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# Teaching Strategies in Language-Diverse Mathematics Classes: A Case Study

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**Abstract**

This study was located in a mathematics classroom in a township school in Port Elizabeth. After an intervention designed to raise awareness of dialogic teaching practices, three teachers introduced exploratory talk, with varying degrees of success, into their mathematics classrooms. Because English, the language of teaching and learning, was not the main language of either teacher or pupils, the emphasis was on integrating isiXhosa into the lessons through exploratory talk in order to build a community of practice. Research has shown that the introduction of dialogue, in the form of exploratory talk, enhances mathematical reasoning skills; however, lack of English competence restricts the development of mathematical discourse among pupils. Through classroom observations and interviews, complementary teaching strategies used by one of the teachers were identified as appearing to improve pupils' mathematical skills. The uses of group work, judicious questioning, implementation of second language teaching techniques, and the development of a positive classroom climate echo Wenger's (2011) prerequisites for a community of practice: domain, community, and practice.

Keywords: Strategies; Mathematics; Dialogue; Community of Practice.



## Introduction

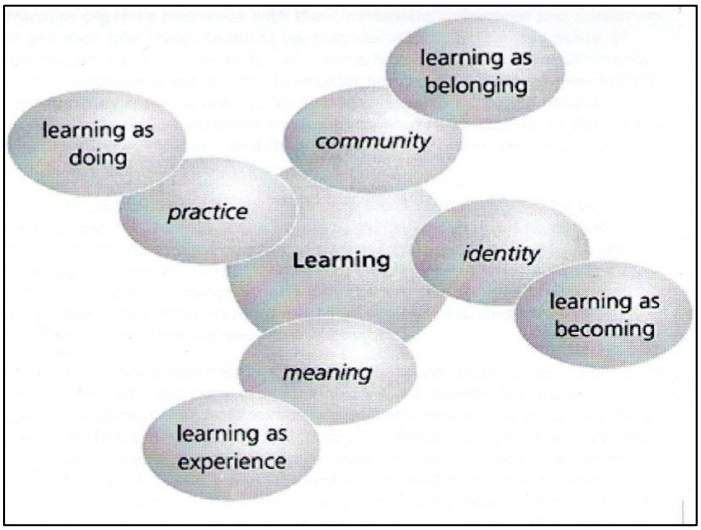
In the majority of South African mathematics classrooms, English is not the first language of either the teacher or the pupils. Teachers are faced with the challenges of not only teaching pupils to be competent in English, the language of power and access to social goods (Gee, 2004; Setati, 2005), but also to understand mathematical concepts that will open doors to tertiary education and career mobility. Transmission style teaching is not peculiar to South Africa; the triadic pattern of teacher initiation, pupil response, teacher evaluation (IRE) is evident in many parts of the world (Chall, 2000). However, when pupils are constrained to using only individual mathematical terms in English, their lack of confidence in communicating reinforces the IRE cycle. Dialogic discourse is more likely to lead to conceptual understanding than univocal discourse (Bakhtin, 1981; Mercer & Littleton, 2007). This article is an extract from the research work reported on in one of the authors' doctoral thesis, *Searching for common ground: Developing mathematical reasoning*

*through dialogue* (Webb, 2010), however, the use of Wenger's framework as a lens to analyse the teacher's practices is a new gaze on the data.

The study was underpinned by a sociocultural framework. Vygotsky (1978) maintains that the construction of knowledge is developed through social interaction. This position is confirmed and expanded by Wenger (2011, p. 1) who uses the term *communities of practice* to refer to "a group of people who share a concern for shared practice, and learn how to do it better as they interact regularly." Communities of practice are formed by people who "engage in a process of collective learning in a shared domain of human endeavour" (Wenger, 2011, p. 1). This concept provides a useful perspective on learning, with the focus being that learning involves social interaction.

Wenger's (1998) framework for learning consists of four components: community, identity, meaning, and practice. He posits that these components need to be integrated for successful learning to take place as a process of cooperation within a community. He defines the component of community as *learning as belonging*, the component of identity as *learning as becoming*, the component of meaning as *learning as experience*, and the component of practice as *learning as doing*.

**Figure 1: Wenger's (1998) framework of learning**




For a community of practice to exist Wenger (2011) suggests three essential components: domain, community, and practice. The membership of a community of practice requires a shared commitment to the domain and it is shared competence that begins to coalesce the members into a group. In this study, the domain is the understanding of, and competence in, mathematics. The community is built by members sharing in joint activities and discussions, and growing relationships that enable them to learn from each other. The development of exploratory talk engenders joint discussions and facilitates shared learning. Practice results from a "shared repertoire of resources: experiences, stories, tools, ways of addressing recurring problems—in short a shared practice" (Wenger, 2011, p. 2). Community of practice members build relationships that help them to learn from one another. Again, the dialogic nature of exploratory talk encourages shared practice as pupils strive to reach consensus.

Dialogue is a powerful learning tool that assists pupils by identifying gaps in their own understanding and in so doing helps them to construct knowledge. Conversations, whether individual, in small groups, or as a whole class, all develop reasoning and problem-solving abilities as well as build self-confidence and improve social skills (Wenger, 2011).

Truxaw and De Franco (2008) maintain that the mere presence of talk does not constitute meaningful talk and that it does not necessarily lead to understanding, but that the quality and types of discourse are crucial in leading to conceptual understandings of mathematics. Mercer and Littleton (2007) concur with that view in their own analysis of talk. They describe types of talk as follows: disputational talk is talk where participants agree to disagree, but where no reasons for decisions are given; cumulative talk occurs when participants simply agree with each other's opinions without engaging with the issue; exploratory talk, which is in their opinion, the most educationally sound method of communication. Mercer and Littleton define exploratory talk as talk:

> *in which partners engage critically but constructively with each other's ideas. Statements and suggestions. ... 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 … knowledge is made more publicly accountable and reasoning is more visible in the talk. (2007, p. 59)*

This research study was prompted by the research question: What teaching strategies do teachers employ in order to teach mathematics understanding in language-diverse classes? The practices of three teachers in similar schools in Port Elizabeth townships were observed and analysed in a previous study (Webb, 2010). The practices of one teacher, who seemed to embrace Wenger's theory in practice, are scrutinised in this article to ascertain whether the learning that seemed to take place during an intervention designed to raise awareness of dialogic teaching practices (as indicated by the differences between the pre- and posttest results) concurs with Wenger's framework.

## Research Design

Three teachers were observed in a preamble study over a period of 9 months, using an observation framework, as they taught Grade 7 mathematics classes. During this period, the teachers attended an intervention where the tenets of exploratory talk were explained and they themselves learned experientially how to recognise exploratory talk in dialogue and to acknowledge that discursive practices in a mathematics classroom increased mathematical reasoning. All three teachers spoke isiXhosa as their first language; they were, however, fluent in English. Their Grade 7 pupils completed pretests before the intervention and identical post-tests 9 months later on mathematical reasoning, numeracy skills, and English skills. Both quantitative (differences between pre- and posttests) and qualitative (classroom observation) results were analysed and written up elsewhere. Although the mathematical reasoning in all three classes improved considerably, the pupils from one school showed statistically significant gains over the other two schools. The practices of the teachers were then analysed to gauge what strategies had been employed that could have contributed further to the differences in scores. When comparing the teaching practices of the three teachers, it became clear that additional strategies could be identified as being integral to one teacher, but were largely absent in the other teachers' practice. The strategies identified were group work, questioning techniques, use of second language teaching strategies, and the engendering of a positive classroom climate. It appeared these strategies could explain the quantitative results showing the gain in one class to be statistically significantly higher than in the other two.

This article describes the practices of one Grade 7 mathematics teacher, Mr Graham (a pseudonym). Here, two lessons conducted by Mr Graham will be described as he teaches fractions through encouraging meaningful dialogue between teacher and pupil, and pupil and pupil (Barwell & Kaiser, 2005). At the conclusion of the intervention, an interview was held with Mr Graham to enable him to reflect on his experiences during the intervention and observation processes.

## Background

Mr Graham is an experienced teacher who has taught for more than 15 years. The location of the school is in the middle of a township. When the study took place, the classroom was observed to be overcrowded. There were 45 pupils seated at tables arranged in three rows running the length of the room. Pupils were seated on both sides of the tables. There was very little room for a teacher to pass among the pupils, however, observation indicated that the pupils were used to group work because they readily congregated in twos or fours when instructed to do so. Noise from the adjoining classroom filtered continually through the partition separating the rooms. Mr Graham and all the pupils in the class spoke isiXhosa as their main language although the language of learning and teaching (LoLT) in the school was English.

Mr Graham planned a series of lessons on fractions during which he initiated the ground rules of collaborative exploratory talk with the pupils. Examples of ground rules were, amongst others: everyone in the group must participate; listen when someone else is talking; give reasons for all your statements; and, you may disagree if you have a different answer (Mercer & Littleton, 2007).

## Lesson One: Comparison of fractions

Mr Graham started the lesson with a question:

> *What do we say about things when we compare them?*

He posed a question that would lead towards the lesson outcome: that by the end of the lesson the pupils would be able to compare fractions, for example, they would be able to compare a half and a quarter. He used an everyday example by asking how the pupils would compare the heights of two girls he pointed out that:

> *Zuki is taller than Yolisa.*

He then asked the pupils to describe a fraction and asked for examples. These questions were posed to elicit prior knowledge.

He gave each pupil a sheet of paper which they folded into four quarters horizontally to represent a *fraction ruler*. One folded row represented one whole; the next row was divided into two halves, the third row was divided into four quarters, and the bottom row was divided into eight eighths. He used this manipulative throughout the lesson to visually compare the sizes of fractions. Mr Graham introduced the word *denominator* and wrote it on the board. The pupils chorused the sound. He challenged the pupils to think:

> *Because eighths are smaller than a half, will halves always be greater than a number of eighths? Why? Will five eighths always be bigger than one half? Why?*

His questions were posed to encourage reasoning and logical thinking. He then moved, from the concrete, to mathematical manipulation by explaining that one could not always use a physical tool but had to know how to multiply fractions:

*What do you do mathematically to get from* $\frac{3}{4}$ *to* $\frac{6}{8}$ *?*

He emphasised that they should multiply by 1, but that the number 1 could be written in many guises, with the same numerator over the same denominator. In this way, he reinforced the meaning of the mathematical terms by writing them on the board so that the pupils both heard and read the English terms.

### Questioning

Although long exchanges did not always take place, Mr Graham asked questions continually to stimulate the pupils' thinking and he encouraged participation, pausing to allow a pupil to react, if only by giving a one-word answer:

*What do other people think?*

*Do you agree with that or don't you agree with that?*

*What do you think about what she has just said?*

He used questions to maintain interest and alertness, and to discover if the pupils understood what he was teaching. The pupils did interact with the teacher because they had to continually field questions that required them to think, not just reiterate the teacher's utterances.

### Group work

At one stage, he asked a question and instructed:

*All those who have their hands up should tell those who don't have their hands up what you have done.*

The pupils spoke to each other in isiXhosa and leaned physically towards each other, pointing to their work. In this lesson, there were no other instances of organised group work, but the pupils chatted to each other informally in groups as they worked.

### Use of second language teaching techniques

Mr Graham used English to teach from the floor, however, he spoke individually to pupils in their main language. The pupils answered his questions in English, but spoke to each other in isiXhosa. Mr Graham introduced mathematics terminology by using everyday examples before using the same terminology with fractions. When he introduced new mathematics vocabulary, he wrote the term in English on the board and asked the pupils to read it aloud. Where possible he verbally gave an isiXhosa translation. He thus combined aural and visual recognition as well as relating the English and isiXhosa terminology.

### Classroom climate

The pupils were relaxed and attentive. They smiled and laughed. Mr Graham interacted easily with the pupils. There was a relaxed, friendly atmosphere.

**Summary**

In this lesson, which occurred early in the intervention, Mr Graham did use questions to guide the development of understanding. Many of the questions were convergent, but he encouraged the pupils to think about each other's contributions. In this way, he engendered a sense of collegiality. He used a familiar context (heights of girls) to lead into the lesson topic, and used paper folding as a manipulative so that the pupils could compare the physical sizes of fractions. There was interaction between the pupils although it was only for a short period. In this lesson, Mr Graham began to build a community of practice by placing emphasis on the domain of understanding fractions in mathematics. He encouraged pupils to talk to him and to each other by using reasoning, and by reflecting open questions that needed unpacking. He thus helped them build confidence in their own notions about fractions and to share in joint activities and practices.

## Lesson 2: Manipulating fractions

Mr Graham taught mathematics as well as language in all lessons, carefully creating situations that built on one another, both in the demands of mathematical knowledge and language skills. He started with a concrete, hands-on activity by giving every group of pupils 18 stones. He asked them to find one half of the stones. They piled them into two groups of nine. He asked them to describe what they had done mathematically. Once he had elicited the answer, he wrote on the board:

$$\frac{1}{2}\times\frac{18}{1}= \ldots$$

and moved on to a lesson about multiplying fractions. He did not merely coach the mathematical procedures, but he said:

> *We want you to discover how to do it on your own. How do you get to find a fraction of that amount?*

He used their previous experience of success with easier fraction examples to move to more complicated examples, for example:

$$\frac{1}{6}\times\frac{18}{1} = \ldots$$

*then*

$$\frac{5}{6}\times\frac{18}{1} = \ldots$$

Each presentation and explanation moved smoothly into a textbook activity, much like activities that would be set in tests and examinations. In this way, the pupils could take the language and thinking skills they had gained by doing the exercises in groups, to the individual activity of completing mathematical tasks in a more formal environment.

### Questioning

Mr Graham moved from the concrete and visual aids of manipulatives to more formal mathematics:

> *When you had to find a half of your pile of 18 stones, how did you get 9? I want you to get to the mathematics.*

He seldom answered a question directly, but redirected pupils' thinking by answering their questions with questions of his own:

> *So what do you think?*

His questions were geared towards encouraging reasoning and logical thinking.

### Group work

The pupils used isiXhosa to communicate within their groups. They were encouraged to record the mathematics as written text using mathematical symbols, and to repeat their reasoning on the board during whole class discussions:

> *Write it in your books while you are working in groups, and then we will have someone report back on the board.*

The pupils were asked to write their calculations on the board and to use mathematical language (in English) to explain to the class what they were doing. They were challenged to find more than one way of reaching an answer:

> *Can you find another way of doing the sum and finding the same answer?*

The pupils were engaged in joint activity, discussing options together with the focus on the problem at hand.

### Use of second language teaching techniques

Throughout the lesson, Mr Graham modelled the language he was expecting the pupils to use:

> *We change the of to multiply.*

He repeated what pupils said and revoiced their statements:

> *Mr Graham: Divide into . . . groups? A very important word. Those groups should be . . . ?*
>
> *Yes, buthi?*
>
> *Pupil: Equal.*
>
> *Mr Graham: All those groups should be equal.*

Finally, they read word sums from a textbook, which required much the same problem solving strategies as the stones activity but without the concrete, hands-on part of the activity.

Mr Graham pointed to more than one way of working out the sums by putting the onus on the pupils to discover alternative solutions:

> *Is there another way of working it out?*
>
> *Do you see the difference between …?*
>
> *Can you do it in the quickest and easiest way?*

### Classroom climate

The pupils were keen to answer questions, they did not seem afraid of making errors, and they did not wait passively for Mr Graham to give the answer. Their behaviour displayed active participation and engagement with the activities presented by the teacher. It was quite clear, from the way they smiled and leant towards each other and engaged with the problems, that they enjoyed the activities. When some groups were quick to complete an activity, Mr Graham praised them by clapping his hands and saying, "Well done, well done!" Classroom observation suggested that the pupils were visibly pleased with themselves because they smiled and used positive gestures and body language.

### Summary

In this lesson, which occurred towards the end of the intervention, Mr Graham once again cemented Wenger's (2011) requirements of domain, community, and practice in his lesson in order to build a community of practice. The pupils were all focussed on either the concrete manifestations of division of fractions by manipulating stones, or on the more abstract textbook examples. They shared a joint enterprise. They were encouraged to use dialogue in isiXhosa to build solidarity and to express their understandings with ease and spontaneity. They developed a shared repertoire of resources by implementing different strategies to solve the mathematical tasks set.

## Reflective discussion with Mr Graham

At the end of the intervention, the researcher conducted an informal and relaxed reflective discussion with Mr Graham to ascertain whether he felt there had been any changes that he had observed during the course of the intervention:

> *There was a great improvement in the class in terms of their enthusiasm for work, their attitude towards speaking in the class, for presenting a job well done. They are able to work on their own – something which at the beginning of the year was quite difficult for them to do.*

The introduction of exploratory talk had given the pupils confidence to speak in English and this had resulted in improved English skills:

> *What I really noticed is that actually they are quite able to express themselves in English now, much better than at the beginning of the year. By switching from isiXhosa to English and using code-switching, they have got more confidence now in speaking English.*

Mr Graham felt that the introduction of exploratory talk had increased the enthusiasm in the classes. Their willingness to engage in dialogue meant that he had a clearer idea of what they understood:

> *You can see they are enthusiastic. They want to know. They think. And as soon as they talk, you know what they know and what they don't know. When they keep quiet you don't know whether they understand or not.*

Mr Graham was extremely positive about his experience during the intervention:

> *Just becoming aware of this process of using language, specifically, language to get them into a deeper understanding of what they are doing – this procedure is something that you just need be aware of and use as a strategy continuously. I did see it working. It is just the realization that this concept can work – you know, just realising that this concept can work!*

Having observed Mr Graham's teaching strategies during previous sessions, it can probably be said that building a community of practice is an integral part of his teaching toolkit. The observed reactions of the pupils showed that the strategies were familiar to them and that a community of practice had been developed because the elements of domain, community, and practice were present.

## Building a framework for learning: community, identity, meaning and practice

In Wenger's (1998) framework, learning should take place in the presence of four factors: identity, meaning, community, and practice.

### Identity

Although Mr Graham spoke almost exclusively in English, and revoiced the pupils' concepts in mathematical English, he did not constrain the pupils to use English. He was able to balance the need for mathematical understanding with the need to develop English competence. The language pupils used was not an issue. Language therefore became invisible as mathematical understanding was foregrounded (Setati, 2005). In fact, Mr Graham encouraged the pupils to use either code-switching or their main language by saying:

> *Please feel free to do it in isiXhosa so that you can understand it.*

Encouraging the pupils to speak in isiXhosa built a shared sense of identity and pride. The relaxed and collegial classroom climate contributed to the development of the pupils' confidence. Mr Graham demonstrated an authoritative but by no means authoritarian presence. He allowed the pupils to experiment with their embryonic mastery over both mathematical and ordinary English, and scaffolded their efforts by providing artefacts, vocabulary (both written and spoken), and by revoicing their utterances in the correct style and vocabulary. He treated learning as a social, communicative process by using group work continually and by encouraging pupils to talk to each other, give reasons for their views, and express their ideas confidently; the lessons took the form of a dialogue between teacher and pupils, and pupil and pupil (Barwell & Kaiser, 2005).

Perhaps the most appealing aspect of visiting Mr Graham's classes was the warm, welcoming buzz that pervaded the classroom atmosphere. Pupils were eager to make contributions in their groups; they were quick to put up their hands to volunteer to report back on the board; they asked questions of Mr Graham and each other; they communicated in a confident social manner. By allowing the pupils to use their main

language and by building their confidence, Mr Graham was leading the pupils towards developing an identity of learning as becoming.

### Meaning

Questions were used to provide opportunities for pupils to express their understanding and reasoning in utterances:

> *Now you have to give us a reason why you have written that kind of number sentence. Can you tell me?*

Mr Graham used open-ended questions, which lead to dialogic learning because there is no simple correct or incorrect answer. He guided the progression of the pupils' thinking towards understanding.

Mr Graham used questioning as a tool to deepen the pupils' mathematical reasoning and to help them verbalise their logic to each other. He used questioning, perhaps intrinsically, for the reasons Mercer and Littleton (2007) propound: to develop the pupil's use of language **as a tool** for reasoning by making explicit their thought, for modelling mathematical language, and for expressing their thoughts in words. Through answering questions for themselves and in their groups, and through using discussion in whatever language they were most comfortable, the pupils were making meaning through learning as experience.

### Community

Through non-judgemental questioning, Mr Graham built up a classroom climate in which the pupils were prepared to take risks. They initiated discussion and were prepared to ask questions of both the teacher as well as their peers.

He also used dialogue to scaffold the pupils' reasoning and actively solicited pupils' views without giving evaluative feedback that could have closed down initial halting responses. In their groups, the pupils stood over their desks to be physically closer to each other and used their main language, interspersed with mathematical vocabulary in English. Mr Graham created a classroom climate conducive to the practice of exploratory talk, because the pupils were encouraged to make explicit their thoughts, reasons, and knowledge, and to share collegially (Mercer & Littleton, 2007). By expressing their reasoning, the pupils grew in confidence and competence in both their mathematical prowess and their English fluency. Mr Graham was at ease with the pupils who responded enthusiastically to his teaching style. He not only scaffolded the terminology and the language that would be useful to the pupils, but also scaffolded their critical thinking through his questioning techniques (Lerman & Zevenbergen, 2004). The activities he developed drew on the pupils' previous mathematical knowledge and language, which enabled them to engage in directed, meaningful exploratory talk. Through developing a non-judgmental classroom climate Mr Graham built a community in which the pupils were learning as belonging.

### Practice

Mr Graham integrated the tenets of exploratory talk from the beginning of the intervention. It became the norm in his class; pupils became used to working in groups, respecting each other's opinions, explaining their understanding in isiXhosa or through code-switching, giving reasons for all their statements and reaching consensus if possible (Mercer & Littleton, 2007). The pupils became familiar with this practice and began to apply the principles unconsciously. In a very real sense he facilitated pupil-centred learning. In Mr Graham's classroom there were instances of disputational and cumulative talk; there were instances of teacher-talk; but there were recognisable instances where pupils engaged with each other, or with the teacher, in the creation of mathematics understanding. This resonates with Barwell and Kaiser's (2005) definition of dialogic learning.

Mr Graham repeatedly scaffolded the strategy and the language and thinking skills that pupils should engage in during problem solving. As regards strategy, he reminded them of the tenets of exploratory talk:

> *What I want you to do is read the problem first; discuss what it is about so that you understand the problem. Think of ways that you can solve the problem and talk about them, but make sure you always tell us why you think what you do.*

Mr Graham modelled the language and vocabulary he wanted the pupils to replicate in their peer group discussions and when they reported back in plenary, but did not draw attention or allude to any mistakes the pupils may have made previously. In this way, he did not dissipate their self-efficacy.

Mr Graham demonstrated sound knowledge of teaching strategies for multilingual classes. He encouraged the pupils to speak in their main language in groups; he revoiced their ideas in English and scaffolded the pupils' reasoning (Moschkovich, 2007). He taught language skills when he gave the pupils the vocabulary necessary for the mathematics they were doing both orally and in writing on the board or on handouts. He also reinforced sentence structure and terminology in an unobtrusive way. He was, thus, giving them the tools to communicate in mathematical English, not just speaking mathematics to them in English. Through judicious use of strategies, Mr Graham was able to link English and mathematical learning without drawing attention to the language the pupils were using, but emphasising their mathematical thought processes and understanding. Through continually allowing the pupils to practice their skills and keeping them focused on their tasks, Mr Graham encouraged learning as doing.

## Conclusion

In language-diverse mathematics classes in South Africa, there is preponderance of teaching in English only and for coercing pupils to answer in English. Research indicates that sociocultural influences have an impact on mathematical understanding and learning, thus dialogue, and the type of talk in which pupils engage, can enhance mathematical reasoning. The premise that teachers should encourage pupils to move along the continuum from traditional, univocal discourse towards dialogic discourse where exploratory talk occurs was illustrated in this study by Mr Graham's practice although at times the discourse moved backwards and forwards on the continuum, depending on the focus of the lesson.

This paper suggests that if various strategies can be implemented in mathematics classes a community of practice can be developed which can lead to effective mathematical learning. The attitude of the teacher is vital in this respect because the transition between languages should be the pupils' choice and not enforced by the teacher. Pupils' own emerging identities, intrinsically entwined with their main language, is a major component of learning (Wenger, 1998)

The teacher can scaffold mathematical learning by judicious questioning with open-ended or Socratic questioning so that the pupils are prompted to give reasons for their answers and are stretched to think and to verbalise their thoughts. By discussing their ideas, pupils can make meaning in their own minds.

The classroom climate can enhance dialogue if it is non-threatening and the pupils feel comfortable in voicing opinions without fear of retribution or ridicule. In this environment, the teacher can cater for both the mathematical and the language needs of the pupils. In the absence of censure and fear, pupils build confidence and community.

It seems that the development of dialogic teaching in multilingual mathematical classes, in the form of exploratory talk, can increase numeracy, mathematical reasoning, and English skills if teachers are exposed to the theory and practice of discourse development through an intervention. This does not happen

overnight and the practice must be implemented continually for their pupils to embed the practice in their psyches.

This study indicates that if teachers are able to introduce Wenger's (1998) four tenets of learning (identity, meaning, practice, and community) it is possible to build a community of practice where learning takes place. If this were to occur on a broad scale, perhaps the mathematical prowess of South African second-language pupils would be improved.

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