THE ROLE OF TEACHERS IN DEVELOPING LEARNERS' MATHEMATICS DISCOURSE

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This paper reports on work in progress on the role of teachers in developing learners' mathematics discourse. This paper therefore presents the rationale for the study, the theoretical framework, which will guide the study. The literature review and the research design and methodology, which will be used in the study, are also presented in this paper. In my previous study, it came to light that learners could not move back and forth between informal ways of communicating and formal ways of communicating without the teacher mediating the move. However, since the focus of my previous study was on the learners, I could not investigate the role of the teacher, hence my present study which will enable me to investigate how teachers play the role of developing learners' mathematics discourse

Introduction

Developing learners' mathematics discourse is a very important aspect in the teaching and learning of mathematics. According to a study conducted by Wachira, Pourdavood and Skitzki, (2013), an important aspect of any mathematics classroom in which learners are actively engaged, is to focus on discourse. The focus on mathematics discourse not only promotes the development of shared understandings and new insights but also contributes to a shift to more mathematical language in the classroom (Manouchehri, 2007). Chapman (2006) agrees with Wachira et al. (2013) that learning any mathematics concept requires a transformational shift from less mathematical language to more mathematical language. He purports that doing mathematics is the ability to say things in appropriate ways and appropriate forms. From Chapman's argument, if learners have not developed scientific mathematics discourse, then they are not yet able to do mathematics. For example, in order for learners to understand functions, they have to understand the formal language of functions.

According to Pimm (1991), learners bring informal mathematics language to the classroom, and this is the language learners tend to use to communicate their mathematics concepts and ideas. As discussed earlier, the same learners are expected to move from using informal mathematics language to a formal mathematics language, which is presented in the language of teaching and learning.

Therefore, it is very important that learners make the move from informal mathematics language to formal mathematics language since it is an expectation in the schooling system (Neria & Amit, 2004). Learners who make the move from informal mathematics language to formal mathematics language are said to have acquired control over the mathematics register as they are now able to talk and mean like mathematicians (Pimm, 1982). Halliday (1975: 65) defines a mathematics register as:

> a set of meanings that belong to the language of mathematics (the mathematical use of natural language) and that a language must express if it is used for mathematical purposes. We should not think of a mathematical register as constituting solely terminology, or of the development of a register as simply a process of adding new words.

From the definition above, a mathematics register is more than just technical terms and vocabulary. It includes being able to argue and justify mathematics concepts using the language of mathematics. Therefore, it is important to develop learners mathematics discourse so that they are able to talk and mean like mathematicians.

In this study, I draw on Mortimer and Scott (2003) and Gee (2005) to define mathematics discourse. Gee (2005) defines discourse as language in use in any social setting such as a mathematics classroom while Mortimer and Scott (2003) define science discourse as talk which enables students to engage consciously in the dialogic process of meaning making and it is through science discourse that students acquire tools which they use to think through the scientific view for themselves. Therefore, from the definitions above, mathematics discourse in this study refers to the mathematics talk which learners and the teacher use to talk, agree or disagree about mathematics ideas and concepts in the dialogic process of meaning making in the mathematics classroom. A dialogic process is an ongoing process where learners compare and check their understanding of ideas with the ideas that are being rehearsed on a social plane. Meaning making is a dialogic process where learners bring together their ideas and work on them (Mortimer & Scott, 2003). In this study, I will focus on scientific mathematics discourse and everyday mathematics discourse.

Scientific mathematics discourse refers to the type of discourse where the learner uses scientific language to communicate mathematics concepts and ideas (Mortimer & Scott, 2003). This type of language is referred to as formal discourse, and this discourse uses specific talk or writing, using the LoLT (Setati, Alder, Reed & Bapoo, 2002). The terms used in scientific mathematics discourse are from the mathematics register.

For example, if a learner is asked to explain how to solve for x in this equation, $2x^2 + 14x - 36 = 0$, the learner has to refer to 2 and 14 as coefficients of x^2 and x respectively, and -36 as a constant in the quadratic equation. This would be scientific mathematics discourse because the learner is employing words such as coefficient and constant, which are terms from the mathematics register. Everyday mathematics discourse refers to the type of discourse where the learner uses everyday language to communicate mathematics concepts and ideas (Mortimer & Scott, 2003). For example, if a learner is asked to explain how to solve for x in this equation, $2x^2 + 14x - 36 = 0$, the learner may refer to 2, 14 as numbers and not coefficients of x^2 and x respectively, and refer to -36 as number and not a constant term in the quadratic equation. This is everyday mathematics discourse because the words used are not specific words from the mathematics register. The study will focus on the role of the teacher in helping learners move back and forth between scientific mathematics discourse and everyday mathematics discourse. According to Hedegaard and Chaiklin (2005), learning becomes very powerful if the teacher keeps in mind that everyday concepts and scientific concepts are very important and that they have to co- exist. In other words, teachers have to practice what they call a 'double move' (Hedegaard & Chaiklin, 2005), where everyday concepts are used to develop scientific concepts and scientific concepts are used to explain everyday concepts. Once learners understand and master the scientific language, they do not have to move back to everyday language (Hedegaard & Chaiklin, 2005).

The development of the mathematics discourse needs to be mediated because it requires the learner to master scientific concepts and these concepts are not acquired spontaneously or through the world of experience (Mortimer & Scott, 2003). The problem that makes my study worth investigating is that mediating scientific knowledge in a dialogic classroom is extremely hard (Brenner, 1994; Wachira et al., 2013). Developing mathematics discourse of learners in a mathematics dialogic classroom where learners' main language is not the language of teaching and learning (LoLT) is not an easy task (Brenner, 1994).

Purpose of the study

The purpose of this study is to investigate the role of teachers in developing learners' mathematics discourse in a Grade 10 functions dialogic mathematics classroom.

Research Questions

1. a) What kind of classroom environment do teachers set up in mathematics functions classroom?
   b) How does the environment set up support (or not) learner participation in the classroom discourse?
2. a) What discourses are used by teachers in the mathematics functions classroom?
   b) How does the discourse-in-use enable (or not) learners to move back and forth between informal and formal mathematics discourse in a functions class?

The research questions have been formulated using the language of the theoretical framework of the study.

Theoretical Framework

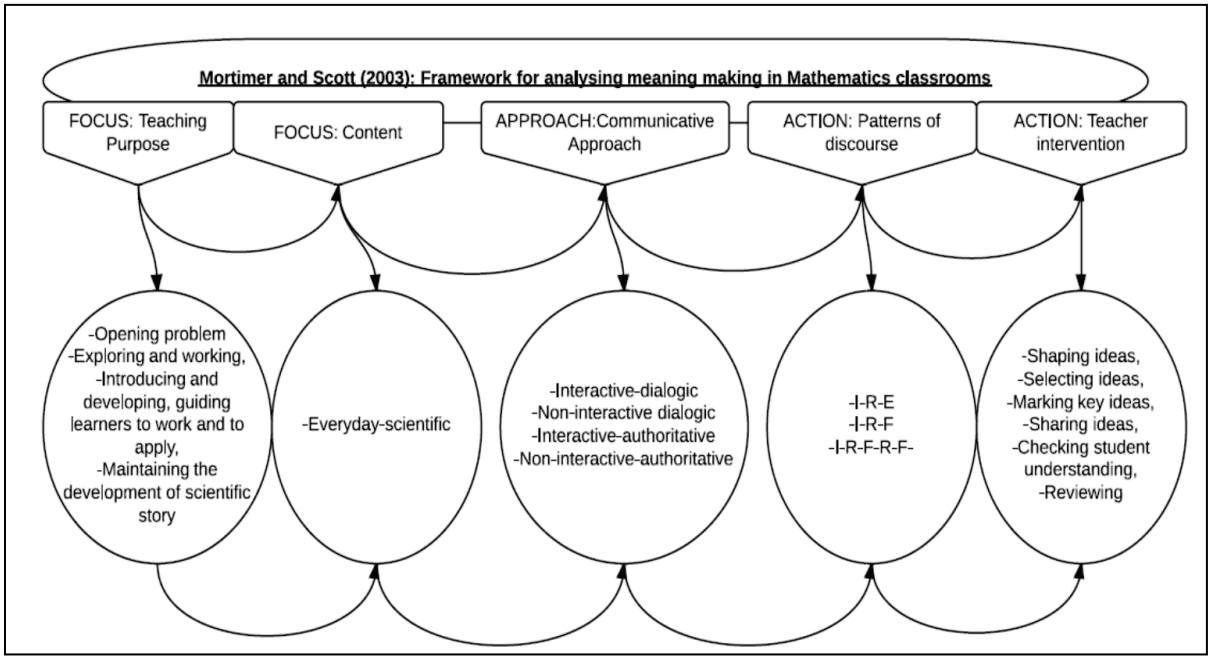
This study situates itself within sociocultural theory and therefore draws on Mortimer and Scott's (2003) theoretical framework, which was developed to analyse meaning making in secondary science classrooms. There are socio cultural theoretical frameworks that were developed within mathematics classrooms. For example Nardi, Biza and Zachariades (2012) proposed a framework for analysing teacher and student arguments. They draw on Toulmin's model which describes the structure and semantic content of an informal argument. The limitation of Nardi et al's (2012) framework for my study is that it focuses on the analysis of teacher and student argument and not on the role of the teacher in developing learners' mathematics formal arguments, which I refer to as scientific mathematics discourse in my study. Therefore, both my study and Mortimer and Scott's framework focus on discourse and that is one of the reasons why Mortimer and Scott's (2003) framework is appropriate for my study. Mortimer and Scott's theory focuses on the role of the teacher in making the scientific theory available to learners and therefore I intend to use Mortimer and Scott's (2003) framework because it provides constructs such as teaching purpose and content of the lesson that explain how the teacher plays the role of making the scientific story available to learners. Mortimer and Scott (2003) also bring the teacher to the fore of their framework and argue that the teacher is of great importance in the science classroom. This framework is therefore appropriate for my study because I will be able to use it to interpret how teachers engage learners in mathematics talk and actions while acknowledging their everyday ways of talking, in an attempt to develop their scientific mathematics discourse. Part of the challenge in using Mortimer and Scott's framework is how it can be recontextualised in the mathematics classroom.

This is a challenge that I hope to engage with in the course of my study as I analyse the data obtained using the terms used in the framework. At the heart of Mortimer and Scott's (2003) theory lies Vygotsky's theory that all learning originates from social situations where ideas are shared through talk, gestures, writing, visual images and action and each individual is able to make sense of what is being communicated and the words used to communicate provide the tools for individual thinking (Mortimer & Scott, 2003). Mortimer and Scott's (2003) framework focuses on talking, meaning making and learning within the science discourse while my study focuses on mathematics discourse. Mortimer and Scott's (2003) framework is based on three aspects which are linked together. Mortimer and Scott's (2003) framework is based on three aspects which are linked together. The aspects are: focus, approach and action. Focus is divided into teaching purpose and content, approach aspect focuses on the communicative approach and then action is divided into patterns of discourse and teacher interventions (Mortimer & Scott, 2003).

Focus	1. Teaching Purpose	2. Content
Approach	3. Communicative approach	
Action	4. Patterns of discourse	5. Teacher interventions

Table 1: Aspect of analysis (Mortimer and Scott, 2003: 25)

The diagram below shows a summary of the theoretical framework of the study.



The theoretical framework will provide me with a lens to view the teaching focus of the lesson, the approach the teacher uses and the action the teacher takes in an attempt to develop learners' scientific mathematics discourse.

Literature review

Teaching and learning mathematics in a second or third language

Many learners find themselves being taught in a language which is not their first or second language (Setati, 2002; Adler, 2000), and this may need the teacher's careful intervention. In studies which were conducted in multilingual classrooms, teachers recognised that learners needed to learn the LoLT and the language of mathematics at the same time (Adler, 2000; Setati, 2002). For example in the study conducted by Adler (2000), instructions where the teacher was teaching both the LoLT and the mathematics language created what she called pedagogical dilemma for the teacher because the teacher did not know whether to teacher the LoLT or continue with the mathematics language. Adler argues that there is no solution to this dilemma but the teacher needs to find a way of managing the situation by being aware and using careful moves during instruction.

Learners in multilingual classrooms move between languages (Setati & Adler, 2000) and cultures (Zevernbergen, 2000). Cleghorn & Rollinick (2002) refer to the movement between the culture of the home and the culture of the school as 'border crossing'. Second language learners have to do a border crossing as well as moving between their home languages to LoLT and between informal and formal mathematics language. This, therefore, means they have to navigate between numerous social languages. In his study, Cuevas found that such learners may find it very difficult to follow the academic language which their teachers use to explain terms and concepts because the language does not relate to the informal talk which the learners bring to the classroom (Cuevas, 1984). The way learners make sense of the mathematics terms and concepts which the teacher is teaching is determined by their understanding of the language (Cuevas, 1984). Therefore, the way the learners will express or communicate their mathematics concepts will also be determined by the way they understand the language which the teacher uses to explain the terms and concepts. Barton and Barton (2005) conducted a study in four schools and one university over a two year period in New Zealand. One of the aims of the study was to examine the impact and nature of language factors in the teaching of mathematics learners for whom English is an additional language. They used observation, questionnaires and interviews for data collection. Twelve mathematics classrooms were observed and 16 students were interviewed.

They found that language features causing difficulties varied across the studies, and appear to depend on the mathematical level as well as the home language and English language proficiency levels. Vocabulary on its own was not the big issue that was anticipated in their study. However, it was a component of the difficulty experienced with understanding mathematical discourse as a whole. Mathematics that was integrated with everyday contexts also caused problems for learners that had difficulties with English as a language. Most learners in this study were unable to communicate their mathematics ideas in English but they were able to communicate the same mathematics ideas in their first languages, and some of the concepts lost mathematics meaning when communicated in their first languages.

The role of the teacher in developing learners' mathematics discourse

Chapman (2006) argues that the teacher has to monitor the way learners use the language of mathematics within the classroom and the teacher has to emphasise, through classroom interaction, that learners use the appropriate language to communicate mathematics. For example, if a learner says 'the same', the teacher has to emphasise that the learner says 'constant'. For Chapman, the role of the teacher in a mathematics classroom is to emphasise the mathematics terms and ensure that learners use the appropriate language to talk about mathematics concepts and hence develop their mathematics discourse.

Wachira et al. (2013) argue for the need for teachers to show their learners that they value understanding the concepts rather than getting correct answers. Teachers need to manage the delicate balance of centralizing and guiding students' thinking while being careful not to overpower the meaning-making and dialogic process (Truxaw & DeFranco, 2007). In a study conducted by Staples and Colonis (2007) in the United States of America, they found that when the teacher allowed learners to respond to questions as a group, the learners stopped responding. When the same learners were given a chance to respond individually and explain their responses, learners became interested in responding to the teacher's questions and there was interaction between the learners and the teacher. Staples and Colonis (2007) also found that learners whose mathematics language skills were not developed struggled to take part in the interaction. Therefore, emphasising the need for classroom interaction may not be sufficient (Chapman, 2006). Deliberate teacher strategies may be required to help learners improve their mathematics language skills. Mercer and Sams (2006) conducted a study to explore the role of the teacher in guiding the development of learners' skills in using language in the mathematics classroom. The study involved 406 children and 14 teachers in schools in Milton Keynes in United Kingdom. Observations and formal assessment in experimental and control classes were used to collect data.

Data was collected through pre and post-intervention video recordings of a focal group in each target class. The study found that providing children with guidance and practice in how to use the appropriate language of mathematics would enable them to use language more effectively as a tool for working on mathematics problems together. However, in their study, Mercer and Sams (2006) did not discuss the different ways that learners can be guided by the teacher to develop appropriate use of mathematics language.

Research design

In order to investigate the role of the teachers in developing learners' scientific mathematics discourse, I will conduct a qualitative study. According to Brantlinger, Jimenez, Klingner, Pugach and Richardson (2005: 195), qualitative research design is a "systematic approach to understanding qualities, or the essential nature, of a phenomenon within a particular research" Schumacher and McMillan (1993) argue that qualitative research views reality as multilayered and interactive. In other words, reality within a qualitative research is a shared experience which is interpreted by individuals who participate in the study. Opie (2004) also argues that main goal of a qualitative study is to understand the social phenomenon from the views of the participants. Therefore, a qualitative study seeks to understand people in their real settings and the reality of the settings changes with the changes in people's perceptions. Therefore, a qualitative approach is appropriate for my study because the study will take place in a real setting, the mathematics classroom, and the researcher will not try to manipulate the teachers' behaviour in any way.

The intention is to work with ten Grade 10 teachers in phase one of the study and then six Grade 10 teachers in phase two and phase three of the study. Phase one will be pre observational interviews, phase two will be classroom observations and then phase three will be post observation interviews. The teachers will be teaching the concept of functions to Grade 10 learners in one province in South Africa. I intend to conduct the study in Grade 10 classrooms because most of the mathematics terms in functions are introduced in Grade 10. Therefore, I intend to investigate how the teacher helps learners to develop their mathematics discourse while learning new terms and concepts. The teachers in the study will be selected from 10 schools.

In keeping with the sampling strategies of a qualitative study, purposive and opportunity sampling will be used in this study (Cohen, Manion & Morrison, 2000).

According to Merrian (1998), purposive sampling strategy is mainly used when the researcher is interested in discovering, understanding and gaining insight into a particular phenomenon. Purposive sampling is very important in my study because I will be able to select information rich cases, for example classrooms which are dialogic in nature. In other words, in line with my interest in investigating the role of the teachers in developing learners' scientific mathematics discourse, it is necessary that I observe lessons where the teachers are aware of their role in this regard. Thus, the main consideration will be in choosing teachers who express developing learners' scientific mathematics discourse as their goal during the lessons. Therefore, participants in my study will be selected purposefully, and the schools will also be selected purposefully. All the schools which will be selected in the study will have multilingual settings in the classroom in order for me to be able to give a rich description of how the teachers develop learners' scientific mathematics discourse in these settings. In summary, the sample for phase 1 of the study will be 10 teachers, the sample for phase 2 and phase 3 of the study will be 6 teachers as discussed earlier. I will take one week of regular visits to schools to familiarise myself with the schools before I start the data collection process. The period of data collection will take about six to ten weeks. The lessons will be about 50 minutes long and I will record lessons for each teacher from the start of the concept of functions topic to the end of the topic. Each teacher will have a total of 8 lessons. This will give me 48 video recordings of the whole study. As I record the lessons, I will take some field notes during the lessons in order to be able to capture as much information as possible.

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