else these discussions may take place. One possible solution may be designed informal learning settings such as zoos, museums, and aquaria. Designed informal learning settings provide a unique venue for students to engage in real-world problem-solving outside the context of their classroom, emphasizing the social nature of learning and imbedding it in authentic contexts with objects representative of natural phenomena. It is essential to investigate what types of conversations students, and for that matter any group of visitors, have around science and math in these settings.

The objectives of this pilot study were multiple: 1) to identify occurrences of students engaged in problem-solving in an informal learning environment, 2) to characterize the
nature of these conversations around problem-solving, and 3) to test the feasibility of a new data collection tool as well as approach to analysis. To meet these objectives, student conversations were captured using the LiveScribe® Pen and further analyzed for instances of problem-solving.

In total, six group conversations were recorded and analyzed. The analysis of the recorded data was based on an analytical model for studying the development of learners’ mathematical ideas and reasoning using the videotape data suggested by Powell, Francisco, and Maher (2003). The analytical process included listening to the conversations, identifying critical events (a situation when students argued, made decisions or discussed how to do something or provided explanations for why they were doing it that way), transcribing and coding.

Due to the small sample size, analysis primarily consisted of descriptive statistics including frequencies and means. The initial data analysis pointed to two factors that contributed to student conversations around science and math while problem solving in an informal learning setting. First, the type of challenge students were asked to complete in the class affected the nature of their conversations.

The students worked in groups of four to six to help recreate the natural environment of the Pacific Northwest to design a sustainable habitat for sea otters that live at Shedd. Each group had a particular mission described below:

- Behavior group: Find a way to use numbers and graphs to represent what otters do.
- Food group: Create a yearly diet for one otter and determine if the team can remain on-budget
- Habitat: Create the winning design for the shape and layout of the otter habitat

All three tasks provided opportunities for students to discuss and make decisions about various mathematical and scientific problems though analysis indicated one particular task had a greater number of critical events per group than others. In particular, the analysis indicated that the “Food” challenge was the most fruitful (M=12.5), followed by the “Habitat” (M=7.3), and the “Behavior” (M=8.0) challenges with the average number of critical events per group at M=9.0.

The second factor affecting conversations was the presence of a chaperone. The analysis indicated that the groups with chaperones had approximately ten times greater amount of conversations regarding science and mathematics concepts and were more likely to reach a solution to their designated challenge. As chaperones were not an initial subject of the study, no demographic data was collected. However, anecdotally it appeared that all chaperones present were either parents or teachers from the school. As the influence of chaperones was an emergent finding, we would like to further investigate this role in the future, including demographic data.

Finally, the Livescribe® pen allowed us to listen to students’ conversations as well as see how they connected to their written work all without interrupting the non-evaluative nature of the informal learning experience. However, it should be noted that some conversations would not be as insightful if we did not have observation notes to accompany them. For example, students were talking about where the otters would find a particular food by referring to a particular resource. The observation notes indicated that students used field guides and dive profiles to identify the primary diet of sea otters to make their decisions. So
as a data collection tool on its own, the Livescribe ® pens may not be sufficient, but they are effective in providing a non-threatening way for recording both verbal and written information.

Research on learning in designed informal learning settings is a developing field of study and there is a need for more research on the nuances of learning experiences at informal settings; this study is instrumental in continuing to propel this line of research forward. Informal learning settings have great potential to engage learners in real-world problem-solving and authentic firsthand experiences with scientific phenomena. Understanding what factors influence the potential to maximize these learning experiences is fundamental to both the professionals of the informal science education field as well as the larger field of education research. As the findings of this study indicate, the role of support systems such as chaperones is key to successfully maximizing these learning outcomes.

References

SCIENCE AND TECHNOLOGY FUNCTIONAL LITERANCY: CASE OF MALAWI

Noel Kufaine ¹ Lusungu Nyirenda ²
University of Malawi, Private bag 303 Chichiri, Blantyre 3 Malawi
¹nkufaine@poly.ac.mw ²lnyirenda@poly.ac.mw

This paper presents some of the findings of the wider study that is still undergoing exploring how science and technology function is perceived. The Government of Malawi through Ministry of Education Science and Technology has embarked on the promotion of science and technology education as an important subject for development.

Science and technology is believed to be a catalyst for the development of both the individual and the nation (Nampota et al 2009, Caillods et al. 1996). It is expected to equip the individual with knowledge, skills, values and attitudes that enable one to perform one’s roles effectively in an attempt to promote and sustain the socio economic development of a nation.
Thus the aim of science and technology in secondary school curriculum was that all secondary school learners be literate in relevant science and technology (Nampota et al, 2009), which is a prerequisite to socio-economic development.

Science and technology is expected not only to be relevant but also appropriate with an aim of building a science and technology culture at school or at home, so that people should participate in the trends in Science and technology because science and technology are being applied in almost every community, hence its key for transformation of community (Sachs and McArthur, 2007). Hence science and technology functional literacy at each level in the realm of science and technology is critical.

With experience from Asia, there is enough evidence that there is relationship between science and technology and development (Caillods et al. 1996) but still science and technology is not a being used in Malawi as such, it raises a question whether the provision of appropriate and adequate science and technology in both primary and secondary schools is really a good foundation for higher education and in turn industrialization?

The introduction of science and technology in Malawi secondary school curriculum triggered heavy debates between University of Malawi faculty of science and the science and technology curriculum developers (Nampota et al, 2009). It was resolved that science and technology as a subject in secondary school curriculum should be removed because it fails to meet the standard as a science or pre-requisite to entry into science subjects in the University of Malawi. The study used interview guided by semi-structured questionnaire, the sample was purposive targeting secondary school teachers and the users of technology in the industry. We also used document analysis in evaluating the science and technology policies and other documents. Grounded Theory analysis was done on data collected. Grounded Theory analysis is described as a qualitative research approach that uses a systematic set of procedures to develop an inductively derived grounded theory about a phenomenon (McMillan, & Schumacher, 2006)

The study revealed that most secondary school teachers are of the view that the Science and technology as a subject should be completely removed from the secondary school curricula so that the ‘traditional’ science subjects remain i.e. physical science, mathematics and others. They also claim that science and technology is a repetition of topics offered in other science subjects. While others still feel that the Science and technology secondary school syllabus should be revised and incorporate content that is relevant and form a pre-requisite for entry to study programs offered by University of Malawi or other universities that are related to Science and technology.

This shows that there is misunderstanding on the whole essence of science and technology and this has created inconsistence in the provision of science and technology in our secondary schools. With the growing belief that only physical science, mathematics and a few others science related subjects are enough to prepare for the production of skilled manpower as far as science and technology is concerned, the effort to develop the science and technology literate community will be a big challenge. The thinking that every subject in the secondary school will only be important if it qualifies as a pre-requisite to entry into the university misleads on the rationale of other applied subjects which are critical for long life learning.
It should be mentioned here that the majority of Malawians find it very difficult to relate to scientific and technological techniques, this means the appropriateness and relevancy of Science and technology offered in schools from the lower level is not yielding expected results. In the industrialized countries, promotion and provision of science and technology is taken seriously and is done from the grass root level, (Caillods et al. 1996) hence a need for Malawi to do something similar. Much as we appreciate the importance of technologies towards development, Sachs and McArthur (2007:64) noted that most developing countries like Malawi prefer to adopt rather than create their own technologies to the extent that they do not take up innovations by the indigenous people seriously.

In science and technology, a lot has been written on the need for countries to have educated and qualified human resources if they are to develop in any way and keep up with the ever-changing nature of our societies. But the level of literacy is a hindering factor, it appears that, its either science and technology is not available as science and technology or the science and technology is misunderstood to mean something else.

By way of conclusion, the strategies designed to increase access to education should not limit to space and equity only, it should also emphasize literacy to specific knowledge for specific purpose in this case science and technology. There is need for a comprehensive understanding of the context in which science and technology undertaken, their forms and their major outcomes. This is important as it provides a basis for identifying viable strategies will ensure effective science and technology implementation. The better science and technology practice heavily depend on the level of literacy which raises the level of enthusiasm to using of science and technology. Therefore, motivation and morale of the students towards Science and technology should also be taken into account. Policies need to be formulated and implemented that will help boost interest of students in Science and technology.

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Using the construct PCK to describe teacher knowledge of two physical science teachers within the context of chemical equilibrium.

**Lebala Kolobe** 1 & **Paul Hobden** 2

School of Education, University of KwaZulu-Natal, South Africa.

1 kolobe@ukzn.ac.za, 2 hobden@ukzn.ac.za

Within the chemistry component of the South African National Senior Certificate examinations, chemical equilibrium was found to be amongst the worst performed topics, with an average of about 33% pass for questions on the topic. Research has shown that chemical equilibrium is difficult for both teachers and learners. Considerable research has been done around misconceptions in this topic and these misconceptions have been found to be common across different areas of the world. Problems around understanding this topic have been attributed to, inter alia: textbook misrepresentation; nature of the topic and teacher knowledge. Many studies (Cheung, 2009a; Treagust, Tyson & Bucat, 1999; Van Driel, de Vos & Verloop, 1999;) have focused on identifying factors that impact on the learning and teaching of chemical equilibrium, including identifying learner misconceptions around the topic of chemical equilibrium. Several suggestions have been made on ways to deal with the misconceptions (see e.g. Cheung, 2009b; Doymus, 2008; Piquette & Heikkinen, 2005; Raviolo & Garritz; 2009). However, very little research has addressed physical science teachers’ awareness of such student misconceptions and how physical science teachers’ knowledge of students’ learning difficulties and pre-conceptions of chemical equilibrium may be used to make the knowledge accessible to learners. There have not been studies that describe the PCK necessary for teaching chemical equilibrium or, specifically PCK of teachers showing consistently good Physical Science results, in South African schools. This short paper is intended to look at exemplars of PCK from teachers with consistently high learner results.

This paper is intended to explore the following research questions: What PCK for teaching chemical equilibrium does each teacher demonstrate? and; How did these teachers develop their PCK? An exploratory case study design was used in this research study. Categories of PCK as argued by different scholars e.g. Ball, Thames, and Phelps (2008); Rollnick, Bennett,
Rhemtula, Dharsey, Ndlovu, (2008); Van der Walk & Broekman (1999), guided the analysis process. PCK is used as a framework for understanding teacher knowledge. Scholars agree that PCK is a form of teacher knowledge where the teacher uses their knowledge of content, teaching strategies and learning to make knowledge accessible. PCK is therefore composed of knowledge of content, teaching strategies, learners and how they learn, as well as teaching context. PCK is a complex form of teacher knowledge that is individualistic, internal, ever changing, tacit, difficult to recognize, train or capture. Scholars are continually working on ways to best describe this crucial component of teaching and learning.

To identify participants of this research, Senior Certificate results in Physical Science, were analysed for those schools with experienced teachers that have been consistently producing good results in Physical Science over a period of five years. For purposes of this paper, only two teachers, showing most extreme differences in their observed PCK will be discussed in detail. The following data collection strategies were used: Teacher educational biographical questionnaires; one-on-one interviews on their plans and approaches when teaching chemical equilibrium; classroom observations and materials used, when teaching the topic. Interviews and classroom observations were transcribed and were analysed systematically through the use of NVIVO. The use of NVIVO will help identify each teacher’s most employed PCK category in a systematic way. Loughran, Mulhall & Berry’s (2004) method of analysis of PCK, using the content representations (shortened CoRes) and Pedagogical and Professional experiences Repertoires (shortened PaP-eRs) is employed to discuss the two teachers’ PCK. Data collected in the questionnaires, interviews and observation transcripts inform the question as to how the two teachers each developed their PCK for teaching chemical equilibrium.

One of the preliminary findings indicates that knowledge of national examinations requirements, a curricular issue, are a major influence in the way teachers help their learners understand and master the skills required. It is a focus on this aspect of PCK that seems to be most dominant, more than any other forms of teacher knowledge. This is gained through experience in marking the Senior Certificate examinations. The teachers’ PCK in action will be described in detail in the presentation and then will be discussed in the light of the findings.

References


Teaching Nature of Science and Scientific Inquiry to Diverse Classes of Early Primary Level Students

**Judith S. Lederman, Selina L. Bartels, Norman G. Lederman**  
[ledermanj@iit.edu, sbartels@iit.edu, ledermann@iit.edu](mailto:ledermanj@iit.edu, sbartels@iit.edu, ledermann@iit.edu)

Scientific Early Childhood Students: literacy is a perennial goal for science education in the United States (NRC, 1996) and worldwide. Students need to understand what science is, how it is done, by whom it is done, why it is done, and be able to apply what they know to make informed decisions about their personal and societal decisions. Attention to this goal should begin in the very early grades and continue throughout all grade levels.

In order to be scientifically literate students must understand the source of scientific information, the limits of scientific knowledge, what characteristics embody science, and how scientific knowledge is developed. The teaching and learning of Nature of Science (NOS) and Scientific Inquiry (SI) are important components of the development of students’ scientific literacy.

In order to understand NOS and SI teachers must provide explicit/reflective instruction (Khishfe & Abd-El-Khalick, 2002). This type of instruction can begin with very small children (Akerson & Volrich, 2006). Since little research has been completed with very young students (K-2 grades), this study examined if diverse first grade students can learn Nature of Science and Scientific Inquiry. In particular, did culture and different beginning knowledge of NOS and SI relate to students’ development of knowledge in these areas?
Design
The subjects in this study were 62 grade one students. The study took place at a public school in the Midwest of the United States: Chicago, Illinois. The students were in three classrooms; one predominately English speaking (24 students), one predominately bilingual Mandarin speaking (13) and one predominately bilingual Spanish speaking (25). Students in this sample had been in the US for various lengths of time from a few months to their entire life. Ninety-four percent of the sample falls below the poverty line in the US.

The researchers pre- and post-tested the students using an oral protocol entitled Young Children’s Views of Science [YCVS] (Lederman, 2012). After the pre-test the researchers taught eight lessons to specifically teach students aspects of NOS and SI that were appropriate for primary students. Students were taught how to make observations and discern between observations and inferences. Students wrote their own questions, planned their own investigations, collected data and made conclusions. During each lesson the researchers explicitly stressed when a NOS or SI aspect occurred in the lesson. Students were also asked to reflect on the NOS/SI aspects that occurred in the lessons. There were two interpreters, one for Spanish and one for Mandarin. These interpreters planned the lessons with the researchers. The interpreters were also science educators, one Masters student and one PhD student.

Data Sources
Data were collected during the Spring, 2012. Students’ views of were measured at the start and end of the research project. The instrument used to assess students’ views of science was the YCVS (Lederman, 2012). The YCVS is a valid and reliable oral protocol consisting of six open-ended questions that have sub questions that can be used. Students were interviewed in groups of three to four students. Interviews in groups allowed the students to feel more comfortable and for the students’ answers to build on each other. The interviews were audio recorded, transcribed and coded. The aspects coded were; science is empirically based, science begins with a question, observation/inference, and characteristics of scientists and science. For each aspect students’ answers were coded as; no answer, inadequate, limited, and adequate. “No answer” views were students without a response. “Inadequate” views were those with inaccurate understandings of the aspect. “Limited” was coded for students with a developing understanding, and “adequate” was coded for students with an appropriate view for their age. Both researchers and translators coded the transcriptions for the pre and post interviews. Any discrepancies were discussed and a 100% inter rater agreement was reached. Frequency data was collected to determine the difference between pre and post students’ understandings.

Results
Large and significant improvement was made in all five areas; empirically based, begins with a question, observation and inference, who are scientists and what is science. Understanding that science is empirically based on the pre-test showed 64% of the students had no understanding, 14% had inadequate and 21% had adequate views. On the post test, 86% had limited and 14% had adequate views. For “science beginning with a question”, 86% of the students had no understanding and 14% had inadequate views, compared with the post-test where 7% had nothing, 36% had limited, and 57% had adequate understandings. Students’ understandings of observation and inference in the pre-test was 57% had inadequate understandings and 43% had limited, on the post-test 7% had inadequate, 29% had limited and 64% had adequate views. For students’ understanding of who scientists are, in the pre-
test 21% had no view, 50% had inadequate and 29% had limited. On the post test for students’ understandings of scientists, 7% had limited and 93% had adequate. In the pre-test students’ understanding of science, 14% had no view, 50% had an inadequate view and 36% had limited. On the post test, 36% had limited and 64% had adequate views.

Conclusions and Implications
Regardless of knowledge, conceptions, demographics, or cultural backgrounds young students are capable of developing more informed views of NOS and SI through explicit/reflective science instruction. These views further young students’ development of scientific literacy. These finding are similar to the Akerson and Volrich (2006) study that found that young children are able to improve their conceptions of NOS given explicit/reflective instruction. This study is also consistent with Akerson & Donnelly (2010) that found children’s NOS views can be improved through explicit/reflective NOS instruction. Given these results, researchers should examine curricular materials for the early grades to incorporate NOS and SI instruction. Early childhood teacher educators should provide experience for their pre service teachers to prepare explicit/reflective lessons that clearly teach and build science literacy. Teachers of young students should understand that students are capable of developing scientific literacy, and need to provide their students with opportunities to design their own investigations, write scientific questions, observe, make inferences and draw conclusions.

References
This paper’s main argument is that despite the concept of scientific literacy being a somewhat flawed notion, it holds currency in diverse groups who influence what is taught in schools. The paper examines the development of the South African School Science curricula over the past two decades in relation to the concept of scientific literacy. Definitions of scientific literacy are numerous and varied, and often get in the way of the actual concepts being taught (Laugksch, 2000; Ramsuran, 2005). It seems that differing parties use it to suit their own ends, and it has become a weasel word (Dillon, 2009). The conceptual framework that guides the paper is that of scientific literacy, and the various contested positions and usefulness of the term will be discussed in the full paper.

According to Carnoy & Samoff (1991), the curriculum is of considerable symbolic value in societies undergoing political and other transition. Prior to 1994, how a pupil experienced the South African school curriculum varied according to the racial group into which the pupil was classified. The responsibility for education was dispersed over a large number of education authorities, differentiated along racial lines. In 1994, over a period of a few months, the former apartheid curricula were replaced by ‘interim core syllabi’ for each subject area. Jonathan Jansen documented the process, and suggested that it had more to do with the politics of transition than with syllabus revision. (Jansen 1998). While the curriculum was purportedly an attempt to effect a complete break with the apartheid education system, many of the syllabi, including the science interim core syllabus, bore a close resemblance to the former Transvaal Education Department ‘white’ education science curricula. From 1994 until the present, South Africa has undergone a series of curriculum reforms and revisions culminating in the Curriculum and Assessment Policy Statement for each subject area. This paper traces the notion of scientific literacy across the four main curricula relating to grades 7-9 in the natural sciences: the Interim Core Syllabus (ICS), Curriculum 2005 (C2005), the Revised National Curriculum Statement (RNCS) and the Curriculum and Assessment Policy Statement (CAPS).

The interim core syllabi for each subject remained in effect until major curriculum reform during the latter half of the 1990s, and were still used from grades 9 to 12 until 2005. In 1996, the ‘outcomes-based’ Curriculum 2005 was developed, to be phased in over a period of years. The curriculum consisted of eight compulsory subjects, or “Learning Areas” one of which was “Natural Sciences”.

Curriculum 2005 was a major departure from the previous curricula, and instead of providing teachers with a list of content to be taught, provided a series of outcomes, ostensibly based on national needs. For the Natural Sciences Learning Area, considerable emphasis was placed on scientific literacy as a major goal for all students to attain by the level at which compulsory schooling ends (grade 9). Although Curriculum 2005 was introduced into schools in 1998, it underwent a review in 2000, as a result of various criticisms of its poor implementation and complex format (e.g. Jansen 1998). A major consequence of the review
was a series of draft National Curriculum Statements (NCS) for each learning area, which were intended to provide a clearer basis for teaching. The paper examines the natural sciences curriculum statement and its approach to the concept of scientific literacy, and questions whether the approaches promulgated achieved the intended outcome of promoting the public understanding of science.

The RNCS provided its own detailed definition of scientific literacy devised by a group of science educators attempting to improve the low base of science education in South Africa. They suggested that the overall objective for Science, Mathematics and Technology Literacy was ‘to ensure that the public is competent, confident and comfortable with the products and processes of science’ (Department of Education 2002). The science RNCS further suggested that scientific literacy would be promoted through three major goals, which are examined in the paper. These three goals were then reformulated into three ‘Learning Outcomes’ which guided the whole of the science curriculum, from pre-school to grade 9. The remainder of the RNCS document is analysed using Roberts’ notions of Vision I and Vision II. Vision I “looks inward at science itself – its products such as laws and theories, and its processes such as hypothesizing and experimenting” while Vision II “looks outward at situations in which science has a role, as decision-making about socio-scientific issues” (Roberts, 2007, p. 9). Issues that are interrogated in more detail are the acceptance of students’ own beliefs as valid knowledge in the natural sciences, the relationship of indigenous knowledge to western science and ways in which IK can be incorporated into classroom teaching and process skills vs. science subject matter knowledge.

Although based on the RNCS, the CAPS document for Natural Sciences grades 7-9 does not spell out its own view of scientific literacy. The philosophy of Natural Sciences are discussed in sections 2.1 and 2.2 of the document, which are discussed in the paper. The remainder of the CAPS document is analysed using Roberts’ notions of Vision I and Vision II as described above (Roberts, 2007). Similarly, the issues listed above are also interrogated in this curriculum document.

The analysis found that the RNCS document struck a balance between Vision I and II of scientific literacy, while the CAPS document tends to favour Vision I over Vision II. The implications of this are that while the CAPS document may provide a good foundation for entry into the FET sciences, some of the ideals of the original intentions of curriculum reform may have been lost in the revision process. We therefore need to work with scientific literacy as a concept, and enable it to work for the development of science education in GET schooling.

The paper concludes with a summary of how the concept of scientific literacy has developed in the curriculum over the course of the last 20 years, and its implications for the development of actual scientific literacy in the South African youth.

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Over the past two to three decades it has been convincingly argued that many of the learning challenges faced by science students are rooted in coming to understand and work with the specialized forms of communication that the teaching of science calls for (e.g., Driver & Ericksson, 1983; Lemke, 1990; Northedge, 2003). From such a viewpoint the disciplinary ways of knowing are inseparable from their discursive representations. Recent work in this area has been diverse and has ranged from making connections with the notion of academic literacy (e.g., in the South African context, see Boughey, 2002) to multimodality (e.g., Tang, Tan, & Yeo, 2011), to how representations affect solving problems (e.g., Kohl & Finkelstein, 2008) to curriculum design (e.g., Van Heuvelen, & Etkina, 2009). While most of the work has been done in a physics setting, no work in physics has looked at how lecturers think about the representational competence of their students in relation to the cultural contexts – discipline, lecturers and students – and how the lecturers consequently constitute their practice to optimize the possibility of learning. The South African Council on Higher Education and the South African Institute of Physics current Review of Undergraduate Physics Education discussion document (CHE-SAIP 2012) in part can be seen to require a much better understanding of this issue because the way lecturers use the representations of physics underpins a contemporary view of learning physics that is based on curriculum experiences that reflect the practices of physicists. This played an important part in motivating our research question: When South African Physics lecturers perceive a lack of representational competence in their students, in the particular contexts in which they work, what are their response strategies to address the issue? By ‘representational competence’ we mean, for the purposes of learning, the ability to engage meaningfully in a disciplinary discourse, which is -- ‘the complex of representations, tools and activities’ that make up a discipline’s system of
communication (Airey & Linder 2009, p. 24). For Physics this includes written and oral
textbook language, diagrams, graphs, mathematics, apparatus, laboratory routines, etc.

In order to address the question as an interpretative case study we interviewed 20 physics
lecturers drawn from five South African Universities. The lecturers volunteered to participate
after solicitation and they signed an ethical committee approved consent form (for ethical
reasons neither the lecturers, nor their universities are identified). The spectrum of
universities encompasses the South African notions of historically black universities,
historically disadvantaged institutions, and historically privileged universities. Mother tongue
diversity across both students and lecturers was also a factor in selecting universities. Semi-
structured individual interviews of between 30 and 60 minutes were recorded and then later
transcribed. In order to formulate analytic categories, the transcriptions were treated in a
hermeneutic cycle of analysis until saturation was reached.

Two theoretical constructs underpinned our methodology: disciplinary discourse and
disciplinary affordance. What is important for our analysis is the ability to engage
meaningfully in a disciplinary discourse. Here, Fredlund, Airey and Linder (2012, p.2)
describe representations as having a disciplinary affordance, which they define as ‘the
inherent potential of that representation to provide access to disciplinary knowledge’. We use
these constructs as a framework for our analysis and to highlight consequent issues.

Five qualitatively different categories of response strategies to deal with the perceived lack of
disciplinary representational competence in students were formulated. These categories are:
Not recognize; Recognize but ignore; Recognize and avoid; Recognize and look for
alternatives; and, Recognize and actively engage. These categories are discussed and
illustrated by transcript excerpts.

In relation to the outcomes the following issues and implications will be discussed: the
lecturer’s conceptual framework for their pragmatic day to day teacher practice; how the
spoken and written language representations used in the physics learning environments
manifested as a principal issue for the different educational contexts; different ways of
actively engaging with perceived lack of representational competence -- achieving ‘fluency’
in representations; and, how physics lecturers need a deep appreciation of how to deal with
achieving representational competence in the South African context.

While the lecturers provided different contextual descriptions of representations that they felt
were needed to provide a holistic understanding of physics, many of them appeared to lack
the culturally linked pedagogical knowledge and insight needed to respond in a way that
could effectively enhance the possibility of learning. Not enough is known about which
representations are needed and why, and what the disciplinary affordances of the various
representations we use in physics are. We conclude that further research in this area is needed
to enhance physics education in terms of both teaching practice and curriculum development.
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Opportunities for developing critical thinking in the CAPS science curriculum

Fred Lubben

University of York
Fred.lubben@york.ac.za

Within South Africa, considerable research has been done on effective strategies for developing learners’ critical thinking, i.e. their ability to make assertions based on judgements of the strength of arguments and evidence (Kuhn, 1999). Notable are Ogunniyi’s (2007) Contiguity Argumentation Theory, and the framework for Inclusive Argumentation developed by Scholtz et al. (2008).

The South African school curriculum has been modified recently, guided by the Curriculum and Assessment Policy Statement (CAPS) (DoBE, 2011). This paper surveys the implications of the tighter curriculum prescription in the CAPS curriculum for Life Sciences (LS) and Physical Sciences (PS) classes, respectively, at the level of Further Education and Training (FET). In particular, the study sets out to draw on the expertise of teachers experienced with the teaching of critical thinking in the previous curriculum, and explores their views on opportunities for teaching critical thinking within the new curriculum. These views are compared with those of teacher trainees. The research questions are:

1. What do experienced teachers in the Life Sciences and Physical Sciences see as opportunities for teaching critical thinking within the CAPS curriculum?
2. How do the views of these experienced teachers compare to teacher trainees’ views on opportunities for teaching critical thinking in the CAPS curriculum?

The findings of this study will inform pre- and in-service teacher development programmes.

In order to identify opportunities for teaching critical thinking, this study uses Facione and Facione’s (1992) six aspects of critical thinking, as follows:

(i) Interpretation of information (clarifying meaning, categorising, decoding significance)
(ii) Analysis of evidence (examining ideas, identifying and analysing arguments)
(iii) Evaluation (assessing claims and arguments)
(iv) Inference (querying evidence, conjecturing alternatives, drawing conclusions)
(v) Explanation (stating results, justifying procedures, presenting arguments)
(vi) Self-regulation (self-regulation and self-correction)

Methods
The opportunistic sample consists of 7 LS teachers and 16 teachers of PS participating in workshops aimed at familiarising them with the CAPS curriculum. All had considerable experience of teaching critical thinking in the previous curriculum. In addition, all Year 4 teacher trainees in LS (n=24) and PS (n=18) at a South African University participated. Previously, they had been taught the principles of critical thinking, and how it may manifest itself in teaching.

The study took place before the implementation of the CAPS curriculum. The CAPS curriculum documents for FET Life Sciences, Grade 10: Life at the molecular, cellular and tissue level and Physical Sciences, Grade 10: Chemical Change were selected for analysis by experienced teachers and teacher trainees. These strands proved to be open to the teaching of critical thinking in the previous (RNCS) curriculum.

Two groups of LS and five groups of PS teachers identified opportunities for teaching critical thinking in selected CAPS curriculum sections using the six categories of Facioni and Facioni (1992). Six groups of LS and four groups of PS teacher trainees did the same. Written records of these group identifications and audio-taped oral reports of the group discussions are used as data sources.

All data have been analysed independently by four researchers for descriptive patterns in aspects of critical thinking present in the curriculum within the teachers’ and teacher trainees’ views, respectively. Subsequently, the views of teachers and teacher trainees were compared. Grounded theory was used to analyse the transcripts of the oral presentations for reasons for identifying opportunities for teaching different aspects of critical thinking.

Findings
Provisional analysis suggests that expert teachers of LS and PS mostly identify curriculum statements allowing opportunities for teaching several critical thinking skills simultaneously. These curriculum statements may be grouped in three categories, i.e. those detailing practical activities, requiring the use of diagrams and models, or focussing on the interpretation of chemical formulae. It is notable that all of these focus on multi-representations of concepts – critical thinking skills are seen as applicable in translating between representations.

These statements are seen as opportunities for promoting, in particular, the skills of interpretation of information, inference and explanation. Very few opportunities are identified for teaching the skills of evaluation (assessing claims and arguments) and of self-regulation, including self-correction. Teachers suggest that opportunities for critical thinking skill development will not only depend on the curriculum statements addressed, but crucially on the teaching strategies employed. Several teacher groups indicate that a predict-implement-explain sequence may allow for developing all six of these skills, including self-regulation.

Teacher trainees identify, by and large, the same curriculum statements as opportunities for developing critical thinking skills as the expert teachers. However, the specific skills targeted by each statement show a wider variety than for the teachers. Several student groups
provide reasoned evidence for using statements for the development of all six critical thinking skills, including evaluation and self-regulation. These findings do not differ substantially for the life sciences and the physical sciences.

**Conclusion**

In order to make the teaching of critical thinking skills explicit, learner materials may need to be developed for using multi-representations when teaching models, diagrams, analogies, equations and practical activities, particularly those prescribed by the CAPS curriculum.

**References**


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**Conceptual gains and persisting misconceptions in undergraduate chemistry**

Marietjie Lutz \(^1\) & Marietjie Potgieter \(^2\)

\(^1\)Department of Chemistry and Polymer Science, University of Stellenbosch, South Africa. \(^2\)mlutz@sun.ac.za, marietjie.potgieter@up.ac.za

“Without explicitly abolishing misconceptions it is not possible to come up with scientific sustainable concepts” (Piaget and Inhelder, 1971). Chemistry students enter university with a number of misconceptions which may either originate from self-developed preconceptions formed without having any prior knowledge or may arise due to inappropriate teaching methods and materials. These misconceptions may persist even up to graduate level and are known to be very difficult to address and require explicit intervention in order to be corrected (Barke et al, 2009). This research study aims to provide conceptual profiles of chemistry students at different levels (first, second and third year) of progression during their undergraduate studies. For this purpose persisting conceptual difficulties and meaningful gains in conceptual understanding of chemistry up to graduate level are identified and discussed.

The Chemical Concept Test (CCT) was previously developed by Potgieter et al. (2008) and used as a diagnostic instrument during this study to provide conceptual profiles of chemistry students at two South African universities, Stellenbosch University (SU) and the University of Pretoria (UP). This study stems from a larger study which started in 2002 and continued for nine years with the aim of monitoring the level of preparedness of first-year chemistry students upon entry to South African universities.
Data were collected from chemistry students at different levels of undergraduate study at SU and UP from 2009 to 2011. Pre-test data for first-year students at SU were collected in February 2009 ($N = 702$) within the first two weeks of start of the first semester. Post-test data for this same chemistry cohort were collected close to the end of the academic year in 2009 ($N = 620$). First-year students from UP were subjected to pre-tests at the start of 2011 and again at the end of the same year subjected to post-tests. Data were collected from second and third year mainstream chemistry students at SU as well as UP were collected near the end of lectures in 2010. The cohort of second year students in the 2010 sample are therefore a subset of the sample of first-year students involved in data collection in 2009. This subset was once again subjected to the CCTs near the end of instruction in 2011 at both SU and UP.

Response frequencies for test items were analysed to in order to identify incorrect answers or combinations of these chosen or produced (in the case of open-ended items) by more than 25% of students in the first-year cohorts. The influence of random guessing in the analysis was removed through the choice of 25% as a threshold value. Two thirds of the 65 items in the instrument attracted a large enough selection of incorrect responses to reveal the problem areas. These problem areas were then monitored for indications of conceptual gain or persisting prevalence at the end of the first, second and third years of chemistry study. These results were also compared to literature findings where possible (Barke et al., 2009; Mulford and Robinson, 2002; Wagner et al., 2002).

Analysis of response frequencies revealed important problem areas in terms of students’ understanding of the core principles of chemistry at different levels of undergraduate study. For some of these problem areas there was a gain in conceptual understanding among cohorts with progress during undergraduate study however analysis clearly pointed out specific concepts as persisting misconceptions throughout undergraduate study up to the end of the final year. First-year students entering SU and UP not only showed a lack of conceptual understanding in areas such as stoichiometry, intermolecular vs intramolecular forces, and acids and bases, but were also struggling with the interpretation of different kinds of representations in chemistry and revealed deficiencies in mathematical skills for chemistry. No meaningful gain was however revealed in more than half of the problem areas previously identified. This lack of improvement in conceptual understanding corresponds with international findings of limited conceptual gain during first-year teaching (Wagner et al., 2002). Response frequencies collected at the end of the second and third years of chemistry study furthermore indicated that mastery of foundational concepts such as the mole concept, stoichiometry, solution chemistry and bond energetics improved slowly with deficiencies persisting to the final year. Students also demonstrated poor understanding of the particulate nature of matter. Electrochemistry also remained a challenging content topic throughout.

Identification and awareness of these persistent deficiencies with regard to conceptual understanding in chemistry is of utmost importance for lecturers to be able to adapt their teaching strategies accordingly in order to abolish persisting misconceptions.

Curriculum support materials as a possible source of erroneous ideas about evolution in the Natural Sciences

Dennis Makotsa & Martie Sanders
Animal, Plant, and Environmental Sciences: University of the Witwatersrand, South Africa
dmakotsah@yahoo.com; Martie.Sanders@wits.ac.za

The problems motivating the study
Learners worldwide come to class with a whole range of unscientific beliefs about evolution (Dreadman & Kelly, 1978; Braemby, 1984; Moore et al., 2006). Many South African Life Sciences learners also have misconceptions about evolution (Kagan, 2011; Lawrence & Sanders, 2012). If learners come to class with erroneous ideas, learning is likely to be problematic, firstly because misconceptions interfere with learning and, secondly, because they are difficult to teach away (Osborne & Freyberg, 1985; van Harmelen, 1999). Compounding the problem is that many South African teachers also have misconceptions about evolution (Ngxola & Sanders, 2008; Molefe & Sanders, 2009). Having teachers with misconceptions is a serious dilemma since they are the ones expected to address learning difficulties. Furthermore, it has been found that misconceptions can escalate when teachers have their own misconceptions (Pelaez et al., 2005). Apparently accurate content about evolution is one area of need for many teachers in South African schools (Stears, 2006).

The aim of the study
In order to address the problem of misconceptions and the attendant challenges, it is necessary to establish what causes them. Research shows teachers as a potential source of errors about evolution in South Africa, but no research has been done on curriculum support materials such as textbooks. Textbooks have great influence on the content that is taught (Ball & Cohen, 1996). The aim was focused into two research questions, one investigating the RNCS policy document, and the other two series of Natural Sciences textbooks, as explained later.

Theoretical framework
Theoretical frameworks show the integrated ideas which need to be understood before a study can be conducted, and their inter-relatedness (Miles & Huberman, 1984). In science education these constructs do not always fit into a single existing framework. Four key areas underpinned this study, and were extensively reviewed in preparation for the research.

Constructivist theories of learning and the impact of prior misconceptions: Research suggests existing ideas on any topic may facilitate or impede the learning of scientific concepts, and that misconceptions hinder learning in several ways (Osborne & Freyberg, 1985; van Harmelen, 1999).
Notions about curriculum and curriculum slippages: Goodlad et al. (1979) point out that the formal curriculum (recorded in policy documents) becomes distorted by perceptions and slippages from the time it is conceived to its implementation in the classroom. The formal curriculum is rarely transmitted intact to curriculum materials, as the perceived curriculum is interpreted by the recipients of the formal curriculum, such as textbook writers and teachers. Such a scenario is worrisome as the magnitude of changes (curriculum slippages) escalates when there are errors in the policy documents, and further slippages can occur when the intended curriculum (as planned by teachers) becomes the implemented curriculum experienced by the learners.

Curriculum support materials: These are invaluable to teachers, particularly when their knowledge and skills may be lacking. Ottevang (2001) uses the analogy of an enzyme-catalysed reaction to suggest how curriculum support documents reduce the amount of time and effort teachers have to expend on lessons. But an assumption is that not only will they be error free, but they should actively help people avoid misconceptions or correct them if learners have them.

Common misconceptions about evolution and their possible causes: In order to recognise and discuss the misconceptions in this study an extensive literature review was conducted on common misconceptions, the correct scientific explanations, and possible cause of misconceptions. This included the use of ‘risk’ terms when explaining about natural selection explanations, for example such as ‘adapt’ and ‘survival of the fittest’. When inadequately explained these can result in misconceptions such as only the fittest can survive and reproduce, and others die out or are killed by natural selection and evolution involves organisms trying to adapt to changing environment (Gregory, 2008; Bishop & Anderson, 2009). A further problem is the problem of fragmentation of concepts when teaching. The theoretical framework facilitated the design of the study and research instruments, and informed the analyses of textbooks and policy documents in this study.

Research design

General research approach: The technique of content analysis was used to identify factors in curriculum support materials which could either positively or negatively influence misconceptions about evolution. Silverman (2006) outlines the procedures involved in content analysis: identifying the relevant documents, selecting a sample of documents to analyse, developing category coding procedures and conducting the content analysis.

The research instruments: The development of the research instruments will be discussed in another paper at the conference. They took the form of checklists, one for the policy document and another for the textbooks. They sought both manifest factors (actual misconceptions in the text) and latent factors (scientifically correct messages with the potential to cause misconceptions, depending on how they are interpreted by the reader). Extensive coding tables were developed to target problems previously identified in the literature.

The sample: Convenience sampling was used. One of the three available policy documents for the Natural Sciences (GET level) was analysed. This was the Revised National Curriculum Statement (Grade R-9) Natural Sciences, as this is the original policy document from which others (such as assessment guidelines) are developed. The choice of textbooks was arbitrary, based on sets of books we had obtained from four different publishers. A series
of Natural Sciences textbooks (Grades 7, 8 & 9) from two different publishers were analysed during the study.

**Research rigour:** Measures put in place to enhance validity and credibility of the findings included face validation of i) the evolution-related content that was analysed in both RNCS and the textbooks, and ii) the instruments (as advised by Fraenkel et al., 2012). The use of the checklist was piloted the first time it was used, to assess its adequacy on data gathering. Finally inter-coder reliability was used to check all coding of the documents.

**Results**
These will focus on the manifest and latent errors and their frequency in the RNCS and for Grade 7, 8, and 9 for the two textbook series, and discussion of factors which could present or address misconceptions. Of particular relevance is the strategy of one of the publishers, which involved pointing out misconceptions and discussing why they were misconceptions.

**References**


AN ACTION RESEARCH STUDY AS A CATALYST TO EMPOWER UN- AND UNDER- QUALIFIED TECHNOLOGY TEACHERS.

Tomé Awshar, Mapotse¹ & Mishack Thiza, Gumbo²

Department of Science & Technology Education, College of Education; University of South Africa (Unisa), South Africa

¹mapotta@unisa.ac.za; ²gumbomt@unisa.ac.za

This is an Action Research (AR) study with the senior phase Technology teachers at selected schools of Limpopo Province. The study was motivated by the fact that Technology Education is a foreign concept to many teachers and a new learning area in school curriculum both nationally and internationally. This was exacerbated by the many educational changes that took place in South Africa in the last 18 years. These changes include the overhauling of curriculum, which was the strategic and symbolic change since the first democratic election of 1994, but followed by its review. Thus, a new curriculum known as Curriculum 2005 (reviewed twice already) was developed in which Technology was introduced as a new subject. These changes drastically affected Technology Education and teachers’ coping demands on both the subject content and pedagogy escalated.

The extent of South Africa’s (SA) un- and under- qualified teachers amongst Technology senior phase teachers has intensified and reinforced that action research (AR) be regarded as a tool for emancipation in the teaching of Technology as apparent from this study. The purpose of the paper is to report DEd inquiry findings from the action research activities that took place in selected schools of Limpopo Province. Technology Education has found its way into school environment successfully and effectively through engaging informants with action research approach. In all the spiral activities of planning, observation, action and reflection during the AR cycle contact sessions with participants, the main goal was to address the following research question: How can action research intervention be used to improve the teaching practice of senior phase teachers who are un- and under- qualified to teach Technology? The presenters argue that inadequate training of Technology teachers’
impact negatively on their teaching practice. The study did identify the gaps and appropriate progressive intervention was embarked on.

The intervention strategies were implemented through the AR cycles in spiral activities of planning, implementation and observation, action and reflection, whose principles were operationalized to develop participants from the situations that they face in their Technology teaching contexts.

The study was designed from both critical theory perspective and participatory paradigm. The following instruments were used as a means to gather data: observations, interviews, questionnaires, field notes, video recording of lesson plans and logs of meetings. The study managed to come up with guidelines to develop and kick start AR with teachers. From the findings an AR model was developed to emancipate the un- and under-qualified Technology teachers. This investigation was shaped by the initial reflection or preliminary study conducted with the participants called reconnaissance study which revealed specific challenges that Technology teachers encountered daily in their classes. These challenges were turned into the themes, which together with the findings from the preliminary study and interview reflection per cycle were used to design the intervention strategies for the next main cycle.

The findings of the study from both the preliminary investigation and main AR reveal an improvement in the teachers’ understanding and implementation of Technology – they were emancipated to a greater extent from the challenges prior to the AR intervention and post the AR intervention. The research findings further reveal that most Technology teachers were not trained or qualify to neither facilitate Technology nor teach it with confidence and every chance of success until an intervention in the form of action research was introduced and has successfully change their situation. It is true that coming together as AR co-researchers was the beginning; keeping together was progressive in Technology teaching; but working together remains our success then, now and in the future – post doctoral studies.

Learning Biosciences through research report writing: students’ views on feedback as feed forward

Mapula Matimolane ¹ & Moyra Keane² & Elizabeth Brenner³

¹ School of Animal, Plant & Environmental Sciences, University of the Witwatersrand, Johannesburg, South Africa. ² Centre of Learning and Teaching Development, University of the Witwatersrand, Johannesburg, South Africa. ³ School of Molecular & Cell Biology, University of the Witwatersrand, Johannesburg, South Africa

¹ mapula.matimolane@wits.ac.za, ² moyra.keane@wits.ac.za, ³ liz.brenner@wits.ac.za

Students enrolled in core undergraduate Biosciences courses are expected to write scientific reports as part of their science degree curricula. This study investigated the needs, experiences and perceptions of students about provision of assessment feedback. The study was conducted in one compulsory Bioscience course and was based on research report writing assessment activities. Writing scientific reports is seen as one way of preparing research-ready students. Additionally, it is seen as a way of inducting students into ‘ways of thinking and practising’ in the discipline. Consequently, a significant part of the teaching, learning and assessment activities are devoted to helping students to write research report based on both laboratory sessions and field work sessions.
In line with its aim of achieving equitable access to all, the post apartheid South African higher education system has widened diversity of student cohort in its classrooms. This widening of access to higher education comes with its challenges. For example, the modicum of unpreparedness of students from disadvantaged teaching and learning backgrounds is exacerbated by limited academic language proficiencies. Therefore, there is a growing need to support students learning and particularly their academic writing. In fact, in dealing with the issue of widening access and improving completion rates the Council for Higher Education, CHE (2004) posits that in South Africa assessment has the potential to facilitate a more equitable access and achievement. The immediacy of formative assessment and feedback is therefore imperative and pivotal in meeting the individual learner’s needs.

In this paper assessment is viewed from a learning-oriented assessment perspective (Carless, 2007). One of Carless’ (2007) learning-oriented assessment approach three core aspects focuses on forward looking feedback (Carless, 2007). The view is therefore to explore the concept of feedback from the perspective of students in order to identify the type and nature of feedback they value. Research on student assessment (Black and William, 1998; Sadler, 1989) consistently demonstrates the importance and benefits of constructive feedback in directing effective student learning. However, the continuing students’ dissatisfaction with assessment and feedback as evident in outcomes of international students’ satisfaction surveys is worth noting. As noted by Nicol (2010), the current research literature focuses less on feedback as a social practice but more on the technical nature of feedback or a “transmission view of feedback” or a monologue practice (p.502). The transmission view of feedback practice is operating on the premise that students would fully comprehend the comments and devise strategies to act on the feedback. The gap in the current research emphasises limited focus on students’ desires and needs regarding provision of feedback especially in the context of massification of and modularised systems in higher education.

This quantitative and qualitative study explores results of a questionnaire completed by 30 second year students, an analysis of individual interviews conducted with seven students and content analysis of teachers-provided written feedback on research reports in one Bioscience course. It further reports on alignment between teachers-provided feedback and students’ needs within a learning-oriented assessment framework. The study further highlights the importance of forward-looking feedback and the development of student self-regulation capabilities.

An analysis of written comments on the research reports revealed that even though some comments were of a feed-forward nature or could be regarded as “usable”, one gets the sense that feedback was mainly “telling” and thus limiting opportunities for dialogue crucial in closing the feedback loop. The potential transferability of these types of comments beyond the end of the modules was less evident. This outcome is due to a lack of clear strategies encouraging self-evaluative and reflective skills among students. The shortfalls in the provision of feedback include the generic comments which were interpreted as being too cryptic and telegraphic to understood and/or use by students. The comments were more focused on identifying and correcting student errors. The majority of the feedback comments provided were task specific.

The study revealed some alignment between current feedback practices and what students value, perceive and prefer. Contrary to popular beliefs, students claimed to value and prefer a combination of specific comments on what they have done incorrectly and on how to improve their marks, rather than feedback in the form of marks only. Furthermore, the substantial amount of feed-forward comments provided in both courses is consonant with
students’ preference of comments which can be used for future assessments. There was a balance in provision of motivational and negative comments which is crucial in promoting engagement with feedback.

Overall, students perceived feedback to be adequate and helpful in enhancing further learning. What was most valuable to the students was the process of draft-feedback-submit which was perceived helpful in enhancing learning and understanding. This study highlights the need for further research to establish how students engage with the feedback provided and to explore ways of providing more usable dialogic type feedback. In university classes where students are often known only by number and where assessment stakes are high, the role of feedback by lecturers deserves greater attention. The opportunities that feedback provides for students’ self-reflection, peer discussion, and conversations with lecturers may be a key factor for improving tertiary teaching and learning.

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References

DO TEACHER BELIEFS MATTER WHEN DEVELOPING PCK AND SMK?

Elizabeth Mavhunga & Marissa Rollnick
Marang Centre, Department of Science and Technology Education, University of the Witwatersrand, South Africa.
Elizabeth.Mavhunga@wits.ac.za, Marissa.Rollnick@wits.ac.za

Purpose and Rationale
The influence of teachers’ beliefs on teaching practices in science education has been given attention in various research studies (Pajares, 1992; Tsai, 2002). More recently the focus has shifted towards understanding the influence of beliefs on the teachers’ Pedagogical Content Knowledge (PCK). The point of fascination with this shift, lies in understanding the interaction between the affective domain as seen through beliefs and the knowledge in the cognitive domain (PCK, SMK, etc.). This paper reflects on the relationship between three constructs that are located in both domains: (i) Topic Specific PCK (ii) Subject Matter Knowledge and (iii) Teacher Beliefs. The rationale for looking at this kind of relationship is because of the increasing awareness of the influence of underlying beliefs on teaching practices (Veal, 2004). Teachers who hold reformed kind of teacher beliefs are reported to practice learner centred teaching (Luft, 2009) which encourages the desired enquiry learning in science. Therefore, are most likely to have good quality of PCK, as the concept of PCK has explicit attention given to both reasoning about the content taught and teaching practices.
that are learner centred. This realization signals the need for synchrony in both the affective domain and the cognitive domain in the equation for teacher efficiency. According to Veal (2004), the future of teacher development programmes lies in the understanding of PCK, SMK and teacher beliefs. Together these constructs ‘combine to form a formidable base for teacher development’ (Veal, 2004, p. 1). However, the challenge remains in understanding how these constructs are acquired respectively, and the nature of their interaction. The purpose of this study is to uncover the relationship of these three constructs following an intervention conducted with chemistry pre-service teachers. The intervention entailed explicit discussion of knowledge components reported to enable transformation of SMK. The research questions explored in this paper specifically are:

(i) What is the impact of the intervention discussing transformation of SMK on the quality of Topic Specific PCK, the understanding of SMK and teacher beliefs?
(ii) Is there any statistical correlation between these three constructs?

Theoretical Framework

Measuring the hidden construct of PCK presents challenges in that there are multiple understandings of PCK in the literature (Kind, 2009). Hence we defined a form of PCK called Topic Specific PCK. The conceptualization of Topic Specific PCK is not the purpose of this paper as it is described in details in another study (Authors, 2012). In essence, the construct of Topic Specific PCK has focus on a specific topic. It emerges from the understanding that content taught by teachers is first transformed into versions that are easy for learners to understand (Shulman, 1986, 1987). Transformation of content therefore happens for each topic taught. There are knowledge components reported to assist teachers to transform their knowledge. These have been identified as: (i) students’ prior knowledge on the topic, (ii) curricular saliency, (iii) knowing what is difficult to teach, (iv) representations and (v) conceptual teaching strategies (Geddis & Wood, 1997). These five knowledge components when used to reason about the content the results are specific to the topic and similar to manifestations observed in class when teachers with PCK teach (Rollnick, Bennett, Rhemtula, Dharsey & Ndlovu, 2008). Furthermore, as the teachers learn to transform their content their understanding of the content is improved (Mavhunga, 2012; Shulman, 1987). All the reasoning, the transformation of content and the resulting improved understanding of content is influenced by the beliefs teachers hold about teaching science. This framework as described above is called the Topic Specific PCK framework (Mavhunga & Rollnick, 2012), was used as a theoretical framework for the study described in this paper.

Method

As the above research questions suggest both quantitative and qualitative methods, we employed mixed-methods research (MM) in our design. The study was located in a final year Physical Science methodology class for the pre-service teachers, involving 16 participants. As suggested in the introduction, an intervention targeting understanding of transformation of Chemical Equilibrium concepts using the above mentioned five knowledge components was implemented. The intervention was structured into 14 sessions of 100 minutes over a period of 7 weeks. Quantitative data for changes in the quality of TSPCK, understanding of SMK and shifts in teacher beliefs was collected through a set of pre and post-tests, respectively. For measuring the quality of TSPCK a tool designed and validated specifically for the Chemical Equilibrium topic (Mavhunga & Rollnick, 2011) was used. The use and further validation of this tool have been reported in other studies (Mavhunga & Rollnick, 2012). The achievement of understanding of SMK was measured using a tool with test items derived from existing tools on chemical equilibrium such as that by Bilgin (2006).
beliefs were measured using the teacher science belief tool designed by Luft & Roehrig (2007). Both the SMK and beliefs tools were considered piloted and validated. Qualitative data for TSPCK and for achievement of subject matter knowledge was collected during the intervention using varied strategies including photographs of written work and audio recordings taken during class activities.

The Results
In comparing the pre- and post-test sets for (i) TSPCK, (ii) Achievement in SMK and (iii) Teacher Science Beliefs, the findings indicate a statistically significant improvement at 99% level of confidence in TSPCK and the SMK, and a 95% significant difference for the Teacher Beliefs. The observed quantitative improvement was strengthened by the evidence for developing Topic Specific PCK and improving understanding of subject matter knowledge found qualitatively in a number of scenarios during the intervention. A positive correlation was found between the quality of TSPCK and SMK, but not with teacher beliefs. The implications of this finding are discussed in detail in the paper and suggest caution for teacher centred beliefs also found to underlie the development of TSPCK. Recommendations for teacher development programmes in South Africa are made to explicitly target learner centred oriented teacher beliefs with all PCK development initiatives.

References
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PROBLEM-BASED TEACHING AND LEARNING IN SENIOR PHASE TECHNOLOGY EDUCATION IN THABO-MOFUTSANANYA DISTRICT, QWAQWA

Maria Matshidiso Mokoen & Mishack Thiza, Gumbo

Boitsebelo Technical School; Office of Graduate Studies & Research, College of Education, University of South Africa (Unisa), South Africa mokoenan3@yahoo.com; gumbomt@unisa.ac.za

Abstract

The aim of this presentation is to report findings of the inquiry into the role that problem-based approach can play in the teaching and learning of Technology Education in Thabo-Mofutsanyana District in Qwaqwa. An inquiry of this nature will contribute to a better understanding of the teaching of Technology, which is still challenging to many teachers. It will contribute to the practice as teachers in the senior phase in Thabo-Mofutsanyana District in Qwaqwa (and hopefully in South Africa as a whole) will value problem-based learning (PBL) in the teaching of Technology. When teaching is based on problem-based tasks a number of related teaching strategies can be considered. These, according to Nieman and Monyai (2006:112) include inquiry learning, problem-solving, and doing either a project or a research project. The mode of teaching that problem-based teaching and its related strategies suggest is a learner-centred one. As a learner-centred mode of teaching, problem solving helps with high order thinking skills (Nieman & Monyai, 2006:112). A technological study involves learners actively in learning through thinking, doing and manufacturing. It is crucial that teachers be able to teach it competently and learners to be able to achieve the most out of it.

The nature of Technology highly suggests the use of the problem solving approach to teaching and learning because it contains problems and problematic situations that require problem solving strategies. Problem solving allows learners to identify with the problem (Nieman & Monyai, 2006:115) and thus to design and develop a solution to it. Here the researcher wishes to indicate the importance of PBL in the teaching and learning of technology. In a study of the importance of PBL, Barell (2007:2) states that life does not come problem-free as it is full of challenging opportunities to learn, grow, reflect and enjoy. Barell (2007:2) then explains that PBL engages learners in life as we know it, that it is full of fascinating problematic situations worth thinking about, investigating and resolving. He then concludes that this may be the most obvious reason why PBL is important to consider.
It is argued that PBL is not just a different method or style of teaching. Instead it is a different philosophical approach to the whole notion of teaching and learning (Savin-Baden, 2000:13). Savin-Baden (2000:13) adds that at the heart of this approach is the development of important abilities, such as flexibility, adaptability, problem-solving and critique. These abilities relate well to what is needed in learning Technology. Abilities such as these have been highlighted by government and industry as central to the development of future professionals (Savin-Baden, 2000:13).

According to Savin-Baden (2000:123), PBL seems to be a form of learning which can take account of and challenge, the idea that there is a body of knowledge to be gained, a series of meanings to be understood and a number of techniques to be acquired. In practice, PBL will largely be based within a particular discipline area, such as economics or engineering (a sister field of technology), and the problem scenarios will be based on key concepts about which learners are expected to know (Savin-Baden, 2000:126).

Qualitative research methodology and design were considered for this study. This choice was made because of the researchers’ desire for the study to be made up of firsthand knowledge of the research setting. Qualitative approach frequently uses observations and in-depth interviews. Johnson and Christensen (2000:20) and Krathwohl (1993:13) write that the study begins without structure but becomes more structured as it proceeds and it also operates in a normal setting. The design that this study has opted for is ethnography. Creswell (2007:242) defines ethnography as the study of an intact cultural or social group (or an individual or individuals within that group) based primarily on observations over a prolonged period of time spent by the researcher in the field. This study followed an ethnographic research design due to the intention to spend some time interviewing teachers and experts, to observe teaching and learning in two secondary schools that participated in Murray & Roberts Technology Olympiad and two secondary schools that did not participate in this Olympiad, and to analyse documents (Technology teachers’ lesson plans and workschedules; portfolios and files of Grade 9 Technology learners) in these secondary schools. This design was used to gain an understanding of the complexities of PBL in the teaching of Technology subject.

The study produced key findings that emanated from comparing participating and non-participating secondary schools in Murray and Roberts Technology Olympiad:

- PBL is an approach that assists learners to associate with the problem while learning;
- PBL is a need in the teaching of Technology;
- Learners enjoy exposure to challenging issues and are able to function at a higher level in as far as thought-provoking skills are concerned;
- Learners treat concepts at higher and deeper level, they stretch their minds and this mind-stretching exercise is good for solving real-life problems during adulthood.
- Learners become more motivated and interested in learning; they no longer function at a tradition of knowledge acquisition but create knowledge themselves;
- Learners are able to discover theories and make inventions, also, the thinking abilities of learners is freed and they are able to function outside restrictions. The retention of information also improves extremely because learners are responsible for knowledge creation.

The following recommendations were made:
- Learning facilitators should workshop and train teachers on PBL;
• PBL should be included as one of the approaches to teach Technology in the CAPS policy document; it should be part of the Technology Education curriculum;
• All schools should participate in Technology Olympiads and EXPOS; and

REFERENCES

Aligning traditional plant healing with classroom science: Methodological insights gained from field entry activities and conversations
Vongai Mpofu¹, Emmanuel Mushayikwa¹, & Femi S. Otulaja¹
¹Marang Centre for Mathematics and Science Education, School of Education, University of the Witwatersrand, Johannesburg, South Africa.
vongai.mpofu@students.ac.za, emmanuel.mushaykwa@wits.ac.za, Femi.Otulaja@wits.ac.za,

Background and rationale
Today, in Africa, the need for integrating traditional medicinal knowledge into school science curriculum is widely recognized (Dei, 2010). As a form of indigenous knowledge (IK), its advocacy falls within the broader movement of integrating IK with classroom science and science cultural reforms. Here, the argument is that in every culture there is science (Snively & Corsiglia, 2001). Aikenhead (1996) says that current school science is a sub-culture of science which in itself is a sub-culture of western culture. Snively and Corsiglia (2001) further posit that the current school science in most continents worldwide is grounded in western-culture and differs from the knowledge grounded in non-Western cultures. In Africa, this phenomenon came about mainly as a result of colonialism. It is for this reason that many stakeholders in science education, like Makhurane (2000) of Zimbabwe, criticise science curricula in African nations for its lack of cultural relevance. Some African countries, like Zimbabwe and South Africa, are on the drive to integrate IK with classroom science. This movement is largely spurred by the ideology of cultural inclusivity, sustainable use and preservation of IK and heritage, as well as the need to redress colonial imbalances (Vhurumuku, Holtman, Mikalsen, & Kolstø, 2008). As noted by M. B Ogunniyi (2007), national curriculum reforms are often based on historical, political and socio-economic reasons. Technological factors can also be added to the list of curriculum reform drivers.

IK-science integration has largely proved to be problematic and limited despite its intensive drives (Mishack B. Ogunniyi, 2011). In many African nations, problems of lack of curriculum materials, content and pedagogy frameworks (Owuor, 2007), contrary teacher-dispositions (Hewson, Javu, & Holtman, 2009), paucity of IK archives (Otulàjà, Cameron, & Msimanga, 2011), teacher inept pedagogical approaches, and limited conception of the nature
of science (NOS) as well as nature of IK (Odora-Hoppers, 2002) have impinged on the successful classroom practice of integrating IK with classroom science. All the complexities and intricacies of integrating IK with classroom science are traceable to the distinct and often conflicting worldviews of IK and western science (WS). These problems are exacerbated by the dominance of western culture over IK (Shizha, 2006). Despite the integration of IK-science at classroom level being a challenge, its benefits to all stakeholders make its pursuance a worthwhile endeavour.

In view of the fact that IK takes several forms, this paper uses the traditional plant healing (TPH) as an illustrative case study. The choice of TPH is based on the central argument that it is directly relevant to the day to day living of the school children in Africa, as 80% of the Southern African populace rely on traditional plant medicine. In spite of the dominance of traditional plant medicine in Africa, the science curricula of many African nations do not feature much of it, as exemplified by the South African case (Hewson et al., 2009). This paper is an attempt to show how the integration of IK with school science can be advanced.

An understanding of the integration of TPH with classroom science could be helpful in developing content and pedagogical approaches to the teaching of IK in science classrooms. Further, it can shed insights into participants’ perceptions (researchers, teachers, traditional healers and learners) of such knowledge and its integration with classroom science. Such insights might help in navigating the integrating of the two worlds with minimum tissue rejection.

**Problem statement, purpose and its significance**

Eurocentric research approaches dominating the study of IK phenomena are contested methodological practices by several indigenes scholars like Smith (1999), Meyer (2008) and Martin and Mirraboopa (2003). Such scholars are advocating for investigating IK phenomena using indigenes research approaches (Smith, 1999). Other scholars are for integrated qualitative-indigenes research approaches (Lowan, 2012) when. The proposal of this study projects the later research approach. But the adopted approach has challenges because very little is known about African indigenes research, in particular the Zimbabwean perspective. This article, therefore, is designed to gain initial entry into fieldwork with a view to gaining insights into an integrated design that combines well established interpretive research approaches with little known indigenes ones. The article aims at conducting methodological strengths, weaknesses, opportunities, and threats (SWOT) analyses at the initial phase of entering the field. This is more or less piloting the methodological process to give insights into the practicability and authenticity of integrating the two approaches referred to here as interpretive-indigenes methodological process. The objective in all this is to eventually use the knowledge gained to enhance the effectiveness of the fieldwork processes and to contribute to the knowledge base of IK-science integration that realistically represents the issues of stakeholders’ dispositions, the content and pedagogical concerns, as well as the tensions and contradictions that characterize such a task and a research process.

The major question this article seeks to address is: how feasible is the integration of indigenes research with western interpretive approaches as a viable research design in a research process? In carrying out this process, the following sub-questions are also addressed.

1. What research protocols need to be adopted/adapted and followed?
2. How are participants to be sampled and how would they relate to each other?
3. What methods of data collection are to be used and how?
4. How will data be processed into information (findings) and presented?
5. What language of communication is most appropriate?

**Methodology**

Observation and conversation methodology are employed for as long as initial field entry phase will take from the 8 of July 2012. The end of the initial field entry phase is determined by the period it will take to gain access to all the target participants (traditional healers, teachers and learners) of the main study. The methodology is guided by an interpretive-indigenes approach to research. The interpretive component is used in the sense proposed by (Patton, 2002) of being open-minded to whatever emerges from the participants’ perspective. On the other hand, the Indigenes component reflects its framing within the African *Unhu/Ubuntu* worldview. Ubuntu is an African-centred world-view that emphasizes the good-of-all, harmony, mutual respect, relational understanding, interdependence, interrelationships, or interconnectedness of all phenomena (M. B Ogunniyi, 2007, p. 971). Interpretive-indigenes depict the development of an emergent integrated design that progresses from known (interpretive) to unravel the unknown (African Zimbabwean indigenes). The next stage is to integrate the two (interpretive-African indigenes).

This study adopts the viewpoints of Dei (2011) concerning blending qualitative with indigenes research approaches. That is, the researcher needs to interrogate and incorporate the indigenous ways of inquiry (Martin & Mirraboopa, 2003). These are inclusive of protocols, sampling, data collection methods, processing and presentation of findings as well as the adoption of the language of communication of participants. In this methodology, similar and unique characteristics of both interpretive and indigenous research approaches are incorporated as functions of the situation to guide on principles for doing ethical and good research.

Research participation is premised on the learning together framework (Mpofu, Mushayikwa, & Otulaja, 2012). The call for participation is on an on-going basis, purposive (Patton, 2002) and drawn from four Zimbabwe secondary education stakeholders’ major category. This is done at the point of gaining access through professional contacts and snowball referrals. These are teachers/educators, parents/community elders, researchers and learners. The present nine participating member team is comprised of four educators (two teachers and two ministry officials), two researchers (the chairperson of the Nziramasanga Presidential Commission of Inquiry into education and training and me, the writer, and three community elders (the chief of Chiweshe and two traditional healers). This sample is large enough to provide a breadth of cultural and professional perspectives necessary to inform the main study, and at the same time small enough to manage and interpret in a deeply meaningful way that sheds useful insights for the main study. Voluntary and parental learner participation is difficult to get as authority to enter into schools has not been obtained and schools have closed for the holidays.

Data collection methods include observations and conversations. The researcher at every pot of call is on the lookout for the sensational and perceptual -incidents or events. This happens before and after gaining field access protocols. Staged (interviews or discussions) or prompt (dialogues or discussions) conversations are organised or take place respectively depending on what the participant prefer. Staged conversations at times are organised as a follow-up to prompt conversations for probing (Patton, 2002). Data is captured through journaling and digitally audio recording all staged conversations and some prompt ones. Shona-English is
used as a language of communication. Data processing is on–going and simultaneous with data collection (Denzin & Lincoln, 2005). The processing of data progresses through the stages of transcribing, translation, interpretation and integration. The research is still in process and is expected to end after gaining access to all the target participants of the main study.

**Presentation of findings, conclusions, implications and recommendations**

This study is current and on-going. However, when completed, the findings will be presented and discussed around the five questions of the study in descriptive, diagrammatic and tabular form, supported by direct excerpts from journal and audio data (Patton, 2002).

**Key words:** Classroom science, conversation, indigenes, interpretive, observation, field, traditional plant healing

**References**


Engagement within hybrid spaces in high school science classrooms

Audrey Msimanga1 & Anthony Lelliott2

Marang Centre for Mathematics and Science Education, School of Education, University of the Witwatersrand, South Africa

1Audrey.msimanga@wits.ac.za; 2Anthony.elliott@wits.ac.za

Abstract

The role and use of classroom talk has been investigated extensively in science education research. Literature reports on the merits of classroom talk as a strategy to promote learner social engagement and to mediate learner conceptual understanding or meaning-making. Yet, research shows that it is not always easy for teachers to facilitate the levels of learner talk required to achieve meaningful learner engagement. Some of the difficulties with the effective use of talk in science classrooms relate to the tension between the need to maintain formal forms of talk typical of science discourse and the desire to break down learner barriers to classroom talk. We draw from the notion of hybrid spaces as used by Berland and Hammer (2012) to understand some of the unconventional forms of talk that we observed in three science classrooms. Berland and Hammer describe hybrid spaces as social spaces where participants engage in combinations of scientific and everyday context-based interactions. We describe some context-based interactions observed in three science classrooms and discuss their implications for science teaching and learning in these contexts. The question we sought to answer was, “What is the nature of social interactions during high school classroom discussions of science concepts?”

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Introduction

The notion of hybrid spaces is borrowed from Berland and Hammer (2012). Engagement in hybrid spaces involves participant ability to draw from a mix of interaction styles that may or may not be conventionally associated with science classrooms. Participants draw from their shared knowledge and understanding of both the established and agreed on scientific discourse and everyday forms of interaction that are part of teacher-learner cultural capital. Thus, classroom talk is likely to at all times, reflect both the collective understandings of scientific engagement as well as the collective contextual everyday ways of interaction. In other words science classrooms are inevitably hybrid spaces, particularly so in multicultural classrooms such as are prevalent in South Africa.

Literature and theoretical framework

Extensive research conducted on classroom talk has established a link between classroom discussion and cognition as well as investigated its use as the tool with which to develop the requisite skills for such cognitive engagement in science classrooms (Lemke, 1990; Mortimer & Scott, 2003). Science education research on classroom talk has however, focussed on understanding the nature of conventional forms of talk or what Luk (2004) termed “institutional talk” as opposed to “non-institutional” or social talk (Alexopoulou & Driver, 1996). Solomon and Harrison (1991, p. 291) argue that “the purpose of social talk is to try out opinions, receive feedback, and respond to others. This necessitates taking on board others' perspectives”. Thus, social talk would draw from and be shaped by the participants’ experiences, thus, constituting a space in which hybrid talk happens. The role of social talk has been explored in mathematics classrooms where talk is implicated in the establishment of intersubjectivity during discussions (Yackel, Rasmussen, & King, 2000). Intersubjectivity or a shared common understanding of tasks and expectations is important for learner conceptual engagement and understanding. Cobb and colleagues assert that social talk to achieve intersubjectivity may include talk about sports, relationships, events and situations outside of the school context. We included in hybrid talk various “unconventional” forms of engagement, interactions that do not conform to mainstream or formal academic talk.

Methodology

Our data was drawn from a larger data set collected as part of a study that explored classroom talk in some Gauteng high schools. We video and audio recorded our classroom observations of science lessons. A thematic cross case analysis was conducted on the lesson transcripts to identify emerging patterns of interaction. From these patterns we determined themes, whether engagement was unique to the cases and their contexts.

Results and discussion

Four themes (categories of engagement in science talk) emerged from our analysis, but in this paper we only report on one, engagement within hybrid spaces: combinations of formal scientific with informal social talk; learner cultural affordances and constraints; using language variously as a resource.

Using excerpts from three teachers’ lessons, we illustrate the different ways in which engagement in hybrid spaces took place. As Cobb and others observed in mathematics classrooms, participants often talked about how to talk about and do science. Two of the three teachers did this through meta-talk. Mr Far used the most meta-talk often referring to the words that he and the learners were using and why they were using them. This relates to the notion of making language visible as discussed later (Setati, Molefe, & Langa, 2008). However, in this case Mr Far was making the English language visible and using this strategy
to explain the relationship between the language of science and day to day English language usage. In one instance, to further explain “inelastic” he said “let me rather use the word stick together...” thus drawing on everyday language to make a science point. There were also examples where in explaining a science concept, both Mr Far and Mrs Nkosi also would present moral lessons for the learners. Such forms of talk were also seen when participants were exploring each other’s understandings of their obligations and talk often shifted to formal school science talk when they moved on to discussing actual science concepts. Cobb and colleagues argued that “both small group and whole class interactions typically involve these two intertwined levels of discourse” (Cobb, Yackel, & Wood, 1992, p. 108).

Aikenhead and Jegede (1999) saw value in the alternate uses of social and formal science talk, arguing that enculturation into school science is easier if school science harmonises with the learner’s world view. This was borne out in our observations in Mrs Nkosi’s lesson on indigenous knowledge of owls, which are surrounded by negative cultural beliefs about their uses in witchcraft. Learner interactions ranged from total silences, to reluctant talk and eventually opening up about their fears and inhibitions in talking about owls. Learners’ cultural experiences were for some a source of alienation between local knowledge and school science and for others affordances to engagement. For example, some learners would not speak directly about owls and death, but used other more acceptable words to describe or provide an analogy for death and/or killing.

The three teachers handled the issue of language in different ways. For example, Mrs Nkosi spoke to her learners in English most of the time, only occasionally in isiZulu. Mrs Thoba on the other hand, never engaged with science concepts in the vernacular language but allowed learners to explain their thinking in their languages. Further discussion on this issue will be given in the full paper.

**Conclusion**

Research on learner participation in hybrid spaces of science talk is important for future understanding of the factors that influence successful science teaching and learning in local contexts in South Africa. While literature records conflicting findings on the effects of learner attitudes on classroom performance, there is consensus on the negative impact of such attitudes on choice of science as a subject and the quality of learner experiences in the science classroom. If as Denley and Bishop (2007) argued, student engagement in science lessons comes through fun, humour, unpredictability and the will to do odd things, then an understanding of the nature of student social talk in South African classrooms could yield important knowledge of learner thinking and attitudes which science teaching could draw from in order to improve learner engagement and performance in science. Further, teacher education could benefit from the findings of such research.

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Science teachers understanding of inquiry-based science teaching (IBST): Case of Rwandan lower secondary school science teachers.

Leon Mugabo¹ and Paul Hobden²

¹Kigali Institute of Education, Rwanda; ²SSMTE, University of KwaZulu-Natal, South Africa

mugabol2000@yahoo.com, hobden@ukzn.ac.za

Abstract
There is a growing body of literature advocating that the use of inquiry is essential for good science teaching and learning (AAAS, 2010 & Anderson, 2002). However, the persistent question raised is that if teachers are to teach science through inquiry, what their understanding of inquiry is since it is argued that for teachers to implement inquiry, they have to hold a clear understanding of what inquiry-based teaching is all about.

This study describes analyses and discusses the Rwandan lower secondary school teachers’ understanding of inquiry-based science teaching as a teaching approach. This new approach was recently introduced into the curriculum as a result of one of the reforms that the science curriculum has gone through during the last decade. The study takes place within the context of Rwanda which has placed science and technology at a top priority to drive socio-economic growth and development of the nation’s human capital in rebuilding the country after the 1994 genocide.

Within a pragmatic paradigm, the study was of a sequential explanatory design using a mixed methods approach (Creswell, J.W and Plano Clerk, 2011). It involved two phases of data collection. Firstly, a survey questionnaire administered to a purposefully selected sample of 200 science teachers was used and secondly, followed by in-depth semi-structured interviews informed by the survey results with a sample of 15 selected teachers.
It was found that teachers had a variety of understandings of inquiry-based science teaching mainly associating it with learner-centered activities and practical work of some kind. The study also revealed that some teachers did not have any acceptable understanding as described either in the literature or in the new curriculum documents. This would lead to anticipating a potential gap between the intended curriculum document and the enacted curriculum based on the variety of teachers’ understandings.

The study therefore serves as a platform for further research especially how do teachers implement this new curriculum, the problems they encounter and/or how they try to overcome those problems.

Key words: Inquiry-based science teaching, teachers’ understanding.

References


Student-Centered Learning Approach and Web 2.0 Tools: a Strategy for Student competence Development in Mozambican Higher Education

**Xavier Muianga¹, Inocente Mutimucuio², Henrik Hansson³ & Amado Mucambe⁴**

¹, ² & ⁴ Faculty of Education - Eduardo Mondlane University, Mozambique
³ Department of Computer and System Science – DSV, Stockholm University, Sweden

¹ xavier.muinaga@uem.mz, ² inocente.mutimucuio@uem.mz, ³ henrik.hansson@dsv.su.se, ⁴ amado.mucambe@uem.mz

Today's society requires graduates with competencies in various domains. Beyond specific professional competencies, it requires generic competencies which include critical thinking, teamwork, research, and lifelong learning. In the recent curriculum reform at Eduardo Mondlane University (UEM) the emphasis is on competencies based curriculum and Student Centered Learning (SCL) to assure the excellence and quality in the teaching and learning process (UEM, 2008). Using this approach students achieve superior results and personal development in terms of higher self-confidence, openness to experience, self-respect, and respect towards others and their environment, etc. (Motschnig-Pitrik & Holzinger, 2002).

The evaluations of curricular reform process in the faculties have shown that transmissible teaching methods dominate university pedagogy (UEM, 1999; Mandlate, 2003 UEM, 2012). All these studies address problems like the use of traditional teaching and learning approaches, the lack of knowledge of new models and student centred learning as pedagogical approaches, and the ICT plays a secondary role in teaching and learning. The lack of quality of new graduates from Institutions of Higher Education is claimed by employers, they are saying that the new graduates do not have sufficient competencies or are not what is required by the current labor market (Mário et al., 2003; Noa, 2010).
The aim of this study is to explore the student centered learning methods with combination of the use of Web 2.0 tools in order to improve student competencies development in the module of ICT in Education of environmental education program.

The central research questions for the study are:

- How does the adoption of SCL contribute to student’s competence development in a course about ICT in Education at the University of Mondlane?
- How does the use of Web 2.0 tools in a course module support the adoption of SCL?

The SCL approach is a complex approach which requires from both the student and the lecturer play important roles in teaching and learning process. The lecturer designs the activities, organizes and assesses the entire process, taking into account the requirements the curriculum. The lecturer shift their role from classroom director-knowledge delivers to classroom facilitator-Knowledge resource (Brush & Soye, 2000). The student follows the process, taking into account their independence, their learning style and their learning needs by be active participants in their learning; they learn at their own pace and use their own strategies; they are more intrinsically than extrinsically motivated; learning is more individualized than standardized (Collins & O’Brien, 2003). The success of SCL is dependent on both the student and the lecturer. At the core of the SCL philosophy is however, the student and his/her attitudes and activities

According to Kember (1997) SCL is “a leaning environment in which knowledge is constructed by student and the teacher is a facilitator rather than (merely) the presenter of information”. This definition is more comprehensive because apart from putting the student at the center, indicating how the process unfolds, underlining constructivism as learning approach used, as well as indicates the lecturer roles as crucial for successful of student learning.

In the last years, the use of Web 2.0 tools for education has been increasing. This is due to the fact that these tools are easily accessible by young people, with strong aspects like communication, information sharing, interoperability and collaboration, based on an open access and open source spirit, and it has facilitated the emergence of web-based communities and new applications like social-networking (Zeininger, 2009).

Cohen et al. (2007) argue that action research is about research that has an impact and a focus on practice. Both lecturers and students participated in decision making and they have control over their environment and activities in learning lives. Two teachers and 16 students were interviewed during the course period. Observations and discussions were conducted with all students in the course (29 persons). Analysis is based both on classroom activities and activities in the Learning Management System. Interviews were transcribed, coded, categorized and further abstracted by merging categories to core aspects.

The pilot project was implemented using the ICT in Education module from the first year of the environmental education program which was organized in Learning Management System.

The curriculum is designed so that most of the time students work independently activities in groups or individually. According to the curriculum design, the module had six hours of face to face contact and 18 hours of independent work during 8 weeks. And the student activities were designed to cover the independent working hours.
This pilot project has confirmed what has already been evident for other researchers who have conducted studies about SCL in other contexts (Brush & Soye, 2000; Froyd & Simpson, 2008; Butler, 2012). And we can conclude that the course design used in this course is one way to successfully adopt SLC and to use Web 2.0 tools to support learning processes.

The results show that by using the SCL approach students can develop different types of competences and skills such as Critical Thinking and Problem Solving, Communication and Collaboration, Information Literacy, Multimedia Literacy and ICT Literacy. Furthermore, they were able to develop interesting contents using these tools and Webquests.

This study showed that this approach requires much additional work for both lecturers and students to strive for development of such competencies. In this regard, the university needs to invest more in SCL teacher training in order to fulfil the new curriculum goals and the necessary transformation of teaching and learning. By doing this, the quality of university education will increase as well as its relevance for both students and the labour market.

References


South African Grade 9 teachers’ and learners’ knowledge about medicinal plants and their attitudes towards its integration into the science curriculum.

Blessings Muza

University of the Witwatersran

bmusa2002@yahoo.com

The context of the study

The integration of indigenous knowledge into the mainstream science curriculum has been advocated for by science educators around the world (Ogunniyi, 2010; Vhurumuku & Mokeleche 2009). The Revised National Curriculum Statements (RNCS) for Grades R-9 (Natural Sciences) clearly advocates for the incorporation of indigenous knowledge into the science curriculum. Learning outcome 3 (LO3) in the Natural Sciences RNCS stipulates that learners must learn science within the context of their historical, societal and cultural knowledge and values (DOE, 2002a p. 20). In the Physical Sciences RNCS, LO3 stipulates that learners should understand “other systems of knowledge, such as indigenous knowledge systems” (DOE, 2003 p. 11). The underlying assumption is that teachers can help learners integrate science and indigenous knowledge but in order to do that, they too must have “adequate understandings of the two thought systems” (Onwu & Ogunniyi, 2006; 129).

Problems motivating study

The challenge is that some teachers are not well informed about the varying indigenous knowledge that typifies the multi-cultural situation in South African classrooms as they have been schooled in western science (Ogunniyi, 2007). This inevitably creates a theory-practice gap which may hinder successful implementation of reforms as teachers play a pivotal role in the implementation process (Sanders, 2006). In conforming to the “learner-centeredness” tenet of Outcomes Based Education (OBE) teachers must see each child as an individual, “and therefore the needs and wants of each child must be met” (Sanders & Kasalu, 2004). The variation in cultures may impede the implementation of this tenet as it might be difficult for the teacher to clearly tease out the factual indigenous knowledge and that which is based on myths and beliefs. Archer (2010) agrees with the need for a reciprocal curriculum but argues that a “complete equality of cultural trade is perhaps too ambitious and unrealistic” (p. 70). This may be true regarding the varying knowledge about traditional medicinal plants. Teachers may be sceptical about the efficacy of the traditional medicines posing a serious impediment to effective curriculum implementation. The question that arises then is whether the integration of IK into mainstream science was well thought out or it is mere ideological
rhetoric based on historical, political or socio-economic policies. It is imperative that the knowledge and attitudes that teachers and learners have be investigated in order to assess the chances of success of the integration. Teachers’ knowledge and understanding of science is known to influence the way they teach in the classroom (Newton, Driver & Osborne, 1999).

**Purpose of the study**

The purpose of the study is to elicit learners’ and teachers’ knowledge about traditional medicinal plants and their attitudes towards integration of that knowledge into the science curriculum. This is with a view to exploring any differences or similarities between the views of teachers and learners. The differences in attitudes could create “cognitive dissonance” between teachers and learners (Webb, Oginniyi, Sadek, Rochford, Dlamini & Mosimege, 2006) or “conceptual conflicts” within the learner (Hewson, Javu & Holtman, 2009). The study aims also at exposing the different traditional medicines in use amongst different cultures based on beliefs and those tested through practice and proven to be potent. Ultimately the study may introduce ways in which science and indigenous knowledge may be integrated in the classroom. Traditional medicines have been chosen on the basis that they can be ‘scientifically’ tested through practice.

**Theoretical Framework**

The study is based on the tenets of constructivism as argued by Piaget (1964) and Phelan, Davidson & Cao’s (1991) theory of cultural “border crossing”. Constructivism is a theory of knowledge development that argues that human beings generate knowledge and meaning from an interaction between their experiences and their ideas (Piaget, 1964). Piaget further suggests that through the processes of accommodation and assimilation, individuals construct new knowledge from their experiences. When individuals assimilate, they incorporate the new experience into an already existing framework without changing that framework (Meadows, 2004). When an individual’s experiences contradict their internal representations, they may change their perceptions of the experiences to fit their internal representations (Piaget, 1964). In this study the learners’ earlier experiences with traditional medicines forms their internal representations and this must be linked with what they learn in the classroom. If the prior knowledge is in conflict with what is learnt in the classroom learning may be inhibited (Freyberg & Osborne, 1985).

The theory of cultural border-crossing postulates that learners have a particular world view based on their cultural values and belief systems. When these learners are exposed to the scientific worldview in the classrooms they may experience ‘conceptual conflicts’ as they tend to subconsciously hold on to their traditional beliefs (Fakudze & Rollnick, 2008). The challenge for teachers is to ensure that transitions from one view to the next must be smooth. The level of ease or difficulty of border crossing has implications for learning as the transition may be “hazardous” or even “insurmountable” (Phelan et al., 1991). By investigating the attitudes of learners and teachers, potential cognitive conflicts could be identified and this may help teachers to help learners to resolve the conflicts.

**Methods**

A case study will be carried out at a secondary school in Meadowlands, Soweto.

**Sample**- a sample of 50 Grade 9 learners and 10 teachers of Natural sciences will be selected using the convenience sampling technique.
Instruments- Structured questionnaires will be used to collect data from both teachers and learners. Unstructured follow up interviews (3 learners and 1 teacher) will be performed on selected participants to probe further their responses to the questionnaire.

Data analysis – both qualitative and quantitative data will be collected and an open coding system and basic statistical procedures will be used to analyse the data.
Ethics- informed consent will be assured for the underage learners and confidentiality will be guaranteed.

Results
Still to be collected.

References- not listed due to space limitations.

UNDERSTANDING PI AMONG PRE-UNIVERSITY STUDENTS: A CASE STUDY OF THE FOUNDATION PROGRAMME AT THE UNIVERSITY OF NAMIBIA.

S.T. Naukushu¹, LL.T. Nghipandulwa¹, C. D. Kasanda² & H.M. Kapenda²
¹Foundation Programme, University of Namibia, Oshakati Campus, Namibia.
²Department of Mathematics, Science and sport Education, University of Namibia, Namibia
snaukushu@unam.na¹
lnghipandulwa@unam.na¹ckasanda@unam.na²&hkapenda@unam.na²

INTRODUCTION

Pi plays a crucial role in the circle geometry as well as other areas of Mathematics and Science. Despite the role it plays, its meaning and significance in Mathematics and science is often underscored. Most of the high school leavers use this number but they are not aware of what it means and its significance in Science. Many learners in the Namibian high schools are aware of the existence of pi; however they do not really know what it means. This study was therefore deemed necessary in the light of emphasizing deep learning of Mathematics as opposed to the rote learning that based on the traditional education.

In this paper the researchers assessed the understanding of pi among the students at a pre-university course, their Mathematical experiences of pi. Furthermore, the researchers also tried to relate the understanding of learners of pi to their academic performance in Mathematics.

Consequently this study sought answers to the questions below:

1. What meaning do the students of the Foundation Programme attribute to pi?
2. To what extent do the students of the Foundation Programme possess a grasp of pi?

Generally findings of this study are that pre-university do not possess strong facility of the pi concept. About 90% Students who have demonstrated low level of understanding about pi seem to have also scored poor marks in geometry. Analysis of the high school curriculum indicated that the concept of pi is not specifically addressed in the high school Mathematics curriculum and could have compromised to an extend the understanding of pi among the students. Moreover, it was deemed imperative to incorporate the teaching about the number pi in the Mathematics high school curriculum.

LITERATURE REVIEW
It could be controversial to come up with a precise meaning of pi. Posamelner and Lekman (2004) define pi from a historical point of view that historically, pi is the numerical relationship between the diameter and circumference of a circle. Posamelner and Lekman (2004) further allude to pi as a geometric constant there by operationally defining geometry as the study of drawn figures.

Pi has a rich history, its history traces up to at least four thousand back. “For thousands of years, mathematicians have attempted to extend their understanding of π, sometimes by computing its value to a high degree of accuracy” (Beckman, 1986). Other literature such as by Boyer and Merback (1991) indicated that before the 15th century, mathematicians such as Archimedes and Liu Hui used geometrical techniques, based on polygons, to estimate the value of π. Eymard and Lafon (1999) on the other hand state that starting around the 15th century, new algorithms based on infinite series revolutionized the computation of π, and were used by mathematicians including Madhava of Sangamagrama, Isaac Newton, Leonhard Euler, Carl Friedrich Gauss, and Srinivasa Ramanujan.

The common idea among the foregoing literature and also by Blamer (1999); Lay-Tong (1986) opine that the number π (pai) is a mathematical constant that is the ratio of a circle’s circumference to its diameter. The literature further state that pi is a constant and is sometimes written πi, is approximately equal to 3.14159. Pi has then been represented by the Greek letter "π" since the mid-18th century (Posamelner and Lekman, 2004). The literature such as by Blamer (1999); Eymard and Lafon (1999) as well as Posamelner and Lekman (2004) further suggest that the number pi (π) is an irrational number, which means that it cannot be expressed exactly as a ratio of two integers (such as 22/7 or other fractions that are commonly used to approximate π); consequently, its decimal representation never ends and never repeats.

For thousands of years, mathematicians have attempted to extend their understanding of π, sometimes by computing its value to a high degree of accuracy. Before the 15th century, mathematicians such as Archimedes and Liu Hui used geometrical techniques, based on polygons, to estimate the value of π. Starting around the 15th century, new algorithms based on infinite series revolutionized the computation of π, and were used by mathematicians including Madhava of Sangamagrama, Isaac Newton, Leonhard Euler, Carl Friedrich Gauss, and Srinivasa Ramanujan.

The recent developments in the history of pi are that is has been adopted and utilised in diverse scientific fields of studies. For instance Posamelner and Lekman (2004) noted that the 20th century, mathematicians and computer scientists discovered new approaches that – when combined with increasing computational power – extended the decimal representation of π to over 10 trillion (10^13) digits. However, the recent study of pi is more record driven rather than actually scientifically motivated.

“While scientific applications generally require no more than 40 digits of π, the primary motivation for these computations is the human desire to break records, but the extensive calculations involved have been used to test supercomputers and high-precision multiplication algorithms (Posamelner and Lekman, 2004).”

Furthermore several people have endeavored to memorize the value of π with increasing precision, leading to records of over 67,000 digits (Posamelner and Lekman, 2004). Because its definition relates to the circle, π is found in many formulae in trigonometry and geometry, especially those concerning circles, ellipses, or spheres. It is also found in
formulae from other branches of science, such as cosmology, number theory, statistics, fractals, thermodynamics, mechanics, and electromagnetism. The ubiquitous nature of $\pi$ makes it one of the most widely known mathematical constants, both inside and outside the scientific community: Several literature such as by Blamer (1999); Eymard and Lafon (1999) as well as Posamelner and Lekman (2004) devoted to it have been widely published. The number pi is celebrated on Pi Day which is 14 March; and news headlines of the day often contain reports about record-setting calculations of the digits of $\pi$.

Furthermore, the later literature noted that pi is used to get the volume or a surface area of a disc, or the circle circumference, areas and volumes of cylinders, spheres and hemispheres etc. It is also used to measure how fast and how powerful a computer is. Because it is so well known it can be used to check computer accuracy and if it has a problem in it software or hardware. Pi is also used to get the value of trigonometry functions like sine, cosine, tangent etc. Pi plays a crucial role in mechanics where it is used to measure circular velocity of rotating objects for instance a truck wheel, motor shafts, engine parts, gears, etc. Pi continues to play a role in the electronics field of study where it aids in the measurement of Ac voltage across a coil and a capacitor. In the natural world thing like ocean wave, light waves, sound waves, river bends.

The Namibian high school Mathematics curriculum assumes that pi is common knowledge and therefore learners are expected to learn it constructively from interacting with their environment. Findings of this study indicated that high school graduates portray schools with low facility of pi. Mathematics teachers often do not deem it necessary to incorporate the teaching of pi as a concept that should be taught but they rather make use of it when teaching circle geometry and other scientific concepts that involve pi. This study therefore deemed it necessary for pi to be integrated in the high school curriculum for the learners to pay tribute to its value and role in the scientific arena.

THEORETICAL FRAMEWORK
This study is informed mainly by the theory of constructivism. The theory of constructivism is mainly concerned with cognition, the progression of development of thinking and reasoning as a human action by individuals. Jooste (2011) noted that the constructive theorists such as Piaget and Vygotsky both advocated and exemplified “transactional, relational and contextualized” approaches for considering human development through interaction with their environment. This study assumes that over their high school years students were subjected to rich environment that they must have interacted with in order to enable them gain a better comprehension of pi.

The researchers therefore opine that the learners construct their Mathematical concepts through their own experiences and prior understanding. This prior understanding should therefore have been acquired from their previous Mathematical background, hence there was no intervention needed to prior teach them about pi.

METHODOLOGY
The thrust of this study was to assess the students’ comprehension of pi as a number, its role in Mathematics and other sciences. To do this the study adopted both qualitative and quantitative research paradigms. Cresswell (2003) indicated that the use of the dual research i.e. qualitative and quantitative approaches has become a common practice and is deemed yielding comprehensive results as it is attributable to the nature of research being conducted. Furthermore; quantitative research consists of those studies in which the data can be analysed in terms of numerical values (Loraine, 1998). The number of leaners exhibiting a better
comprehension of pi was assessed and quantified in terms of the numerical scores and hence this study deemed it necessary to employ quantitative study.

Ideas of learners, opinions and previous experiences of learners could not be expressed as numerical values thus qualitative research design was also employed to aid the analysis of unquantifiable data collected for the purpose of this study. Furthermore; learners had to reflect from their previous Mathematical experiences which required them to bring forward qualitative information hence qualitative information. Qualitative studies deal with studies that reflect preferences, personal opinions, experiences or views of people to be studied (Loraine, 1998).

To assess the comprehension of pi among the learners stratified random sample of 40 students of the Foundation Programme.

“A method of sampling that involves the division of a population into smaller groups known as strata. In stratified random sampling, the strata are formed based on members' shared attributes or characteristics. A random sample from each stratum is taken in a number proportional to the stratum's size when compared to the population. These subsets of the strata are then pooled to form a random sample (Loraine, 1998).”

The strata were designed because of the nature of the responses; Foundation Programme students were divided into three groups as per the demand of the course depending on their Mathematical abilities. Hence to ensure an equal representation a random sample of 48 students (sixteen students from each class) was selected for the purpose of this study.

PRESENTATION AND DISCUSSIONS OF THE RESULTS
Students were asked to indicate their grades in Mathematics at grade 12. Table 1 shows their responses.

Table 1: Grades of Foundation programme students in their Mathematics grade 12 examinations N=48.

<table>
<thead>
<tr>
<th>Grade</th>
<th>No. of students</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>3</td>
<td>6.25</td>
</tr>
<tr>
<td>C</td>
<td>21</td>
<td>43.75</td>
</tr>
<tr>
<td>D</td>
<td>21</td>
<td>43.75</td>
</tr>
<tr>
<td>E</td>
<td>3</td>
<td>6.25</td>
</tr>
<tr>
<td>Total</td>
<td>48</td>
<td>100</td>
</tr>
</tbody>
</table>

From table 1 it appears that 50% of the students have quite a good mathematical background and therefore should possess a better understanding of pi.

Students were asked at what grade they first encountered pi, Table 2 shows the responses of students.

Table 2: The grades levels of their education at which Foundation programme students learned about pi.
Table 2 indicates that the concept of pi is developed as early as grade 6. This means such learners encountered the concept of pi at quite a young age and therefore have interacted with it for over 5 years.

Students were asked to indicate the sources of information where they learned about the concept of pi. Among the students 18 (37.5%) indicated they learned about pi from their teacher; 12 students (25%) from their books, 3 students (6.25%) indicated internet, 15 students (31.25%) indicated that pi became an integrated part of their knowledge that they just acquired and hence could not remember.

Furthermore, students were asked to explain what pi meant to them; 9 (18.75%) indicated pi means \(\frac{22}{7}\), 12 (25%) indicated pi means 3.141592654, while 7 (14.5%) students indicated that pi means 3.142, while 3 students (6.25%) indicated pi means 3.14 moreover, 14 (29.25%) students indicated pi is a ratio of a circle’s circumference to its diameter and 3 students (6.25%) indicated that they have no idea about what pi means. From the results it is clear that only about 30% of the students had an accurate meaning of pi.

Students were also asked to indicate the relationship between pi and \(\frac{22}{7}\); their responses are summarised in Fig 1.

<table>
<thead>
<tr>
<th>Grade level</th>
<th>No. of students</th>
<th>Percentage of students (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>6</td>
<td>12.5</td>
</tr>
<tr>
<td>7</td>
<td>6</td>
<td>12.5</td>
</tr>
<tr>
<td>8</td>
<td>12</td>
<td>25</td>
</tr>
<tr>
<td>9</td>
<td>9</td>
<td>18.75</td>
</tr>
<tr>
<td>10</td>
<td>15</td>
<td>31.25</td>
</tr>
<tr>
<td>Total</td>
<td>48</td>
<td>100</td>
</tr>
</tbody>
</table>

![Fig.1: students’ responses on the relationship between pi and \(\frac{22}{7}\).](image-url)
Fig 1 indicates that most of the students (81.25%) of the students opined that there was no difference between pi and $\frac{22}{7}$. This is a common misconception in Mathematics, which is concurrent with the work of Posamelner and Lekman (2004) who indicated that research has proven that about 75% of high school leavers possess misapprehensions about pi and $\frac{22}{7}$.

Students were then asked to indicate what type of a number pi is, students responded according to the available options to these were; improper fraction 6 (12.5%), proper fraction 0 (0%), whole number 3 (6.25%), decimal 27 (56.25), mixed number 12 (25%).

The other issue that was addressed by this study was whether pi is a rational or an irrational number. Fig. 2. Indicates the responses of students to the question of rationality of pi.

The other crucial issue in the study of pi was what the exact value of pi is. To date mathematicians and scientists did not really get the value of pi as to how many decimal places (Posamelner and Lekman, 2004). This study posed a question among the respondents as to what the value of pi is. To this question 5 (10.42%) students indicted pi is exactly equal to 3.142857143, while 24 students (50%) indicated that the exact value of pi is 3.1421592654, furthermore 13 (27.08%) indicated that pi is exactly equal to 3.14 and 6 (12.5%) indicated that they had no idea. This shows that students do not really have a clue of what pi is. It also means that they did not understand fully the idea that pi is an irrational number that is why its decimals neither terminate nor repeat.

Fig. 2. Students’ responses on the rationality of pi.

On the uses of pi most of the students, 39 (81.25%) identified the primary use of pi in Mathematics as to find the area and circumference of circles, 3 (6.25%) students indicated the use of pi in Mathematics as to evaluate trigonometric functions and 6 (12.5%) of the students had no idea of what Mathematical use of pi is. At their level students seem to have an idea of the role and significance that pi has in geometry. However students seemed to be challenged as to what use pi has in other areas of Mathematics other than geometry. The students were unable to find other uses of pi beyond geometry.

The other interest of researchers was to find other uses of pi beyond the Mathematical world, i.e. the role that pi play in other areas of sciences other than Mathematics. To this question, 3 (6.25%) students indicated pi is only used in Math, 6 (12.5%) of the students indicated that pi
was used in social sciences to understand the processes. Unfortunately, such “processes” were not mentioned by them. Further 6 (12.5%) indicated the use of pi in statistics (no elaborations were made), three (6.25%) students indicated the use of pi in cosmology (no elaborations were made), 6 (12.5%) of the students indicated the use of pi in Physics and 27 (56.25%) did not respond as to what role pi plays in other areas of science other that Mathematics.

Researchers were also interested in finding out what sources of information introduced pi to the students. To this 3 (6.25%) students indicated that they saw pi in a book grade 6, Further 6 (12.5%) indicated from a grade 8 text book, 3 (6.25%) students saw pi in a book no grade was indicated, 6 (12.5%) obtained the existence of pi from the calculator and 3 (6.25%) indicated pi became an integral part of their lives and hence could not remember from what source they obtained the existence of pi and 27 (56.25%) did not respond.

Students were also asked to indicate the school subject where pi was first introduced to them, 39 (81.25%) indicated pi was first taught to them in Mathematics, the remaining 9 (18.75%) did not remember the subject that introduced pi to them for the first time.

The researchers were also interested in finding out the topic of the subject that introduced them first to pi. Their responses are summarised in Fig 3.

From Fig. 3 the majority, 17 (35.4%) of the respondents first encountered pi in the topic of area and perimeter, specifically in finding the area and perimeter of circles. This was followed by 14 (29.1%) who indicated that they had encountered pi in geometry.

CONCLUSIONS AND RECOMMENDATIONS
The following conclusions were made from the basis of the data presented in this study.
Some of the students learned about the number pi as early as grade 6 while others only come to learn it in grade 10. There is need to start teaching or introducing Mathematical content at the same grade levels in Namibian schools.
Most of the students had the idea that pi is an irrational number but could not explain why. Moreover, students did not seem to understand the characteristic features of irrational numbers. This needs to be emphasised in the Mathematics classrooms.
Nearly all of the students lacked an understanding that scientists have not really found the exact value of pi to date. The students therefore used their approximated values of pi and
took them to be exact. This could be that their teachers never explained that all values of pi used in their mathematical content do not really represent the exact value but are mere approximations.

Most of the students adequately summarised the use of pi in Mathematics as to find the area and circumference of circles. However most of the students could not really account for the use of pi beyond the mathematical arena. Teachers need to extend the use of numbers beyond the Mathematics classroom.

REFERENCES

An investigation on the effectiveness of the Sci-Bono outreach programme in the teaching of electrochemistry at Grade 11

**Trust Nkomo**, Dr Emmanuel Mushayikwa
School of Education, University of the Witwatersrand

Abstract
This is a pilot study of an academic study to investigate the effectiveness of the Sci-Bono outreach programme in the teaching of electrochemistry at Grade 11. Electrochemistry is considered to be one of the most difficult topics, (De Jong, O., Acampo, J. & Verdonk, 1995 and Nestor, Shafer and Ditzler, 2008). The study involved 5 of the 25 schools at which the Sci-Bono outreach programme is run. Learning outcomes were used to measure effectiveness. A pre-test was given before intervention and a post-test was given after intervention. The difference between the pre-test and post-test mean scores would give a measure of how much learners had gained from the intervention. A sample of learners were interviewed after the post-test to find out why they had given particular answers for questions in the pre-test and post-test. This would reveal whether there were any misconceptions or not, and if there were, were they eliminated by the intervention or not. Both the interveners and teachers at the school were also interviewed. There was a significant difference between pre-test and post-test mean scores. Interviews revealed that there were misconceptions that were
eliminated by the intervention. The analysis of test results and interviews suggests that the programme in question is effective.

**Introduction**
According to Department of Basic Education’s report on the National Senior Certificate Examinations of 2011, learners have been performing poorly in Physical Sciences for quite some time. The Third International Mathematics and Science Study (TIMSS) report of 2003 had revealed the same scenario, (Reddy, 2006). The National Senior Certificate Examinations Report of 2011 also gives low percentage pass rates in Physical Sciences. Various efforts have been made with the view of raising the pass rate in Physical Sciences. A number of intervention programmes have been put in place in an attempt to improve learner performance in Physical Sciences. Sci-Bono Discovery Centre, a Science Centre for the Gauteng Department of Education, runs such programmes and among them is the outreach programme. The said programme targets grade 10 to 12 Physical Sciences and Mathematics. Any intervention of this kind is aimed at improving the understanding of concepts in the area of intervention. Unlike educators at previously disadvantaged schools, Sci-Bono outreach educators have all the resources they need at their disposal. They have laptops and projectors to use in the classrooms. They also have a wide range of software that they use in their lessons. The Sci-Bono teachers can also access any materials they may require for practical lessons. The programme is unique. It targets 25 secondary schools per year and the outreach educators visit each school once a term and that amounts to four times a year. **There has been growing need to know how effective it is, especially in treating those topics considered difficult.**

The focus of the study was only on the teaching and learning of Physical Sciences. The study was narrowed to investigating the effectiveness of intervention in only one topic, electrochemistry, which according to De Jong, O., Acampo, J. & Verdonk (1995) and Nestor, Shafer and Ditzler (2008), is difficult to teach and learn. The effectiveness is measured in terms of how much learners have gained from the lessons conducted by Sci-Bono teachers. Learners are therefore the main subjects of the study. To find out the influence of the host teachers, these teachers were interviewed about content of the tests and related misconceptions, those observed and those suspected.

**The purpose of the study**
The purpose of this study was to investigate the effectiveness of the Sci-Bono outreach programme in the teaching of electrochemistry at grade 11. The results of the study would give a reflection as to whether the project is achieving what it is meant to achieve or not.

**Research questions**
**Main question**
How effective is the Sci-Bono outreach programme in the teaching of electrochemistry at grade 11?

**Sub questions**
(i) How much change is observed in the learners’ ability to answer questions on electrochemistry after intervention by Sci-Bono outreach educators?
(ii) Does the teaching by Sci-Bono outreach educators clear the common misconceptions learners have in electrochemistry?

**Significance of the study**
Investigating the effectiveness of the Sci-Bono outreach programme in the teaching of electrochemistry would give the implementers valuable feedback as to whether the programme is achieving what it was meant to achieve or not. From this feedback decisions could be made that could lead either to the expansion of the project, refocusing the project or even marketing the programme for implementation by other bodies.

The study will also provide valuable information for planning teacher development activities. Sci-Bono has a teacher development unit which works closely with the Gauteng Department of Education’s similar unit in running training science workshops for teachers from public schools.

Sci-Bono outreach teachers themselves would benefit from the study as it is bound to reveal their areas of strength and weakness in the teaching of electrochemistry. This would influence them to come up with strategies that will make them more effective in teaching this and other difficult topics. Use of such strategies would benefit the learners who are beneficiaries of the programme as well as Physical Sciences teachers from the target schools.

**Conceptual Framework**

Berk’s model of evaluating teaching effectiveness has 12 strategies (Berk, 2005). From the whole list only one strategy was used, which is, measuring learning outcomes. This was due to the scope and depth of the study. Goe, Bell and Little (2008), are also of the opinion that an intervention programme has to be measured by outcomes.

Student learning in this study was based on the conceptual change model proposed by Posner, Strike, Hewson and Gertzrg (1982). Drawn from the conceptual change model, the model of effectiveness constructed by the researcher in this study involves the elimination of misconceptions, which should result in the development of new concepts that should also lead to improved performance by learners.

Constructivists hold a view that before school instruction, learners already have certain knowledge and they suggest that this knowledge be taken into consideration when teaching. The ideas learners have may be “vague”, “wrong” or “correct”. Their being wrong or right is when they are being measured against a certain accepted scientific idea. It is when the idea does not align with the accepted ideas that a teacher would want to shift the learner’s thought and understanding towards this accepted scientific idea. Hewson, Beeth and Thorley (1998) refer to this as teaching for conceptual change. They define this as the teaching that explicitly aims to shift students’ thinking in order to lead to conceptual change. Teaching for conceptual change should therefore result in some form of change regarding the idea the learner initially had.

**Methodology**

To measure effectiveness, a learning outcomes measure, one of the strategies to measure teaching effectiveness proposed by Berk (2005), was used. The study included three methods which are observation, diagnostic tests (pre-test and post-test) and interviews. Learners were given a pre-test before the lesson. The pre-test covered both content and misconceptions. The content part reveal how much learners knew and the questions on misconceptions revealed the misconceptions learners had in electrochemistry. This was followed by a lesson observation which revealed the strategies used by the Sci-Bono outreach teachers. This gave a clue as to how they enable learners to understand concepts and also how they deal with
misconceptions. At the end of the lesson learners were given a post-test which had the same level of difficult as the pre-test. Both tests were marked and the marks were recorded.

In this study, learners, the subject teacher at the school and the intervener were interviewed. In the interview with the learner the interviewer tried to find out why the learners gave particular responses in both the pre-test and the post-test. This revealed how much content knowledge the learners had gained and also whether misconceptions had been eliminated or not.

The interview with the subject teacher was meant to find out if he/she is aware of the misconceptions which the learners had in electrochemistry or not and whether he/she thought they were well dealt with or not. The study was also meant to establish what ideas these teachers had on addressing the misconceptions and as well reveal what the each teacher had learnt from the intervener. Teachers were also asked why they had accepted Sci-Bono intervention. The interview with the intervener was meant to reveal reasons why he/she employed particular strategies observed. These include particular instances where he/she interacted with the learners. For both learners and educators guided interviews were used and responses were recorded.

The study was carried out at 5 schools that are current beneficiaries of the Sci-Bono outreach programme. All these schools are in the Gauteng province. These were schools that had requested for intervention in electrochemistry, redox reactions in particular. The schools were randomly selected such that all schools in the list had equal chances of being selected.

All grade 11 learners who do Physical Sciences from each selected school wrote the pre-test and post-test. From the 5 schools all the grade 11 Physical Sciences teachers and all interveners for this grade and subject were interviewed. Stratified random sampling was used to select learners for interviews. Learners were classified into three categories i.e. top achievers, average achievers and poor achievers informed by the pre-test scores.

Results
There was a marked difference between the pre-test and post-test scores. This was even reflected in the mean scores of both tests.

There was an interesting pattern in the answering of pre-test questions. Learners from a particular school would give the same wrong answer for a particular question. This was despite writing the test from different corners of the classroom.

In the interview most learners indicated that in the pre-test they gave certain answers because they understood the concept differently from what they were made to understand during intervention. For a practical related question, learners pointed out that they had been assisted by the practical they had done during intervention. The practical in the question was similar to the one they did during the intervention. Even during the lesson some learners seemed not to be confident enough to handle equipment and chemicals. The practical demonstration of how to handle the equipment and practicals helped demystify the misconceptions.

Mean Scores at schools A, B, C, D and E
The interviews for Sci-Bono educators yielded similar answers, especially when they were asked why they used a particular strategy. From the second interview it became apparent that they had done the planning together and discussed the approaches they had planned. They also pointed out the importance of observing each other’s lessons after having planned together. The Sci-Bono teachers revealed that they asked questions whose responses would show whether learners had misconceptions or not. They said in their planning, they also consider dealing with common misconceptions. They however seemed not to be aware of certain misconceptions that the researcher was interested in.

In 4 of the 5 schools, host teachers acknowledged that learners had misconceptions. Two alluded this to shortage of materials for carrying out practical lessons. Three out of five teachers pointed out that this was due the fact that the topic is difficult. Three of the 5 teachers acknowledged having learnt something from the lesson and could explain what they learnt. Two teachers had suggestions for Sci-Bono teachers in lesson delivery in electrochemistry. One teacher pointed out that he believed learners would perform better in the post-test that in the pre-test but however challenged the Sci-Bono teachers to give the same post-test in their next visit to find out if the learners would still be able to answer those questions.

**Analysis**
Test results were analysed at the confidence level of 95%. A two tailed t-Test for paired means was used in the analysis.

**Example of data analysis**

<table>
<thead>
<tr>
<th>t-Test: Paired Two Sample for Means</th>
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<tbody>
<tr>
<td>Variable 1</td>
<td>40.83333</td>
<td>70</td>
</tr>
<tr>
<td>Variable 2</td>
<td>574.1667</td>
<td>250</td>
</tr>
</tbody>
</table>

Analysis Test results were analysed at the confidence level of 95%. A two tailed t-Test for paired means was used in the analysis.
In all the 5 schools that calculated t-value was found to be outside the range between the two-tail critical values and this means that the hypothesised mean difference is rejected.

There were similar wrong answers given by learners in the pre-test. This shows that some learners had misconceptions in this topic. Particular misconceptions were picked at particular schools, indicating that it could have come from the teaching. Practicals done during intervention helped learners to grasp some concepts. In the interviews some learners referred to the practical work in their explanations.

Host teachers also benefited directly from the outreach programme. Some had been of the view that they could not do certain practicals but learnt how they could easily do so. Some of the teachers learnt ways of explaining certain concepts.

**Conclusion**
Since in all the cases the null hypothesis was rejected we can then conclude that the differences between the mean scores were caused by the intervention. The same would apply to the differences between scores in the pre-test and post-test for individual learners. This therefore implies that the Sci-Bono outreach programme is effective in the teaching of electrochemistry at Grade 11.

The programme benefits learners who are currently in the programme as well as those to be taught by the host teachers who witness the teaching. The programme thus yields sustainability in the teaching of electrochemistry as teachers are indirectly trained as they sit in the classroom during lesson delivery.

**References**


Developing Pedagogical Content Knowledge for teacher education through teaching genetics to pre-service teachers: A self-study

Eunice Nyamupangedengu 1 & Anthony Lelliott2
1School of Education, Marang Centre for Mathematics, Science and Technology Education, University of the Witwatersrand, South Africa; 2 School of Education, Marang Centre for Mathematics, Science and Technology Education, University of the Witwatersrand, South Africa
1eunice.nyamupangedengu@wits.ac.za, 2anthony.elliott@wits.ac.za

Introduction
I am a teacher educator at a higher education institution in South Africa. I joined the institution five years ago, straight from a high school classroom. I had been a high school biology teacher for 14 years. After two years of my practice as a teacher educator, I was invited to facilitate a workshop on the teaching and learning of genetics to a group of Life Sciences subject advisors6. I was invited in my capacity as a biology lecturer responsible for teaching genetics at the Higher Education Institution. The invitation was a wake-up call which made me realise that I was no longer a high school teacher but a teacher educator. I began to wonder if my move to teacher education had changed my practice to suit my new role and responsibilities. I therefore decided to investigate my own teaching through a self-study. The self-study is ongoing. The focus of this paper is to share my insights on

- How an examination and a reflection of my past practice informed my present practice.

Theoretical framework
In this study, I am evaluating my transformation from a high school teacher to a teacher educator with reference to my Pedagogical Content Knowledge (PCK). To help explain the transformation of my practice, the models of PCK by Rollnick, Bennett, Rhemtula, Dharsey, and Ndlovu (2008) and Pedagogical Content Knowing (PCKg) of Cochran, DeRuiter, and King (1993) are the windows through which I am examining my practice. I chose the model by Rollnick et al. (2008) as it has manifestations of teacher knowledge that can be used as indicators of a teacher’s PCK. From Cochran et al. (1993), I adopted the concept that teachers’ knowledge expands as they gain experience and reflect on their practice.

Method
Memory work is the method that was used in this self-study. Memory work is a self-study method in which we revisit and critically reflect on the events that have happened in our lives. What we remember and how we remember what happened in our practice form the basis of who we are today (Samaras & Freese, 2006). Artefacts are used to bring back the memories. The artefacts that were used in this study are my genetics course outlines, course notes and the workshop module.

Data collection

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6 A subject advisor is an educator who is a specialist in a particular subject in this case Life Sciences who then oversees the teaching of that subject in a district.
I examined all my artefacts and wrote a narrative based on my reflections of these artefacts. The narrative was then exposed to colleagues for discussion.

Data analysis
Although this study is a self-study, the analysis was structured in action research cycles: identification of the issue; design of an action; implementation of the action; evaluation of the action, leading to the second cycle: identification of a new problem; etc.).

A sample of the results
I identified a number of action cycles from the narrative of my memory work. In the first action cycle, the problem that I identified was that when I started work as a teacher educator, there was no detailed syllabus with clearly defined objectives as was the case in high school. There was also no course outline to show me how I needed to go about the teaching of genetics course. I had to construct a course outline from scratch. After identifying this problematic situation, I had to come up with a plan of action. The action I took involved looking at past exam papers to find out the depth of content and skills required. From there I used my high school experience to come up with the course outline and the teaching and learning activities. The course outline was produced and the course was successfully taught and hence to some extent, the desired outcome was achieved. However, without any formal training or preparation as a teacher educator, the course outline that I produced was a reflection of my high school focuses; supporting my students’ understanding of content. I didn’t realise that as a teacher educator, I needed to also look at how the students can teach that content.

When I became a teacher educator, I found myself in a big lecture theatre doing most of the talking during the lectures. I could not think of any activities that would be appropriate for use in a big lecture room. Doing group work or individual activities during lectures whereby I could move around helping my students was no longer possible. Students now had to wait for a particular day to do any practical activities. My high school approaches could no longer fit the available resources. This new situation was problematic and was never adequately addressed or resolved.

Conclusion
An examination and reflection of my past practice has made me realise that as a teacher educator I need different knowledge and skills; what I will call PCK for teacher education. The implications from this insight are that there is need for formal induction of new teacher educators so as to facilitate the building of their PCK for teacher education.

References
Towards Making Indigenous Knowledge Socially Relevant to Learners: A Review of the Science and Indigenous Knowledge Systems Project

Femi S. Otulaja

Marang Centre for Mathematics and Science Education, School of Education, University of the Witwatersrand, Johannesburg, South Africa.

Femi.Otulaja@wits.ac.za

Over the past three decades, there have been continuous calls for the recognition of indigenous knowledge systems (henceforth, IKS) or multicultural science (Snively and Corsiglia, 2001) as equal in status to Western science (henceforth, WS). In this pursuit, there has been acknowledgement that WS is multicultural (Harding, 1998); that is, that WS, as we know it, borrowed from and woven together most of its tenets from various other IKS worldwide. As part of this call for recognition of IKS, there have been robust calls to integrate IKS and WS at the classroom level in indigenous communities around the world (Ogawa, 1986; Ogunniyi, 1988; Jegede and Aikenhead, 1999), because “… in most science classrooms around the globe, Western science has been taught at the expense of indigenous knowledge” (Snively and Corsiglia, 2001). In moving toward possibilities of integrating IKS and WS, there have been concerted efforts by various indigenous groups and researchers to develop curricular materials to make the teaching and learning of IKS and WS go hand in hand, both in the formal classroom (Ogunniyi, 2004; 2007; Hewson and Ogunniyi, 2011) and in informal settings (Barnhardt and Kawagley, 2005). In addition, there have been calls to document and archive IKS in their various locations (Otulaja, Cameron and Msimanga, 2011) because the human custodian of IKS are getting old and dying and may not have the chance to pass on their IK. The archiving of IKS is important because many who grew up with WS paradigm are not at par with their IKS and have often looked down and/or despised their IKS thinking it belonged in antiquity; it is superstitious, and irrelevant. This has left room for exploitation of indigenous communities without adequate compensation and not many to fight on their behalf.

It is heart-warming to know that many countries have recently awakened to formulate IKS policies that include requiring IKS inclusion in the school curriculum. South Africa, since independence has enacted IKS policy that specifically asks teachers to include IK in science teaching. Recent curricular revisions kept the provisions of the need to teach IK with science; even though it does not specifically prescribe how teachers would do so. This then leaves teachers and advocates of IKS-WS integration to device ways to implement the policy provisions. It is in this vein that the Science and Indigenous Knowledge Systems Project (SKIPS) has been endeavoring to train science teachers to integrate IKS and WS in the classrooms, and to research and archive records of indigenous studies carried out in South African and Mozambique.

In light of the efforts of SKIPS, especially in assisting the training of teachers to implement IKS-WS integration in the science classroom and to develop curricular materials, this paper intends to answer the following three research questions; 1) How can IKS be made socially relevant to learners?; 2) What parts of IKS should be made socially relevant to learners?; and 3) Why should IKS be made socially relevant to learners? Answers to these questions are rooted in disseminating widely what many of the teachers and researchers in this project have discovered. Teacher’s self-discovery, the valuing, understanding, developing and documenting her own IKS becomes salient before being able to elicit and value the IKS that learners bring into the classroom (Otulaja, Cameron and Msimanga, 2011). Teachers need to
engage learners in constructive pedagogy using dialogic argumentation that helps learners value and understand the science in IKS and the IKS in science. Teachers’ documentation of these interactive engagements, using various media, prints, audio, video, digital, newsletters, storytelling, dances, indigenous games, and instruments and implements (indigenous technologies), which should be brought in for hands-on experiments to authenticate the relationships of IKS and WS, create archival materials for future use and dissemination as and when needed, is paramount and salient. Inviting the human archives and custodians of IKS (the Elders) in the community into the classroom could personify and exemplify IKS and generate learning opportunities for all involved. Instituting place-based indigenous science pedagogy (Chinn, 2007) involving flora and fauna and their healing properties, could be used to develop the learning of the relationship to and the use of the environment. In conclusion, understanding IKS in relation to WS through argumentation pedagogy can generate cognitive development of learners and the need to preserve local IK for the next generations to come.

References
The use of Mastering Chemistry as an academic support and monitoring tool in first year Chemistry

Vino Paideya\textsuperscript{1} and Patrick Ndungu\textsuperscript{2}
School of Chemistry and Physics, University of KwaZulu-Natal, P/Bag X45001 Westville Durban 4000, South Africa
\textsuperscript{1}paideya@ukzn.ac.za, \textsuperscript{2}ndungup@ukzn.ac.za

The school of Chemistry and Physics at the University of KwaZulu Natal has recognised that the relatively large intake of first year students (approximately one thousand) makes it extremely difficult to provide individual attention, regular practice and assessment opportunities to all first year students enrolled in the introductory chemistry module, when using the current methods of teaching and learning. These pro-active exercises are essential for development of a student’s conceptual understanding of chemistry as a whole. Impediments to implementing such tasks to 1000 first year students can be attributed to factors such as lack of manpower and time on task required and ‘law of diminishing returns’. In an attempt to overcome these hurdles, and taking into consideration students of the twenty first century as technologically savvy individuals, an online learning, support and monitoring tool, Mastering Chemistry, was implemented with the first year chemistry module.

This paper reports our initial implementation of a web based tutorial system, mastering chemistry, with the 2012 cohort of first year chemistry students. Our main aims were to assess how the mastering chemistry programme impacts on the pass rates between various academic segments of the student cohort. Firstly we look at factors such as the frequency at which students engaged with the programme, whether the student’s engagement with the programme had an effect on their pass mark, or whether their prior knowledge, via correlating matric scores, had a greater effect on a student’s performance throughout the year. Secondly, we interrogate the quality of results between regular users and less regular users of the programme through an analysis of students’ examination results. This article is premised on active learning principles and the theoretical assumption that encouraging active learning principles and students time on task enhances learning. The findings suggest that there is a moderate positive correlation between students mastering chemistry scores and their test marks, and final exam marks. Qualitative data suggests that mastering chemistry has the potential to provide academic support through practice, revision and reflection and offer opportunities for constant monitoring. It is essential to take cognisance of such technologically advanced student’s, and an online tool such as mastering chemistry which takes advantage of the modern student’s predilection for such systems.

\textbf{Keywords:} mastering chemistry, online learning tools, first year chemistry
Collaborative planning and International Team Teaching of a chemistry topic for ESD

Andrew Petersen 1, Lebona Nkhalhe 2 & Gillian Kay 3

1,3 School of Education, University of the Cape Town, South Africa; 2 Thandokhulu High School, Mowbray, Cape Town

andrew.petersen@uct.ac.za, Lnkhalhe@yahoo.co.uk, gillian.kay@uct.ac.za

In this study we report on an international team teaching strategy to develop lessons as part of a learning module on Education for Sustainable Development (ESD). This “global” ESD module is being implemented against the time frame of the United Nations Decade of Education for Sustainable Development (2005-2014). The ESD study is located in grade 8 class in a School in the Cape Town Metropole in South Africa. The aim of the study is to describe the enactment of a chemistry lesson with an ESD focus.

The study seeks to answer the following research questions:

1. What is the teachers’ PCK in teaching combustion and how is this influenced during the collaborative development of the lesson.
2. How effective is the lesson in influencing learners’ ideas about sustainability?

In an attempt to describe the enactment of the lesson, this study uses a qualitative and interpretive research approach (Erikson, 1986). In order to capture and describe the implicit nature of teachers’ unique knowledge, Pedagogical Content Knowledge (PCK) is an appropriate conceptual framework (Shulman, 1986; Grossman 1990). The methodological tools used to portray a teachers’ PCK include CoRes (Content Representations) and Pedagogical and Professional experience Repertoires(PaP-eRs) (Loughran et al., 2001; Rollnick et al., 2008). A CoRe provides a composite overview of how a teacher conceptualises the content of a topic (Loughran et al., 2006) including the “big ideas” associated with teaching the topic and is based on interviews using prompts to elicit a teacher’s PCK:

<table>
<thead>
<tr>
<th>Table 1: Prompts used in the interviews to generate CoRes (Loughran et al., 2006, p.25)</th>
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<tbody>
<tr>
<td><strong>Prompts</strong></td>
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<td>1. What you intend the students to learn about this idea?</td>
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<tr>
<td>2. Why is it important for students to know this?</td>
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<tr>
<td>3. What else might you know about this idea (that you don’t intend your students to know yet)?</td>
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<tr>
<td>4. What were the difficulties/limitations connected with teaching this idea?</td>
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<tr>
<td>5. What Knowledge about students’ thinking do you know of which influences your teaching of this idea?</td>
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<tr>
<td>6. What other factors influence your teaching of this idea?</td>
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<tr>
<td>7. What teaching strategies did you use and Why? (and particular reasons for using these to engage with this idea)?</td>
</tr>
<tr>
<td>8. What specific ways of ascertaining students’ understanding or confusion around this idea (include likely range of responses).</td>
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The collaborative teaching approach used in this study follows the theoretical model of a lesson study (Fernandez, 2002) as proposed by Lewis, Perry and Hurd (2009). Using the "research lesson" approach makes..."various types of knowledge more visible"(Lewis et al., 2009, p.287). The PaPeR (Loughran et al., 2001) is based largely on the data gathered at each stage of the teaching event:

1. Investigation of the content areas and developing contextually relevant strategies for ESD. During this stage of the research process, preliminary interviews will be held with the relevant teacher to elicit their understanding about the topic and their PCK using CoRes.
2. Planning of the “research lesson” lesson. The teachers then collaborate using Skype to develop preliminary lesson outlines. These Skype sessions were recorded.
3. Conducting the research lesson using a lesson study format which enables in-situ data collection.
4. Reflective practice session: Excerpts of the lesson or “classroom windows” are identified for the stimulated interview session.

Lewis et al. (2009) suggest that the rationale for using the lesson study as a model for instructional improvement is that it makes the implicit explicit and enables educators to track “… intervening changes in Teachers Knowledge and beliefs, Teachers Professional Community and Teaching-Learning Resources” and possibly student learning. This model therefore also complements the conceptual framework of PCK.

In this study we portray the teachers' PCK and describe the enacted practices during the collaborative teaching of a topic in chemistry. Due consideration is given to the different contextual realities of the teachers concerned (Japan and South Africa). The study also attempts to describe how ITT shaped the SA teachers' PCK and influenced the teachers' work ethic. We also describe the possible influences of the lesson on learners’ perceptions of sustainability.

References
A case study exploring two life science teachers’ enacted practices in working class schools in the Cape Town Metropole

Andrew Petersen 1

1. Schools Development Unit, School of Education, University of the Cape Town, South Africa.

Both internationally and locally, there is little evidence to show far-reaching curriculum reform, directed at transforming teachers practice from a traditional to a more learner-centered approach (Stoffels, 2008; Clark & Linder, 2006; van den Akker 1998). Previous research also highlights the challenges faced by teachers equipped with inadequate skills and a lack of effective training or modeling to implement a learner-centered curriculum (Stoffels, 2008). The aim of this study was to provide insight into the enacted practices and the underlying reasons for the practices of two teachers with different educational backgrounds and different levels of experience. Both were teaching Grade 10 Life Sciences in the same school which serves a working class community in the Cape Town Metropole. This study sought to find the answer to the following research questions:

What were the enacted practices of selected Grade 10 life Science Teachers and to what extent did their experience influence their practice?
Why did they enact these practices in their classroom?

In order to understand the complex nature of the enacted practices of these teachers, Pedagogical Content Knowledge (PCK) as described by Shulman (1986) was found to be particularly useful as a theoretical framework. An elaboration of PCK has been provided by Abell (2007) who combined the ideas of Grossman (1990) with the broader description of PCK by Magnusson, Krajcik and Borko (1999). This study is conceptually grounded in the five components of PCK according to Magnussen et al. (1999) The enacted practices of selected Grade 10 Life Science teachers in this study are described in terms of these five components: orientation towards science teaching, knowledge of students’ understanding in science, knowledge of science curriculum, knowledge of science instructional strategies and knowledge of assessment of science learning.

In an attempt to find out how teaching and learning unfolds in the Grade 10 Life Sciences classroom, it was thought appropriate to use a qualitative interpretive approach (Erikson, 1986). As this study also requires an in-depth study of teachers enactment of the curriculum (ie., what practices occur in the Life Sciences classroom and why they were happening) a narrative case-
study approach was most appropriate (Clandinin, 1992). Similar to the approach of Grossman (1990, p. 150), the intention was to “[identify] patterns and themes within the individual case that could be useful in the comparative cross-case analysis”. Also, this multiple case study draws heavily on the approach of Park and Oliver (2008) and is grounded in a social constructivist framework. In this research study, which is modelled on the study by Park and Oliver (2008), data were gathered using multiple data sources including semi-structured interviews, lesson observations and stimulated interviews using video and/or audio recordings of the lessons. The value of using standardized open-ended interviews is that it improves the comparability of the responses, provides complete data which can easily organised and analysed (Cohen, Manion & Morrison 2000, p. 271). Teacher resources used in preparing their lessons, including textbooks and other relevant materials, were collected. Face-to-face interviews were conducted with the teachers before and after teaching the topic. The pre-lesson interviews (using the prompts in table 1 below) probed teachers understanding of the topic as well as their planning strategies, explanations, and resources used in their lessons.

Table 1: Prompts used in the interviews to generate CoRes (Loughran et al., 2006, p.25)

<table>
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</tr>
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</table>

Post-lesson interviews included a stimulated reflection of the lesson (including video and/or audio transcripts) and as the need arose further interviews were held to clarify issues that arose during data analysis about the teachers practice.

Content Representations (CoRes) and Pedagogical and Professional Experience Repertoires (PaP-eRs) (Loughran, Berry and Mulhall, 2006) were developed for each teacher and out of these descriptions case studies were developed. In each case study the profiles of teachers were constructed using a PCK Evidence Reporting Table (ERT) (Park and Oliver, 2008), which is based on the description of PCK by Magnusson et al. (1999).

Although the two teachers had quite different academic qualifications and experience what they shared was a similar perception of the learners poor work ethic and content deficit. However, their attitudes and approaches to their learners was very different and the levels of engagement varied. This variance was reflected in the types of instructional strategies and frequency of the different types of questions asked. Teachers showed a differentiated approach, which was linked to their experience. Teachers with more experience clearly demonstrating a more in depth
knowledge and range of pedagogic strategies. The experienced teacher in this study was also able to identify the salient facts that needed to be taught, however, despite being able to describe the contextual constraints was not able to transform this knowledge into a form that can be appropriated by the learners. The less experienced teacher, seemed to overemphasise the context and being weighed down by the contextual constraints and her own limitation was only capable of delivering a very restricted curriculum. Teachers model their approach on their previous experience (i.e., teacher-centered secondary and tertiary education) in what has been described as the “conservatism of teaching” (Grossman, 1990, p.10). In this case both Teachers used a persistent didactic or transmissive teaching model (Loughran et al., 2006) and clearly were unable to offer the kind of scaffolding required so that their learners could engage in effective learning.

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Conceptual difficulties in solution chemistry flag at-risk students

Marietjie Potgieter, Shalene Bothma and Mariska du Preez

Chemistry Department, University of Pretoria, South Africa

The interface between school and higher education in South Africa has often been characterised in terms of an ‘articulation gap’. With the objective of an appropriate response following transformation at secondary level, this study contributes to a thorough assessment of baseline conceptual understanding in first-year chemistry to inform teaching at South African universities. Success at first-year level is a growing concern for tertiary institutions in South Africa, especially in science and mathematics. Early identification of students at risk of failing first-year chemistry allows timely intervention.

In this study we have analysed self-constructed drawings of a chemical reaction in aqueous medium to document conceptual difficulties that students may have in this area and to investigate the predictive power of specific conceptual problems for risk of failing first-year chemistry. This is a mixed methods study situated in the constructivist paradigm which also draws from knowledge of misconceptions in solution chemistry (Barke et al., 2009; Naah & Sanger, 2012), the triplet modality of representations in chemistry (macro, submicro and symbolic; Gilbert & Treagust, 2009) and challenges associated with interpretation of symbolic representations (Taber in Gilbert & Treagust, 2009).

Research questions:

- What do first-year students’ drawings of a precipitation reaction in water reveal of their conceptual understanding?
- What is the correlation between specific conceptual problems and success in first-year chemistry?
- What conceptual and reasoning difficulties do students reveal in explaining their self-constructed drawings of a precipitation reaction in water?

Data were collected as part of a baseline pre-knowledge test (Potgieter et al., 2008) written in February 2011 by all first-year chemistry students enrolled for BSc programmes at the University of Pretoria. Data were also collected as part of a post-test written by the same group in October 2011. Students were given a reaction equation and asked to draw a microscopic representation to illustrate this chemical reaction using specific symbols for the species involved: 

$$\text{NiCl}_2(\text{aq}) + 2\text{NaOH}(\text{aq}) \rightarrow \text{Ni(OH)}_2(\text{s}) + 2\text{NaCl}(\text{aq})$$

A random sample of 10% of the scripts were selected for detailed analysis of the drawings (pre-test, \(n = 56\); post-test, \(n = 44\)). Drawings were coded for accurate or flawed representation of bonding, ion dissociation and stoichiometry, including conservation of atoms. The students in the pre-test sample were classified according to their performance in the first semester module, CMY 117, i.e. whether they have passed or failed the module. This analysis was repeated for the post-test sample and was compared with performance in the second semester module, CMY 127. The impact of specific conceptual deficiencies as revealed by the drawings was calculated as the
product of the prevalence of the problem (% of sample) and the percentage of students who demonstrated the problem and also failed the respective module.

Semi-structured interviews were conducted with a representative sample of students to probe the conceptual and reasoning difficulties that gave rise to the flaws in submicro representations. The interview data are being analysed using the cognitive load theory (Sweller et al., 1998) to guide the analysis. It will be especially important to understand the thinking behind complete dissociation of all species or completely ignoring the phase information in the equation, because this is the apparent oversight with highest negative impact according to the results. The second most important problem to be probed is that of lack of overall conservation of atoms.

We expect that the findings of this study will create an awareness of potentially crippling conceptual and reasoning difficulties experienced by first-year chemistry students when presented with a symbolic representation of a chemical reaction in aqueous medium. We hope to use these results to encourage lecturers to integrate submicro drawings into their teaching and assessment at first-year level as a way of addressing these problems.

References


Science student teachers’ perceptions of the relationship between science and technology

Willem Rauscher¹ & Nicolaas Blom²

¹Department of Science, Mathematics and Technology Education, University of Pretoria, South Africa; ²Department of Science, Mathematics and Technology Education, University of Pretoria, South Africa

¹willem.rauscher@up.ac.za, ²Nicolaas.Blom@up.ac.za

The integration of Natural Sciences and Technology in the Intermediate Phase may pose various challenges when it comes to the implementation thereof in 2013. The question as to who will be responsible for teaching this new subject, Natural Sciences and Technology, is especially
problematic. It may, for example, determine how this subject will be taught and how content will be prioritised. The marginalizing of Technology in the *Curriculum and Assessment Policy Statement* (CAPS, Department of Basic Education, 2011), which is evident from the fact that the volume of learning content and teaching time of Science is significantly more than that of Technology, suggests that Science teachers would be responsible for teaching this new subject. Most Science teachers in South Africa, however, have had inadequate training in Technology Education and, therefore, might not have a sound understanding of the nature of technology or its interconnected relationship with science. This may have disastrous consequences for Technology Education. Gardner (1995:25), for example, avers that if technology is projected through a scientific lens, it may present a distorted view of the nature of technology; an emphasis on scientific laws and theories may result in a failure to properly address design and problem-solving, which are prominent characteristics of Technology Education.

Although the epistemological relationship between science and technology is well documented in the literature, it seems that the way in which Natural Sciences and Technology will be integrated and implemented in the Intermediate Phase, has not been properly researched and documented. Such research is significant since the way in which teachers perceive the relationship between science and technology will govern the way in which they will integrate the subjects. For example, the perception that technology is a product and not a process may influence their teaching and learning of technological concepts and processes (Sidawi, 2009:271). Also, if teachers perceive technology as applied science (TAS) they wrongly assume that all technological artefacts are founded on scientific principles (Sidawi, 2009:274). It is for this reason that it is important to investigate Science student teachers’ perceptions of the relationship between science and technology as it will have a profound influence on the way in which this new subject will be taught.

This study utilised five distinctive markers (i.e. objectives, objects of research, methodology, characteristics of results, and criteria of quality), summarised by Ropohl (1997:66-67), as the conceptual framework. These five distinctive markers were augmented by adding aspects regarding the TAS view. These aspects include the misconception that technology is merely applied science and that science is therefore the source of technological innovation, and the possible negation that technology has its own separate body of technological knowledge.

Quantitative research was conducted to provide insight into Science student teachers’ perceptions of the relationship between science and technology. A Likert-type questionnaire was administered to 32 third year university students who selected General Science as an elective subject as part of their four year Bachelor of Education (B.Ed.) degree course. The Likert-type questionnaire was constructed by using statements that were derived from the conceptual framework. The students completed the questionnaire at the end of their third (final) year of

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1 Although these students had Technology as a school subject, they have had no exposure to Technology (as an elective subject) as part of their B.Ed. degree course at the University of Pretoria.
General Science training. The number of student responses to each of the various scale options (i.e. strongly agree, agree, disagree, or strongly disagree) were calculated to determine the degree to which the students agreed with each statement.

The results, emanating through descriptive statistics, show that the student teachers who participated in this study view technology simply as applied science and that science is the source of technological innovation. The implication of this perception, as pointed out by Davies (2003:208), is for a hierarchical relationship in which Science is regarded as more important than Technology. Davies (2003:208) further notes that if this belief is left unchallenged, it would lead to impoverished classroom practice in which the mutually supportive conceptual and procedural links between science and technology would remain undeveloped.

Participant responses to the five distinctive markers (i.e. objectives, objects of research, methodology, characteristics of results, and criteria of quality) used as the conceptual framework of the study, suggest that the student teachers at least have a basic conception of the relationship between science and technology. Although this bodes well for the integration of Natural Sciences and Technology in the Intermediate Phase, it does not inform how the school curriculum will be interpreted and implemented in the classrooms. For this reason it is recommended that follow-up studies be conducted to investigate how Natural Sciences and Technology are operationalised in the classrooms. It is also recommended that the curriculum for the training of Intermediate Phase Science teachers at Higher Education Institutions should include some tuition on the nature of technology to ensure that future Natural Sciences and Technology teachers properly address design and problem-solving (Technology) in the new subject and not only focus on laws and theories (Science).

References


**Student perceptions of and attitudes towards first-year General Chemistry practicals**

Liezel Retief¹

¹Stellenbosch University

¹liz@sun.ac.za

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Laboratory practicals play an important role in the teaching and learning of Chemistry. The current first-year Chemistry practical curriculum at the university at which the study was conducted has no defined outcomes, aims and objectives for the practical sessions. Reid and Shah (2007) have argued that chemistry practical curricula should be rethought in order to develop practical activities that are much better suited for the outcomes we wish the students to attain. Literature also suggests that the students’ perceptions of the usefulness and applicability of a subject, method or technique impacts their success rate in that subject (Johnstone, 2000; Henderleiter & Pringle, 1999) and that laboratory work has an impact on enhancing student attitudes towards science; stimulating interest, enjoyment and motivation of science learning (Hofstein & Lunetta, 2004; Shulman & Tamir, 1973). It is therefore of interest to us to investigate what the first-year students’ perceptions and attitudes are towards practical training, what they perceive the outcomes of Chemistry practicals to be and how/whether any of these changes during the year. We are also interested to investigate their perceptions on the outcomes achieved of Chemistry practicals and how these correlate to those of the tutors and lecturers.

In the second phase of the study the questionnaires will be distributed to other universities of the Western Cape in order to compare data. Results will be used to create a more positive atmosphere that is conducive to increased motivation and dedication. This is part of a larger study that aims to review the practical curriculum in order to enhance the student’s understanding.

This paper will discuss some of the results obtained by the pilot study done during 2012 at the Stellenbosch University.

This research is situated within a postpositivist paradigm informed by motivational theory (Eccles & Wigfield, 2002).

The following research questions were asked:

- What are student perceptions of and attitudes towards first-year General Chemistry practicals?
- How do student perceptions and attitudes change during the course of the semester/year?
- How does student perception of the purpose of Chemistry practicals correlate to those of lecturers and tutors?

Sproul (1988) suggests that a questionnaire is an appropriate research tool when attempting to collect information about people’s “attitudes, values, beliefs, or self-reports...”. DeVellis (2003) states that when a construct cannot be measured directly, then a questionnaire that contains scale items that represent the desired construct can be a useful means of measure. Therefore for our study in order to measure a student’s attitudes and perceptions, a survey was seen as the most practical and effective methodology. Although literature indicates the presence of several attitude studies using questionnaires as test instruments, Blalock et. al. (2008) has reported that the majority of science attitude test instruments show an absence of psychometric evidence and have several methodological issues including the absence of reliability, validity and a disregard for missing data. Therefore we felt the need to develop our own test instrument and refine and analyse it using the Rasch model in order to increase validity and reliability.

An exploratory sequential mixed-method approach was used. A Likert scale questionnaire was developed where the items and response options were qualitatively generated based on informal
small group and individual interviews with students, student written feedback and email questions sent to lecturers as well as information obtained from literature. Using the students’ and lecturers’ own wording ensured both face and construct validity. The instrument consisted of three subscales; namely to probe student perceptions and attitudes regarding the laboratory experience, the tutors/demonstrators, and the outcomes expected from the laboratory training.

The questionnaire was distributed to first-year Chemistry students at the start and the end of the first semester as well as at the end of the year of 2012. A separate questionnaire was distributed to lecturers and tutors with regards to what they believed the outcomes achieved should be and what they believed was achieved.

Quantitative data analysis was done using the Rasch model. Early results show indications of clear trends of differences between the perceptions of lecturers, tutors and students with regards to their perceptions of the outcomes achieved. Initial comparison of data indicates that the majority of students have idealistic expectations of the benefits of Chemistry practicals. Some of these perceptions and attitudes included students being enthusiastic, excited and interested in the practical sessions. Students also indicated positive attitudes towards tutor effectiveness. The data was processed and the main findings based on the research done during 2012 will be reported in this paper. Final conclusions and recommendations will also be discussed.

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References
Teaching chemical bonding for conceptual change

Angela Roche 1 & Marietjie Potgieter 2

1 St Alban’s College, Pretoria, South Africa; 2 Department of Chemistry, University of Pretoria, South Africa.

rochea@stalbanscollege.com, marietjie.potgieter@up.ac.za

Chemistry is a vast subject and at secondary school level the basic concepts need to be cemented in pupils’ understanding in order for them to progress in the study of the subject at tertiary level. Teaching of chemistry at secondary school level is not always carried out in the most effective way and this is often because teachers do not realise the difficulties experienced by pupils while studying a conceptually challenging topic. The development of a teaching strategy to assist teachers is thus of value.

The research questions:

• Do focused intervention questions followed by rapid feedback to pupils foster sound concept formation in chemical bonding?
• Is this new teaching method more effective than traditional methods?

This study involves action research in secondary school classrooms with the findings from the study are being used to further inform current teaching practice. A mixed methods approach is also used. The teaching method is a set of focused intervention questions administered at relevant stages during the teaching of the topic. Pupils answer these questions with the help of their learning material and are given rapid feedback with an evaluation of their answers. This questioning process is designed to focus pupils’ attention on the relevant concepts and the feedback is to inform pupils of their progress in mastering the topic. The effectiveness of the method was measured using a concept development test. The learning gain in a test group was compared to that of a control group in a quasi-experimental study.

Learning is defined according to the constructivist perspective with mental models as a theory of learning that forms part of this paradigm (Coll & Treagust, 2003). The process of learning can be seen as a process of conceptual change which is generally defined as learning that changes an existing conception (Duit & Treagust, 2003). Pupils begin their study of a topic with some degree of preconception, or with misconceptions. The development from this state to one in which pupils do have a coherent conceptual understanding is regarded as conceptual development in this study and was measured by comparing pupil score on a pretest to the score on a post test. The intervention questions were designed to focus pupils’ attention on the aspects of the teaching material that are essential for conceptual development and also to make them aware of how their own understanding is developing. Metacognitive processes involve knowing
what you know, why you know it and how you came to know it. Metacognition is recognised as contributing to deeper and more transferable learning, in general and specifically in chemistry (Rickey & Stacey, 2000). When learning complicated concepts like chemical bonding, understanding one’s own pathway to knowing is an important part of learning. The intervention questioning process is coupled to immediate task-level feedback, which improves pupil learning but also enhances teaching (Shute, 2008).

A quasi-experimental setup using four classes of Grade 10 boys at St Alban’s College were used for this study. Two classes received the intervention and two classes served as the control group. The sample size was approximately 80 learners, divided into the four classes. Class allocation is not random as it is determined by the subject combinations of the pupils. Three different teachers share the teaching of the four classes. The two classes that received the intervention questions were taught by different teachers. All teachers use the methods and techniques that they normally use. There was no prescription regarding teaching method. The only distinction between the test and control groups was the administration of the intervention questioning process.

Measurement of the effectiveness of the intervention method was done by comparing the learning gain in the test and control groups (Hake, 1998). The learning gain was determined through the use of a concept development test developed by the investigator. This test tool contained a set of 25 conceptual questions, either requiring selection of a correct answer from a multiple choice selection or requiring a free response answer. Both groups of pupils, the test and the control group, wrote a pre-test and a post test. A correlation analysis and a Rasch analysis determined the validity and reliability of the testing tool (Cronbach’s alpha 0.89). Performance data collected by means of the concept development test were analysed using a paired t-test of learning gain. Results from both runs of the intervention process show that the test group has a statistically significant greater learning gain (LG) over the control group (Table 1).

Table 1: Learning gain in control and test groups in 2011 and 2012 groups of pupils

<table>
<thead>
<tr>
<th></th>
<th>Control Group</th>
<th>Test Group</th>
<th>t-Test results</th>
</tr>
</thead>
<tbody>
<tr>
<td>LG 2011</td>
<td>0.16</td>
<td>0.33</td>
<td>Not yet checked*</td>
</tr>
<tr>
<td>LG 2012</td>
<td>0.34</td>
<td>0.45</td>
<td>t = 4.74, df 79, prob&lt;0.0001</td>
</tr>
</tbody>
</table>

*will be filled in when final abstract is prepared.

In addition certain qualitative results were obtained. Most pupils were not able to use correct terminology when answering intervention questions – despite being able to use notes and books while answering. Understanding was vague and could not be accurately expressed through use of correct new terms. Pupils are often able to correctly select an answer from a multiple choice selection but are then not able to describe the same answer in their own words or by using diagrams. Conceptual change or development happens gradually for many pupils.

References:
Pre-service teacher education has undergone many changes in the past 30 years. Controversies exist about many aspects of the programme but one of the most contentious issues is the mode of delivery of the content and its methodology. Between the science content and methodology lies the students’ pedagogical content knowledge (PCK) which refers to their ability to transform content knowledge for teaching. The name PCK was first introduced by Shulman in 1986, though the concept has been in existence far longer. PCK is regarded as tacit knowledge gained in practice (Kind, 2009) and thus difficult to pass on to others. Most importantly, it is topic specific (Mavhunga and Rollnick, 2011) and thus needs to be learnt for every topic taught. This study investigated two aspects of PCK – the possibility of teaching it to pre-service teachers and the possibility of transferring the knowledge gained across two topics in physical science.

Much has been done in the 25 years since Shulman first introduced the idea of pedagogical content knowledge as the knowledge used by teachers to transform content into a form that can be used in the classroom. A look at the literature suggests that despite an enthusiastic uptake of Shulman’s ideas, there have been as many models of PCK as there are researchers. In two recent reviews by Abell (2007) and Kind (2009), both researchers attest to the multiplicity of representations and terminology in the area and agree that thinking about PCK has yet to unify into a single paradigm. Despite this lack of agreement amongst researchers, PCK remains a useful construct and in Abell’s and Kind’s view is an invaluable theoretical framework for understanding teachers’ knowledge. Much research has also been devoted to capturing and portraying PCK using CoRes and PaP-ers (Loughran, Berry, & Mulhall, 2004), but fewer attempts have been made in science education to assess its quality. Part of the problem in this regard is the lack of agreement that still exists over what exactly is being assessed. In our view, the value of PCK for improving the quality of teaching lies in its topic specific nature.

Different models of PCK are employed in the studies cited above but our interest is predominantly in topic specific PCK. To this end we have developed the construct of topic
specific PCK (Mavhunga and Rollnick, 2011) which is related to Ball et al.’s specialised content knowledge for teaching (Ball, Thames, & Phelps, 2008). Hence we regard topic specific PCK as the understanding that provides the needed knowledge for SMK transformation in a particular topic. When a specific topic is thought through, certain topic specific components of PCK are considered. We identify these as (i) Learners’ Prior Knowledge, (ii) Curriculum Saliency (deciding what is important for teaching and sequencing), (iii) What makes topic easy or difficult to understand, (iv) Representations including powerful examples and analogies and (v) Conceptual Teaching Strategies.

This study looks at the possibility of transfer of topic specific PCK between two topics in physical science in a group of final year pre-service teachers and seeks to answer the following questions:

1. What is the quality of PCK that is captured and portrayed by the student teachers as demonstrated by CoRes constructed after an intervention aimed at teaching them topic specific PCK in chemical equilibrium?
2. What is the quality of PCK that is captured and portrayed by the student teachers as demonstrated by CoRes constructed in a different topic, they taught during their school experience?
3. What is the relationship between the quality of their PCK in the two different topics as represented in the CoRes?

16 final year pre-service teachers were exposed to a 6 week intervention aimed at improving their PCK on chemical equilibrium (Mavhunga and Rollnick, 2011). Results showed a significant improvement in both their topic specific PCK and their content knowledge as a result of the intervention. During the intervention they completed a major assignment where they completed an adapted CoRe based on the components of topic specific PCK mentioned above. They were also required to complete an examination equivalent assignment where they were asked to carry out a similar task on a different topic which they had taught during their teaching experience. The CoRes produced for the major assignment and examination equivalent constituted the data for this study.

A rubric used for the evaluation of Topic Specific PCK using a specially designed instrument in the main study was adapted and used to assess the PCK of the students in the topics as demonstrated in the CoRes used for the two tasks. The rubric is based on the five components enumerated above. Analysis is ongoing, but the topic specific PCK scores of the two assignments will be converted to Rasch measures. The Rasch statistical model transforms the raw scores from the ordinal scale type rubric into statistics probability measures that are at equal intervals, enabling the establishment of a rank order for both persons participating in the test and the items. Once the rank order and Topic Specific PCK measures are obtained for both data sources, it will be possible to determine how successfully the pre-service teachers’ understanding of PCK and their topic specific PCK was transferred to a different topic. The reliability of the measures will also be determined.

References


The Integration of Socio-Scientific Issues into the Grade 11 Biology Curriculum in South Africa

Eugenie Rudolph¹ & Lindelani Mnguni²

¹Department of Science, Mathematics and Technology Education, University of Pretoria, South Africa; ²Department of Science, Mathematics and Technology Education, University of Pretoria, South Africa
¹genierudi@gmail.com, ²lindelani@up.ac.za

The integration of socio-scientific issues into Biology education remains a priority for academic institutions who believe that education should be used as a tool to empower societies. However, Dewey, a popular advocate of the use of education to empower societies has been criticised for failing to “resolve the dualism between the school and society that he fought to overcome because he failed to account for the many institutions in society which provide education” (Zuga, 1992: 5). The argument is that school is not the only agent of socialization and in order for education to effectively address socio-scientific issues, there has to be a synergy between the curriculum and everyday life. Integrating socio-scientific issues into a curriculum however remains a challenge for scholars. For example Ekborg (2010) indicates that if the scientific component of the formal curriculum goes against a normative system of values which students subscribe to, their affect-based responses may be hindered, jeopardizing even their critical reasoning. As a result students may revert back to defending socio-cultural views instead of the socio-scientific ones. Nevertheless Kloop, Severiens, Knippels, van Mil, Marc, Ten and Geert (2010: 1128) argue that science subjects such as Biology could incorporate “scientific literate competences that students need to be able to live and participate with reasonable comfort, confidence, and responsibility in a society that is deeply influenced and shaped by the applications, ideas and values of science.”
In the current study therefore the researchers aimed to explore the integration of socio-scientific issues into the Grade 11 Biology curriculum. Of particular interest was the incorporation of HIV/AIDS and green economy content into Biology. The main research question that was asked was “how does the Grade 11 Biology curriculum integrate HIV/AIDS and green economy content knowledge?”

In this qualitative study an inductive curriculum analysis approach was used to determine the integration of socio-scientific issues into the Grade 11 Curriculum and Assessment Policy Statement (CAPS) Biology (Department of Basic Education, 2010). In this method the researchers, using a previously validated instrument, examined sections of the Biology curriculum document in order to identify specific emerging themes and subthemes which relate to HIV/AIDS and green economy education.

In the process of examining sections of the Biology curriculum, as suggested by Schiro (2008: 7), the researcher probed for “the specific concepts that the curriculum is concerned with and the nature of this kind of knowledge” in relation to HIV/AIDS and green economy education. The instrument used consists open-ended questions which according to Nicholls (2003) and Evans and Davies (2000) may be formulated by the researcher prior to document analysis based on the objectives and the research question of the study. In the current study these questions were adopted from Schiro’s (2008) previously validated standard inventory for curriculum analysis. Responses were then formulated inductively by the researchers using verbatim and narrated extract from the document being analysed. The formulated responses were then used to make inferences regarding the integration of socio-scientific issues in the Biology curriculum.

Data show that there are prescribed scientific concepts that are taught to students in relation to HIV/AIDS and green economy. These include tissues, cells and molecular studies; structures and control of processes in basic life systems; environmental studies; and diversity, change and continuity. HIV/AIDS forms part of the tissues, cells and molecular studies knowledge area, while green economy content is part of the environmental studies section. It was observed that the content integrated may not be applicable to everyday life and also lacks scientific depth. The emphasis of the Biology curriculum in this regard is on ensuring that students develop specific skills and construct content knowledge which is discipline-specific. To this end, the learning outcomes and assessment strategies do not relate to empowering students with skills for everyday life even though application of knowledge is listed as a learning outcome. In fact, there is no indication as to how should students apply knowledge and how this will be assessed. Overall it appears that content knowledge of HIV/AIDS and green economy is integrated into Biology as extra content and the subject is not dedicated exclusively on these areas.

The strategy for integration of HIV/AIDS and green economy content into Biology is in line with recommendations for interdisciplinary collaboration in teaching about socio-scientific issues (UNESCO, 2006). Mnguni (2011) and Van Laren (2008) however indicate that incorporating content knowledge as extra content may limit the effectiveness of this knowledge since superficial context-specific detail is incorporated. UNESCO (2006) also supports this view in that because there is already a certain degree of content within the subject, which carries a particular level of priority, content added as extra content will potentially receive lesser coverage.
and attention. Consequently the researchers argue that the HIV/AIDS and green economy content incorporated in the Biology curriculum will probably not lead to student empowerment for everyday life.

References
Development of an instrument for checking documents as a potential source of misconceptions

Martie Sanders, Tholani Tshuma & Dennis Makotsa
Animal, Plant, and Environmental Sciences; University of the Witwatersrand, South Africa
Martie.Sanders@wits.ac.za; tholanitshuma@yahoo.com; dmakotsah@yahoo.com

This paper describes the development of analytical tools for investigating policy documents and school textbooks as a potential factor which could influence erroneous ideas. Both types of documents act as curriculum support materials for teachers, and as such should not only be error-free, but should assist teachers (who often have misconceptions themselves) in diagnosing and addressing misconceptions. The paper describes the process used by a team of three researchers to design the instruments, focuses on steps taken to improve the rigour of the instruments, and highlights the issues facing researchers trying to develop instruments for content analysis of documents. Although the topic area investigated was “evolution”, the lessons learned during this process are widely applicable to other subject areas.

Rationale for the study
Research into the existence of ‘misconceptions’ about various science concepts has burgeoned since the concept was highlighted in the 1970s and 1980s. Although pre-existing misconceptions can be used as a building block for facilitating the construction of scientific understanding (Clement, Brown & Zietsman, 1989) they can be an obstacle to the successful learning of science concepts. Osborne and Freyberg (1985) outline four unsatisfactory learning scenarios for students entering the learning situation with prior ideas at variance with the accepted ideas of science, resulting in problems with constructing the ideas science teachers are trying to facilitate in students.

Before students can be helped to construct scientifically acceptable ideas teachers must first identify what misconceptions exist, and to what extent, so they can make informed decisions on how to proceed. In South Africa the nature and extent of misconceptions about evolution held by high school Life Sciences learners reveals useful patterns in terms of which ideas are particularly extensive (Kagan, 2011; Lawrence, 2011). Secondly, in order to develop a successful strategy to deal with the erroneous ideas, the sources of the errors need to be understood. South African research reveals that teachers, the very people entrusted with addressing learners’ misconceptions, often have misconceptions themselves (Molefe and Sanders, 2009; Ngxola, 2012), so that the teaching of evolution often becomes a case of the blind leading the blind.

Two further studies reported at this conference (Makotsa, and Tshuma) investigated curriculum support materials as a possible source of misconceptions about evolution Ottevanger (2002) uses the analogy of an enzyme-catalysed reaction to explain the role of curriculum support materials in helping teachers perform their function with less time and effort expended, something very important when teachers are poorly qualified. Makotsa and Tshuma (individually) set out to investigate the possible influence of two such support documents on the existence of misconceptions about evolution: the curriculum policy statements, and textbooks. However, a problem emerged – the lack of any appropriate analytical tools to analyse textual materials as an
influence (positive or negative) on misconceptions. It emerged that instruments for analysing textbooks are just too specific in what they look for (e.g. syntax issues, terms used, content covered, teaching and learning approaches used) to make finding an existing instrument likely.

**Aim of the paper**

The aim of this paper is to describe how such tools were developed. Although this paper uses misconceptions about evolution to illustrate the development of document analysis checklists, the lessons learned are much more broadly applicable. We believe that valuable insights and lessons emerge from which researchers in other disciplines can benefit.

**Developing analytical tools for document analysis**

Content analysis was used to review the documents. Weber (1990: 9) describes content analysis as “a research method that uses a set of procedures to make valid inferences from text”. Checklists were developed for the study, as Gawande (2011) suggests they improve consistency during document analysis. Numerous authors provide advice on the theory behind developing tools for analysing textual materials (Krippendorf, 2004; Zhang & Wildermuth, 2009; Bergman, 2010; Fraenkel, Wallen & Hyun, 2012). In our paper we will elaborate on the advice distilled from these sources and what we learned whilst developing the checklists.

**Deciding on a research approach:** Regarding initial decision-making about an appropriate research approach, two issues emerged as important: the i) the qualitative / quantitative question, and ii) the inductive versus deductive reasoning question. Essentially methodological decisions are dictated by the researcher’s paradigmatic beliefs about the nature of reality and the nature of knowledge development. We identified with the pragmatic paradigm, which holds that rather than being determined by ontological and epistemological beliefs researchers’ actions are dictated by the reality of what problems are being investigated and the best methods to achieve answers to the questions (Mertens, 2005). This inevitably results in mixing methods traditionally held to be quantitative or qualitative. We used both elements, focussing on the nature of the problems as well as their extent. We will describe how our pragmatic stance also resulted in a mixing of a deductive approach (looking for trends already determined in the literature) and inductive reasoning (allowing trends to emerge from the data).

**Determining what to look for and defining terms, and developing a coding scheme:** We wanted to identify both positive and negative influences of the documents. We also used the notion of manifest and latent factors (Fraenkel et al., 2012). Manifest errors are obvious statements which require no interpretation (in this case actual erroneous statements) whilst latent factors require interpretation of the textual inferences (whilst certain statements may not be scientifically incorrect, their wording might lead to misconceptions). The literature on misconceptions about evolution revealed three potential categories of latent factors: the use of risk terms and euphemisms, the absence of adequate explanations, and problems caused by fragmentation and sequencing (Nehm et al., 2009). As will be described in the paper, the checklist we developed therefore had columns for the two main types of factors (manifest and latent) as well as three sub-categories under latent factors. The process of developing the categories and codes will be explained.
**Sampling the documents, and choosing a unit of analysis:** We will explain why a mixing of units of analysis had to be used (words, phrases, chapters) as well as the need to identify and analyse both pre-requisite and requisite content necessary for understanding about evolution by natural selection.

**Improving rigour:** This is not a single step, but infiltrates every aspect of the research process. The results of research are strongly dependent on the quality of the research tools, which influence the trustworthiness and credibility of the findings. We will describe both the theoretical importance of the processes used to improve rigour, and the method used: these include face-validation (of the prerequisite and requisite content to be analysed, and the content of the checklists); pilot testing (a vital aspect, according to Van Teijlingen & Hundley, 2001), the extensive and iterative immersion in the data (Polit & Beck 2004), the importance of the inter-coder reliability checks (Tinsley & Weiss, 2000), and the crucial role of the frequent debriefing sessions (Shenton, 2004).

**References**


Using pre-service teachers’ reflections to explore the assessment practices of mentor Physical Science teachers in Limpopo Province.

Suresh Kamar Singh1
1University of Limpopo
suresh.singh@ul.ac.za

Current policy documents promote assessment for learning as a strategy to address the transformational challenges facing the country. The Department of Education has adopted a transformational pedagogy with respect to the implementation of the new curriculum. The new Curriculum and Assessment Policy Statement (CAPS) has identified transformation as one of its principles, and ‘identify and solve problems and make decisions using critical and creative thinking’ as one of it aims (DoE, 2011). The system seeks to produce critical, creative and innovative teachers and learners. This study explores some of the assessment practices of mentor Physical Science teachers as recorded in the reflections of pre-service teachers. The study examines the assessment practices of mentor teachers by focusing specifically on activities that
promote creativity, innovation and critical thinking. Pre-service teachers were required to reflect on all assessment practices of mentor teachers including informal and formal assessments. Critical social theory formed the backdrop for this study.

The role of the teacher in helping to improve learners’ critical and creative thinking skills includes examining the personal qualities required of teachers, the classroom climate and teaching practices which best support it. Pre-service teachers are required to learn from and in practice during their teaching practice. The purpose of the study was to critically examine the assessment practices of mentor teachers using the reflections of pre-service teachers. The reflections of the pre-service teachers examined all aspects of the mentor teachers’ practice including a critical examination of assessment practices. In their reflections, pre-service teachers were required to determine if the practices of the mentor was in line with the policy requirements and involved creativity, innovation and critical thinking. To determine if mentor teachers are meeting the transformational goals of the country, the following research questions will be addressed:

1. Does the assessment practice of mentor Physical Science teachers promote critical and creative thinking?
2. Does the assessment practices of mentor Physical Science teachers promote or undermine the transformational goals of education in South Africa?
3. What lessons can be learnt from the reflections of pre-service teachers about the assessment practices of mentor Physical Science teachers?

This study takes place in the Capricorn and Vhembe Districts of the Limpopo province of South Africa. The pre-service teachers are currently registered for the Bachelor of Education (B.Ed) degree and are in their final year of study. The researcher lectures Method of Physical Science in the B.Ed degree and is the coordinator of the B.Ed programme. Qualitative methods of data collection were used in this study. The data was collected through the written reflections of pre-service teachers and group interviews. Samples of assessment tasks given by mentor teachers were used as supporting evidence for the reflections of pre-service teachers. Pre-service teachers were required to observe 10 lessons presented by mentor teachers and reflect on their mentor teachers’ assessment practices against the policy requirements.

The results from the study reveal that: teachers are confined to the textbook for their assessment activities; questions from past year examination papers are imported for tests and exams; critical thinking and creativity is absent in assessment; teachers seldom prepare their own assessment activities; the pace setter is followed rigidly leaving little room for teachers to be innovative; whole class discussion involving question and answer and group activities were the predominant teaching and learning activities; teachers did not pose high-order questions during their informal assessments; summative assessment was the norm; and group activities that learners engage in do not allow for debate, discussion, airing of different opinions and room for learners to reach consensus with respect to the topic being discussed.

The teacher’s ability to engage in critical activities plays a significant role in developing critical learners. The reflections of pre-service teachers revealed that teachers merely posed recall or
simple explanation questions to learners orally and in the group activities. They adhered to the policy. Textbook activities were used as group or assessment activities and assessments lacked transparency. Testing is the dominant form of assessment used by teachers.

The recommendations of the researcher, based on the findings of the study, are for the Department of Education to:
1. organise professional learning communities urgently so that teachers are able to learn from peers and colleagues;
2. hold cluster workshops for teachers to assist with the development of materials and interpretation of policy documents;
3. conduct workshops on material development and interpretation of policy;
4. set up professional development programmes for teachers;
5. develop a comprehensive website for teachers in Limpopo so that have access to other resources;

Other recommendations include:
1. design a short course on assessment for teachers; and
2. establish a network among teachers for sharing ideas, resources and teaching strategies.

It is evident from the reflections of students that the stipulation of the number and types of assessment that a teacher needs to conduct, according to the policy documents, handicaps them. This prescription does not promote critical and creativity thinking and undermines the transformational goals set for education in South Africa.

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How physical science teachers’ enrolled in an ACE programme define themselves
This research focused on teachers who were registered for an Advanced Certificate in Education (Physical Science) (ACE). Teachers register for an ACE if they do not have the required qualification to teach the subject at FET level. Teachers registered for the Physical Science ACE were asked to complete a questionnaire as part of a larger project. The questionnaire revealed that a number of the teachers never intended to become teachers of Physical Science. This revelation prompted this research as we wished to find out how these teachers came to be physical science teachers. We wished to find out if they shared common experiences that may have influenced them to become physical science teachers. The critical question that drove the research was: how do teachers registered for an ACE in Physical Science define themselves?

The new South African curriculum for the FET (Further Education and Training) band, the National Curriculum Statement (NCS) (2003) envisages teachers of the new education system as qualified, competent, dedicated and caring. Each teacher is expected to fulfil all the roles of the educator as set out in the Norms and Standards for Teacher Education (2000). If policy documents hold such high expectations of what teachers should be, the question arises how teachers view themselves against these expectations. Do these teachers develop an identity that characterises them as physical science teachers or are their identities similar to the identities of any other teacher? How did they come to develop the particular identities that they hold? The NCS holds high expectations of teachers, implying that teachers can reform easily to become the type of teachers that are able to competently implement Curriculum 2005 (DoE, 2003). This is hugely problematic as research has shown that a mismatch exists between the policy image of the teacher and the professional identity of the South African teacher (Jita & Vandeyar, 2006). This mismatch between policy images and teachers’ identities is by no means restricted to the South African context as the same phenomenon was observed in the United Kingdom (Moore, Edwards, Halpin & George, 2002).

Vloet and van Swet (2010) concede the complexities of professional identity and define it as stories professionals tell about themselves at a specific moment in a specific context, while Lasky (2005) defines teacher identity as the way in which teachers define themselves to themselves and to others. Where Spillane (2000) views identity as a sense of self that is socially constructed within social settings, further research takes a broader view of teacher identity, extending it not only to their sense of self, but to their knowledge and beliefs, dispositions, interests and orientation towards work as well (Drake, Spillane and Hufferd-Ackles, 2001). Teachers often define their identities in terms of the level at which they teach (elementary, middle school or secondary) (Sachs, 1999). In the South African context the discipline may be more important in influencing professional identity than the actual level of teaching. Day, Kington, Stobart and Sammons (2006) also found that secondary school teachers’ subject and its status are closely related to identity.

The framework that underpins the study is an adaptation of the Beijaard, Verloop and Vermunt (2000) framework that defines the identities of teachers as consisting of three parts: the teacher as subject matter specialist; the teacher as pedagogical expert and the teacher as didactical expert. The first category is self-explanatory; in Beijaard et al’s framework, the teacher as
pedagogical expert refers to teachers’ engagement and involvement with learners, while the teacher as didactic expert refers to the teacher’s planning, execution and evaluation of lessons. We used these categories to assist us in identifying teachers’ views of themselves (Stears, James and Good, 2012).

This study is part of a larger study on teacher identity. Students enrolled for the ACE were asked to complete a questionnaire which served as data for the larger project. The data revealed that five students never intended to become physical science teachers. These five students were purposefully selected to participate in this smaller study as we wished to find out how they came to define themselves in the way they do, given the fact that teaching was not their first choice.

This is an interpretive study as we wished to interpret teachers’ views of themselves as physical science teachers. As data were collected through interviews and observations this study is defined as a qualitative study. The research design is a case study of five teachers registered for an ACE in Physical Science. Data was collected through interviews and lesson observations. Each teacher was interviewed twice. The second interview was linked to a lesson taught by the teacher.

The findings reveal that the teachers had ambitions to become nurses, doctors or engineers but never considered teaching as a career. This indicates an interest in science more so than an interest in education. A common thread is that the teachers themselves, as well as others, viewed them as good science students and placed them in science streams or pushed them to do science. The teachers report that even at college they were pushed into science courses because there were vacancies and they were perceived to be the most suitable candidates. The context in which these students operated defined them as good science students, although when measured against a wider context, they were average students who were not very good at science, hence their inability to qualify for the courses they aspired to. The participants were not interested in teaching, but developed an interest in Physical Science. Because of their average performance none of them could qualify as FET teachers and consequently all qualified as primary or junior secondary teachers. Classroom observations also revealed that teachers focused on the transmission of content and were at pains to demonstrate that they had knowledge of the content they were required to teach. They concede that they did not pay much attention to innovations in pedagogy.

In the GET phase the focus is more on teaching the child holistically than on the discipline, while in the FET phase the focus shifts to specialist teaching. To move to the FET phase where emphasis is placed on the discipline was what these teachers aspired to. When given the chance due to the shortage of qualified teachers, they jumped at it only to find that they were not sufficiently qualified to teach Physical Science at that level. The ACE proved to be a life line as it afforded the opportunity to improve their qualifications. All the teachers saw value in the ACE as it improved their disciplinary knowledge. They were not particularly interested in changing their pedagogy. The NCS expected teachers to adopt a more learner-centred approach, but these teachers were only interested in improving their disciplinary knowledge. Rather than see themselves as teachers of Physical Science, these teachers defined themselves as physical science specialists who happened to be teachers and their participation in the ACE programme
supported this perception. We therefore conclude that these teachers’ identities appear to be shaped by their knowledge of Physical science with little or no recognition given to the pedagogical or didactical aspects of teaching.

References


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**Is classroom observation a good measure of normal classroom practice?**

Dale Taylor 1  Anthony Lelliott 2

1 *Physics Department, University of Cape Town, South Africa*; 2 *Marang Centre for Mathematics and Science Education, University of the Witwatersrand, South Africa*
The obvious way to find out what is happening in classrooms is to spend time in them, thus classroom observation is a popular tool. However a classroom with a stranger added is to the normal classroom situation as Survivor ‘reality’ television is to true pioneering – it may look good on television, but the presence of the television cameras changes the reality. Although a researcher may want to be a non-participant observer, the very act of introducing an observer into a classroom changes the dynamic of the classroom. In addition the researcher is a particular measuring instrument, conditioned by her subjectivity to pay more attention to certain details, and less attention to other details. The purpose of this paper is to investigate the trustworthiness of classroom observation with eight physical science teachers where I spent two whole school days in each of their classrooms. Although this research was carried out in science classrooms, the results are applicable wherever classroom observation is used.

Maxwell (1996) argues that the two main threats to validity in the social sciences are ‘reactivity’ and researcher subjectivity. Reactivity is the “influence of the researcher on the setting or individuals studied” (p. 91) whereas researcher subjectivity arises because a researcher comes to the research with preconceptions and values through which the data is viewed. Breen (2001) shows how different people make contradictory observations after watching the same video. Brown and Dowling (1998) argue that ‘construct validity’ is central: the measured constructs should be valid measures of the corresponding theoretical constructs. In this case observed lessons should be a measure of ‘normal classroom practice’. Merriam and Simpson (1984) call this internal validity.

There were two broad moves I made to address classroom reactivity: I attempted to reduce the effect of my presence on the classroom dynamic, particularly by addressing power relations in the eyes of the teacher and the learners, and I asked teachers what effect they thought my presence had on them and their learners. In other words, I took steps to reduce the reactivity and to account for it.

There is consensus that it is not possible to eliminate researcher subjectivity, but there are different ways of dealing with it. Lather (1986) suggests a vigorous reflexivity throughout the research process. I used a narrative approach to classroom observation, writing the story of each lesson as it unfolded (Adler & Reed, 2002), which addressed the threat of subjectivity by producing rich data (Maxwell, 1996). I also used a video camera which allowed me to revisit the lessons and fill in more details on the lesson narratives. However the video camera exacerbated classroom reactivity. I talked to the teachers about their lessons and afterwards gave each teacher a full set of her lesson narratives – these were member checks which brought the research subject’s point of view to the observation. I also explicitly identified my own subjectivities with respect to my research project, arising from my science teacher self, my social justice self, my methodology lecturer self and my researcher self (Peshkin, 1988).

There are two methods which get used for addressing researcher subjectivity which I did not use: triangulation and intercoder reliability (Cohen, Manion, & Morrison, 2000). Intercoder strategies do not eliminate subjectivity, they merely bring different subjectivities to bear on the data, and
may in fact render subjectivity invisible where multiple researchers have similar subjectivities. Triangulation is not appropriate for classroom observation since there is often a gap between what teachers do and what they say they do (e.g. Simmons et al., 1999).

To analyse the extent of the reactivity of the classrooms, I audio recorded the interviews with teachers, and analysed the transcripts. I found that despite my efforts to reduce reactivity, my presence had an effect. However this effect was not constant, for example one teacher at first experienced nervousness to the extent of his mouth drying out, making it difficult for him to speak, whereas some teachers reported that they forgot about my presence at times during the second day I visited. With some learners my presence had no effect observable by their teachers, whereas with others there were significant silencing effects, both positive and negative – inhibiting bad behaviour but also inhibiting learners’ contributions to the lesson particularly in classrooms which are usually bilingual. With two teachers a greater than normal portion of the lessons were conducted in English for my benefit. It proved most difficult for learners to ignore my presence in two township classrooms, in part because the learners assumed I was important because of my skin colour. Overall it seems my visits had minimal effect on four teachers and their classes. But the other four teachers all felt the impact of my presence significantly, as did some of their learners. My presence appeared to have more impact on the teachers than the learners, though the measures were different, with the teachers self reporting and the effect on learners judged by their teachers. Asking the teachers about their experience of having me present gave me the opportunity to apologise for the discomfort which some of them experienced as a consequence of my research project.

With regard to my subjectivity, the lesson narratives proved to work well as rich data. The member checks in some cases interrupted my assumptions, thus challenging my subjectivity. In my analysis of lessons (reported elsewhere) I was transparent both about my methodology and analysis, allowing a reader to make judgements about the quality of the data. While rich data and member checks reduced the biasing effect of my subjectivity, transparency showed the ways in which my subjectivity influenced the research.

What I present here is a best case scenario, where I went to some lengths to reduce the effects of classroom reactivity and my subjectivity, and yet these effects were both substantial. I contend that the trustworthiness of classroom observation data is too easily assumed, and thus recommend measures be taken to reduce reactivity and researcher subjectivity, as well as to represent it so that through such transparency the research can be read appropriately.

References
Ways in which Life Sciences curriculum support documents potentially influence erroneous ideas about evolution

Tholani Tshuma & Martie Sanders
Animal, Plant, and Environmental Sciences; University of the Witwatersrand, South Africa
tholanitshuma@yahoo.com; Martie.Sanders@wits.ac.za

Context of the study
Prior to 1994 no evolution related aspects were taught in South African schools, as the topic was considered to be anti-Christian propaganda (Lever, 2002). At the FET level, evolution was introduced in Grade 12 in 2008, and it was then that South African Life Sciences textbooks incorporated the topic as a section to be covered.

The problems motivating the study
The study was motivated by two main problems. Firstly, worldwide research shows that internationally many learners have misconceptions about evolution (Nehm, Rector & Ha, 2010; Gregory, 2009; Aleixandre, 1994). Local research shows that many South African learners also have misconceptions about evolution (Kagan, 2011; Lawrence and Sanders, 2012). A dilemma arises because studies have shown that many teachers (who are the ones supposed to remedy learners’ misconceptions) also have erroneous ideas about evolution. This is true internationally (Nehm et al., 2010; Gregory, 2009; and Deadman & Kelly, 1978) and in South Africa (Ngxola & Sanders, 2009; Molefe & Sanders, 2009). The problem is aggravated by the idea that misconceptions are an obstacle to and hinder learning (Ausubel, 1968).
Secondly, there is a research gap. Research has been done relating to learners’ and teachers’ misconceptions about evolution in South Africa, but no research has been done on curriculum support documents as a potential source of erroneous ideas about evolution.

The aim of the study
The aim of the study was to investigate ways in which teacher support documents influence misconceptions about evolution, either in a positive or a negative way. Two research questions guided the study, one focussing on policy documents and a second on Life Sciences textbooks.

**Conceptual framework**
According to Maxwell (2005, p. 33), a conceptual framework ‘is primarily a conception or a model of what is out there that you plan to study, and what is going on with these things and why - a tentative theory of the phenomenon that you are investigating’ (Maxwell, 2005, p. 33). This definition highlights that a conceptual framework focuses on the central issues of the study or important ideas, concepts, and variables and how they are all related and linked (Miles & Huberman, 1984). Some of the concepts may turn out to be theories, whilst others may not necessarily have a theoretical basis, so the term ‘conceptual framework’ is more appropriate than ‘theoretical framework’. Anfara & Mertz (2006) see it as the framework, grid or scaffold that assists researchers in understanding the phenomenon under investigation. In this study the main ideas that are situated firmly within the conceptual context of this study include: misconceptions; types of curriculum and curriculum ‘slippages’; and curriculum support materials. The linkages of these ideas to each other provides the conceptual framework for this research.

Misconceptions about evolution are those ideas which are categorised as unscientific according to expert science knowledge (Abimbola, 1988). The misconceptions literature was widely consulted, as well as the correct scientific explanations, to allow for errors to be detected in the documents, and results to be interpreted.

Goodlad et al. (1979) suggest that there is no such thing as a single curriculum, and that the initially conceptualised curriculum becomes modified as different people access and interpret it during the implementation process. These authors see the ideal curriculum as the one put forward by state organs and other institutions of social influence. This is then recorded as the formal curriculum which is embedded in curriculum documents. Those reading the policy documents (e.g. teachers and textbook writers) transform it into the perceived curriculum. Teachers then plan lessons, which become the intended curriculum, which then is implemented as the operational curriculum during the day-to-day classroom learning situations. These ‘curriculum slippages’ (Goodlad et al, 1979) mean that any errors or shortcomings in policy documents may be escalated in the textbooks.

Curriculum support materials are those resources which can be used by teachers to support them in their teaching role. They include policy documents (which direct the teacher what to teach) and textbooks for learners (which the teacher uses during teaching and learning, and can greatly support them regarding what to teach and how to teach it). However, one assumes that such documents will not contain errors, and that they will actively try to identify and address common misconceptions.

**Research design and methods**
In order to answer the research questions, a document analysis approach was followed, using the technique of content analysis, in accordance to the recommendations by Zhang and Wildermuth (2009) so as to reveal manifest problems (actual misconceptions in the documents) and latent factors (correctly worded statements but which are inadequate or could be
misinterpreted, thus resulting in misconceptions). Two new instruments were designed, as no existing instruments could be found (as explained in another paper at this conference). Deductive reasoning was used, as categories were identified after an extensive literature review on the key factors known to cause misconceptions about evolution. A list of categories and codes was developed and then used to identify problems as the relevant chapters were read.

Four policy documents exist for the Life Sciences. Because the original National Curriculum Statement had been lacking in content, a revised New Content Area Framework for Life Sciences (Department of Education, 2007) was issued, and this was the policy document analysed for the research. Six Life Sciences textbooks, from two different textbook series from two different publishers, were investigated.

Results and discussion
In this paper, the results are discussed in the context of the literature reviewed and the aims of the project. The results are analysed in the context of manifest errors and latent factors and how these two are likely to influence misconceptions about evolution. In both instances, the influence of manifest and latent factors on misconceptions is viewed in the context of policy documents and textbooks.

The findings from this research provide insights for teachers on how curriculum documents could result in the development of misconceptions about evolution. To the publishers, curriculum designers and the Department of Education, the research results could inform the writing of revised editions of their documents.

References
The Impact of Knowledge of Educational Context on Turkish teachers’ teaching of Stoichiometry in South Africa

M.H. Yildirim,

University of the Witwatersrand

mhuseyinyildirim@gmail.com

“The diversity of schools in South Africa is enormous” (Rogan & Aldous, 2003). This diversity of schools with respect to their quality, teachers, and learners creates a variety of teaching contexts (Rogan & Aldous, 2003) and, consequently, a challenge for teachers in South Africa. As discussed above, the diversity of schools in South Africa demands a great deal of adaptation from all teachers. Thus educational context is an important influence on teaching in South Africa and knowledge of it is essential to transforming subject matter knowledge for teaching. Knowledge of educational context is the knowledge of all forms of contextual factors that affect teaching practice in a unique Educational Context. Knowledge of educational context is an essential component of Pedagogical Content Knowledge which was first introduced by Shulman (1986) as a special form of knowledge for teaching. Pedagogical Content Knowledge is an amalgam of general pedagogy, subject matter, and educational context such that Pedagogical Content Knowledge influences teaching to produce the best transformations and representations.
for learners (Berry et al., 2008) and is used as a theoretical framework and a category of knowledge in many studies on teacher education (Shulman, 1987). Many of these studies refer to the importance of educational context but do not study it specifically. This paper will therefore focus on the Educational Context in South Africa particularly and its impact on the teachers’ Pedagogical Content Knowledge. Then, Pedagogical Content knowledge is used as a theoretical framework for this study. There are Turkish science teachers teaching in different South African schools. They have had to adapt to the South African milieu. In order to investigate the impact of educational context on teachers’ Pedagogical Content Knowledge, there is a need to find a situation where one can eliminate other conflicting issues. Thus for this paper, it was decided to select a group of well-qualified teachers for whom the Educational Context would be the major challenge. To sum up, the presence of Turkish science teachers in private schools in South Africa provides a unique opportunity to study the impact of Knowledge of Educational Context on Pedagogical Content Knowledge.

Another purpose of the study is to create context informed topic-specific transformations on a particular topic. There have already been attempts to describe topic specific Pedagogical Content Knowledge with reference to particular chemistry topics (Van Driel et al., 1998a, Author et al., 2008). This study will investigate the impact of educational context on the teaching of one of the most difficult topics in chemistry, namely Stoichiometry, in which learners are doing poorly because it is difficult to learn and teach (Dahsah & Coll, 2007). Therefore impact of Educational Context on teaching Stoichiometry will be explored through the following research questions;

1. How can we capture and portray the teachers’ Knowledge of Educational Context with regard to Stoichiometry?
2. What impact does Knowledge of Educational Context have on teachers’ Pedagogical Content Knowledge when adapting to a new context?

**Methodology**

This research uses a comparative case study approach to explore similarities, differences, and associations between the cases. Examination of similar cases in a very intensive manner will help to find common patterns and differences with a large amount of descriptive depth and characteristics of the Educational Context. Three Turkish physical science teachers with similar backgrounds teaching at three different schools were involved in this study. Loughran, Mulhall and Berry (2004) developed a tool to explore Pedagogical Content Knowledge of teachers. This includes two analysis tools Content Representations (CoRe) and Pedagogical and Professional experience Repertories (PaP-eR). CoRe tries to capture content taught while teaching. PaP-eRs capture specific practices done while teaching to help Content Representations. I have used pre-observation semi-structured interviews with teachers by the help of guiding questions adapted from the CoRe prompts used to capture and portray Pedagogical Content Knowledge of the teachers (Loughran, Mulhall & Berry, 2004). I have also used semi-structured interviews with 2 administrators for each teacher and a questionnaire for their learners to explore educational context from the perspective of the students, administrators. This will give a deeper understanding of the Educational Context around the teachers rather than exploring the Educational Context only from the teachers’ perspectives because these are the main factors that create the specific Educational Context around the teachers in South Africa. I have observed
their classes while teaching reaction stoichiometry. After analyzing the classroom observations, a video stimulated recall post-interview will be conducted with each teacher about the important points in the video record of each observation, to interpret and validate the data. Thereafter, analysis and interpretation of the observations will be verified by each teacher. By the help of these data I will also improve and validate their Content representations.

Results
By using pre-observation interviews with teachers and observation videos from their classes, I have created a specific CoRe for each teacher. Similarities and differences between these will give me information about their knowledge of educational context and how do they use it because all teacher have similar background, teaching same topic in different schools. Then, this study will try to answer research questions by the analysis of CoRes and video stimulated recall post-interviews. This study shows that these teachers used different teaching strategies adapted to their own educational context. It is easy to see the effects of individual educational context on each teachers’ teaching of Stoichiometry. During the analysis of pre-observation semi-structured interviews with teachers and classroom observation, the CoRes show the effect of pressure from administration for success, external examinations, mathematical level of learners, subject meetings with other teachers, syllabus on their teaching of Stoichiometry. According to these findings it might be possible to draw a framework Knowledge of Educational Context. The CoRes and PaP-eRs created in this study might help other physical science teachers for teaching of stoichiometry through the strategies used in a similar educational context.

References
A METACOGNITIVE INVESTIGATION OF MY PERSONAL MATHEMATICS COGNITION – A COMPARATIVE ANALYSIS

Catherine Zoghby1 & Pieter van Jaarsveld2

1 Wits School of Education, University of the Witwatersrand, Johannesburg, South Africa; 2 Wits School of Education, University of the Witwatersrand, Johannesburg, South Africa.

1 catzoz@gmail.com 2 Pieter.vanJaarsveld@wits.ac.za

There is recurring feedback regarding the poor mathematics achievement in South Africa, and many researchers have attempted to identify the source of this problem. The students’ lack of understanding, due to inadequate teaching methods, has been the focus of many discussions and much research has been completed in an attempt to find a solution for this shortcoming. The 2011 report of the South African Department of Basic Education on the National Senior Certificate mathematics examination indicates poor understanding of mathematics content areas and a lack of good mathematical skills and language. The report suggests that these issues are due to the quality of teachers in the classrooms. In order to address these concerns, I intended to go straight to their root – the South African teacher. However in order to make this study realistic, I had to start small with the knowledge and understanding of one teacher – me.

The problem is that I do not know the levels of my understanding or thought processes, for different mathematical objects and concepts. If I were to discover this level and improve it, I would be able to use this ability repeatedly to assess my understanding of any given mathematical object or concept before teaching them in a classroom situation. This would enable me to teach having a better enriched and mathematically proficient understanding of the content. This study investigated my personal mathematics cognition, using metacognition as a tool to discover my level of understanding, in a comparative analysis that used the insights of my research participants.

The purpose of this study was to compare and contrast my metacognitive processes to other qualified mathematics teachers (in analysing the same mathematical objects) to ascertain the level of my understanding. I then assessed the new knowledge that I had gained in analysing the participants’ responses, and comparing them with my own. In order to develop a deeper and richer understanding of the specific mathematical objects and topics, my attention needed to be focused on each object (through the process of metacognition). This purpose made it easy to shape my research questions.

I. What is my understanding of a given mathematical object?
II. How do I examine and deepen my understanding, through comparing the analysis of my response with others’?

In cyclically creating and changing my own thoughts and actively building up knowledge I engaged in radical constructivist learning. The notions of concept image/ definition (Vinner, Tall and Dreyfus), instrumental/ relational understanding (Skemp) and the five strands of mathematical proficiency (Kilpatrick et al) served as a theoretical framework. Each strand of
mathematical proficiency (conceptual understanding, procedural fluency, strategic competence, adaptive reasoning and productive disposition) was used individually in the analyses processes. This study examined and identified the different levels and stages of understanding using an action research approach. As the educator and the researcher, my focus was on the research and aims of the research, which were for improving teaching and learning in the classroom – beginning with my own knowledge and understanding. The study was qualitative in that the analyses were of participants’ written responses. The sample included three qualified teacher’s with whom I compared my level of understanding. The research instrument was a type of questionnaire in which four mathematical objects were given with a request for doing and talking about each of them in as much detail as possible. The process began with my written response to four mathematical objects. Three participants then responded to the same mathematical objects. All four responses were analysed and a level of understanding discussed for each participant. The varying levels were then compared and conclusions and recommendations reached.

This research study yielded interesting results. I found a remarkable difference in levels of understanding using the different theoretical frameworks as measures. In comparing my level of understanding to that of the participants, I found so many gaps in my knowledge. I found my level of understanding was very superficial which surprised me. In addition, in order to analyse the participants’ responses accurately, I needed to investigate the meaning of the mathematical objects – this deepened my level of understanding. The direction of my research changed in consultation my supervisor (as my sounding board). I realised that while I assumed I understood each object so much better through the research process, I didn’t even think about the possibility of misunderstanding the objects from the very beginning. In reanalysing the data, I saw a number of incorrect assumptions that I had made about each mathematical object, making some of my analyses comments incorrect. The research questions were answered, although not in the way that I expected. I found my level of understanding was insufficient for teaching the four different mathematical objects, and was able to recognise what I didn’t know. I was able to examine and deepen my understanding through comparing the analysis of my response with others who had more experience than me. I found gaps in my knowledge that I didn’t expect to find, and was able to address and try to understand the missing/ incomplete knowledge. My recommendations would be for more teachers to use the tool of metacognition in order to discover their understanding (or lack thereof) of certain mathematical concepts, in an attempt to deepen that understanding to attain a teaching method that is both knowledgeable and understandable.
MATHEMATICS EDUCATION (Long Paper Abstracts)
Students’ Beliefs and Attitudes towards Mathematics in Mozambique: Influence of Parents, Economic Resources, and Cultural Factors

Adelino Evaristo Murimo & Helen J. Forgasz
Monash University, Australia
aemur1@student.monash.edu.au; helen.forgasz@monash.edu.au

Abstract
The findings reported in this article are part of a larger study that examined the influence of parents, economic resources, and cultural factors (e.g., gender, home language, geolocation, and siblings) on self-perceived achievement in mathematics and other school subjects (SPA), and perceived usefulness of mathematics (PUM). The study involved 300 grade 7 students, and 225 parents from five public schools (3 urban, 1 rural, and 1 remote) in the central Province of Sofala in Mozambique. Surveys and interviews were used to collect data. Both the girls and the boys believed mathematics was their worst school subject and physical education their best. Gender differences in SPA were noted only in regard to moral and civic education and favoured girls. Parents’ perceived achievement for their children was similar to that of students, but they viewed mathematics as less useful for their offspring than the students themselves. A trend to view mathematics as more useful for boys than for girls was also noted among students and parents. Parental education, geolocation, number of siblings, and possession of electricity, TV, and internet at home were the most salient predictors of students’ SPA and PUM. Implications of the findings for policy and practice are discussed with emphasis on the role of parents as socializing agents of children’s task choices and achievement.
Designing a PCK framework for the professional development of statistics teachers

A. Makina
University of South Africa
makina@unisa.ac.za

Abstract
High-quality statistics teacher education and development is crucial if educational delivery in South Africa is to be improved. Shulman presents pedagogical content knowledge as a separate and unique domain of knowledge necessary for the teachers of all subjects. Based on the experience as a statistics teachers for many years and on the literature on pedagogical content knowledge for teachers from several researchers based on Shulman this paper proposes the design of a pedagogical content knowledge framework that guides the development of pedagogical content knowledge of secondary school statistics teachers during professional development.

It is against this background that the paper aimed to clarify the design of a pedagogical content knowledge framework using a section of statistics, bivariate data, which guides the development of pedagogical content knowledge of secondary school statistics teachers during professional development. The paper therefore describes and discusses the implications of a pedagogical content knowledge framework for statistics education. Conceptual frameworks, against which the pedagogical content knowledge framework for the development of Grade 11 and 12 statistics teachers were developed, are discussed. The goal of the pedagogical content knowledge framework was based on the need to help teachers during professional development to be competent and confident in teaching Grade 11 and 12 statistical concepts. Furthermore it helped teachers to be reflective of their instructional practice in ways that can improve the teaching of statistics concepts. The reflective accounts shared between the statistics teachers and the researcher enabled the continual improvement of the statistics pedagogical content knowledge framework. The unique characteristic of the framework is that allows the integration of technicalities and complexities of the theory and practice of teaching using pedagogical content knowledge and also gives room for improvement during and after each professional development for both the educators and the teachers. Through the PCK framework developers can be better positioned to plan, implement and access ways to improve teachers understanding of the subject they teach. This paper stimulates national and cross-national dialogue among policy makers and educators regarding programs and curricular to improve preparation and practice in secondary school statistics.

Key words: pedagogical content knowledge, pedagogical content knowledge framework, secondary school statistics, professional development, teacher knowledge

Teachers’ Reflections on Nonstandard Students’ Work
Arne Jakobsen & C. Miguel Ribeiro

Department of Education, University of Stavanger, Norway; Research Centre for Spatial and Organizational Dynamics (CIEO), University of Algarve, Portugal

Abstract
One of the tasks of teaching (Ball, Thames, & Phelps, 2008) concerns the work of interpreting student error and evaluating alternative algorithms used by students. Teachers’ abilities to understand nonstandard student work affects their instructional decisions, the explanations they provide in the classroom, the way they guide their students, and how they conduct mathematical discussions. However, their knowledge or their perceptions of the knowledge may not correspond to the actual level of knowledge that will support flexibility and fluency in a mathematics classroom. In this paper, we focus on Norwegian and Portuguese teachers’ reflections when trying to give sense to students’ use of nonstandard subtraction algorithms and of the mathematics imbedded in such. By discussing teachers’ mathematical knowledge associated with these situations and revealed in their reflections, we can perceive the difficulties teachers have in making sense of students’ solutions that differ from those most commonly reached.

PROCEDURAL SPECTRUMS: TRANSLATING QUALITATIVE DATA INTO VISUAL SUMMARIES

Debbie Stott, Mellony Graven
South African Numeracy Chair, Rhodes University, South Africa

Abstract
In earlier work we introduced the notion of a procedural fluency spectrum as a way of analysing the wide variety of learner responses to an orally administered numeracy interview instrument. One of the conclusions of the earlier article was to interrogate the value of the spectrums by using them to analyse and summarise our data. In this paper we explore the viability of using a procedural fluency spectrum as a means of translating the methods recorded on the qualitative interview records into quantifiable, visual summaries of the learner data at given points in time. By presenting this we wish to contribute methodologically to how qualitative data captured in a numeracy interview might be usefully translated into visually quantifiable summaries of learners proficiency levels. We propose that this may be of value to other researchers working with the Learning Framework in Number or other such assessments or recovery instruments. Our findings suggest that such summaries provide quick visual access to the picture and that different type of outputs generated from this data could provide many different perspectives.
Teachers’ perceptions of factors that contribute towards their effective practice: what the data tell us

G. H. Stephanus¹ & M. Schafer²
gervasius2006@yahoo.com; m.schafer@ru.ac.za

Abstract
This paper presents findings from a broader PhD study that aimed to explore and analyse the Geometry teaching practices of five purposefully selected secondary school teachers in Namibia who are regarded as effective mathematics teachers by their peers. The primary object of the broader study was to understand teachers’ perceptions of factors that contributed towards their effective teaching of geometry. This paper does not focus on effective teaching per se but on teachers’ perceptions of the factors that contributed to their success as effective mathematics teachers. The selected case study schools where the teachers taught were representative of high performing Namibian schools in terms of learners’ mathematics performance in the annual national examinations. This investigation was done through a process of classroom observations where the teachers’ instructional practices were observed and analysed using an adapted model of teaching for mathematical proficiency as developed by Kilpatrick, Swafford and Findell (2001) (referred to as Kilpatrick model). The study also used open-ended and semi-structured interviews with teachers. These interviews took the form of post lesson reflective and stimulated recall analysis sessions with the participating teachers. Teachers were asked to identify multifaceted factors aligned with some of the strands of the Kilpatrick et al. (2001) analytical tool that they believed influenced their own effectiveness in teaching mathematics. Part of the analysis of the data, from interviews with the five selected teachers, is presented in this paper.

STUDENT CONCEPTUALIZATIONS OF 3-VARIABLE FUNCTIONS AND THE ROLE OF VISUALIZATION IN THE LEARNING OF MULTIVARIABLE CALCULUS.

Jonatan Muzangwa
Department of Curriculum Studies, Great Zimbabwe University, Zimbabwe
jonamuz@gmail.com

Abstract
This paper focuses on undergraduate students taking Calculus course in a BEd degree programme offered at local university in Zimbabwe. The paper analyses student conceptions and misconceptions on the graph of surfaces by use of visuals which were constructed using Mathematica software. The theoretical frameworks used focussed on conceptual understanding. The results indicated that students conceptualise better through use of visuals and also the use technology which plays a key role in enhancing better understanding of calculus concepts motivated the researcher to investigate on this area.
Pedagogic strategies used by educators who do not speak the learners’ main/home language for proficient teaching of functions in multilingual mathematics classrooms.

Lydia Mutara¹ and Anthony A. Essien²
¹ University of the Witwatersrand, South Africa; ²University of the Witwatersrand, South Africa
¹ lmutara@telkomsa.net; ²Anthony.essien@wits.ac.za

Abstract
Research has long acknowledged the role of pedagogic strategies such as code switching in the teaching and learning of mathematics in multilingual context. Some of these strategies, however, are more effectively employed if the teacher shares the same home language as most of the learners in the class. A good number of foreign teachers teach in multilingual classrooms in South Africa. At JBC (pseudonym) school, the matric results have steadily improved over the years despite the fact that the foreign teachers who teach mathematics at FET level do not share a common home language with the learners. This qualitative case study had for aim to establish the teaching strategies used by these foreign educators for proficient teaching of mathematics in multilingual classrooms and how they encourage learner participation in the teaching of functions. The study was informed by Kilpatrick, Swafford and Findell’s (2001) five components of proficient teaching of mathematics. Two foreign teachers teaching functions in two Grade 11 classes were observed and interviewed. The findings revealed that the two teachers have access to a range of teaching strategies which they employ fluently and appropriately. Linking previously learnt material to new concepts, exploration over a well thought out example space, sequencing and predicting mathematically were used to promote mathematical proficiency. To encourage learner participation in mathematical discourse, the teachers used adjusted speech, revoicing and group dynamics. It is recommended that teachers should have access to a range of strategies and be able to adapt them to suit their situations and mathematical content.
Tensions in the transition from informal to formal geometry

Lynn Bowie
Division of Mathematics Education, University of Witwatersrand, South Africa
lynn.bowie@wits.ac.za

The nature of Euclidean geometry as both concrete, in that it is linked to physical objects, and abstract, in that it is organised into an axiomatic system, creates interesting tensions that can be both productive and cause problems in the process of learning and teaching it. The National Curriculum Statement for Mathematics (South African Department of Education, 2003) for grades 10 – 12 in South Africa indicates grade 10 as the transition point from working with an informal study of geometry to a more formal study of geometry. In this paper I examine how a popular textbook for grade 10 Mathematics managed the tensions inherent in working with this transition point.

Dimensions of learning as identity: A demonstration from culturally-based lessons in Grade 9 mathematics

Madusise, Sylvia & Mwakapenda, Willy
Department of Mathematics, Science and Technology Education, Tshwane University of Technology, Soshanguve North Campus
MadusiseS@tut.ac.za; MwakapendaWWJ@tut.ac.za

Abstract
This qualitative study examined the impact of culturally-relevant mathematics lessons on learners’ mathematical identity. Three Grade 9 mathematics teachers and their learners from one rural middle school in South Africa’s North West Province participated in the study. Through mathematising culturally-based activities, the research team indigenised (i.e. adapted to local culture) two Grade 9 mathematics topics. A teaching and learning unit on the indigenised topics was designed and implemented in five Grade 9 classes at the same school. In the discussion in this paper, we consider mathematics learning as a process of developing a mathematical identity. We address how Grade 9 learners’ practices in mathematics classroom communities shape learners’ perspectives of themselves. In this paper we view identity in two ways: how individuals know and name themselves, and how individuals are recognised and looked upon by others. We argue that culturally-relevant pedagogy can facilitate the development of learners’ mathematical identities by rationally using learners’ cultures to serve as a bridge between the learner and the subject. Learners’ mathematical identities were determined through analysing their narratives of mathematics classroom practice. We argue that the three interrelated dimensions: Competence, Performance and Recognition can be used to describe learning as identity. The paper analyses learners’ narratives of mathematics classroom practices in Grade 9 to demonstrate these dimensions of identity in the activity of mathematics learning.
Key Words: Culturally-relevant pedagogy, identity, mathematics classroom community
The intended and the implemented: one task in a GeoGebra context

Margot Berger

*Marang, University of Witwatersrand*

margot.berger@wits.ac.za

Abstract

There is often a misalignment between the intended pedagogical purpose of a task and its implementation by learners. This may be exacerbated when the mathematical task exploits the affordances of technology. In this paper I use a dedicated framework to isolate, *a priori*, the possibilities and limitations of a specific GeoGebra-based mathematical task and to compare this with the actual realizations of this task by a group of students. These students were participating in a post-graduate university course for in-service mathematics high school teachers in South Africa. The analysis demonstrates that although a specific computer-based task may have one pedagogic purpose and appropriate mathematical and technical demands, different students may require different levels of scaffolding to complete the task. As a result, they may engage in the task at various levels of cognitive demand.

An Assessment of Theory of Computation in Computer Science Curricula

C. M. Keet

*University of KwaZulu-Natal, South Africa*

keit@ukzn.ac.za

Abstract

Computing curricula are regularly reassessed and updated to reflect changes in the discipline. Currently, the ACM/IEEE curriculum ‘CS2013’ is under review, which provides the main international guiding principles for curriculum development. We assess this curriculum focusing on one of the core themes of computer science, being Theory of Computation. We examine how it is implemented in computer science curricula around the world, and the sentiment around teaching it. Two surveys were conducted, examining curricula and syllabi of computer science degrees and an online opinion survey. Theory of Computation is part of 84% of the consulted curricula around the world, but taught at only 27% of the South African universities, and these syllabi contain substantially more Theory of Computation topics than the basic core in CS2013. The online survey not only confirms this but also indicates inclusion of even more topics as essential for Theory of Computation and shows that it is mostly solidly part of the degree programme as a core course and mostly in the 2nd or 3rd year, despite that for more than half of the respondents, the course causes issues in the university system.
Integrating visual and analytical strategies: An analysis of Grade 11 learners’ problem solving approaches to a reflective symmetry task.

Michael Kainose Mhlolo
Rhodes University – FRF Mathematics Chair, Mathematics Teacher Enrichment Programme (MTEP)
M.Mhlolo@ru.ac.za or mikemhlolo@yahoo.com

No soul thinks without a mental image – Aristotle

Abstract
Learner ability to integrate visual and analytical skills when solving problems is espoused in mathematics education hence it has been put on the spot light both locally and internationally. In this paper I analyse learner responses to a transformation geometry task which had the potential of being solved from both a visual and an analytic approach. A visual - analytic model is used to describe learner responses. Specifically, the paper aims at understanding which approach learners preferred, whether the approach was used efficiently and whether or not any attempts were made to integrate the approaches. The analyses revealed that learners used the visual approach predominantly; they did so inefficiently and there were no indications of integrating the approaches. Similar findings have been documented and attributed to how reflective symmetry is introduced to learners. This underlines the problem with an approach to teaching which stresses visual appreciation disconnected from formalisation.

How did pupils solve Number Brick after lessons of Substantial Learning Environment in Central Province, Zambia?

Nagisa Nakawa
Child Psychology Department, Tokyo Future University, Japan
nagisa.nakawa@gmail.com

This article qualitatively discusses the characteristics and difficulties that three pupils showed during solving number brick after mathematics lessons at the basic level in the Republic of Zambia. Number brick is part of Substantial Learning Environment (SLE) which is teaching unit. The analysis of the interviews by pupils identified four learning characteristics observed in these three students’ activities: recognising and discovering number sequences and rules, the mixed method of calculations; instability of learning, and the way of expressions. They were also negatively and positively related to teaching in class.

On the constituents of Primary Maths Teacher Identity: Towards a model.
Pausigere Peter ¹ & Graven Mellony²

¹ PhD Fellow, South African Numeracy Chair, Rhodes University, South Africa; ² South African Numeracy Chair, Rhodes University, South Africa

¹ peterpausigere@yahoo.com; ² m.graven@ru.ac.za

Abstract
This paper discusses key constituents in developing a model of Primary Maths Teacher Identity. In enlisting the core aggregates of Primary Maths Teacher Identity this paper is informed by the literature on maths teacher identity, situative-identity theories (Lave & Wenger, 1991; Wenger, 1998) and Bernstein’s (1975; 2000) sociological theory. Empirically the paper draws on data obtained from interactive interviews with 10 sampled primary maths teachers who were participants in a numeracy community of a practice-informed teacher professional development programme called NICLE. The research indicates that subject specialisation, phase specialisation, reform education policies, teacher education, school context, life maths experiences and school maths learning experiences, constitute the main components of Primary Maths Teacher Identities.

Operationalising Wenger’s three modes of belonging in the context of a mathematics teacher enrichment programme

Nyameka Kangela¹, Michael Kainose Mhlolo² & Marc Schafer³
Rhodes University – FRF Mathematics Chair - Mathematics Teacher Enrichment Programme (MTEP)

¹ g11k7223@campus.ru.ac.za; ² M.Mhlolo@ru.ac.za; ³ M.Schafer@ru.ac.za

Abstract
The focus of this paper is the application of Wenger’s, (1998) notion of learning architecture as an analytical framework for evaluating mathematics teacher participation in an in-service professional development programme. Wenger warns of a breach between theory and practice; suggesting the need to recontextualise the social learning theory into our teacher development programme. To situate our teacher enrichment programme as a community of practice, the paper begins by elaborating on the two design elements of such a community and shows how these relate to our programme. The paper then gives the theory behind the three modes of belonging (engagement, imagination and alignment) and discusses how they will be operationalised in our study. We end the discussion by noting the complexities inherent in such work.
An examination of pupil difficulties in solving geometry problems

Roger MacKay

Schools Development Unit, University of Cape Town
roger.mackay@uct.ac.za

This paper builds on previous work and represents the next iteration of developmental work relating to Grade 12 pupils’ activity in Euclidean geometry problems by examining the strategies they employ that may be causal to their failure in some of these problems. Previous work indicated that pupils exhibited significantly lower competence in developing deductive proofs compared to the calculation of quantities, even in different types of problems drawing on similar propositions. The paper draws on empirical data of pupils who were tested on matched computation-type and proof-type problems to explore what they did more carefully. The idea that pupils may be employing a series of visual templates that are related to the geometrical diagrams to facilitate their reasoning, in the way that said templates represent the Euclidean geometry theorems, is considered in this paper. Finally, the paper suggests that pupils appear to lack insight into the relations between propositions with reference to announced geometrical structures.
SCIENCE & TECHNOLOGY EDUCATION (Long Paper Abstracts)
Abstract
The purpose of this study was investigating research questions around Computer Applications Technology (CAT) educators’ adaptation to frequent changes in technology. The paper draws on the latest, most relevant research findings available, in a literature review covering aspects related to novice and experienced educators, methodological weakness and research in the Southern African context. The study is located within a relevant conceptual framework that clarifies issues around technology, Information and Communication Technology, CAT, computer literacy and e-education. The methodology is described, including attention to the importance of dependability and interpretation issues for the qualitative part of the research design, and consideration of issues related to reliability and validity for quantitative designs. The discussion of results provides insight into biographical details of respondents and participants’ responses during semi-structured interviews - these are in some instances connected back to literature. In conclusion, results are organised to answer research questions, implications suggested and recommendations made, along with discussion of the strength and limitations of the study. Finally, the importance of the research reported in this paper is justified in terms of filling gaps identified in literature to make original contributions towards scholarly debate in the field.

Effects of Dialogical Argumentation Instruction (DAI) in a Computer-Assisted Learning (CAL) environment on grade 10 learners’ understanding of concepts of chemical equations.

Frikkie George¹ & M Ogunniyi ²
¹ Department of Education, University of the Western Cape, South Africa; ² School of Science and Mathematics Education, University of the Western Cape, South Africa
¹ frik.george@yahoo.com; ² mogunniyi@uwc.ac.za

Abstract
This study explored how Dialogical Argumentation Instruction (DAI) within a Computer-Assisted Learning (CAL) environment enhanced students’ understanding of concepts of chemical equations. In particular it focused on aspects of dialogical argumentation and whether it is applicable to the science classroom. Furthermore it investigated whether to modify, adopt or redesign existing argumentation theories to improve the learning of concepts of chemical
equations. Computer Assisted Learning (CAL) was used to provide the premises to build an appropriate argumentation framework.

The National Education Department encourages the use of computers and computer software in implementing outcome-based curriculum in the classroom, as stated in its e-Education policy. They argue that “South African students in the GET and FET bands should be information communication technological literate by 2013” (DoE, 2003). The Education Department aims to create new models of learning that will radically change the concept of education and the delivery of it (DoE, 2003). The Education Department is currently busy to streamline the curriculum even more by lessening the administrative burden on both educators and students by making new changes to the curriculum, in the form of the Curriculum Assessment Policy Statements (CAPS).

Another aspect of this study is to determine to what extend CAL in science is being used currently in selected schools in the Western Cape. A number of schools in the Western Cape have ICT resources. For example a high school in Kraaifontein have data projectors in every classroom. My observation has been that these are not used optimally.

Making Educators’ use of Virtual Learning Environment Tools relevant for Open Distance Learning across Africa

Leila Goosen 1 & Lizelle Naidoo 2
1,2 School of Computing, University of South Africa
1 GooseL@UNISA.ac.za; 2 NaidooL@UNISA.ac.za

Abstract
The purpose of this study was investigating research questions around educators’ use of Virtual Learning Environment (VLE) tools, justifying importance and relevance for Open Distance Learning across Africa. Latest research results on the generation of learners we are teaching, their learning styles and needs are presented. Our literature review continues overviewing the VLE, followed by the extent to which learners use it. Educators’ adoption of new technologies is also interrogated. The study is located within a relevant conceptual framework that clarifies issues around a selection of the tools available within the institutional VLE. Methodology described attends to the importance of interpretation for qualitative parts of research design and considers issues of reliability and validity for quantitative designs. Both quantitative and qualitative results are discussed, providing insight into educators’ responses - these are in some instances connected back to literature. We indicate the possible implications of our results for other educators and make recommendations about how these could be applicable and useful for them. In conclusion, results are organised to answer the original research questions posed, we reflect on how our results make an original contribution towards scholarly debate in the field and identify options for further research. “Our vision is to become Africa’s premier distance education provider, serving every country on the continent and transcending language and cultural barriers” - University of South Africa.

Comparative effects of two and three dimensional methods of graphics in autocad on
interest of national diploma students in engineering graphics

J. A. Jimoh

Department of Science and Technology Education, University of Lagos, Akoka, Nigeria; Postdoctoral Fellow, (2012) Institute of Science and Technology Education, University of South Africa, Pretoria
bayojayjay@yahoo.com; jimohja@unisa.ac.za

Abstract
This study was designed to determine comparative effects of two and three dimensional methods of graphics in AutoCAD on National Diploma students’ interest in engineering graphics. The study was a pretest, posttest, non-equivalent control group quasi-experiment which involved groups of students in their intact classes assigned to treatment groups. Two research questions and three hypotheses, tested at 0.05 level of significance, guided the study. The sample size was 227 ND I mechanical engineering technology students in the polytechnics in the south-west geopolitical zone of Nigeria from which 108 students constituted treatment groups assigned to AutoCAD 2D method, and 119 students constituted another treatment groups assigned to AutoCAD 3D method. The instruments used for data collection was Engineering Graphics Interest Inventory. Mean and ANCOVA were used to analyzed the data collected. The study found AutoCAD 3D method more effective in improving students’ interest in engineering graphics than AutoCAD 2D method but the effect was not found to be significant. There was no significant effect of Gender on students’ interest in engineering graphics favouring. The study found no significant interaction effects of AutoCAD methods and gender on interest of National Diploma students in engineering graphics. Hence, irrespective of nature of gender, learners will record improved interest in engineering graphics when AutoCAD 3D method is employed for teaching.

Keywords: AutoCAD techniques, National Diploma Students, Engineering Graphics, Computer-Aided Design (CAD)

Teachers’ views on the integration of science and indigenous knowledge systems in the South African school curriculum: The debate continues.

Keith Langenhoven¹ & Ruth Stone²

¹University of the Western Cape
¹klangenhoven@uwc.ac.za; ²njstone@mweb.co.za

Abstract
Teachers have difficulty in implementing the South African Department of Education’s IKS policy directive that an integrated science and indigenous knowledge systems curriculum should be part of the school science curriculum. This study draws on views and experiences from nineteen available teachers who were actively involved in a series of seminars and workshops presented by the Science Indigenous Knowledge Systems Project from 2008 to 2012. A Dialogical Argumentation Instructional Model based on Toulmin’s Argumentation Pattern was used in the seminars and workshops as a framework to initiate debate on sociocultural issues.
Participating teachers responded to a reflective diary questionnaire and focus group interviews and their responses were collated and clustered to serve as qualitative data for this study. Contiguity Argumentation Theory (CAT) was used to analyse the teachers’ responses, and CAT categories were applied to describe the cognitive changes that the teachers experienced. The findings suggest that the seminar-workshop series contributed to teachers making a mind shift away from their initial misgivings about the notion of integrating science and indigenous knowledge to one of acknowledging the potential benefits of an integrated science and indigenous knowledge curriculum.

**Teaching Thinking, Study, Investigative and Problem Solving Skills in Biology: A case of curriculum implementation in Zomba schools**

Nellie M Mbano

*University of Malawi, Chancellor College, Faculty of Education, Zomba, Malawi.*

nelliembano@gmail.com

**Abstract**

This paper reports on a study of how new content free topics in Junior Secondary Biology were perceived by teachers as way of exploring the implemented curriculum. The topics were study, thinking, investigative and problem solving skills. It was hypothesized that there would be a mismatch between what the curriculum developers and textbook writers desired and how teachers taught them, since teachers had no experience in them. Questionnaires were administered to 32 teachers from randomly selected schools in Zomba, an administrative district in southern Malawi. The results were analysed using a theory of curriculum implementation developed by Rogan and Grayson (2003). This theory has three interrelated constructs namely Profile of Implementation Capacity to Innovate and Outside Support. The study found that there were inadequate Outside Support and Capacity to Innovate which resulted in low level Profile of Implementation. Underqualified teachers in low resourced schools said the topics were difficult, but tried to teach them as presented in the syllabus. On the other more qualified teachers in better resourced schools left out many of the objectives in their teaching, although they saw them as easy. Although teachers appreciated the value of the new topics in assisting learners in understanding and skill acquisition, they showed generally more negative perception of the new topics with remarks such as difficult, boring and irrelevant. They felt they needed in-service training on the teaching of the new topics and provision of more resource materials for them to teach more effectively.
An evidence based findings of the effects of Active Teaching and Learning Methods on Large and under resourced Primary School Science class

Andrews Nchessie; Dorothy Nampota & Mercy Kazima

Kasungu Teachers Training College, Mathematics & Sciences Department, Private Bag 23, Kasungu, Malawi; & Curriculum and Teaching Studies, University of Malawi, Curriculum & Teaching Studies P.O.Box 280,Zomba, Malawi; Curriculum and Teaching Studies, University of Malawi, Curriculum & Teaching Studies, P.O.Box 280,Zomba, Malawi.
anchessie@yahoo.com, dnampota02@yahoo.co.uk, mkazimam103@yahoo.co.uk

Abstract
This paper reports part of the findings of a small study that was conducted in the process of undertaking an intervention. Some of the aims of the interventions were to determine the effects of active teaching and learning approaches on influencing children’s’ creativity in the development of teaching and learning materials in a large and under resourced science and technology primary school class in Malawi. Key idea sentences/explanations and cloze procedures were used to teach a standard 7 class by one of the authors for a period of 10 weeks. Before teaching each of the five topics, a pretest was given to the learners to assess their level of understanding of the topic and after teaching a similar test was given to the learners in form of a post test. The same was done with the control group. Four data collection methods were used to collect data thereby making use of both quantitative and qualitative research methodologies. While the pre and post tests served as quantitative methods, focus group discussions and classroom observations served as qualitative methods. The findings demonstrate with broad strokes that active teaching and learning techniques has an influence on the learners creativity as demonstrated by several inventions and the development of the learners own teaching and learning resources. Therefore, this paper will highlight the learner’s creativity in the development of the teaching and learning materials and implications of the findings for teaching in Malawi primary schools large and under resourced classes so as to ensure and promoting access to socially responsible mathematics science and technology education.

Mapping sustainability and science education

Allyson Macdonald

School of Education, University of Iceland, Reykjavík, Iceland
allyson@hi.is

Abstract
The aim of this paper is to consider opportunities for science education and sustainability as pedagogic practice. To do this some key characteristics of recent science education are discussed as well as developments in sustainability and sustainability education. An overview of science and sustainability in the curriculum is followed by a brief discussion of approaches to learning. Finally two dimensions, science for experts vs. science for all, and sustainability as principle vs.
tactic are identified and mapped against each other giving rise to four ways in which science can contribute to sustainability as pedagogic practice. They are science and technology education, education for sustainable development, sustainability science education and sustainable education.

**Conceptual, attitudinal and practical change concerning Science and Indigenous knowledge integration using argumentation**

Olufunmilayo I. Amosun\(^1\); Meshach B. Ogunniyi\(^2\)
funmiamosun@gmail.com\(^1\); mogunniyi@uwc.ac.za\(^2\)

**Abstract**

In 2004, the School of Science and Maths Education (SSME) embarked on the Practical Argumentation Course (PAC), aimed at equipping science teachers with skills for Science and Indigenous Knowledge integration (SIKI) in science classrooms. PAC provided opportunity for participants to explore the nature of Science (NOS), nature of IKS (besides the metaphysical aspect), along with dialogical argumentation (DA) and related Contiguity Argumentation Theory (CAT). The paper used a mixed method qualitative, with basic statistic to reports the cognitive, attitudinal, and practical change trajectories of participants who enrolled in the PAC, highlighting reasons for their initial oblivion/negativity. Their continued niggling concerns about the feasibility of implementing the curriculum mandate to integrate science and IKS were dialectically discussed. Ogunniyi’s CAT theory helped to locate the status of their conviction. Claims to acquisition of knowledge and skill for using argumentation as a tool for socio-culturally relevant instruction is elucidated. Catalytic factors that accelerated change are presented, in terms of CAT, together with the disclosed internal self-argumentations.

**The effects of a Science-IKS program on participating educators’ views regarding the implementation of an integrated Science-IK curriculum in South-Africa.**

\(^1\)Dinie, S. \(^2\)February, F. & \(^3\)Kroukamp, G.
University of the Western Cape, South Africa
sdinie@uwc.ac.za; february.florence@uwc.ac.za; 32920225@uwc.ac.za

**Abstract:**
A case study with a group of 19 educators enrolled in a Master’s in Science and Mathematics Education course in a South African university were exposed for two years to the following modules: an Argumentation-Discursive course (A-D course), modules on philosophy and history of science, Nature of science (NOS), Indigenous knowledge (IK) and Nature of Indigenous knowledge (NOIKS) as well formed part of a Science-Indigenous Knowledge Systems Project (SIKSP), which they attended and participated in workshops developing integrated Science-IKS materials and lesson exemplars for classrooms, specifically addressing Learning Outcome 3.
(LO3) and Specific Aim 3 (SP3) as prescribed by the Revised National Curriculum Statement (RNCS) and Curriculum and Assessment Policy Statement (CAPS) for the Natural and Life Sciences curricula. A predominantly qualitative research approach was used to gain insight on the teachers’ perception with regards to the implementation of an integrated Science-IK curriculum enshrined in the RNCS and CAPS. The SIKSP course provided the educators ample opportunities to argue by being inducted into a Dialogical Argumentation Instruction model (DAIM) which is a teaching methodology based on argumentation to aid learning in science through addressing various socio-scientific issues as topics.

The findings of this study indicate: (1) the main reasons why educators oppose such an integrated Science-IK curriculum are because they know very little about IK and IKS and this affects their implementation and (2) that educators who are in favour of an integrated curriculum, highlight and impress the importance of relating science to learners’ everyday cultural experiences. Furthermore most of the educators who shifted their views from being opposed to at the beginning of the program, to in-favour of the curriculum after the program, appear to have shifted their views as a result of being exposed to the program. These shifts are explained by using the Contiguity Argumentation Theory of Ogunniyi (2007), which can account for these shifts in cognition. The implications of this study highlights the importance of developing intervention programs that address “demystifying’ indigenous knowledge and the development of exemplar resource materials, which teachers can access and use to prepare lessons as a matter of urgency in order for LO3 and SA3 to be actualized in classrooms.

Key Words:

The Integration of ICTs in the Teaching and Learning of Mathematics, Science and Technology Subjects in Swaziland Secondary Schools

Ntombenhle Dlamini¹, Michael Mhlungu² Linda Simelane³, Musa Hlophe⁴, Thembelihle Dlamini⁵,

Mathematics, Science & ICT department, National Curriculum Centre, Swaziland
ncc@africaonline.co.sz

Abstract
The opportunities brought by Information and Communication Technology (ICT) have opened up new learning environments which can be utilized by educators in the teaching and learning of Mathematics, Science and Technology (MST) subjects. Literature shows that the quality of teaching and learning can be enhanced through effective integration of ICTs. This pilot study explores the trends in the integration of ICTs in the teaching and learning of MSTs in Swaziland schools. Specific focus is on ascertaining if teachers and learners integrate ICTs in teaching and learning of MSTs.
This is an exploratory study which seeks to understand the use of ICT tools in the teaching and learning of MSTs. Data collection was through questionnaires administered to practising teachers and learners in three Senior Secondary schools, purposively selected on the basis of availability of the ICT programme in the schools. Analysis of data revealed the main findings to be shortage of ICT tools, lack of knowledge, underutilisation and inefficiencies in the use and integration of ICTs in the teaching and learning of the sciences. No school plan of action for using the ICT tools in the MSTs was found in all the three schools. It can be concluded that there is limited integration and access to ICT tools and infrastructure by both learners and teachers in the Mathematics, Science and Technology Education (MSTE) classrooms in Swaziland.

Key words: ICT- Information and Communication Technology; MST- Mathematics, Science and Technology

Validating an instrument for use in assessing the technological literacy of upper secondary school students

Melanie B Luckay & Brandon I Collier-Reed
Centre for Research in Engineering Education & Department of Mechanical Engineering, University of Cape Town, South Africa
mb.luckay@uct.ac.za, brandon.collier-reed@uct.ac.za

In this paper an instrument for assessing upper secondary school students’ levels of technological literacy is presented. The items making up the instrument emerged from a previous study that used a phenomenographic research approach to explore students’ conceptions of technological literacy in terms of their understanding of the nature of technology and their interaction with technological artefacts. The instrument was validated through administration to 969 students on completion of their 12 years of formal schooling. A factor analysis and Cronbach alpha reliability co-efficient was conducted on the data and the results show that a four-dimension factor structure (namely, Artefact, Process, Direction/Instruction, and Tinkering) strongly supported the dimensions as developed during the original phenomenographic study. The Cronbach alpha reliability co-efficient of each dimension was satisfactory. Based on these findings, the instrument has been shown to be valid and reliable and can be used with confidence.
The status of technological literacy and awareness among learners

Moses Makgato
Department of Educational studies, Tshwane University of Technology, South Africa

Abstract
The economic development in the world dependent on the technological literacy of every citizen. This refers to the knowledge, skills, and usage of technology for survival by making ones life better and improving human life. This study investigated the level of technological literacy among learners of grades 8-12 from schools in Soshanguve and Garankuwa. The participants were 90 learners selected conveniently during National Science Week. Learners completed questionnaires responding to biographical information and variables measuring aspects of technological literacy. The data was analysed using SPSS software to obtain frequency distribution and statistical correlation between biographical data and aspects of technological literacy. The study found that majority of learners in grade 11 have a considerable idea about technology. The study found that there is no significant difference between girl learners and boy learners with regard to the awareness of technology. However, there is much to be done promote technological literacy at schools for all learners across the gender.

Challenges facing FET teachers in the implementation of Technology in the Further Education and Training Band in North West

Keorapetse N. Marumo
Department of Basic Education and Training, North West Province, South Africa
MKeorapetse@nwpg.co.za

Abstract
The change in the political climate in South Africa brought with it inevitable curriculum reform and Technology emerged as a new subject in the Further Education and Training (FET) Band. The newness of Technology and the new pedagogy of the curriculum reform created more challenges for this subject than any other subject (Makgato, 2003a: 18). The implementation of Technology has been surrounded by problems of a different nature (Department of Education, 2000: 11) hence; its implementation was carried out under a cloud of misconception regarding the nature of such a subject and its value to the school curriculum (Du Plessis & Traebert, 1995: 68). The purpose of this study was to identify and evaluate the challenges experienced by Technology teachers in the Further Education and Training (FET) Band and to suggest the mechanisms that can be used to address these challenges. Both qualitative and quantitative methods were used in this study. The study involved all Further Education and Training Band teachers offering Technology in 12 high schools. The number consisted of 60 teachers teaching Technology, 12 heads of Department for Technology and six (6) Subject Advisors for Technology based at the district office. The total population was 78. The findings of this study
revealed that very few teachers had received formal training in the teaching and assessment of Technology. Lack of qualifications or little knowledge in the subject compromised the quality implementation of the subject due to minimal conceptual knowledge that goes with lack of appropriate qualification.

Exploring the nature of knowledge building amongst teachers using the argumentation instructional strategy: Reflections from a community of practice

Duncan Mhakure, Ngonidzashe Mushaikwa & Lynn Goodman
Centre for Higher Education Development – ADP, University of Cape Town, South Africa; School of Science and Mathematics Education, University of the Western Cape, South Africa; Western Cape Education Department, South Africa
Duncan.Mhakure@uct.ac.za, ngonie68@hotmail.com; Lynnleegoodman63@gmail.com

ABSTRACT
This article reports on a study conducted to explore the nature of knowledge building in a group of science education practitioners who have been introduced to an argumentation instructional strategy. Data on the reflections obtained from these practitioners were collected through a survey and were analysed using both quantitative and qualitative methods. The findings from the study have shown that argumentation is a critical tool, which, if applied to science education, will enhance rationality in the scientific discourse among science learners, thereby enabling them to conceptualise abstract concepts. From the findings, it has become apparent that science has a social construct, meaning that science can no longer be seen as separate from the socio-cultural setting of a community. Although the findings of the study show that argumentation presents significant opportunities for the social construction of knowledge in science education, a number of science teachers are not using it, citing a lack of pedagogical knowledge. The implications of these findings are discussed in detail in the study.

Key words: Nature of knowledge, argumentation instructional model, reflection, community of practice.
A case study using dialogical argumentation to explore grade 10 learners’ scientific and indigenous beliefs about lightning

Partson Virira Moyo & Meshach B. Ogunniyi
partsonvirira2004@yahoo.co.uk; mogunniyi@uwc.ac.za.

Abstract
This paper is based on a wider study on the relative impact of an argumentation-based instructional intervention program on grade 10 learners’ conception of lightning and thunder. In that main study, 16 grade 10 learners were exposed to a variety of activities that taught them the skills of effective argumentation. Using those skills, the learners were then involved in a number of other activities such as explaining observations that they made as they did experiments on static electricity. These activities were aimed at helping the learners to explore their understanding of science, indigenous knowledge systems and the nature of lightning. In some of those activities, the learners were presented with stories related to lightning and challenged to work out possible explanations of causes of lightning and to support their positions with evidence. The learners had to interact with these stories at individual, small group and whole group levels. This paper is based on those stories. Before the intervention program, the learners had been asked to state their knowledge or beliefs about the causes of lightning. The study showed that, initially, all the learners explained the causes of lightning in terms of science and none in terms of indigenous knowledge. After the activities on argumentation, science and indigenous knowledge and in response to the stories related to lightning, the learners seemed to realise and accept that science explanations of lightning were inadequate in explaining this complex natural phenomenon. Other explanations from indigenous knowledge systems are needed to supplement and compliment scientific explanations. The results show that a dialogical argumentation instruction can help learners to acquire a deeper, broader and more satisfying understanding of lightning. The implications of these research results are that teachers need to borrow from different worldviews when they teach about natural phenomena such as lightning and thunder to learners from indigenous groups of people.

Teachers’ and teacher trainers’ reflexivity and perceptual shifts in an argumentation-driven indigenized science curriculum project

Meschach Ogunniyi¹
¹University of the Western Cape
¹mogunniyi@uwc.ac.za

Abstract
One of the aims of the new South African science curriculum has been for teachers to integrate in their classrooms two distinctly different knowledge corpuses namely, indigenous knowledge (IK) and school science. To achieve this aim an argumentation-driven indigenized science curriculum was developed. An argumentation framework was chosen because it has been reported in a plethora of studies to provide the needed atmosphere where teachers can freely express their
views, clear their doubts and even change their views about implementing a presumably controversial curriculum. This paper reports the experiences of teachers and teacher trainers (henceforth subjects) involved in the development of an indigenized science curriculum. The data sources consisted of the subjects’ responses to a questionnaire, transcripts of interviews, personal notes and ‘reflective diaries’ or experiences over a period of two to three years. An analysis of the data showed a general perceptual shift among the subjects in favour of implementing the indigenized curriculum than was the case before participating in the project. Further, the subjects adduced justifiable reasons for their perceptual shifts, thus indicating the potential of argumentation for knowledge building and belief revision about professional practice.

Key words: Teacher and teacher trainers, argumentation-driven science curriculum, indigenous knowledge, reflexivity and perceptual shifts, reflective diaries.

Knowledge production of indigenous technology: learners’ understanding of their context

Sylvia Manto Ramaligela

Department of Mathematics, Science and Technology Education, Tshwane University of Technology, South Africa
RamaligelaSM@tut.ac.za

Abstract
Indigenous technology can be employed by the native inhabitants of the country and it constitutes an important part of their cultural and should therefore be protected against exploitation by industrialized countries. The purpose of this study was to investigate learners’ awareness of indigenous technology that is produced in their community. The participants of the study were 90 learners from grades 8-12 from Tshwane West districts who were conveniently selected. The study used questionnaires to collect data which was designed to measured learners’ awareness of indigenous technology. The data was analysed using SPSS software to obtain frequency distribution on the aspects of indigenous technology. The paper employs the conceptual framework of “knowledge production”. The findings indicated that most of the learners seem to be aware of the term ‘indigenous technology’ which means that the level of their knowledge production was more orientated toward technology produced in their context. However, there is still a need to teach them how this knowledge can be used, protected and passed on in order to benefit them as well as the community around them. There is a need for further study to understand the depth of knowledge they hold in indigenous technology. The findings of this study can help the department of education as well as university to further provide training to teacher on how indigenous technology can be utilised and protected in order to improve our economy.

Moving classroom practices beyond the positivist view of scientific knowledge
construction

Senait Ghebru¹ & Meshach Ogunniyi²
¹,²School of Science and Mathematics Education, University of the Western Cape
¹sberhe@uwc.ac.za, mogunniyi@uwc.ac.za

Abstract

This paper develops a case for moving classroom practices from the positivist view to the socio-constructivist view of scientific knowledge construction. Beginning with a review of literature on the generation of scientific knowledge claims through the lenses of the positivist and socio-constructivist viewpoints, the paper discusses how both views influence the perspectives in science education and instructional practices. Our contention in the paper is that argumentation is an effective rhetorical tool for discourse particularly with respect to socio-scientific issues which impinge on our sensibilities far beyond the confines syllogistic arguments, empiricism or positivism. In the same vein, the paper addresses different forms of arguments and dialogues that have potential for improving the teaching of argument in science. We see critical discourses as a form of persuasive or rhetorical dialogue and scientific inquiry as a type of inquiry dialogue that scientists deploy to buttress their claims. Further, it is our view that in the pursuit of knowledge building classroom discourses should reflect the two forms of dialogues as well.

The challenge of training Eritrean and South African teachers to implement a culturally relevant science-IK curriculum

Senait Ghebru¹ & Meshach Ogunniyi²
¹,²School of Science and Mathematics Education, University of the Western Cape
¹sberhe@uwc.ac.za, ²mogunniyi@uwc.ac.za

Abstract

Curriculum reform is considered in most countries as a viable means for responding to socio-political changes. To meet the demands of independence African countries have embarked on curriculum reforms compatible to the postulates of their emancipation. A common theme to these curricula is to make education relevant to the daily experiences of the learners. However, the contention of this paper is that well-trained teachers curriculum reforms are unlikely to achieve the goal relevancy. The paper reports the outcomes of some attempts that have been made in Eritrea and South Africa (the focus of this study), to train teachers to implement exemplary science-IK curricula which relate school science to the indigenous knowledge (IK) of the learners. The findings indicate that argumentation instruction was effective in enhancing teachers’ understanding the curricula as well as increased their awareness of the need to implement the curricula in their classrooms.
The role of Indigenous Knowledge Systems in enhancing grade 9 learners’ understanding of a Natural Science Education Curriculum: An survey in a Geography classroom in Cape Town, South Africa.

Alvin Daniel Riffel 1 Keith Langenhoven 2 Meshash Ogunniyi 3

1 Department of Education, University of the Western Cape, South Africa; 2 Department of Education, University of the Western Cape, South Africa. 3 Department of Education, University of the Western Cape, South Africa.

1 alvin@weathershop.co.za, 2 klangenhoven@uwc.ac.za 3 mogunniyi@uwc.ac.za

Abstract
This paper looks at the role of Indigenous Knowledge Systems (IKS) in enhancing learners’ understanding of the concepts in a Natural Science and Social Sciences Curriculum, with specific reference to a geography classroom. During the survey, pre-post-test and observation stages of the author’s main research study, with a quasi-experimental case study-type of design, what became apparent was that IKS are preserved in the memories of elders of ‘indigenous’ communities, and that this knowledge is gradually disappearing due to memory lapses and the deaths of the custodians of this knowledge. Cultural knowledge that could enhance learners’ understanding of difficult concepts in a science or geography classroom is slowly fading and disappearing from the cultural heritage of our communities. The DAIM-model (Dialogical Argumentation Instructional Model), and a quasi-experimental research design model, incorporating both quantitative and qualitative research methods (‘mixed methods’), was employed to collect data in a public secondary school in Cape Town in the Western Cape. In the main research study, a survey questionnaire on the attitudes and perceptions of grade 9 learners towards high school, as well as their conceptions of weather (CoW), was administered before the main study to give the researcher some background information for use in piloting an instrument to be used in the main study. The study then employed a dialogical instructional model (DAIM) with an experimental group (E-group) of learners who had been exposed to the intervention stage, and noted and recorded differences from between the responses of this group and the control group (C-group) which had had no intervention. Learners from the two groups were then exposed to a MLT (Meteorological Literacy Test) pre-post evaluation test before and after the DAIM intervention. The results from the two groups were then compared and analysed according to the two theoretical frameworks that underpinned the study: Toulmin’s Argumentation Pattern - TAP (Toulmin, 1958) and Contiguity Argumentation Theory - CAT (Ogunniyi, 1997). Further analyses were conducted of learners’ beliefs and indigenous knowledge according to their conceptual understanding of the weather related concepts used in the NCS (National Curriculum Statement), in current use at the time of the study, of the Department of Education. Some interesting findings emerged from the study, and, based on these findings, certain recommendations were suggested on how to implement a DAIM-model in the classroom using, or incorporating, IKS content. These recommendations are in the form of suggestions to clear the way towards developing a science–IK curriculum for the Natural Sciences and Social Sciences in all South African schools. For the purposes of this paper, we will focus on the first part of the quasi-experimental design research method, which is the learner
survey and pre-test results, the purpose of the paper being to describe the process used in determining learners’ perceptions of IKS and weather related concepts, and to offer suggestions in terms of integrating IKS in a science curriculum.

To What Extent Do Learning Styles Influence Academic Performance Across Chemical Concepts?

Dereje Andargie Kidanemariam¹, Harrison I Atagana²*, Temechegn Engida³

¹Institute of Education, Debre Berhan University, Ethiopia
²Institute for Science and Technology Education, University of South Africa.
³Faculty of Science, Addis Ababa University, Addis Ababa, Ethiopia.

Introduction

The current study was designed to show the link between Felder-Silverman learning styles and academic performance in some fundamental concepts in chemistry and give an insight that needs to be considered for more plausible and possible instructional actions. Therefore research questions of this study were: (1) How much variance in academic performance in some fundamental concepts in chemistry can be explained by variations in Felder-Silverman learning styles? (2) How well do the learning styles predict academic performance in these concepts in chemistry among preparatory school students?

The Felder & Silverman learning style model was first developed in 1987 by renowned scholars called Felder (who is an expert in chemical engineering) and Silverman (an expert in educational psychology) and cited first in engineering education and then in science education literatures (Felder & Silverman, 1988). Felder (1989) explains learning style in terms of learner’s preference to receive (taken in) and process information. This learning style model has four dialectic dimensions: visual/verbal, sensory/intuitive, active/reflective, and global/sequential.

Research Method: This study was conducted on grade 11 natural science students in two preparatory schools (pre-university) in Ethiopia. In both preparatory schools, chemistry is taught through standardized TV instruction, standardized students’ chemistry textbook, and classroom chemistry teacher with same educational rank (all were first degree holders). The population for the study was 902 natural science students out of which 167 students willingly participated in this study. The sample size was estimated by the formula: 50 + 8 k or 104 + k, k stands for the number of independent variables (Leech, Barrett, & Morgan, 2005). However, to minimize non-response rates 167 students were used. The 167 participants were selected by disproportionate stratified sampling technique based on academic performance.

The translated (Amharic) version of Felder-Soloman’s Index of Learning Styles (ILS) was used to identify students’ Felder-Silverman learning styles. The cronbach’s alpha value for the
Amharic version of ILS was .73 for visual/verbal, .73 for sensory/intuitive, .68 for active/reflective, and .64 for global/sequential. This cronbach’s alpha values report is similar to the original version of ILS and can be used for research purpose (Litzinger, Halee, Wise, & Felder, 2007). Their academic performance on fundamental concepts in the topics: Atomic structure & periodic table, and chemical bonding and structure were measured using a 21-item chemistry test. The items were constructed based on tables of specification and the following formula:

\[
\text{total number of items per topic} = \frac{\text{number of items in the test} \times \text{periods allotted for the topic}}{\text{the total number of periods for topics in which the test is constructed}}
\]

The computation of KR-20 reliability test showed that reliability index of the 21-item chemistry test was .90. Therefore, this indicates that the test was reliable to measure students’ academic performance on the aforementioned chemistry topics.

**Results and discussion:** The mean (m) and standard deviation (std.) of academic performance of sensing learners (m = 11.90, std. = 3.01), intuitive learners (m = 11.7, std. = 3.15), visual learners (m = 11.72, std. = 3.05), verbal learners (m = 12.06, std. = 3.02), active learners (m = 11.88, std. = 2.92 ), reflective learners (m= 11.83, std. = 3.17), sequential learners (m= 11.49, std. = 3.09 ) and global learners (m= 12.04, std. = 3.01) showed only slight difference. These comparisons of means of academic performances of students with different learning styles suggest that their academic performance on the same test constructed from some fundamental concepts in chemistry is approximately the same. These sample statistics shows that academic performance of students with different learning styles on fundamental chemical concepts was comparable. This implies that performance of the sample students on these fundamental concepts in chemistry was not linked to learning style differences.

Regression Model: Academic Performance = β₀ + β₁ (Visual/Verbal) + β₂ (Sensing/Intuitive) + β₃ (Active / Reflective) + β₄ (Sequential/Global) + ε

The fulfillment of assumptions of multiple regression, such as linearity, normality (using scatter plots), collinearity (using VIF, Tolerance), and normality of residuals (using residual plots) were checked on the data and followed by the regression analysis. The result of the regression analysis that shows the proportion of prediction of academic performance in chemistry in the fundamental concepts that could be explained by learning styles was reported using the coefficient of determination (R square). The coefficient of determination (R square) was 0.012. This means that only 1.2% variation in academic performance in the concepts can be predicted from variation in learning styles. The remaining 98.8% of variance in academic performance in the concepts could be explained by variables other than learning styles. Therefore, this implies that the total power of learning styles to explain academic performance on these concepts is very small/nearly nil.

This 1.2% variation in academic performance that linked to learning styles was subjected to statistical significant tests, which indicated that the probability of finding R square of the sample in the population that explain academic performance via learning styles is not statistically significant at α = 0.05, F (4,162), p = 0.746. This implies that the combination of different
learning style dimensions (i.e. the regression model) is less likely to predict students’ academic performance in the fundamental concepts considered in this study. Therefore, none of the learning style dimensions in this regression model are important predictors of academic performance in this study.

The results of this and other similar studies such as Al-Jaroudi (2009), shows that learning styles do not have the same influence on different concepts in chemistry. Hence chemistry teachers may need to give relative priority to representational nature of the fundamental concepts and other instructional variables than to worry much about learning styles when teaching concepts such as the ones considered in this study.

Reference


Exploring Effects of Argumentation Instruction Model on Science-IKS Curriculum in Teacher Education

Simasiku Siseho¹, Daniel Angaama² & Meshach Ogunniyi³

School of Science and Mathematics Education, University of the Western Cape, South Africa

¹simasiku.siseho@gmail.com, ²danangaama@gmail.com & ³mogunniyi@uwc.ac.za

Abstract

The central concern of this paper is to explore the effects of an Argumentation Instructional Model (AIM) on Science-IKS curriculum in teacher education. The paper, a part of a larger study, focuses on what we call “A Reflective Diary of the Science and Indigenous Knowledge Systems Project (SIKSP)”’. It is a narrative based on 19 in-service teachers’ experiences in the SIKSP using AIM. The major emphasis was to develop sets of materials and strategies to support argumentation in the classroom and assess teachers’ development with teaching argumentation. Data collected by video- and audio-recordings focused on the teachers’ attempts to implement these lessons at the beginning and end of the year. At some stage, analytical tools for evaluating the quality of argumentation were developed based on Toulmin’s Argumentation Pattern (TAP) and Ogunniyi’s Contiguity Argumentation Theory (CAT). Analysis of the data
shows that although the way the teachers used AIM vary, they all demonstrated considerable expertise in their use of this mode of instruction. Further, the results indicate that the pattern of use of argumentation is teacher-specific and context dependent.

**Science Literacy and Science Communication for Sustainability**

Kazu Kitahara

1 School of Science Education, Tokyo University of Science, Japan.

kazuokit@rs.tus.ac.jp

In Japan, we had national project of science and technology literacy 2005-2008. This was the project of clarifying the knowledge, skills and concepts to be shared by all people for the sustainability of the world and society. We published reports of seven panels and summary report. The seven panels were mathematical science, material science, life science, information science, human/social science, earth/astronomy/environmental science and technology. Then we organized science cafés, science festivals and public lectures to implement science literacy. After the 3.11 disaster in 2011, we have realized the importance of science communication between different fields of science and technology and social cohesion on the basis of science. Thus in 2012, we have launched “Science Communication Center” in Japan Science Technology Agency (JST) to promote science communication activities. We encourage scientists to have science communication with society not just to teach general public, but rather to extend their research beyond their own scientific motivation. This is also related to the quality assurance of higher education in a way that students may learn how to engage in society. I would like to report on these activities in Japan.

**What teachers say they want and what is offered.**

A study of KwaZulu-Natal science teachers’ professional development needs.

Mr. Casimir Mutabazi Karasira and Professor Paul Hobden

School of Science, Mathematics and Technology Education

University of KwaZulu-Natal.

karasirafr@yahoo.fr & hobden@ukzn.ac.za

**Abstract**

There is currently a broad consensus that teachers play a central and key role in any model of educational improvement (Hewson, 2007). Unfortunately one cannot even rely on the experienced teachers to cope with new educational landscapes when teachers are faced with curriculum change and new educational constraints. Hewson (2007) argues that “in the current climate of change and reform; even when teachers were highly effective at an earlier stage, they
may need reconsideration and updating. As the educational context changes, teachers’ existing practices and beliefs may not be well matched with the revised demands of new reform efforts” (p. 1180).

Maximizing staff development to strengthen students’ achievement remains a challenge for both educators and legislators. This is the case in South Africa and most developing countries. Even if in South Africa, mathematics, technology and science education have been identified as critical areas for reform in schools due to a large number of under-qualified and inexperienced school teachers (Morar, 2002), very often professional development opportunities are offered without taking into account the real teachers’ needs.

Assuming that “At all levels of education today, every successful instructional improvement program, curriculum reform and revision, school restructuring design or systemic reform initiative have at its centre the provision of high quality professional development” (Guskey. 2000, p.4) and that professional development activities tend to be more effective if they are based on assessed teachers needs, seen as a collaborative action that is supported by teachers themselves and stakeholders in education, there is a pressing need to identify teachers needs before taking any actions.

In the perspective of assessing teachers’ needs and teachers’ collaborative action, this research study was concerned with what KwaZulu-Natal science teachers say they want in terms of professional development and what is actually offered by professional development providers to help teachers update their knowledge and acquire new required skills.

To find out if there is a match or a mismatch between what is expressed as need and what is offered by providers, a descriptive research design using a survey method of gathering the data was used. A survey method of gathering data can take two different forms that are: (1) a form of a questionnaire in which the respondent fills out a form, or (2) an interview schedule, where the researcher asks to the respondent the questions directly”. In order to collect data required to answer the research questions, a questionnaire and an interview were used. These instruments enabled both qualitative and quantitative data to be gathered. A postal questionnaire was sent to science teachers and 51 science teachers returned the completed copies of the questionnaire. In addition, an audiotape-recorded interview of thirty minutes was held with and targeted individuals in charge of science teachers’ professional development at the DOE level, at the university of KwaZulu-Natal and at Project implementer’s level such as CASME, PROTEC and Toyota Teach Program.

The data from the postal questionnaire were coded, captured, analysed, and interpreted. Tape-recorded data collected by interviews was transcribed, categorized, summarized after repeated listening to recorded tapes. The categorization of the tape-recorded information gained from interviews was done with the research questions in mind.

Among the more significant findings were: (1) participants in the study considered the understanding of OBE and the new curriculum as the most pressing need followed by the improvement of content knowledge and pedagogical content knowledge; (2) workshops was seen as the appropriate professional development activity for the improvement of the
understanding of OBE and the new curriculum; and; (3) formal courses were considered as the best way of improving both the content knowledge to be taught as well as the pedagogical content knowledge. Overall, the providers expressed that there was not one need that was seen as the most pressing but rather a number of needs that were required to be addressed. Content knowledge and pedagogical content knowledge have been mentioned by most providers (6), other needs indicated were familiarity with the curriculum (6) and management skills including laboratory management skills (3). Some providers’ opinions showed that they did not have specific ideas and ways of addressing teachers’ needs and others showed that a combination of ways would help teachers to improve.

If science teachers are seen as the most influential factor in the core science educational process and considering that to ensure successful development in education, teachers need to play an important role in defining goals, content and implementation of any new innovations, teachers’ opinions and views would be placed at the centre of any design of professional development activities.
The Drop In- Centre established by the Community Outreach Centre (COC) at St. Mary’s is a place of care and comfort for the children of the surrounding area that are orphaned and vulnerable. These children face many challenges, such as being part of child-headed households, HIV/AIDS, poverty and social instability. The children at the Drop In- Centre have no access to exercise and sport at school, in the community and at the Drop In- Centre and they do not enjoy the many benefits of exercise. There are a wide range of health benefits associated with being physically active, both in terms of physical and mental well-being. Regular exercise improves balance, increases coordination, builds strength, develops fundamental and locomotive skills and improves overall health (Kremers, Dijkman, de Meij, Jurg & Brug, 2008). Physical activity also helps to relieve stress, decrease anxiety, and helps to ward off depression (Kumakech, Cantor-Graae, & Maling, 2009).

Physical fitness can be described as a set of attributes that are either health- or skill-related. The degree to which people have these attributes can be measured with specific tests (Caspersen, Powell & Christenson, 2005, p. 128). There are four main components to physical fitness; these are aerobic endurance, muscular endurance, muscular strength and flexibility. Fitness testing includes a series of measurements that help determine the physical fitness of an individual (Quinn, 2009). There are a number of possible tests and measurements that may be used to determine an individual's baseline fitness level. The fitness tests used in this study were adapted from FitnessGram and were specifically for children.

This was a case study that focused on the student’s experience of exploring and developing physical fitness in children (ages 7-10) at this Drop In-Centre. The student negotiated the plan and activity with the management of the Outreach centre and implemented it at the Drop In-Centre. A reflective diary and observation records were completed by the student. The programme planned and implemented had the participants involved in circuit training and games as part of the development of physical fitness. Observations and interviews with the children were used during data collection. The data was analysed both quantitatively and qualitatively. The quantitative data from the fitness tests were recorded as the scores obtained for each of the children. This score was interpreted qualitatively. The qualitative data was analysed used content analysis.

The student experience was of a personal and professional nature. The personal nature was linked to the conceptual, social and emotional experiences, which served as development for teaching and researching. The professional nature was the From the interviews it became clear that none of the participants had a full understanding of what exercise is, how it is used to improve fitness and what the benefits of exercise and of being physically fit are. The findings of this study suggest that social dynamics and the socio-economic status of a child play a role in the development of physical fitness. The children are not granted the opportunities to participate and
enjoy the benefits of being involved in physical movement. The study also found that the children’s knowledge and understanding of fitness and exercise, and its importance and benefits should be improved. There are a number of factors that contribute to one’s fitness. Understanding why it is important to be fit and to exercise, how it is done and what activities are considered to be exercise; play an important role in ones fitness (Kilpatrick, Hebert & Bartholomew, 2005).

A further finding was that as the researcher the student was faced with a major challenge and had to re-think the practices that were taught. The procedures and instruments that are used to test the physical fitness of children may not necessarily be applicable for the South African context. During the study a Western model for exercise and fitness was used to test the children at the Drop In- Centre. This is problematic because the context is different from the one that the test is designed for. Black children from low socio-economic backgrounds cannot be expected to perform the same way as that of a child from a Western, higher socio-economic background, because there are a lot of factors that influence ones fitness (Welk and Blair, 2001).

A circuit training programme was developed for the children. Games were also designed for the participants that incorporated some form of exercise, targeting different muscle groups. There was however a greater interest from the participants in indigenous games. Indigenous games are viewed as being recreational, and are characterized by organised play that follows a certain structure and flow according to agreed-upon rules that reflect a socio-cultural dimension of reasoning and behaviour (Burnett & Hollander, 2002). This interest in indigenous games together with the findings support the assertion that a uniquely African programme for sport and exercise has not as yet been established and there is great urgency for models that will be developed in Africa by Africans and for the benefit of Africans‖ (Toriola & Amusa, 2010).

A conclusion made is that a student can learn so much more about teaching Life Sciences from a Service-Learning engagement activity than just teaching it in the classroom. Furthermore, the physical fitness of children is an essential developmental aspect that should be catered for during their development for more active adults who understand the importance of being physically fit.

References