USING ADAPTED LESSON STUDY TO FACILITATE MATHEMATICS TEACHERS' META-COGNITIVE THINKING SKILLS (SANPAD PROJECT)

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The South Africa Netherlands Research Programme on Alternatives in Development (SANPAD) project, which involves colleagues and postgraduate students from the North-West University (Faculty of Education Sciences, Mathematics Education, Potchefstroom campus, South Africa), the Walter Sisulu University (Faculty of Education, School of Continuing Professional Teacher Development, Postgraduate and Research, Umtata Campus, Transkei, Eastern Cape, South Africa) and the University of Utrecht (Dr Maarten Dolk, Freudental Institute, Netherlands), examines possible practical ways of addressing the 'crisis' in Mathematics education relating to the level and quality of meaningful learning.

The 2012 symposium is presented in four phases in which the following different sub-papers are read:

1.1 THE NATURE OF TEACHING AND LEARNING MATHEMATICS IN RURAL SOUTH AFRICAN SCHOOLS: A RURAL PERSPECTIVE

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The teaching of Mathematics and learner achievement is regarded as one of the weakest twins in the field of mathematics education in South Africa. This has been particularly so in rural and township areas (as compared to their urban counterparts), due to factors such as the allocation of resources and systemic neglect over the years. This imbalance has been observed and confirmed by the Minister of Basic Education, Angie Motshekga: "One key area of focus will be the rural schools in our country, many of which are inadequately provided for in terms of infrastructure (class rooms and basic services like water and electricity), as well as facilities, with a complete lack of libraries, laboratories, or even sport and playground facilities" (Motshekga, 2009: 4).

Among all the provinces whose majority communities reside in rural areas (and that may thus be referred to as rural provinces), the Eastern Cape and Limpopo provinces take first place when it comes to the negative correlation between mathematics teaching and achievement. Studies conducted on achievement in mathematics and the challenges associated with rural learners' achievement in mathematics have shown that despite challenges faced by mathematics teachers in rural areas, conditions have been created to enable learners to achieve just as ably as learners in urban and more advanced communities. Rather than to get stuck in predicting doom and gloom, South African

researchers have recently started to focus on ways in which this challenge could be addressed (Fleisch, 2008; Horne, 2007).

The term rural has many definitions, but all seem to lead to similar contexts that may differ in terms of the degree to which resources and opportunities are created for people who reside in such environments or conditions.

Rural life and rural development have largely and unrealistically been modelled against the wishes and needs of urban communities, whose life patterns have historically been fashioned after the Western-type of culture in general and the Eurocentric model in particular. Gallagher (1993) and Gruenewald (2003) describe education within rural contexts by calling for 'place-conscious education'. Rural consciousness takes the feelings, soul and meditations of rural people as prime point of departure in learning and teaching. Any rural education initiative that is to make meaning for and have an impact on rural learners should address and take into account the context of the rural child. It should also be in line with and understand what Budge (in Balfour, Mitchell & Moletsane, 2008) calls the 'peculiarities of the locals'. Some of these unique peculiarities would be social theories such as Ubuntu (Seepe, 2004), which are concerned with the self in the environment and in the community, from an African perspective.

Of particular importance to all researchers in these fields is whether instruments for measuring the performance of rural learners take into account issues associated with rurality and rural people. Such instruments should reflect the 'peculiarities' of the lives of rural people and incorporate their cultural norms and social theories (e.g. Ubuntu and cultures of rural people), as accentuated in the 'enculturation' of mathematics suggested by Bishop (1988).

Several strategies within the constructivist domain, such as reflective and meta-cognitive teaching and learning, tend to agree with modes of teaching and learning that allow for the exploitation of the 'inner consciousness' of the rural child. Rural 'peculiarities' should also be considered when the teaching and learning of rural and township children is planned. All things considered, culture and thinking cannot easily be divorced from each other.

1.2. MATHEMATICS EDUCATION AND META-COGNITIVE TEACHING AND LEARNING SKILLS

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International research indicates that the ability to be receptive to a variety of thinking skills can be developed and improved by giving a person the opportunity to become aware of

his/her own thought processes while engaged in doing mathematics and solving problems (Lucangeli & Cornoldi, 1997). This process of analysing one's own thoughts is called meta-cognition (Hartman, 2001a). Meta-cognition is essential for the application of appropriate information and strategies during problem solving (Lucangeli & Cornoldi, 1997; Pugalee, 2001). It includes teachers'/learners' awareness and regulation of and reflection on their own cognitive processes (Fortunato, Hecht, Tittle & Alvarez, 1991) as well as a variety of decision-making strategies that manifest in identifiable behavioural modes such as predicting, planning, revising, making choices, checking, guessing and classifying (Allen, 1991). Meta-cognition therefore appears to be an indispensable element of problem solving that helps the individual to identify strategies and hence to work strategically when solving mathematics problems (Davidson & Sternberg, 1998).

The research team believes that poor performance in mathematics may be ascribed to factors such as teachers' inadequate reflection on and implementation of meta-cognitive teaching-learning strategies. Teachers rarely, if ever, demonstrate to their learners exactly what 'learning how to learn' means, the meaning of 'thinking about one's own thinking', and how to become a problem solver. In fact, many learners do not have the slightest idea as to what exactly it is that they are doing. To this day, 'learning how to learn' still does not form part of the South African school curriculum (Van der Walt, 2006).

For the purpose of this study the description of Artzt and Armour-Thomas (2001) suffices, namely: the teacher is a problem solver who ought to solve problems (teaching) meta-cognitively but also to direct and guide learners to acquire meta-cognitive strategies and skills (Hartman, 2001b). This implies that a teacher does not only challenge learners intellectually, but also supports them in their efforts to acquire and effectively learn strategies and skills in the mathematics class (Van der Walt & Maree, 2007).

Teachers' knowledge of the subject matter, the learners in their class and learning strategies influence the quality of their instruction (Ball & Bass, 2002). The planning of lessons is based on the meta-cognitive teaching-learning strategies of the specific content area and declares how the teacher is going to teach the subject matter (Van der Walt & Maree, 2007). Koutseleni (1991) asserts that when teachers are aware of their own meta-cognitive strategies and teach their learners different meta-cognitive strategies, the latter overcome obstacles to solve problems. The learners are encouraged to think aloud, not only to provide a final answer to a problem, but also to explain their own thought processes. Teachers should actively support learners and guide them to become aware of and use their meta-cognitive abilities. Aspects of a Mathematics teacher's knowledge for effective teaching and supporting their learners' learning – planning lessons, evaluating learners' learning,

assessing assignments and completing the curriculum content – are meta-cognitive in nature (Ball, Thames & Phelps, 2008).

Observable features of lesson study include the following: considering the long-term goals of learning; planning and conducting the lesson; collecting data during the lesson; reflecting on and discussing data from the lesson study to discover implications for future teaching (Lewis, Perry & Murata, 2006). On completing a lesson study, teachers document their work in a report that describes the lesson they designed, how the lesson worked and what they have learnt about teaching and learning from the lesson study (Ono & Rerreira, 2010). It is clear that 'lesson study' provides a way for mathematics teachers to work collaboratively in schools. Being involved in a lesson study meta-cognitively, they implement, improve and reflect on their own meta-cognitive teaching-learning strategies. Elements of lesson study, such as improving learners' focus during learning activities and developing effective learning experiences, require metacognitive knowledge and skills (Lewis, Perry & Murata, 2006).

2.1 MATHEMATICS TEACHERS' META-COGNITIVE SKILLS AND MATHEMATICAL LANGUAGE IN THE TEACHING OF TRIGONOMETRIC FUNCTIONS IN TOWNSHIP SCHOOLS

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Meta-cognitive skills are an important role player in effective mathematics teaching and learning (Kramarski & Mevarech, 2003; Lai, 2011; Van der Walt & Maree, 2007). Several authors emphasise the importance of mathematical language in mathematics instruction and learning (Beck & Mckeown, 2007; Pierce & Fontaine, 2009). For the Grade 10 learner, trigonometry is a new section of mathematics with a plethora of new terms and concepts that were not addressed in previous grades (DBE, 2011). The central research question that this paper seeks to investigate is: What mathematical language and meta-cognitive skills are used by mathematics teachers when they teach trigonometric functions and apply them in solving problems in the FET phase? The answer to this question will support the development of effective facilitation activities, which will enable teachers to reflect on and discover their own meta-cognitive teaching-learning skills. This paper reports on the identification and analysis of teachers' meta-cognitive skills and mathematical language usage in their teaching of trigonometric functions to solve problems.

The research arena of mathematics education proliferates with literature on mathematical language, thinking theories and models (Bruning, Shaw & Ronning, 2004; Flavell, 1976; Fox & Riconscente, 2008; Gernetzky, 2010). However, not much scholarly work is available on the combination of mathematical language and meta-cognitive skills, as the available

literature mainly centres on the teaching and learning of mathematics, meta-cognition and mathematical language.

Authors such as Davis et al. (2008) and McNiff (2008) describe complexity theory in education as a theory of change, evolution and adaptation, often in the interest of survival, and often through a combination of cooperation and competition which involves learning in non-linear terms. The authors of this paper view the teacher as a learning system whose learning evolves as a sum of all the parts that contribute to the learning of the teacher (the knowledge of the teacher, her/his experience, the community in which she/he lives and works, the learners whom she/he teaches, fellow teachers, the learning culture at the school, and the curriculum) – hence the selection of complexity theory as prevailing theory in this study.

In order to address the research question above, the researchers conducted an empirical study of educational design research in which inductive (qualitative) methods are employed. According to Van den Akker et al. (2006), educational design research has its origins in experimental research and blends empirical educational research with the theory-driven design of learning environments. As educational design research is normally used to understand how, when and why educational innovations work in practice, this was considered the perfect methodology for finding the ways in which meta-cognitive skills and mathematical language can be enhanced for more effective teaching of trigonometry and simultaneous design of the next lesson. According to Gravemeijer and Van Eerde (2009), as well as Dolk, Den Hertog and Gravemeijer (2002), design research is not limited to student learning only, but can be applied to the learning of the teacher too.

Data collection for the purposes of this study comprised the completion of the Teachers' Meta-Cognitive Skills Questionnaire (TMCSQ), individual interviews and lesson observation. Preliminary findings indicate that participant teachers seemed to use their meta-cognitive skills but were not really aware of using it. Indications are that mathematical language usage can be improved and that teachers often used code switching (i.e. explaining in the mother tongue, Setswana) during the observed lessons. These findings will be discussed in more detail in the presentation.

2.2 BENEFITS OF LESSON STUDY FOR MATHEMATICS TEACHING

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The ability to reflect on teaching practice is considered essential for effective instruction (Sowder, 2007). However, there seems to be a paucity in research in South Africa on mathematics teachers' reflective practice. In order to study this ability to reflect, the concept of lesson study was introduced to five mathematics teachers in a rural school in the Free

State. The purpose was to investigate these teachers' reflective practice while they collaboratively planned and reflected on the teaching of a lesson.

Research has shown that lesson study impacts on teachers' understanding of learner thinking. It enhances teachers' content knowledge and awareness of new approaches to teaching; it helps teachers to connect their practices to school goals and broader goals; it creates a demand for improved instruction, and it allows competing views to be heard during the reflection stage of the lesson study cycle (Lewis, cited in Sowder, 2007). In South Africa, a school-based in-service education intervention programme, modelled along the lines of the Japanese lesson study, was launched in Mpumalanga in 2000 (Jita, Maree & Ndlalane, 2007). Based on this lesson study approach a system was established in which teachers could rely on each other, hold discussions and explore alternative solutions to problems experienced in their teaching of mathematics (Jita et al., 2007).

Data for Posthuma's research was obtained by means of two individual interviews with each of the five teachers, video-recorded observations of the teaching of the planned lesson, field notes taken during the lesson study group meetings and document analyses (lesson plans and reflective writings). The data was coded using the computer programme Atlas.ti 6, and one of the categories that emerged from the coding was 'contextual factors that might influence teacher reflections'. All teachers reported positively on their cooperative planning of a lesson, revealing that they learned much from the experience of planning with the goal to improve learners' understanding of concepts. Additionally, they reported that they were teaching with more confidence as a result of watching themselves as teachers and learning from watching their colleagues. They also expressed a sense of increased and deeper awareness of their learners' needs and the importance of involving learners in their lessons. Lastly, two of the teachers regarded the lesson study experience as self-research that enabled them to compare themselves with their colleagues and to observe their own actions critically while watching the post-observation videos. These findings echo results by Coe, Carl and Frick (2010), who mention that 1) lesson study can act as an agent of change in a culture of isolation; 2) participants become comfortable with having colleagues observe them teach; 3) an increase in content knowledge is realised by participating members; and 4) lesson study provides an approach that is sustainable and effective in meeting the needs of learners.

The findings of this research study indicate that through engaging in the lesson study experience, the five teachers improved their reflective practice, reported an increase in self-knowledge and found new ways of teaching mathematics to learners. This has potential value for the planning of professional learning programmes, where teachers can be encouraged to talk about their classroom experiences, share their joys and challenges with

one another and strive to build a community of reflective practitioners that will enhance their learners' understanding of mathematics.

2.3 FACILITATING META-COGNITIVE SKILLS IN MATHEMATICS TEACHING IN THE O.R. TAMBO DISTRICT OF THE EASTERN CAPE

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This paper reports on research carried out in collaboration with mathematics teachers in Further Education and Training (FET) schools in the O.R. Tambo district municipality. The main aim of this study was to equip mathematics teachers with meta-cognitive teaching skills. Once acquired, these meta-cognitive skills enabled individuals to reflect on their actions, thereby improving their teaching performance.

Meta-cognitive teaching strategies relate to planning a lesson, self-monitoring, evaluation and revising. Strategies to promote meta-cognition include self-questioning, thinking aloud during task performance, and reflecting on one's thoughts and knowledge. According to Fisher (1998), meta-cognition refers to the unique capacity of humans to reflect on their knowledge and actions. John Dewey defines reflection as the active, persistent and careful consideration of any belief or form of knowledge (Posthuma, 2011) that emanates from self-commitment to solve a problem.

Lesson study is a professional development tool that originated in Japan and in an adapted format, spread worldwide (Fernandez, 2005). It has the potential to enhance teachers' knowledge by enabling them to work collaboratively on aspects of lesson study such as planning, teaching strategies and reflection (Lewis, Perry & Murata, 2006).

The data for this study was generated by means of action research, an approach that focuses on action and research in a participative manner (Gray, 2009, p. 313). Data was gathered during focus group interviews with four mathematics teachers, teaching grades 10, 11, and/or 12. The teachers participated on basis of willingness and availability. The study probed them to reflect on the performance of the mathematics learners they taught. The researcher solicited their individual views on the performance of their learners during 2011 (detailed results are shared during the presentation of this paper) and further explored how they would go about to improve the previous years' learner performance in mathematics. The aim was to enable them to communicate about their actions in mathematics teaching and learning, and to work collaboratively in *lesson study* and enactment through *action research.* Participant teachers reported for example that their learners had performed badly in mathematics across all grades taught in 2011. Although all teachers noted a slight

improvement in Grade 12 mathematics performance, they could not attribute this slight improvement to their own improved teaching strategies.

Mathematics teachers reported that class attendance by Grade 12 learners was regular and that school attendance in Grade 12 was monitored by school management teams and subject teachers. Parents also encouraged their children to attend school when they were in Grade 12. However, school attendance by learners in Grade 10 and 11 was poor because of not being monitored. Furthermore, subject teachers did not know their learners by name because of the overcrowding in Grade 10 and 11 classes. As a result, mathematics teachers did not know which learners were struggling with which content knowledge.

In order to improve learners' mathematics performance, teachers should encourage learners to solve mathematics problems on the chalkboard, thereby facilitating learning through thinking aloud and peer learning. They should also encourage learners to volunteer for solving maths problems on the chalkboard, but would need a way of dealing with those who would never volunteer.

3.1 MATHEMATICS TEACHERS' META-COGNITIVE STRATEGIES IN A RURAL SCHOOL

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There has been an increased awareness of the need to improve Grade 12 mathematics results in schools over the past few years. Soobryan (Department of Basic Education, ANA, 2011c, p. 6) argues that it is necessary to improve learners' mathematical performance in lower grades because this influences performance at the higher level. Moreover, it is necessary to develop the teaching environment where teachers and learners can mature into the practice in which they engage (Jaworski, 2006, p. 187). Because most teachers teach according to their own experiences, they mostly stick to the same teaching and learning strategies in which they were taught.

Meta-cognitive strategies such as planning, monitoring and evaluating are important for learning tasks where one can reflect on one's own learning. By using these strategies, teachers can come to understand that they have the ability and power over their own teaching processes (Chamot & O'Malley, 1994, p. 267). Fisher (1998, p. 2) argues that teachers reflect on their thought processes or existing knowledge when they think meta-cognitively. When teachers and learners reflect on their own thinking, share their

experiences and present their strategies, others (teacher and learners) can observe the connections that are made between the strategies used (Hancewicz, 2005, p. 82).

The purpose of this study is to investigate mathematics teachers' meta-cognitive teaching strategies so as to develop these in practice through the adapted lesson study approach. In this qualitative study, the researcher investigates how mathematics teachers reflect on their use of meta-cognitive strategies in their classrooms. Data was collected from intermediate phase mathematics teachers in a rural school in North-West. During semi-structured interviews the teacher meta-cognition skills questionnaire (TMCSQ), compiled by the SANPADMATH project, was administered to the participants. The aim was to collect descriptive data to establish the meta-cognitive strategies used by these teachers, as well as their understanding of the use of meta-cognitive teaching strategies in practice. The data was analysed by means of content analysis where qualitative responses to open-ended questions such as the TMCSQ were used to interpret and make sense of the data (Nieuwenhuis, 2010, p. 100). The discussions were recorded, transcribed verbatim and analysed by open coding.

In this presentation the results of this study are reported, analysed, interpreted and discussed.

3.2 TEACHERS' DEVELOPMENT OF THE META-COGNITIVE SKILLS IN MATHEMATICS PROBLEM SOLVING OF LEARNERS IN RURAL PRIMARY SCHOOLS IN THE EASTERN CAPE

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The acquisition of mathematical skills for problem solving is critically important in today's sophisticated technological world. There is growing evidence that meta-cognition application is an important component of academic success in general and mathematics achievement in particular. Teachers' application of meta-cognition therefore directs and reflects their own teaching practice behaviour, and this augments learners' learning with understanding (in problem solving). The purpose of this paper is to report on a qualitative research study about the extent to which mathematics teachers implement meta-cognitive strategies in problem solving. Five teachers and 30 learners from three selected primary schools in the Mthatha district of the Eastern Cape participated in the study. Teachers were selected from three different primary schools, while learners all came from one selected (invited) school. The selected participants were believed to be information rich and able to help answer the research question. The main research question was: In what ways do teachers develop learners' meta-cognitive skills in mathematics problem solving in their classrooms?

Interviews were conducted with both teachers and learners, and lessons were observed. The interviews focused on teachers' knowledge or understanding of meta-cognitive strategies of mathematics problem solving. Observation centred on teachers' way of using meta-cognitive strategies in the classroom and the ways in which learners solved problems using those strategies. The progress made will be reported with regard to the data collected and analysed.

4.1 DEVELOPING AND PILOTING THE TEACHERS' META-COGNITIVE SKILLS QUESTIONNAIRE (TMCSQ) FOR PROSPECTIVE FOUNDATION PHASE TEACHERS

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Meta-cognition is a person's knowledge and awareness of his/her own cognitive processes – something that is crucial for understanding and learning (Flavell, 1976; Wilson & Bai, 2010; Veenman et al., 2006). However, there is only limited research that specifically explores prospective teachers' conscious awareness of their own meta-cognitive skills and knowledge, as well as of their ability to think about, talk about and write about their own thinking (Wilson & Bai, 2010, p. 269; Zohar, 1999).

It is essential for a teacher to be able to think about his/her own thinking, because the role that he/she will play in the classroom influences the quality of his/her own teaching. Furthermore, these thoughts lead to the adaptation of his/her teaching approach and cause him/her to incorporate teaching strategies that will bring about meta-learning and meta-cognitive thinking within learners as well.

Few tests have been developed and standardised that are sensitive and aware of the diverse profile of teachers in South Africa. There is a need for designing and standardising an assessment tool that will assist in measuring the meta-cognitive knowledge and skills of prospective teachers and in developing these skills during prospective teachers' preparation/education (Wilson & Bai, 2010; Zahar, 1999). The aim of this study is therefore to develop a tool for assessing teachers' meta-cognitive skills that will directly inform the planning of such an intervention strategy. The TMCSQ informs tertiary institutions about the meta-cognitive skills of prospective foundation phase teachers and responds to the call of the Department of Education for the development of assessment instruments to improve teacher development and preparation/education.

According to Kaplan and Saccuzzo (2009), who concur with Foxcroft and Roodt (2002), an educational psychometric test can be defined as a set of items that are designed to measure characteristics of human beings that pertain to skills or behaviour. These are based on

literature and theory, and are developed through a survey research design. This study focuses on the development (and eventually the standardisation) of the TMCSQ.

During the planning phase of the TMCSQ (before November 2011), questionnaires (from international sources) that assess teachers' awareness of meta-cognitive skills were identified and evaluated against the unique needs of the South African context and the aim of the test. None were found adequately suitable. The TMCSQ was subsequently developed as an initiative by the SANPAD team in November 2011. SANPAD partners, who come from diverse backgrounds and are all working on meta-cognition in their own studies, all contributed to the items in the TMCSQ.

Afterwards, the original statements/items in the questionnaire were reviewed by national and international experts on meta-cognition, as well as statisticians and local and diverse prospective and in-service teachers. Specific attention was given to content, clarity, cultural and linguistic appropriateness and general layout of the questionnaire. After these reviews, the questionnaire was revised and improved and language edited (English and Afrikaans). Special attention was paid to aspects of validity and reliability of the TMCSQ.

A stratified sample (N = 100) was drawn for the pilot study to represent a randomly selected group of prospective foundation phase teachers from the first to the fourth year of study (B. Ed degree) from all three campuses of the North-West University. The three campuses each has a unique biographic profile in terms of culture, language and socio-economic status, which should be taken into consideration when data is interpreted. The questionnaire was administered in the same week across all three campuses (N = 100). The Statistical Consultation Services at the North-West University assisted with the calculation of statistical techniques for analysis. The data was tested for statistical significance (e.g. factor analysis, measures of reliability and validity, item analysis) as well as analysed and interpreted, and the results will be presented at the conference. Examples of the refined statements that were statistically significant will also be presented. The TMCSQ is in the process of being translated into Setswana, one of the eleven official languages of South Africa, and some of these items will also be presented at the conference.

4.2 MATHEMATICS SUBJECT MATTER KNOWLEDGE FOR TEACHING IN THE FOUNDATION PHASE

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Mathematics specialised content knowledge (MSCK) was explored, summarised and analysed to define the ontological and epistemological meaning of MSCK and describe its methodological implications for mathematical teaching in the foundation phase. MSCK is essential for effective mathematics teaching because this knowledge distinguishes a mathematics teacher from people in any other profession (Ball et al., 2008). A conceptual study was conducted to find theoretical clarity on the meaning of MSCK, with special reference to its meaning for mathematics teaching in the foundation phase. This paper describes MSCK with regard to the content area: number, operations and relationships (CAPS, DoE, 2011), for inclusion in the preparation of prospective foundation phase teachers.

According to the Department of Higher Education and Training (DHET), one of the basic competencies of a beginner teacher is to *be knowledgeable about the school curriculum and be able to unpack its specialised content* (2011, p. 56). Jansen (2011) argues that this is not true of most South African teachers and adds that an effective intervention of teacher knowledge in mathematics education might be necessary. However, the mathematical knowledge required for teaching (Ball, Thames & Phelps, 2008) should be clarified before an effective intervention can be planned. Hence, a critical elaboration on mathematical subject matter knowledge with special reference to specialised content knowledge (SCK) is provided. Non-empirical research was conducted in the form of a conceptual study employing data collection from documents and content analysis. The following are examples of documents that were used to collect this data: several research articles on mathematical knowledge for teaching; the Foundation Phase yearbook for student teachers (NWU) (with special reference to mathematical modules' description of mathematical knowledge for teaching); national policy documents (including the Minimum Requirements for Teacher Education Qualifications (DHET, 2011); the Curriculum and Assessment Policy Statement (CAPS) (Department of Basic Education, 2011a); and international standards for mathematics teacher education. These documents were studied, summarised and analysed, using open coding. The codes were organised into categories and the categories into themes to elaborate on the meaning of SCK (Nieuwenhuis, 2010; Frankel, Wallen & Hyun, 2012).

Preliminary findings of this study elaborated on definitions of MSCK (Bair & Rich, 2011; Ball et al., 2008). Results from these document analyses will be presented at the conference.

4.3 THE INFLUENCE OF A LARGE-GROUP TEACHING STRATEGY ON THE SELF-REGULATION OF TERTIARY STUDENTS

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Quality higher education is characterised not only by the ability to discover knowledge independently, to comprehend the relationship between new and existing knowledge and to apply knowledge in problem-solving situations, but also the desire for more knowledge (De Bruin, 2007, p. 228). Mathematics education may therefore not flourish under some of the more traditional teaching styles (Maree *et al.*, 2006, p. 1). A supporting body of literature has grown around the idea that optimal academic performance relates to the measure of self-regulation that a learner is capable of demonstrating. This paper focuses on the aspect of self-regulation, which includes self-responsibility and planning.

As lecturer in a compulsory Mathematics module taken by third-year education students, it came to the researcher's attention that students lack both motivation and self-regulation strategies in this module. To address this apparent absence of self-regulation strategies in tertiary students, a large-group teaching strategy was implemented as an intervention to determine its influence on the study habits and self-regulation strategies of tertiary students.

According to Meltzer and Manivannan (2002, p. 639) a number of studies have shown that active learning methods are effective in learners' learning of concepts. These methods endeavour to increase learners' involvement during class activities as opposed to the traditional 'lecture'. The aim of the large-group teaching strategy as a learning strategy is to increase teaching productivity in higher education, while at the same time decreasing input (Steyn, 2011). The large-group teaching strategy involves different elements that include the following: the lecturer; the study guide; learning material; the digital book drive (which contains text as well as recorded explanations and examples by the lecturer); e-learning platform; contact sessions; team teaching; individual support in the form of facilitation; peer assessment and reflection (Steyn, 2011). The present study focuses only on certain aspects of large-group teaching, namely self-responsibility; planning; organising and self-management; collaborative learning (part of self-regulation). The research question that guides this paper is: To what extent does the large-group teaching strategy influence the self-regulation strategies of tertiary learners who take mathematics as a compulsory module?

For the purpose of this study a quantitative design was used to investigate the relationship between variables (Creswell, 2009, p. 4), namely self-regulation as the dependent variable and the large-group teaching strategy as the independent variable. The quantitative study consisted of a one group pre- and post-test to determine if there had been a significant difference between learners' self-regulation strategies before and after they were exposed to the large-group teaching strategy. Two questionnaires were administered, namely the Study Orientation Questionnaire in Mathematics (SOM) (Maree, Prinsloo & Claassen, 1997b), and a closed Likert-type questionnaire (composed by the researcher), hereafter referred to as the

Self-regulatory and Large-Group Teaching Strategy questionnaire (SLGTS). Although the SOM is a standardised test and consists of six fields namely study attitude, mathematics anxiety, study habits, problem-solving behaviour, study milieu and information processing (Maree *et al*., 1997b, pp. 5-6), this paper will focus on study habits only. According to Maree *et al.* (2006, p. 6) successful study habits include the daily use of learned, consistently effective study methods and habits such as time management and preparation, working through of previous test and exam papers, working out of more than just the familiar problems, as well as the follow-up of problems in mathematics. It also includes the willingness to promptly complete and submit homework and tasks. This field is an indication of the extent to which study attitudes in mathematics manifest in particular study habits in mathematics. The SLGTS contains items regarding self-regulatory strategies and the large-group teaching strategy. The study population consisted of all third-year students in the Faculty of Education at a South African university taking mathematics (space, shape and measurement) as a compulsory module. The sample consisted of the 89 students who also completed the SOM (Maree *et al*., 1997) and the SLGTS questionnaire as a pre- and a post-test.

The statistical results of this study will be reported on in full at the symposium.

References

Allen, B.R. (1991). *A study of meta-cognitive skill as influenced by expressive writing in college introductory algebra classes.* Unpublished doctoral dissertation, Louisiana State University and Agricultural and Mechanical College.

Artzt, A.F. & Armour-Thomas, E. (2001). Mathematics teaching as problem solving: a framework for studying teacher meta-cognition underlying instructional practice in mathematics. In Hartman, H.J. (Ed.). 2001. *Meta-cognition in learning and instruction*. Dordrecht, Netherlands: Kluwer Academic Publishers.

Bair, S.L. & Rich, B.S. (2011). Characterizing the development of specialized mathematical content knowledge for teaching in algebraic reasoning and number theory. *Mathematical Thinking and Learning*, 13(4), 292-321.

Balfour, R.J., Mitchell, C. & Moletsane, R. (2008). Troubling Contexts: Towards a generative theory of rurality as educational research. *Journal of Rural and Community Development*, 3(3), 100-111.

Ball, D.L. & Bass, H. (2002). Toward a practice-based theory of mathematical knowledge for teaching. In Davis, B. & Simmt, E. (Eds.), *Proceedings of the 2002 Annual Meeting of the Canadian Mathematics Education Study Group*, (pp. 3-14) Edmonton, AB: CMESG/GCEDM.

Ball, D.L., Thames, M.H. & Phelps, G. (2008). Content knowledge for teaching: What makes it special? *Journal of Teacher Education*, 59(5), 389-407.

Beck, I.L. & McKeown, M.G. (2007). Increasing young low-income children's oral language repertoires through rich and focused instruction. *The Elementary School Journal*, 107, 251-271.

Bruning, R.H., Shaw, G.B. & Ronning, R.R. (2004). *Cognitive psychology and instruction* (4th ed.). Upper Saddle River, NJ: Merrill/Pearson Education.

Chamot, A.U. & O'Malley. (1994). Language learner and learning strategies. In N.C. Ellis (Ed.), *Implicit and explicit learning of languages* (pp. 371-392). London: Academic.

Coe, K., Carl, A. & Frick, L. (2010). Lesson study in continuing professional teacher development: A South African case study. *Acta Academica*, *42*(4), 206-230. Available from http://journals.sabinet.co.za/WebZ/images/ejour/academ/academ_v42_n4_a8.pdf?sessionid=01-59893-1679460615&format=F

Creswell, J.W. (2009). The selection of a research design. In Creswell, J.W. (Ed.), *Research design: qualitative, quantitative and mixed methods approaches*. (3rd ed.). (pp. 3-21.) Thousand Oaks, CA: Sage.

Davidson, J.E. & Sternberg, R.J. (1998). Smart problem solving: how meta-cognition helps. In Hacker, D.J., Dunlosky, J., Graeser, A.C. (Eds). *Meta-cognition in educational theory and practice.* Mahwah, NJ: Erlbaum.

Davis, B., Sumara, D. & Luce-Kapler, R. (2008). *Engaging minds – Changing teaching in complex times.* (2nd ed.). (244 pp.) New York: Routledge.

De Bruin, K. (2007). The relationship between personality traits and self-directed learning readiness in higher education students. *South African Journal of Higher Education,* 21(2), 228-240.

Dolk, M., Den Hertog, J. & Gravemeijer, K. (2002). Using multimedia cases for educating the primary school mathematics teacher educator: A design study. *International Journal of Educational Research*, 37(2), 161-178.

Fernandez, C. (2005). Lesson study: A means for elementary teachers to develop the knowledge of mathematics needed for reform-minded teaching? *Mathematical Thinking and Learning,* 7(4), 265-289.

Flavell, J.H. (1976). Meta-cognitive aspects of problem solving. In L.B. Resnick (Ed.), *The nature of intelligence.* (pp. 231-235). Hillsdale, NJ: Erlbaum.

Fleisch . (2008). *Primary education in crisis*. Cape Town, SA: Juta.

Fortunato, I., Hecht, D., Tittle, C.K. & Alvarez, L. (1991). Meta-cognition and problem solving. *Arithmetic Teacher*, 39(4), 38-40.

Fox, E. & Riconscente, M. (2008). Meta-cognition and self-regulation in James, Piaget and Vygotsky. *Educational Psychology Review*, pp. 373-389.

Foxcroft, C. & Roodt, G. (2002). *An introduction to psychological assessment in the South African context.* Cape Town, SA: Oxford University Press.

Frankel, J.R., Wallen, N.E. & Hyun, H.H. (2012). How to design and evaluate research in education (8th ed.). USA: McGraw Hill.

Gallagher, A. (1993). *The power of place*. New York: Harper Collins.

Gernetzky, K. (2011). *Language 'main issue' in literacy, maths marks*. Accessed from http://www.businessday.co.za/articles/Content.aspx?id=148991 on 21 July 2011.

Gravemeijer, K. & Van Eerde, D. (2009). Design research as a means for building a knowledge base for teachers and teaching in mathematics education. Accessed from http://www.eric.ed.gov/ERICWebPortal/search/detailmini.jsp?_nfpb=true&_&ERICExtSearch_SearchValue_0=EJ844056&ERICExtSearch_SearchType_0=no&accno=EJ844056 on 27 March 2012.

Gray, D.E. (2009). *Doing research in the real world*. Thousand Oaks, California: Sage.

Gruenewald, D.A. (2003). Foundation of place: A multidisciplinary framework for place-conscious education. *American Educational Research Journal*, 40(3), 619-654.

Hancewicz, E. (2005). Writing in the mathematics classroom. In Kenney, J.M. (Ed.). *Literacy strategies for improving mathematics instruction*. (pp. 72-86). Alexandria: Association for Supervision and Curriculum Development.

Hartman, H.J. (2001a). Developing students' meta-cognitive knowledge and skills. In Hartman, H.J. (Ed.). *Meta-cognition in learning and instruction. Theory, research and practice*. Dordrecht, Netherlands: Kluwer Academic.

Hartman, H.J. (2001b). Teaching meta-cognitively. In Hartman, H.J. (Ed.). *Meta-cognition in learning and instruction.* Dordrecht, Netherlands: Kluwer Academic.

Horne, T. (2007). A comparative study: The language proficiency (English) and numerical skills of elite matriculants and presumptions and questions about affirmative action and ensuing actions. Alberton, SA: Horne & Horne.

Jansen, J. (2011). No hope for teachers. Times Live. Accessed from http://www.timeslive.co.za on 13 October 2011.

Jaworski, B. (2006). Theory and practice in mathematics teaching development: critical inquiry as a mode of learning in teaching. *Journal of Mathematics Teacher Education*, 9, 187-211.

Jita, L.C., Maree, J.G. & Ndlalane, T.C. (2006). Lesson study (Jyugyo Kenkyu) from Japan to South Africa: A science and mathematics intervention program for secondary school teachers. In B. Atweh, A.C. Barton, M. Borba, N. Gough, C. Keitel, C. Vistro-Yu & R. Vithal (Eds.), *Internationalisation and globalisation in mathematics and science education* (pp. 465-486). Dordrecht: Springer.

Kaplan, R.M. & Saccuzzo, D.P. (2009). *Psychological testing. Principles, applications and issues.* (7th ed.). Belmont, CA: Wadsworth.

Koutselini, M. (1991). *Child development and school reality*. Nicosia: Pedagogical Institute of Cyprus.

Kramarski, B. & Mevarech, Z.R. (2003). Enhancing mathematical reasoning in the classroom: The effects of cooperative learning and meta-cognitive training. *American Educational Research Journal,* 40(1), 281-310.

Lai, E.R. (2011). *Meta-cognition: A literature review*. Accessed from http://www.pearsonassessments.com/research on 10 October 2011.

Lewis, C., Perry, R. & Murata, A. (2006). How should research contribute to instructional improvement? The case of lesson study. *Educational Researcher,* 35(3), 3-14.

Lucangeli, D. & Cornoldi, C. (1997). Mathematics and meta-cognition: what is the nature of the relationship? *Mathematical Cognition*, 3, 121-139.

Maree, J.G., Prinsloo, W.B.J. & Claassen, N.C.W. (1997a). *Handleiding vir die studie-oriëntasievraelys in Wiskunde (SOW).* Pretoria: Raad vir Geesteswetenskaplike Navorsing.

Maree, J.G., Prinsloo, W.B.J. & Claassen, N.C.W. (1997b). *Studie-oriëntasie vraelys in Wiskunde (SOW).* [Study Orientation Questionnaire in Mathematics (SOM).] Pretoria: Raad vir Geesteswetenskaplike Navorsing.

McNiff, J. (2008). The significance of 'I' in educational research and the responsibility of intellectuals. *South African Journal of Education*, 28, 351-364.

Meltzer, D.E. & Manivannan, K. (2002). Transforming the lecture-hall environment: The fully interactive physics lecture. *American Association of Physics Teachers*, 70(6), 639-654.

Motshekga, A. (2009). Basic Education: Minister's Budget Speech. Parliamentary Monitoring Group. Available online at http:/pmg.org.za/node/16832.

Nieuwenhuis, J. (2010). Qualitative research designs and data-gathering techniques. In Maree, K. (Ed.). *First steps in research*. Pretoria: Van Schaik, pp. 70-97.

Ono, Y. & Ferreira, J. (2010). A case study of continuing teacher professional development through lesson study in South Africa. *South African Journal of Education*, 30(1), 59-74.

Pierce, M. & Fountaine, L.M. (2009). Designing language instruction in Mathematics. *The Reading Teacher*, 53(3), 239-243.

Posthuma, A. (2011). *The nature of mathematics teachers' reflective practice*. Unpublished Thesis, University of Pretoria.

Pugalee, D.K. (2001). Writing, mathematics, and meta-cognition: Looking for connections through students' work in mathematical problem solving. *School Science and Mathematics,* 101(5), 236-245.

Seepe, S. (2004). *Towards an African identity of higher education*. Johannesburg: Vista University Press.

South Africa. Department of Basic Education (DBE). (2011a). *Curriculum and Assessment Policy Statement (CAPS) FET Band Mathematics Grades 10-12.* Pretoria: Government Printer.

South Africa. Department of Basic Education. (2011b). *Integrated Strategic Planning Framework for Teacher Education and Development in South Africa, 2011-2025.* Department of Higher Education and Training. Pretoria: Government Printer.

South Africa. Department of Basic Education. (2011c). *Report on the Annual National Assessment (ANA).* Pretoria: Department of Education.

South Africa. Department of Higher Education and Training (2011, July 15). Notice on National Qualifications Framework, Act 67 of 2008. Policy on the Minimum Requirements for Teacher Education Qualifications (Notice 583 of 2011). *Government Gazette*, 34467, pp. 3-62.

Sowder, J.T. (2007). The mathematical education and development of teachers. In F.K. Lester (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 157-223). Charlotte, NC: Information Age.

Steyn, H. (2011). Oral communication. Potchefstroom (Documents in possession of researcher).

Van den Akker, J., Gravemeijer, K., McKenney, S. & Nieveen, N. (2006). Educational Design Research. Accessed from http://www.fisme.science.uu.nl/publicaties/literatuur/EducationalDesignResearch.pdf on 27 March 2012.

Van Der Walt, M. (2006). *'n Ondersoek na Metakognisie in Wiskundeonderrig en -leer met besondere verwysing na die Senior Fase*. Potchefstroom: North-West University. (M.Ed. dissertation) 223 pp.

Van der Walt, M.S. (2008). *Aanpassing van die Studie-oriëntasievraelys in Wiskunde vir gebruik in die intermediêre fase.* (Adapting the Study Orientation Questionnaire in Mathematics for use in the intermediate phase). Unpublished doctoral thesis. Potchefstroom: North-West University (Potchefstroom Campus).

Van der Walt, M.S. & Maree, J.G. (2007). Do Mathematics learning facilitators implement meta-cognitive strategies? *South African Journal of Education,* 27(2), 223-242.

Veenman, M.V.J., Van Hout-Wolters, B.H.A.M. & Afflerbach, P. (2006). Meta-cognition and learning: conceptual and methodological considerations. *Meta-cognition Learning,* 1, 3-14.

Zohar, A. (1999). Teachers' meta-cognitve knowledge and the instruction of higher order thinking. *Teaching and Teacher Education,* 15, 413-429.

Zohar, A. & David, A.B. (2009). Paving a clear path in a thick forest: a conceptual analysis of a meta-cognitive component. *Meta-cognition Learning*, 4, 177-195.