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Experiential Teacher Training for Language Diverse Mathematics Classrooms

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ABSTRACT In the Eastern Cape, South Africa, the hegemony of the English language has led to teachers and pupils interacting in classrooms through using mainly English. The intervention described in this paper introduced in-service teachers to the practice of dialogic teaching using exploratory talk in the pupils' main language. The teachers' themselves engaged experientially with triggers consisting of Raven's Standard Progressive Matrices and mathematical reasoning cartoons; and grappled with the frustrations of achieving in assessments that were written in an unfamiliar language. They were tasked with translating their experiences into classroom practice. The results of the study, indicated through teacher reflections, show that using the pupils' main language as a resource in the mathematics classroom could lead to the development of rich mathematical cognition and understanding.

INTRODUCTION

Research worldwide has shown that the introduction of dialogue and discussion in schools can enhance learning (Webb 2015; Mercer and Littleton 2007; Webb and Treagust 2006). However, dialogue and discussion are not necessarily the norm in Eastern Cape classrooms in South Africa (Webb and Webb 2008). Most pupils learn in a language which is other than their main language and many teachers share their pupils' language proclivity (Webb 2015; Webb and Webb 2013; Webb and Treagust 2006; Adler 2001), which could be a contributing factor towards the prevalence of structured, teacher-centred teaching. Most of the pupils in this province of South Africa are isiXhosa main language speakers while the official Language of Learning and Teaching (LoLT) in their schools is English (Webb 2015; Webb and Treagust 2006). Political and economic imperatives in South Africa dictate that social and academic mobility depends on English competence.

Objectives of Study

The objective of this paper is to describe an intervention with mathematics teachers concerning the introduction of dialogue in mathematics classrooms in the form of the practice of exploratory talk, using the pupils' main language, in mathematics classes where pupils are traditionally silent (for the dual reason that it is a cultural norm, as well as that the pupils are reticent to speak unfamiliar mathematical language in a language that is itself unfamiliar). The claim is that pupils' mathematical reasoning could be made explicit if they could be taught to develop a dialogue closely resembling exploratory talk by using their main language while interacting in groups. The teachers experienced and reflected on the strategies themselves during the intervention before they replicated the strategies in their classrooms and reported on the results.

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Literature Review

Setati (2008) notes that in South Africa mathematics is not only taught in English to promote understanding of the subject, but also to enable pupils to become competent in the language. Neville Alexander, as quoted from an interview in the DVD "Sink or Swim", comments that "What most people don't understand is that it doesn't follow, therefore, that they will acquire the best command of English if they are taught from day one through the medium of English. That does happen, of course, but it happens only under very specific conditions, conditions which don't exist in most South African schools" (Westcott 2004). The difference between the multilingual settings in South Africa in general, and the Eastern Cape in particular, compared with

multilingual schools in other countries is that second language pupils of the latter contexts are immersed in English communities, whereas Eastern Cape pupils have little or no opportunity to develop what Cummins (1984) describes as their Basic Interpersonal Communication Skills (BICS) in English (Webb 2010). The lack of developed BICS in English means that there is a paucity of experiential language skills available to the pupils with which to develop their Cognitive Academic Language Proficiency (CALP), as regards speaking, as well as regards reading and writing (Cummins 1984). This is particularly prevalent in mathematics contexts where pupils are confronted with the expressions and sentence structure of conversational English as well as the vicissitudes of mathematical English, with structured, specialised vocabulary.

Fundamental to a sociocultural explanation of learning and development is Vygotsky's (1978) proposal that children's intellectual development is shaped by the acquisition of language, as this makes dialogue possible between and among children and other members of the community (Mercer and Littleton 2007). Vygotsky believed that interaction between a child and others (discussion, dialogue, argument) at an intermental level becomes internalised as a basis for intramental reflection and logical reasoning – and that there is a dialectic relationship between the two so that understanding occurs through interaction with others.

Vygotsky viewed the construction of knowledge as a social activity where more able adults and peers facilitate the child's learning experiences. The knowledge gained is internalised. Gee (1994) maintains that cultural models exclude non-mainstream outsiders (in this instance pupils whose main language is not English) from contributing to educational discourse as they do not know the "rites of passage" for entry to the "club" (Gee 1994: 143). In the case of South Africa the cultural model in schools is articulated through the medium of the English language, which marginalizes those who are not fluent (Webb and Webb 2008). Gee warns that dominant discourses, particularly school-based discourses, privilege those who are "mainstream/insiders" and disadvantage those who have not yet mastered the discourse (Gee 1994: 158).

In order to counteract teaching and learning obstacles in multilingual classrooms, Planas and Setati (2009), Setati (2008), Moschkovich (2007) and Adler (2001), amongst others, have researched teacher support strategies to promote mathematical discussions. These strategies include modelling patterns of discussion and vocabulary usage, re-voicing pupil contributions, building on pupils' verbal offerings, code-switching, and acting as a language guide. The aim of this paper is to report on the implementation of an intervention to introduce teachers experientially to dialogic strategies, which advocate intertwining both English and the pupils' main language, which teachers could use in mathematics classrooms to increase instances of dialogue.

Multilingual mathematics teaching and learning has become a worldwide issue and noted researchers have conducted studies on the strategies that might aid teachers to enhance their pupils' mathematical understanding (Vorster 2008; Moschkovich 2007). There is a tension between what language experts believe should be policy and the articulation and implementation of the particular policy (Heugh 2008). Following this line of argument Heugh (2008) suggests that in South Africa after 1994 too much emphasis was placed on policy and too little on policy interpretation, implementation and teacher training. Despite research findings, which highlight the importance and effectiveness of mother-tongue education, English is the chosen language of the majority of parents and teachers in South Africa for teaching and learning because it is seen as a means to access social goods (Setati 2008). Lack of fluency in English as well as lack of fluency with specialised mathematical terms and expressions in English impedes pupils' contribution to classroom discourse.

Discourse is multifaceted as it encompasses pupils being receptive (listening, reading, interpreting) as well as being expressive through speaking, writing, gesturing and imagining (Webb 2010). Dialogue, in general, is used to mean the interchange of ideas between two sources. However, in this paper it is focused on the development of classroom talk. Mercer and Littleton (2007) have scrutinised different types of dialogue that are apparent when pupils construct dialogue thoughtfully to solve problems. The problem central to this paper is the apparently low level of dialogue and mathematical discourse that occurs in many Eastern Cape multilingual mathematics classrooms. In this paper the author has concentrated on exploratory talk, rather than other dialogic practices, as it has

been researched thoroughly with pupils of different ages in the United Kingdom and with Spanish-speaking pupils in Mexican schools (Rojas-Drummond and Mercer 2004) as well as with pupils in Science classes in the Eastern Cape (Webb and Treagust 2006). Mercer and Littleton (2007: 59) define exploratory talk as follows:

"Exploratory talk is talk in which partners engage critically but constructively with each other's ideas. Statements and suggestions are offered for joint consideration. These may be challenged and counter challenged, but challenges are justified and alternative hypotheses are offered. Partners all actively participate and opinions are sought and considered before decisions are jointly made. In exploratory talk, knowledge is made publicly accountable and reasoning is visible in the talk".

Mercer and Littleton (2007) maintain that language is 'a social mode of thinking'. It can be manipulated as a tool for teaching and learning; developing knowledge; increasing shared understanding and solving problems. Their findings support a sociocultural view of intellectual development, as proposed by Vygotsky (1978), and show positively the value of teaching pupils explicit use of language to enhance reasoning. This paper describes how teachers themselves experienced the benefits of engaging in exploratory talk during problem solving.

Exploratory talk foregrounds reasoning and, as such, it is most applicable in mathematics classrooms. Pupils present their ideas clearly and unambiguously so that they can be analysed and appraised by others in the group. They then compare possible explanations and reach decisions jointly. It thus uses conversation to reach visible, rational consensus. Unfortunately in the Eastern Cape many factors, such as teachers' lack of content knowledge and lack of fluency in English, conspire to make the majority of the mathematics classrooms resemble Alexander's description above (Webb 2010). In these classrooms practice of exploratory talk may not necessarily occur spontaneously.

Exploratory talk has to be taught explicitly and practised continually for results to be evident (Mercer and Littleton 2007). To this end, pupils should be taught that their understanding requires a high level of speaking and listening (in whichever language that they understand best). In order for this to occur ground rules for speaking and listening should be formulated collectively by the teacher and pupils. Discussion should include all participants and mutual respect should be afforded for all persons, opinions and ideas; all relevant knowledge and information should be shared and not withheld; reasons should be requested and given for all claims; and the groups should strive to reach agreement (Mercer 2004).

If pupils could recognise the advantages of using group work, it may encourage them to engage with each other more. Attending to a range of ideas could help pupils to reach a more informed decision by learning how 'to think aloud' and expressing their ideas with confidence. By engaging in group work pupils are able to think more clearly when alone. By helping others to learn pupils clarify their own understanding. Talking allows pupils to reflect on how and what they have learned. Often pupils come to the conclusion that they can learn better together than alone. This development can only take place through the conscious guidance of the teacher, who is far more than a facilitator of learning, but "someone who can use dialogue to orchestrate and foster the development of a community of enquiry in a classroom in which individual teachers can take a shared, active and reflective role in building their own understanding" (Mercer and Littleton 2007: 74). The teacher becomes a key discourse guide and models ways of developing exploratory talk by asking for reasons at appropriate times and reviewing with the whole class what has been achieved and what they may have learned. During the review plenary session at the end of a lesson the teacher can model the mathematical terms and concepts that the pupils have encountered – and the new mathematical words, sentences and discourses that may have been introduced in English. In this way English terms are correlated with the mainly isiXhosa terminology that the pupils have used in their dialogue.

METHODOLOGY

The paper describes an intervention over six months with a cohort of 179 practising teachers who were studying for a university qualification in urban, semi-urban and rural areas of the Eastern Cape, South Africa. They were studying for a module which formed part of a qualification curriculum that was designed to introduce teachers to the theory and practice of dialogic prac-

tices, especially exploratory talk. The module aimed to encourage them to become participant observers in their own classrooms where they reflected on their own language practices and were required to comment on the use of exploratory talk in their classes. All the teachers had more than five years' teaching experience. Qualitative data were generated from written reflections sparked by open-ended questions of a questionnaire. Various exercises were introduced in the module and the data generated by the teachers' experiences while being engaged in the exercises were qualitatively analysed. The research methodology also used teacher reflections and descriptions of their lessons in which they focused on dialogic strategies. The researcher conducted workshops in all areas, thus was able to observe the teachers' reactions and hear their reflections as she had easy access to the teachers and was able to build up a rapport with them over the six-month course of the contact sessions.

The aim of the experiential exercises used with the teachers was to make them aware of strategies that could be effective when teaching mathematics to multilingual pupils, with the emphasis on exploratory talk. Examples of the exercises they participated in were:-

1. They wrote a numeracy assessment in a language that was not their main language;
2. They were given triggers to precipitate group discussion;
3. They conducted their own mini research projects in order to introduce exploratory talk in their classrooms.

These were all opportunities for holistic learning and knowledge construction.

So that the teachers could relate to the pupils' difficulties while writing assessments in a language that is not their main language, they were given a numeracy assessment to complete. The teachers whose main language was isiXhosa were given copies of the test in English; the teachers whose home language was English were given copies in isiXhosa. After the exercise a discussion highlighted their emotions and frustrations with the inability of some of them to understand the questions even when they were convinced that they knew the correct answers.

This exercise gave the teachers an experiential gaze into the realities that are current in their classrooms. The teachers shared the frustration of their pupils as they looked for language clues to scaffold their meaning. The teachers discussed at length in their groups the language support offered in the test by the graphics attached to the written questions, for example, a diagram of a ruler and pencil to illustrate measuring the length of the pencil. They recognised contextual clues and discussed how they would be able to implement similar support in their own classes. An outcome was their insistence that pupils would not be able to answer a test in their main language as their literacy competence in their primary language was so poor. The hegemony of English is usually propounded as the reason for choosing English-only over mother tongue education (Setati 2008), but it seems that the hegemony of English has marginalized the mother tongues insidiously so that the main language is devalued to the extent that pupils are no longer, and do not wish to be, literate in these languages. This means that there is both an internal motivation for the choice of English only (illiteracy in mother tongue) and an external motivation (the lure of social goods). The teachers also mistrusted translations because of the variation in dialects. They felt that they were conditioned to think mathematically in English so that thinking mathematically in isiXhosa would be an added struggle. Through this exercise, they not only experienced the realities of their classroom but they also learned the value of scaffolding mathematical problems by using language skills and graphic organisers.

The researcher introduced triggers in the form of Raven's Standard Progressive Matrices (RSPM) items and mathematical reasoning cartoons to guide the teachers towards critical thinking and reflection (Raven et al. 1998). Because the teachers taught mathematics in different phases, there could have been a power relationship in their groups that could have limited their interaction. If one person had known more mathematics than the others, he or she could have dominated the group interaction. Triggers, to which none of the teachers had been exposed, were used in order to raise their consciousness about the forms of dialogue in which they were engaging. The triggers were used to enable teachers to develop their own appropriate language in either mathematics or English or both. The teachers, in groups in each centre, developed their own particular set of ground rules for the introduction of exploratory talk; the teach-

ers worked first individually then in groups to solve examples from the RSPM test and then they worked with the mathematical reasoning cartoons, practising the agreed tenets of exploratory talk so as to cement in their own experience the advantages of dialogue in problem solving.

RSPM items consist of diagrammatic, visual problems and are used to test cognitive skills. These tests are used extensively in psychology and education as a test of non-verbal reasoning. The test is divided into 5 parts (A, B, C, D, and E). Each part has 12 puzzles (60 in total) in increasing degrees of reasoning difficulty. As the tests are language-free, but use mathematical patterns, they were chosen as appropriate triggers for the intervention.

The teachers had to decide in groups which of the possible eight given options would best fit a gap left in the visual pattern. In their groups they practised abiding by the ground rules for exploratory talk in their main languages. These discussions also enabled them to approach problem solving in groups where the object was not only to solve the problem, but to tease out the verbal mechanics of moving towards consensus. Each group presented its collective reasoning in a plenary session.

Another trigger to develop exploratory talk in the teachers' main language was the implementation of mathematical reasoning cartoons. The use of cartoons to encourage reasoning in a science context was first conceptualized by Naylor and Keogh in 2000. The cartoons are designed to have a minimum of text and are drawn simply. They are designed to promote reasoning and discussion. An aspect of the cartoons that has an empowering effect on the teachers is that the sense of 'unknowing' can be transferred onto the children depicted in the cartoons. Various viewpoints are expressed about the topic, some indicating typical misconceptions, and other views expressing alternative answers. Dabell and Mitchell (2007) published a set of Mathematics Concept Cartoons, which were redrawn and adapted to suit the context and curriculum of South Africa. Each situation shows pupils discussing an alternative mathematical conception.

For example, in the mathematical reasoning cartoon depicted in Figure 1, the pupils are debating the answer to an addition calculation with fractions. The pupils around the table each have a different perception. The objective of a mathematical reasoning cartoon is for the pupils to discuss their own perceptions in the light of the statements in the mathematical reasoning cartoon and to analyse which opinion(s) expressed in the cartoon bubbles are mathematically correct. Ultimately they should devise a mathematical statement of their own which describes the scenario depicted, preferably in the form of "I think… because…"

The discussion in groups about the mathematical reasoning cartoons helped the teachers to ground the practice of exploratory talk in mathematical activities. They were encouraged to focus on their dialogue; to notice when they were using instances of exploratory talk (for example: "The right answer is 6 because the pattern is 3, 4, 5 in a different order in each row"; "I disagree, because there must be lines, squares and crosses in each row, so I think it must be 3"). They were also made aware of the language they used in dialogue – was it mainly their main language or English?

In these two tasks the teachers realised how difficult it was to apply the ground rules of exploratory talk when they were trying to solve a problem. Because of this experience they realised that they would have to coach their pupils continually (Mercer and Littleton 2007).The investigation thus enabled them to experience the value of learning and practising the ground rules of exploratory talk – and the difficulty in adhering to them. Often the voice level of their conversations increased as they tried to shout each other down; they did not listen to each other as they wanted to have their own point heard; and they focused on the correct answer rather than giving reasons for their statements - issues which they would have to control in their classrooms.

Through the experience of participating in the same exercises that they could use in turn with their pupils, they became aware of the objectives of the exercise; interacted together to reach a solution; and practised exploratory talk They were able to experience in practice Vygotsky's (1978) concept of the Zone of Proximal Development (ZPD) when a more capable peer could guide them towards a solution. The exercise also showed them experientially how much more comfortable they felt discussing their reasoning in their main language than in English (Setati 2008 et al.); and how much the discussion enabled them to reach informed consensus on the answer (Mercer and Littleton 2007).

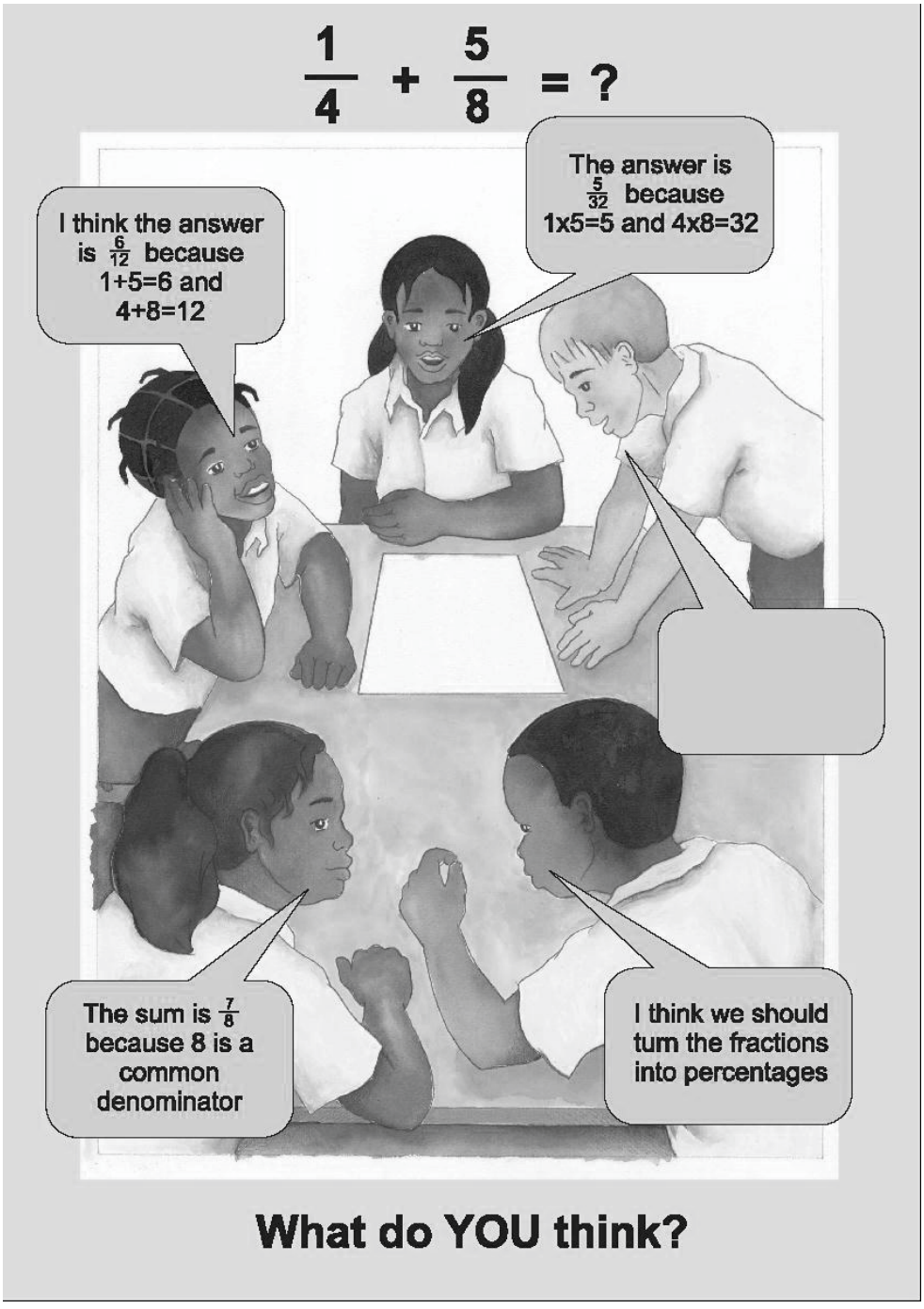

Fig. 1. Example of a mathematical reasoning cartoon
Source: Author

The mathematical reasoning cartoons highlighted common misconceptions in basic mathematics which were printed as statements attributed to the children in the cartoon. Exploratory talk enabled the teachers to question the authority of the text as some of the statements by the pupils printed in the cartoon were incorrect. This exercise again gave the teachers an insight into the problems faced by their pupils. They could also experience the power of dialogue and collaborative learning in their groups (Mercer and Littleton 2007).

After a period of introduction and practising, could the teachers in turn promote and implement exploratory talk successfully in their mathematics classes? They were asked to conduct a mini research project with their pupils by introducing exploratory talk using the pupils' main language as a resource, and to write an assignment on their experiences and insights concerning their own research; as well as to reflect on the efficacy of the exercise. The research assignments were designed to give the teachers exposure to the plan-act-observe-reflect cycle of action research. They were required to:

- Develop lesson plans that would in part introduce exploratory talk utilizing the pupils' main language;
- Implement the lessons in their classrooms;
- Observe the pupils' engagement with different types of talk;
- Reflect on the lesson in their written reports.

The teachers reported their findings in both oral comments in class, in written assignments and in a questionnaire.

RESULTS

The results indicated overall that the teachers could introduce dialogic strategies in their multilingual mathematics classrooms with varying degrees of success. By writing up the interactions and answering open-ended questions it became clear that the teachers had genuinely engaged experientially with the strategy.

The results will be discussed according to the three activities the teachers engaged in as described in the methodology:

1. They wrote a numeracy assessment in a language that was not their main language;
2. They were given triggers to precipitate group discussion;
3. They conducted their own mini research projects in order to introduce exploratory talk into their mathematics classrooms.

The activities were designed to provide an opportunity for the teachers to put the theory they had learned into practice and give them the confidence to implement the strategies in their classrooms.

In the first exercise where the English-speaking teachers were given the isiXhosa translations of the assessment to complete as though they were under examination conditions.

Their reactions were similar in the urban, semi-urban and rural areas:

"I totally disengaged";
"I lost interest";
"Not good";
"I got on with other work";
"Irritated, upset, you can't help yourself";
"I was exhausted to work in a language I can't understand".

One teacher commented.

"We now understand the importance of group work, and social work - peer learning, the importance of getting pupils to talk. That's where real learning takes place. We know from this practical example. I now know why students just write out the exam paper during an examination, because you can't bear to be doing nothing. You don't want to stand out and look as though you are stupid. You want to be seen to be writing as though you know what you are doing".

The isiXhosa-speaking teachers were not comfortable writing the test in their main language. A teacher from a rural area commented:

"For isiXhosa-speakers it was difficult because we have been conditioned. When we see a mathematical problem it is in English, not in isiXhosa. So we struggle to interpret what it really means from isiXhosa to English".

Many teachers said they felt the translation was incorrect, despite the fact that the translation had been checked by two isiXhosa linguists at the university. They debated the choice of different words. Some teachers claimed that if the pupils wrote assessments in isiXhosa they would battle as pupils cannot read or write in their vernacular, although they speak isiXhosa fluently. They felt that the mathematics register should be developed in isiXhosa so that teachers and pupils could speak the language of mathematics in their main language. However, a ca-

veat was raised about the different dialects of isiXhosa. They felt it would be difficult to come to an agreement about the correct isiXhosa word to use for a concept.

As regards the second exercise, when discussing solutions to the triggers the teachers' arguments became more and more refined – and more mathematical. The teachers interspersed their colloquialisms with mathematical terms as they started talking about parallels, diagonals, vertical, horizontal and mathematical operations. Their reasoning and discussion progressed from informal talk to mathematical discourse. In a discussion after this exercise, the teachers in an urban setting commented on how exploratory talk could help in solving geometry riders as they felt that each pupil could bring a different gaze to a geometry rider and, through dialogue in the pupils' main language interspersed with English, they could reach a consensual conclusion by constructing their own meaning.

The teachers were required to account for the steps they went through in order to reach consensus in their group when using each trigger. Their reflections at the end of the workshops indicated that they were amazed at the depth of understanding that they had achieved through using the ground rules that they had developed for their own exploratory talk, which in turn were based on those of Mercer and Littleton (2007). The exercises with triggers elicited the following themes: the advantages of group work; the advantages of developing and adhering to ground rules; the power of dialogue in the form of exploratory talk that enabled students to solve problems that they were unable to do without the aid of a more-knowledgeable peer (Vygotsky 1978). An added construct that emerged was the general feeling that group work decreased anxiety.

Concerning the third exercise, the research assignments produced by the teachers, vignettes of authentic exploratory talk were transcribed and the pupils' reflections recorded. The main theme that emerged from this exercise was that teachers were able to demonstrate that, after an intervention, they could orchestrate the use of exploratory talk with their pupils in their mathematics classes. In the assignments teachers reflected on their own experiences, and reported feedback from the pupils, about the introduction of exploratory talk in their classrooms. The teachers mentioned the collegiality and security that the group work afforded the pupils:

"It does help because if a pupil makes a mistake someone will say it is wrong and will explain why it is wrong. At the same time talking in groups gives the pupils confidence to talk in front of other pupils - and then in front of the teacher."

They also reported that they concentrated and became engaged with the problems that they were tasked to solve. Exploratory talk aided their understanding:

"Exploratory talk helps them to be more focused on what they are calculating. It makes them look at things in a different way and to read the questions carefully before answering it."

"It helps because they get to understand why things are the way they are. They are given a chance to be wrong and find out why they are wrong, and they are helped in understanding things much better. They are not just left to find for themselves."

The teachers felt that the pupils also took cognizance of the ground rules of exploratory talk:

"If one person's talking they can't barge in and talk in front of them."

The teachers also voiced their opinions on exploratory talk. They mentioned particularly the use of the pupils' main language during group interactions:

"Exploratory talk helped my pupils to stimulate them to take part in the discussion by allowing them to use their own language of choice. They were code-switching whenever they feel like."

The introduction of ground rules together with exploratory talk had an effect on the pupils' behaviour as well as critical thinking skills:

"It also improved their inter-personal relations as they paid respect to one another. Their interaction within the group improved the listening, leadership and communication skills of the pupils as in the ground rules they were required to listen to each other and respect each other's ideas."

"By justifying the counter-argument by using valid reasons, the discussions were interesting and of a high quality. There was a joint thinking which was critically evaluated by all the members of the group. Ideas were challenged but at the end members of the group put

suggestions and alternatives and came to a consensus."

The perennial arguments associated with group work, about time consuming practices and increased noise, were aired:

"It takes so much time. There is noise during exploratory talk."

One urban teacher touched on the difficulties pupils had in sticking to the ground rules. She realised that both she and the pupils were learning the strategy together as she comments, *"When WE attempted the second problem"*. She identified with her pupils and showed solidarity with them.

"It was interesting to watch mixed groups as they did different things. Two groups were using what they considered to be exploratory talk. After the first problem I asked them to reflect on their discussion and they realised that at most times they were not actually using exploratory talk. When we attempted the second problem they guarded themselves and they tried to implement exploratory talk although they were struggling to follow the ground rules. When it came to writing they struggled to translate their ideas into mathematical language since they used their mother tongue during their discussion but they battled to translate the mathematical concept of compound and simple interest into English words and symbols".

The teacher also mentioned the difficulty pupils had when moving from the spoken to the written word and the difficulty in translating from everyday isiXhosa to mathematical terminology.

DISCUSSION

In the reflections and evaluations after the intervention, the teachers expressed their appreciation of the opportunity to experience feelings of alienation and frustration (with the assessment task); feelings of exploration and extension (with the action research assignment) and awareness of the power of dialogue (in their group interactions).

The teachers were sensitised, through personal experience during the intervention sessions, to the frustrations some pupils feel when being assessed in English. They demonstrated how to use language and contextual clues to scaffold meaning; learned how to scaffold mathematics problems by using language skills and experienced the practice of exploratory talk (Mercer and Littleton 2007). They saw experientially how Vygotsky's (1978) ZPD could be utilised and they realised the power of using their main language in dialogue in their groups (Setati et al. 2008). The results suggest that the intervention provided opportunities for teachers to promote dialogic teaching.

In a subsequent study (Webb 2015) exploratory talk was introduced to three different cohorts of teachers by using mathematical reasoning cartoons. In the first cohort the teachers used mathematics reasoning cartoons that were imported from the United Kingdom; in the second instance expert mathematics teachers constructed the cartoons that were used in a South African context; in the third instance teachers constructed their own cartoons using their pupils' alternate conceptions from their test and examination scripts. In all three cases the results indicated that the pupils' reasoning skills increased after the use of dialogic practices, especially the development of exploratory talk.

CONCLUSION

Although the sample described represents a small portion of the mathematics teachers in the Eastern Cape, South Africa, the results of the intervention indicate that teachers can be persuaded of the advantages of teaching and learning as a social activity. Teachers can be introduced experientially to the benefits of using dialogue, in the form of exploratory talk, to clarify mathematical reasoning. They in turn can transfer dialogic methods into their classrooms with varying success. The teachers themselves experienced an improvement in their mathematical discourse as they practised exploratory talk in groups.

In this paper three parts of an intervention are described– an assessment in an unfamiliar language (to sensitise teachers to the pupils' experiences); problem solving in groups using different types of triggers (to experience the power of dialogue in the form of exploratory talk); an action research assignment (to assess the effect of introducing exploratory talk in their classes). The intervention is uncomplicated and has the potential to be easily, and affordably, expanded and transferred to other areas and other teachers so that discussion and dialogue can be introduced as a teaching strategy to enhance mathematical learning.

RECOMMENDATIONS

A dual role for teachers of teaching mathematical competence as well as teaching English competence might be addressed through careful planning and implementation of exploratory talk as a teaching strategy. Further research could study the effect of an intervention that includes, either jointly or severally, talking, reading writing and critical thinking in order to ascertain whether mathematical reasoning could be further improved.

In an area where pupils are constrained by their knowledge of both mathematics and English, strategies that enable them to harness their innate verbal fluency in their main language as well as to garner the aid of a more able peer could only be an advantage. With constant encouragement for the implementation of dialogic practices in multilingual mathematics classrooms, the move from informal mathematics talk in the pupils' main language to formal mathematical discourse could be achieved in time.

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