PROBLEMS
OF EDUCATION
IN THE 21st CENTURY
Vol. 77, No. 4, 2019

FOUNDATION PHASE STUDENTS' METACOGNITIVE ABILITIES IN MATHEMATICS CLASSES: REFLECTIVE CLASSROOM DISCOURSE USING AN OPEN APPROACH

Simon Adjei Tachie
University of the Free State, South Africa
E-mail: tachiesa@ufs.ac.za

Abstract

The research findings describe a model of experiential learning that promotes the development of foundation phase student teachers' metacognitive abilities for mathematics through classroom reflective discourse using an open approach. A case study was carried out on two foundation phase mathematics classes in South Africa's universities; data were collected through observation and focus group interviews. The research's main findings indicated that student teachers' interest in reflective classroom discourse is important using an open-approach-based mathematics class, which helped pave the way for the student teachers to exhibit metacognitive abilities relevant to the teaching and learning steps of a foundation phase mathematics class. Deciding on the type of problem to work on, posing open-ended problems to colleagues for discussion in class, stimulating students' reflective self-centred learning, whole-class discussion, comparison of a particular problem and summarising important information for self-development in teaching and learning through connecting students' mathematical ideas all formed part of reflective classroom discourse. Recommendations were made for further development of metacognitive abilities.
Keywords: *mathematics class, metacognitive strategies, open approach, preservice teachers, reflective classroom, school learners, student teachers*.

Introduction

Educating the current generation of student teachers for 21st century classroom mathematics is part of a human activity that helps to develop students' mental processes. This research focused on enhancing student teachers' critical thinking, which, in turn, contributes to their decision-making processes and helps them to solve everyday problems. Considerable research attention has been paid to performance in mathematics, and researchers have identified various reasons for the poor performance of learners in mathematics worldwide. The results of a 2011 assessment by the National Assessment on Education Progress in the United State found that only 40% of American fourth-grade learners had achieved mathematics proficiency standards (Ottmar, Rimm-Kaufman, Berry, & Larsen, 2015). This finding led to the American National Reform regarding the effectiveness of teachers and their role in reversing poor mathematics achievement among American learners. Teachers play a critical role in learners' mathematics learning and achievement (Chetty, Friedman, & Rockoff, 2011; Hiebert & Grouws, 2007; Ottmar et al., 2015). South Africa has developed an assessment tool, the Annual National Assessment (ANA), to establish the cause of learners' weaknesses in mathematics at all levels in the country (Department of Basic Education, 2013). This tool assists teachers to

https://doi.org/10.33225/pec/19.77.528 ISSN 1822-7864 (Print) ISSN 2538-7111 (Online)

apply relevant skills and strategies for problem-solving, and supports teaching and learning in schools. For teachers to solve mathematics problems successfully, they must generate strategies, such as using metacognitive skills, to solve the problems. What the literature fails to report on comprehensively, in South Africa and many other parts of the world is the use of metacognitive abilities needed to develop foundation phase students' skills in mathematics through reflective classroom discourse using an open approach to mathematics. This research thus reports on a study conducted in the South African context to enhance foundation phase mathematics students' (pre-service teachers who will be teaching the first three years of school) use of metacognitive strategies for teaching of mathematics through reflective classroom discourse using an open approach.

Sustainable curriculum reform and development of any country's educational system requires that practical professional development engages university lecturers and school teachers in observing and reflecting on their learners' learning as it relates to reform practices. Some studies on curriculum reform and professional development of teachers have focused on particular countries and on specific areas of learning that have been incorporated into professional learning design (Beswick, 2014; Watson, Beswick, & Brown, 2012). A review of related literature in an international context points to teaching and learning that focuses on classroom discourse in an open approach, and which will help today's generation of teachers to enhance learners' mathematics abilities (Suriyon, Inprasitha, & Sangaroon, 2013; Usiskin, 2012). Other studies have demonstrated that acquiring mathematical knowledge and skills to improve understanding of concepts is an essential recipe for academic achievement in the future for preparing individuals to attain economic wellbeing, and to prepare them for total participation in democratic processes (Duncan & Magnuson, 2011; Foster, 2010; Siegler et al., 2012; Sitabkhan & Platas, 2018).

Related studies (for example, Teaching in the 21st Century (MT21) and the Teacher Education and Development Study: Learning to Teach Mathematics (TEDS-M); Initial Teacher Education Research Project (ITERP), a five-year study (2012-2016), initiated by JET Education Services, and National policy - Minimum Requirements for Teacher Education Qualifications (MRTEQ) conducted in South Africa have attempted to establish the best way related programmes offered by universities for training teachers for the Foundation Phase level contribute to the development of preservice teachers' mathematics knowledge. These programmes provide support in preparing student teachers for teaching mathematics successfully at the foundation phase level in schools in the 21st century (Blomeke & Delaney, 2012; Deacon, 2016; Rusznyak & Bertram, 2013).

Statement of the Problem

An increased interest in the area of mathematics education to find out how preservice teachers are prepared to teach mathematics in both primary and secondary schools has emerged in recent years (Fonseca, Maseko, & Roberts, 2018). Consequently, scholars have investigated relevant skills and strategies that can be used or applied by foundation phase student teachers to teach learners in the future. Proper classroom management using an open-approach system and creation of a positive social environment through classroom discussion may influence teachers' instructional decisions, and may contribute to effective teaching, thus having a positive impact on learners' learning in the classroom. Most studies on strategies that facilitate good classroom management and teacher development to enhance effective teaching and learning, as well as social interactions among teachers, focus on teachers using a lesson study model in schools. Nonetheless, there is scant evidence of studies on student teachers' use of classroom discourse using an open approach to improve their metacognitive abilities in acquiring mathematics knowledge for teaching and learning. The absence of student teachers' use of classroom discourse using an open approach to improve their metacognitive abilities relating to most mathematics curricula or national standards and professional development efforts in the South African education system led to the current study. To address the problem described above, the following research question was posed:

In what ways do student teachers' use of classroom discourse in an open approach help to enhance their meta-cognitive abilities in foundation phase mathematics teaching and learning?

Conceptual-Theoretical Framework

The aim of this research was to present a model of experiential learning that could enhance student teachers' metacognitive abilities in reflective classroom discourse in an open approach to mathematics classes at the foundation phase. The study involved mathematics student teachers who participated in class discussions and applied problem-solving in a professional development project for preservice teachers under the supervision of their mathematics lecturer.

The research was underpinned by a constructivist learning approach. Constructivism is considered to be a theory of learning that demonstrates pedagogical practices associated with so-called constructivist teaching, whereby a teacher encourages learners to communicate and justify their thinking during the course of solving a problem at hand. Constructivist teaching facilitates classroom discourse and identifies relevant pedagogical activities to help learners develop their understanding of a particular concept (Ni Shuilleabhain & Seery, 2018; Simon, 1995). In a constructivist learning environment, learning is driven by the problem to be solved in the classroom. Learners learn content and theory within discourse and an open approach that is founded on knowledge that is built actively by connecting and constructing new knowledge through reflective classroom discourse that incorporates manner and meaning from problem-solving activities (Ertmer & Newby, 2013). The theory is, thus, conceptualised through constructivism and metacognition, in order to change the face value of a problem through construction of new knowledge.

As a university lecturer responsible for training teachers to teach foundation phase mathematics, the researcher encounters student teachers who sabotage themselves before they even walk into the mathematics classroom for the first time. They do this as a result of a fear of intimidation by peers, based on their inadequate understanding of mathematics. It has been the researcher's experience that, before expecting these students to learn new concepts and strategies for mathematics teaching in an open approach discussion, the lecturer must, first, help students change their perspective, from "I can't", to "I see what I can already do, now let's see what else I can do". As indicated by Jagals (2015), a constructivist teaching approach reminds teachers how to craft strategies that embrace students/learners in an inclusive classroom, with the aim of achieving effective learning of the subject matter. Through these practices the teacher can become aware of and, therefore, interpret, learners' thinking and learning in order to make ongoing instructional decisions.

In this research, the researcher acted as a facilitator during teaching and learning of mathematics problem-solving in a classroom discourse project that used an open approach. Doing so enabled him to observe students (preservice teachers) in their demonstration of applied competence for conceptual understanding in problem-solving. This was done through sharing of ideas and reflection of their (students) own thinking. In demonstrating applied competence and classroom practice in the teaching of foundation phase mathematics, the student teachers were able to integrate knowledge, skills, values and attitudes in authentic, real-life teaching contexts, while they solved mathematics problems. Researchers emphasise the importance of involving student teachers in classroom discourse using an open approach, in order to improve student teachers' meta-cognitive abilities in the mathematics classroom. For example, Suriyon et al. (2013) and Usiskin (2012) described appropriate classroom discourse using an open approach that focuses on issues identified by the researcher or considered to be best practices for developing learners' meta-cognitive abilities in a mathematics class.

Studies have found that learners' academic achievement is likely to improve when they are given the chance to engage in self-regulatory activities, such as planning and managing time, concentrating on instruction, and coding information strategically (Schunk & Zimmerman, 1997) in a discoursive manner. Learners have to be explicitly taught metacognitive learning strategies for teaching and learning (Camahalan, 2006; Du Toit & Kotze, 2009; Skolverket, 2012). Recent studies noted that it is not sufficient for learners to arrive at a correct mathematical solution of a problem – what is important is their ability to justify and determine the reasonableness of their solutions, the efficacy of the approach chosen, and their ability to consider other possible strategies to arrive at the correct solution. These abilities are vital for the current generation (Skolverket, 2012; Tachie & Molepo, 2018), and the approaches can only be justified if student teachers actively reflect upon their work, or problem-solving strategies, in an open approach that enhances their metacognitive abilities. Doing so helps student teachers to learn new ways of looking at the way we teach and assess learners from a more qualitative perspective (Hill, 2012). In the same way, an emphasis on the necessity to develop student teachers' metacognitive abilities for dealing with foundation phase mathematics teaching and learning is advocated by Hill (2012), Bureau of Exceptional Education and Student Services (2010), and Hawley and Valli (1999). These researchers claimed that, in some circumstances, student teachers should not only be involved in identifying their need to be assisted; instead, they should also be involved, where possible, in designing the ways in which their needs might be addressed in order for them to develop the concept of experimentation. In other words, student teachers, as individuals, ought to perform experiments and then come together as a class to share or discuss their results. A good mathematics classroom should be an interactive environment that encourages learners to discover problems for themselves; discussions should not only include what must be learnt, but also the process of why and how to learn using different strategies (Cardelle Elawar, 1995; Department of Basic Education, 2011a; Hawley & Valli, 1999).

Importance of Metacognition

Metacognition, as defined by Flavell (1971), refers to thinking about one's own thinking, and metacognitive knowledge is gained through experiences shown by an individual or oneself. The individual sets goals for the execution of a particular task to achieve understanding, and then uses relevant strategies to monitor progress towards the set learning goals. According to La Misu, Budayasa and Lukito (2018), a metacognition profile is a natural and intact description of a person's cognition, which involves their own thinking in terms of using their knowledge, planning and monitoring of own thinking processes, and then evaluating own thinking results when understanding a concept.

The purpose of the study conducted in Kendari, Indonesia by La Misu et al. (2018) was to produce the metacognition profile of mathematics and mathematics education students regarding their understanding of the concept of integral calculus. Their findings indicated that, in the summarising category, both the mathematics students and mathematics education students used metacognition knowledge and metacognition skills to understand the concept of indefinite integrals, while, for definite integrals, the mathematics education students used only metacognition skills. In the explanation category, mathematics students used knowledge and metacognition skills for understanding the concept of indefinite integrals, whilst they only used metacognition skills in definite integrals, while mathematics education students used both knowledge and metacognition skills simultaneously to understand the concepts of indefinite and definite integrals. This means that, when training student teachers who will teach and learn foundation phase mathematics, both knowledge and metacognition abilities in classroom discourse in an open approach are important for developing students as preservice teachers.

The present research established whether foundation phase student teachers were perceived to be making use of both knowledge and metacognition in reflective classroom discourse, using an open approach that supported their understanding of mathematics. Across the globe, a similar study was conducted in six countries, namely, Taiwan, South Korea, Bulgaria, Germany, Mexico and the United States. The purpose of the research was to investigate how those countries prepared their middle school teachers for teaching mathematics to middle-school learners. The researcher found that there were vast differences in the respective countries' preparation programmes (Fonseca et al., 2018; Schmidt et al., 2007). This implies that, in preparing student teachers for the foundation phase in South Africa, relevant programmes, which help develop learners' contextual understanding about the learning of mathematics at the foundation level, should be applied to assist student teachers.

In this research, student teachers learned about various teaching and learning strategies and their application thereof in mathematics classrooms. The application of this concept (metacognitive strategies) in the current study was intended to inculcate the culture of inclusive practices in mathematics classroom discourse among student teachers, in order to develop their metacognitive abilities in the teaching of foundation phase mathematics. This would be done through sharing of ideas when engaging in problem-solving and through constructive criticism from either the lecturer or student colleagues, who served as observers. The discussion was therefore envisioned to empower student teachers to become agents for change in the implementation of classroom discourse in mathematics problem-solving by applying inclusive teaching practices, and thus, catering for a diverse learner population, including learners with disabilities, in the mathematics classroom and developing their (learners) metacognitive abilities. Through these activities, students would learn how to embrace different opinions in an inclusive environment for their teaching practices, and how to make their teaching and learning accessible to all learners, including those with disabilities.

Research Methodology

General Background

The purpose of this research was to present a model of experiential learning that would enhance and develop student teachers' metacognitive abilities in an undergraduate programme, through classroom discourse and an open approach. The research presents specific examples of skills and strategies, training practices and educational activities undertaken by the students. These have been successfully implemented in an undergraduate programme. Acquiring knowledge and disseminating it for human development in an education sector was a worthwhile undertaking.

This was a qualitative, case study that comprised one university's second-year B.Ed. students, who were aged between 18 and 45 and who served as a target group or subject of the study. They participated in a Professional Teacher Development Project that illustrated a new model of experiential learning, which was designed to enhance students' metacognitive abilities in an undergraduate programme through classroom discourse using an open approach.

Data were generated through participatory action research (PAR). Gills and Jackson (2002, cited by MacDonald 2012), state that PAR, as a form of action research, is the "systematic collection and analysis of data for the purpose of taking action and making change" by generating practical knowledge. The purpose of the research was to change the way foundation phase student teachers learn mathematics, in order to improve their metacognitive abilities through reflective classroom discourse using an open approach. The research was conducted among second-year student teachers, with a population of 150. The sample comprised 50 students. The purposive sampling method was used to select the participants as well as the class that participated in this study, following the guidelines indicated by Curtin and Fossey (2007). This university was purposively selected for the current research.

In order to understand the context as a source of data, the researcher played the role of a participating observer. Details of observations are explained in this section. This study was conducted at a university in South Africa that offers extensive education opportunities, and whose teaching management programme cuts across or covers school curricula. The innovation of reflective classroom discourse using an open approach to develop students' meta-cognitive abilities for teaching foundation phase mathematics was introduced through the Preservice Teacher Professional Development Project, which was presented in collaboration with, and supervised and monitored by a group of lecturers involved in research into mathematics education with the aim of developing foundation phase teachers' teaching of mathematics in South Africa. The applicable innovation was emphasised as an important method for developing mathematical thinking among students in a reflective classroom requiring problem-solving. Data were collected from two main sources: observation and student focus group (face-to-face) interviews. The purpose of the focus group was to ensure productive interaction between the researcher and the students in order to yield detailed, rich data sufficiently relevant to assist foundation phase teaching and learning; the discussion focused particularly on the topic being researched. Students were able to build on each other's ideas and comments suggested, in order to achieve the objective of the study. The researcher ensured that no particular group or individuals, especially by the outspoken individuals dominated the discussion. He achieved this by distributing questions randomly to the participants and also paying equal attention to the participants' discussions, in order to encourage discussion and maintain focus. Notes taking, recording of the proceedings as well as capturing of non-verbal cues were meticulously done by the researcher and, in some cases, the researcher combined the oral data with observation as a techniques for data gathering and analysis with the help of an assistant (Maree, 2007). A plan was drawn by the researcher to help him capture exactly what was said/discussed by each group and was used for data analysis in combination with observations. Permission to conduct the research was obtained from the relevant authorities.

Research Procedure

In this research, the researcher used a student-centred teaching and learning approach to collect data. The lecturer (researcher) acted as a facilitator of teaching and learning, while the student teachers occupied the central position in the teaching and learning activities. This was done so as to ensure full acquisition and meaning-making of meta-cognition, which was expressed by the students themselves as they performed reflective classroom discourse activities in an open approach that aimed to ensure acquisition of conceptual understanding of the content taught or discussed, rather than the procedural knowledge of teaching. The mode of delivery of the lesson was primarily a face-to-face, problem-solving discourse using an open approach; the students displayed different approaches to solving mathematical problems and gaining conceptual understanding through discussions, challenges, constructive criticism, open presentation and reflection in the classroom. This process enabled the student teachers to demonstrate applied competence, commitment and responsibility, all of which are required for academically and professionally qualified teachers in diverse education contexts in the country in the future.

Trustworthiness of the Study

To ensure the trustworthiness of the research, the researcher approached it from an interpretivist point of view, based on the constructivist approach that underpinned the study.

The researcher, having considered the purpose of the study, selected the relevant participants as well as the instruments. Emphasis was on the multiple realities that people might have in mind, and the different insights they might have gained through describing their perspectives and awareness, based on the reality constructed in relation to instruments and the group of people selected for this study (Cohen et al., 2001). The reality construct was done through a reflective classroom discourse that used an open approach. This, the researcher believed, enabled student teachers to display their metacognitive abilities as they embarked on various activities for solving mathematics problems. In their research, Cohen et al. (2001) noted that this might indirectly assist in future teaching and learning of the foundation phase mathematics learners.

Data Analysis

Data were analysed by means of content analysis relating to the learning of foundation phase mathematics in reflective classroom discourse using an open approach to enhance metacognitive abilities. Data were analysed at two levels, namely, discursive practices and the textual level. On the discursive level, the researcher analysed the student teachers thought processes relating to problem solving, and their abilities on the textual level. Analysis was based on what students reported about the strategy regarding reflective classroom discourse using an open approach to the development of metacognition for teaching foundation phase mathematics (Woodside-Jiron, 2011). Data analysis was done according to five procedural, open-approach-based teaching steps demonstrated by the student teachers in the mathematics class. This was based on the observation and focus group interviews. What the student teachers demonstrated in class was used to compare with what the literature reported about reflective classroom discourse involving metacognition development.

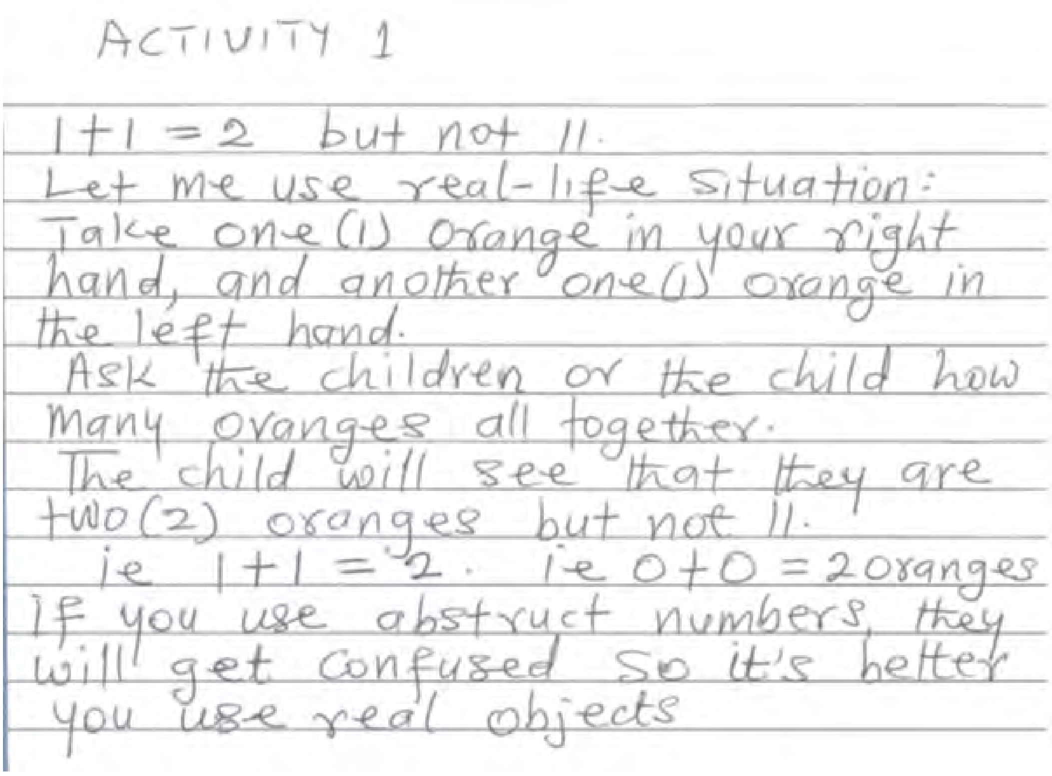
Research Results

After engaging in discourse with one another and with the lecturer, the student teachers were able to create and construct appropriate learning opportunities that developed their metacognitive abilities required to teach diverse learners. This was done by applying learning theories pertaining to mathematics, as well as general theories of learning and learner development for problem-solving. The results are presented according to the themes that emerged during analysis of the classroom observation together with focus-group interviews data. Themes refer to: (a) the kind or type of problem that should receive attention in classroom discourse; (b) posing open-ended, problem-solving questions to colleagues in class for discussion, (c) self-centred learning by students; (d) whole-class discussion and comparing methods/procedures for a particular problem; and (e) summarising important information through connecting student teachers' mathematics ideas that emerged during reflective classroom discourse.

Deciding on the Kind or Type of Problem to Work on in Classroom Discourse

Deciding on the kind of problem that must be solved is a fundamental step that leads to the solving of a problem or signals the beginning of a problem-solving situation. Students indicated that not all mathematics problems could develop learners' thinking abilities. According to them, the most difficult step in learning is to come up with new ideas. It was therefore important for the students to overcome this hurdle by deciding on the type of problem to work on. In order for them to generate ideas that were relevant to teaching and learning in foundation phase classes, students should encourage the solving of problems that ultimately help to develop or improve learners' conceptual understanding of mathematics, rather than focus on procedural knowledge. The solving of problems included situations that emanate from real-life problems.

For example, one student indicated that a Grade 3 learner was asked to give an answer to the statement, 1+1=11, and explain why the answer was not 2. When student teachers were asked to demonstrate how they would assist Grade 3 learners to understand the concept of 1+1, this was how some of the students, after they had undertaken certain activities with their colleagues, expressed their views in the open-approach, reflective classroom discourse (see Figure 1 - Activity 1).
Student 1:


ACTIVITY 1

1+1 = 2 but not 11.
Let me use real-life situation:
Take one (1) orange in your right hand, and another one (1) orange in the left hand.
Ask the children or the child how many oranges all together.
The child will see that they are two (2) oranges but not 11.
ie 1+1 = 2. i.e O+O = 2 oranges
If you use abstruct numbers, they will get confused so it's better you use real objects

Figure 1 (Activity 1). How a student explained 1+1 to Grade 3 learners.

With reference to Figure 1 above, this is what some groups as well as some individual students had to say:
Group 1, 2 and 3 students: *If not because of this study, we wouldn’t have known how we would have solve this problem using new acquired skills.*
Student 2: *The other group did excellent work through demonstration by explaining how a lecturer in the university classroom executed an activity in a conceptual manner.*
Student 3: *I have to come out of a model/designing an activity that would help me solve problems in different activities*.

Posing Open-Ended, Problem-Solving Questions to Colleagues in Class for Discussion

Students indicated that, in class, they always posed open-ended, problem-solving questions related to problem situations presented by their lecturers. Students designed templates with key points that helped them to solve the problem at hand. They explained that designing a template was the start of the problem-solving process. The template helped them to acquire relevant yet different skills to develop learners at all levels. This is what some participants agreed on:

Student 5:

> *At this stage, we have very enthusiastic in solving the problem through reflective discourse in an open-based approach whereby each one of us in the group gets chance to contribute to the success of the solution to the problem.*

According to the students, they were not concerned about how they (student teachers) reached the correct answer; instead, they were interested in the strategies or methods used in activities 1 above, and how it would help learners understand the concept. In so doing, their behaviour demonstrated the use of metacognition abilities as they embarked on trial-and-error activities to solve the problem. All these activities were identified through observation. The lecturer observed the students' desire to find solutions to the problem on their own.

Students' Self-Centred Learning

Students indicated that their self-centred learning activities started when they tried to solve problems related to real-life situations, and compared these problems to those introduced by their lecturers during teaching and learning.

Students 3 and 5:

> *It is right to compare and contrast ideas in constructive manner in an open classroom system whereby everybody is able to critique to the success of the lesson.*

The students understood that teaching of foundation phase learners should always be activity oriented; learners' metacognitive abilities needed to be considered and they should be guided on how to learn. Students therefore usually grouped themselves in the classroom under the supervision of their lecturer, and presented individual activities in turn. They were assisted by their colleagues as well as their lecturer.

Class Discussion and Comparison of Methods/Procedures for Particular Problems

Whole-class discussion was a relevant step and reflected students' metacognitive strategies for problem-solving. As already indicated at the students' self-centred learning stage, class discussion and comparison of methods/procedures enabled them to redevelop and restructure the lesson templates used during the self-centred learning stage. The students then had opportunities to compare and contrast their ideas through the open approach, through reflective discourse. This process helped them to develop their metacognitive abilities in mathematical problem-solving; they could understand and apply different conceptual knowledge to their problem-solving activities. Some students had this to say:

Student 2:

> *All lecturers should embark on this approach: develop our skills of teaching in the near future.*

Student 5:

> *In the process, I saw that wow, I could solve some difficult problems without realising it.*

https://doi.org/10.33225/pec/19.77.528 ISSN 1822-7864 (Print) ISSN 2538-7111 (Online)

PROBLEMS
OF EDUCATION
IN THE 21st CENTURY
Vol. 77, No. 4, 2019

Student 1:

What a creative ideas! Is it me to do a, b, c without fear or favour but all with joy.

Summarising Participant Information through Connecting Students' Mathematics Ideas That Emerged in the Reflective Classroom Discourse

At this stage, students had to evaluate the whole activity. Learners learn better when they know what they are supposed to learn. Students, therefore, assessed themselves based on their individual activities or whole-class discussion during an open approach. Students indicated that doing various activities under the guidance of their lecturer, together with an open approach, assisted them in understanding various concepts, and this improved their thought processes. The following sentiments support these statements:

Student 2:

What we did in class was that when the lecturer posed a problem, we, the students, try at the beginning by saying that this what we are going to do; it's about this particular content, apply your theory and dramatise it for the success of your learners. And in so doing, we were able to understand different concepts spontaneously.

Students 1 and 3:

Our lecturer never leave us alone in class. He always give us a clue of what to be learnt, then allowed us to plan, and presents activities for the success of the lesson. Because he always wanted us to serve the purpose of the lesson, his monitoring strategies helped us to achieve that for which activity-based learning was the order of the day.

Student 5:

It is better for every lecturer to have a plan at the beginning then you always have a work or engagement. For instance an ice begger [ ], so you always find someone who is an ice-begger. So the first thing that I have to look for in my activity is the ice-begger that is linked to the theory.

In most cases, it is advisable to have a video; a YouTube video could give a brief introduction to what will be done in class. Alternatively, learners could play a game, or change seats so that they sit next to someone else, or the teacher could ask learners to give feedback on the previous class in a creative way; thus they can do an activity to elicit initial engagement. Teachers also have to provide explanations of the vocabulary that will be used in a specific activity, because one cannot assume that learners know the meaning of specific words or concepts. Teachers must also always have measurable objectives for activity-based learning in class.

The final step is the conclusion, which connects students' ideas. Behaviour and students' metacognitive strategies involves evaluating validity and correctness of ideas and ways that learners performed in response to the initial problem situation. For assessing ideas and strategies, students valued effective ideas and ways, for example, of applying the idea of how to solve the problem of 1+1 = 2 but not 11, this was considered to be a simple way to solve problems through demonstration by making use of physical objects and it takes less time to do that.

PROBLEMS
OF EDUCATION
IN THE 21st CENTURY
Vol. 77, No. 4, 2019

Focus Group Discussion and Observation Based Results

Eight to ten students were distributed into six groups. These students were carefully selected into each of the six groups in order to get relevant details to supplement classroom observation data that had already been collected. Each group was given questions based on the themes that had emerged from the observation as discussed above. The groups were carefully monitored when the questions were thrown at one particular group and all information given was recorded and checked by the assistant. During the interviews, all group members under the supervision of their group leaders, were asked to pay attention to the answers given by the particular group in order to deliberate successfully and achieve better understanding of the emerging themes. It continued in this way until all data collection had been exhausted. Open-ended questionnaires were given to the students. Some of the questions included: What do you think of the discussion?; What do you like about this discussion?; In what ways do you think this discussion has helped you to achieve your classroom problems/objectives? Where were you able to obtain new information for classroom improvement? In answering of the questions, they (students) were required to start with general information and arrive at specifics. The researcher checked the responses. In analysing the answers the students provided the way they started from the general and arrived at the specific were thoroughly checked. For example, when the groups were asked to comment on the discussion based on Activity 1, this is what some of the had to say:

Group 1:

> *In fact, in our group, we were really very impressed by the way that student-teacher went through that activity to convince the learner(s) in question. It was very practical and you could see what was happening in a real-life situation, and this helps not to confuse the learners. We can now see the different between an abstract presentation and practical presentation. This is what we need to demonstrate at all times as future teachers. We also give challenging questions to learners and again give them chances to think about it and relate it to the real-life situations. This will help them to understand the real concepts the more*.

Group 3:

> *We could now see different ways of guiding our future learners by showing different skills, activities, concepts, models, pictures, etc. to make our teaching enjoyable and understandable which we never knew at the beginning. Really working together as groups and planning and sharing of ideas openly like this is really valuable and helps to build our skills and strategies of teaching small kids. Unlike the teacher who only challenged the learner by mere talking without any illustrations is not a good way or procedure of teaching foundation phase learners*.

Group 5:

> *The reason why most teachers cannot develop their skills and strategies by applying practical work in their teaching is that, in most cases, the problem may come from the Department of Education, whereby you are being forced to complete the syllabi at all cost without taking into consideration the cognitive level of the learners. When this happens, you will be forced to teach abstractly without doing illustrations of this nature and this does not help you as a teacher teaching foundation phase learners. This must in fact, be looked into by those at the management level in order to recruit teachers with relevant skills and strategies to improve teaching and learning of foundation phase mathematics*.

https://doi.org/10.33225/pec/19.77.528 ISSN 1822-7864 (Print) ISSN 2538-7111 (Online)

Discussion

The main findings of the research indicated that students' interest and involvement in reflective classroom discourse was important when using an open-approach-based mathematics class, and paved the way for students to exhibit metacognitive abilities relevant to the following teaching steps: Deciding on the type of problem to work on; presenting open-ended problems to colleagues in class, self-learning by students, whole-class discussion, comparison of a particular problem to already-solved ones and summarising participant information through connecting students' mathematics ideas. These were the themes that emerged in the classroom discourse. The findings further illustrated the importance of reflective classroom discourse in an open approach, which, as already stated paved the way for the development of metacognitive abilities, and which helped to bring successful activities for students' mathematics problem-solving to fruition. Clearly, after the activity, students could solve problems successfully; they could apply various problem-solving skills to create a positive mindset for problem-solving by designing methods/procedures for future learning and teaching, and they could continue solving problems with greater confidence. These gains support a statement by the Department of Basic Education (DBE, 2011b) that classroom mathematics in education for the 21st century generation forms part of human activities that help to develop the mental processes of the person concerned, or for a learner, to enhance logical and critical thinking, both of which contribute to decision-making processes and help to solve the everyday problems of life.

The findings, also indicated, that students' reflective classroom discourse using an open approach, and their metacognitive application abilities were poor before they were exposed to this research intervention. This is because students' responses, based on their lived experiences shared during focus group interviews, informed the researcher that reflective classroom discourse in an open approach was important in the teaching profession and needed attention. Students 2 and 5 reported as follows:

> *Student 2: This activities that we went through during this study was a breakthrough in our teaching career. It really serves as a guideline for us to practice as future teachers.*
> *Student 5: Initially I felt shy to discuss my weakness in public whereby others would get to know that I don't know this and that but now I boldly share information or ask information from others and this has opened my eyes to plan my future lessons with different strategies based on these activities that we went through.*

This assertion is in line with a review of related literature in an international context, which refers to teaching and learning that focuses on current classroom discourse in an open approach to enhance students' abilities when teaching mathematics (Suriyon et al., 2013; Usiskin, 2012). This finding is also congruent with the work of Ottmar et al. (2015); Chetty et al. (2011) and Hiebert and Grouws (2007), and confirms views in international literature that drew the attention of the American National Education Reform, and focuses on the effectiveness of teachers and their role in reversing poor mathematics achievement among American learners – teachers play a critical role in learners' mathematics learning and achievement in the country. This means that both lecturers and teachers play critical role in shaping the lives of students and learners respectively. In this regard, Student 1 had the following to say:

> *I could now see different ways of guiding my future learners by showing different skills, activities, concepts, models, pictures, etc. to make my teaching enjoyable and successful which I never knew at the beginning. Really working together as groups and planning and sharing of ideas openly, I think is a good idea for us to know as future teachers. Now I can see that I know what is expected of me as future teacher; I could develop so many concepts, ideas to solve problem unknowingly which I did not know before. This is really a hands-on information. If all our lecturers would be doing this we would find our training very easy.*

The findings of this qualitative investigation suggested that students could improve their metacognitive abilities if they are exposed to reflective discourse using an open approach. Students who solved mathematics word problems in this study reflected metacognitively on problem-solving processes and became aware of their person, task and strategy knowledge (Ertmer & Newby, 2013; Little & McDaniel, 2015). It appears that metacognitive reflection can result in more than one type of knowledge, these being, knowledge of the person and task. Students acquired skills to challenge their colleagues in problem-solving activities; this improved their metacognitive abilities. By doing so, they were able to shape their own thinking by linking it to either their previous or current knowledge (Costa, 1984; Hill, 2012). When students are exposed to such experiences, they can create activities that enhance their metacognitive abilities for dealing with the teaching of foundation phase mathematics in schools. Because they (student teachers) became familiar with different activities to be carried out at different stages by learners, students indicated that through self-centred learning, planning and by monitoring their thinking processes throughout their problem-solving activities, as well as evaluating the results of their thinking, they were able to learn a great deal before group discourse, and this helped them to understand different concepts simultaneously (La Misu et al., 2018).

The review of students' responses showed, furthermore, that, through this research intervention, they were able to propose new ideas that they had initially thought were too difficult to execute. This, they said, was very important for deciding about the type of problem to work on. For example, before they could design a template for solving a problem, there were certain steps that that had to be followed and which helped them to acquire different skills and concepts spontaneously in problem-solving. This finding supports studies that reveal that students' academic achievement is more likely to improve when they are given the chance to engage in self-regulatory activities in a discursive manner, and are explicitly taught metacognitive learning strategies for teaching and learning (Camahalan, 2006; Du Toit & Kotze, 2009; Skolverket, 2012; Tachie & Molepo, 2018). Students also indicated that this learning was successful because of the directives they received from their lecturers.

Student 5:

> *the lecturer highlighted on the difficult part first for us and later asked us to show him what we came up with. And after the lecturer had shown you that, you could then design an activity for a very difficult concept. He then went ahead to show you the theory.*

The following sentiments were elaborated on further by Student 5:

> *if the lecturer had introduced the theory first to us, we would have argued that no no we would never be able to do this, this is too difficult for us to understand and we would not be able to do but now that he showed us how to do it, it has become very easy for us to do. This according to me is how I would be teaching my learners in the near future in order to develop their conceptual understanding and metacognitive abilities as mine has been developed. If you do something first without students realising that they are engaging with the theory, and then showing them the theory afterwards, they are far more confident when attempting whatever you want them to do.*

Research Value

The purpose of this research was to enhance students' metacognitive abilities in reflective classroom discourse using an open-approach-based mathematics class for students training to become foundation phase mathematics teachers. They participated in class discussion through problem-solving in the form of a Preservice Teacher Professional Development Project effort under the supervision of their mathematics lecturer.

The preliminary review of the literature reflected on the conceptual and theoretical framework underpinning this study and discussed the background, data collection and data analysis procedures and implications for this research regarding innovation of classroom discourse in an open approach to improve meta-cognitive abilities of students training to become foundation phase teachers. Reflective classroom discourse in an open approach to improve metacognitive abilities is a new area of study, and the results of the current research will add to the existing literature on the way lecturers can assist student teachers to achieve teaching and learning of mathematics by foundation phase learners. Teachers have to have measurable objectives and must use an approach that involves activity-based learning in class.

Conclusions

In conclusion, it is obvious that students training to be foundation phase mathematics teachers can develop the metacognitive abilities required for teaching foundation phase mathematics through reflective classroom discourse using an open approach and must be encouraged at all times. This was evident through the following five teaching and learning steps that were identified by this study during observation and focus-group interviews: Deciding on the type of problem to work on; posing open-ended problems to colleagues in class for discussion; reflective self-learning by students; whole-class discussion; comparison of a particular problems and summarising important information for self-development in teaching and learning through connecting students' mathematical ideas that emerged in the reflective classroom discourse. For example, if teachers are able to set distinct objective(s) in their planning, it will inform the choice or kind of teaching and learning resources to be used by teachers, as well as the form of assessment to be administered to the learners. The objectives of the lesson can thus be achieved.

Recommendations

For further studies, the following aspects that relate to this article can be focussed on by researchers in the future.

Investigating types of problems, whether similar or different, in an open group discussion among students of the same cohort in a collaborative lesson study format can offer a possible way to increase students' metacognitive abilities for foundation phase mathematics teaching and learning.

Since reflective discussion using an open-approach process is an effective way of engaging students in an activity-oriented environment, and students feel positive about it, it ought to be carried out on regularly as it helps students to participate actively when they receive input from experienced people, such as lecturers who frequently work with different lesson study presentations during workshops with teachers and pre-service teachers.

Mathematisation assists in mathematics problem-solving through summarising important information for self-development in teaching and learning. This occurs by connecting students' mathematics ideas. It emerged in the focus-group reflective classroom discourse that students could be encouraged to embark on open-approach discourse at all times in order to develop their metacognitive abilities for teaching and learning foundation phase mathematics.

Reflective classroom discourse in an open-approach for developing metacognitive abilities among students training to be foundation phase mathematics teachers can be adapted to the South African context. A number of schools, colleges and universities can, over a period, be used for pilot studies following a design research approach by choosing a theme and a topic in the curriculum documents. This type of research will engage students in problem-solving discussions, stimulate them to reflect on their conceptual procedures, gain the understanding required to arrive at the solution, and use follow-up records for improvement.

ISSN 1822-7864 (Print) ISSN 2538-7111 (Online) https://doi.org/10.33225/pec/19.77.528

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PROBLEMS
OF EDUCATION
IN THE 21st CENTURY
Vol. 77, No. 4, 2019

Received: *May 08, 2019* Accepted: *August 10, 2019*

Simon Adjei Tachie	PhD, Lecturer, School of Mathematics Natural Science and Technology Education, P O Box 301, Bloemfontein, South Africa. E-mail: tachiesa@ufs.ac.za Website: http://www.ufs.ac.za ORCID 0000-0003-1535-7312.