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Transforming Mathematical Discourse: A Daunting Task for South Africa's Townships

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In this study, the authors describe the voices and practices of four mathematics teachers in a K–7 "Coloured" township school in the context of the Eastern Cape of South Africa. The authors begin with an explanation of the context of the township in terms of its history, languages, diversity, educational system, and mathematics education. Through observing and describing four mathematics classroom discourses, two from the Foundation Phase and two from the Intermediate Phase, the authors illustrate the relationship between the participating teachers' voices and practices within their socio-cultural and socio-historical context. Additionally, the authors describe the complexity of transforming mathematics education and suggest that implementing the Revised National Curriculum Statement requires an epistemological shift in perspective regarding teaching and learning that promotes mathematical understanding. The authors' analyses show the importance of transforming mathematics education and the responsibility of higher education institutions in the preparation of future teachers compatible with the new societal demand.

KEYWORDS: access and equity in mathematics education, beliefs and practices, mathematics classroom discourse, mathematics teacher professional development, mathematics teacher transformation

The exponential growth of communication technology has created a world in which even the most remote classroom and school system can now be part of

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the world discussion about social justice, access and equity, and teacher preparation. Our time is fortunate to witness the demise of educational systems that intentionally oppress the weakest members in society in preference of the strongest. In the field of education, those abuses created systems of education that were inherently prejudicial and seriously undermined the ability of certain groups of people to advance and succeed in their communities. Due to technology, however, the world can now see what was once hidden. Technology has made it possible to act upon what is seen and there is now a global consciousness developing that demands that there be standards developed regarding access and equity in education, that social justice norms be applied to all students in a school system, and that professional preparation programs be developed which will equip teachers with the experiences needed to teach in a manner compatible with twenty-first century expectations.

In this research study, we address these new expectations and the rise of global consciousness to the importance of education by observing a previously underrepresented and underserved urban township school system in a country once governed by one of the world's most oppressive governments. South Africa, once famous for its class system known as Apartheid, is now a democratic state attempting to remake itself into a model of equity and fairness for all of its citizens, regardless of race. In this study, we consider the ramifications that Apartheid had on its educational system and its lingering impact today. We discuss with teachers in four different classrooms the effect their inadequate teacher preparation has had on their students who leave school with alarmingly high rates of illiteracy in mathematics. We also observe the imprints created by Apartheid in its unequal funding of South Africa's four racial school systems and the large class sizes found in Black and Coloured schools especially. South Africa is now addressing these failures and has made great strides toward overcoming their past historical struggles. By observing and describing mathematics teaching and learning in one school system and its attempt to overcome such a history of educationally inadequate and harmful practice, we hope the research community will recognize the importance of this study for (urban) education worldwide.

Situation of South Africa before 1994

The history of South Africa (SA) and its present struggles with educational reform in general, and mathematics education reform in particular, cannot be understood unless one understands the history of Apartheid itself, and the colonialism from which it grew. Under Apartheid, White South Africans (about 9.2%) dominated the other three racial groups: the Blacks (or Africans) 79.5%; the Coloureds 8.9%; and the Indians/Asians, the smallest group, 2.5%. The system they created was an attempt at social engineering; its official goal was to deliver to each separate culture what it deemed necessary for that culture. A "convenient myth" (Morrow, 1990, p. 175) was perpetuated, which held that each group's racial differences rendered them incompatible with each other and therefore unable to coexist within the same society. In reality, the Apartheid system was a thinly disguised but extreme form of racial discrimination designed to separate and control the "lesser" races of people.

Apartheid created a language barrier as well for the education of the non-white racial groups. In 2001, it was reported that approximately 75% of the population of SA spoke one of nine indigenous languages: Ndebele, Pedi, Sotho, Swazi, Tsonga, Tswana, Venda, Xhosa, and Zoulou (Gilmartin, 2004). Before 1994, there were only two official languages, namely English and Afrikaans (which is an adapted Dutch language) and respectively spoken by 13.5% and 8.5% of the population. No language represents the majority in SA. Although most of the population is either Black or Coloured, and speak a variety of other indigenous languages, all education in SA was delivered in these two official and foreign tongues even though less than a quarter of the entire population spoke either of these two languages at home (Gilmartin, 2004).

The educational system established under Apartheid was incredibly disparate and inequitable across these racial groups. Four distinct school systems were developed, each serving their own separate groups. Purporting to offer education along the lines of the USA South's "separate but equal" methodology, these four systems were anything but equal. Edusource Data News reported that funding per student (in Rands) at the time of liberation (1994) for the African student was 2,184, while the White student received 5,403, the Indian student 4,687, and the Coloured student 3,691 (Edusource Data News, as cited in Gilmour, 2001). The National Education Policy Investigation (NEPI) reported that core syllabi, not entire curriculum, were made available to each school in each system, but were so diverse and numerous (over 1400 different ones) that they, combined with different examination systems, created even more separation and isolation among groups (NEPI, 1993, as cited in Gilmour, 2001).

Teacher preparation also presented a glaring inequality in SA schools. When compared to a standard measure of matriculation plus 3 years teacher education; 46% of African teachers, 29 % of Coloured teachers, 7% of Indian teachers, and 1 % of White teachers were found to be under qualified to teach in their respective schools (Gilmour, 2001). In Apartheid SA, it was usual practice for White teachers to attend school up to the twelfth grade and then receive 3 additional years of teacher education to qualify them as teachers. In contrast, the Coloured person, who is neither Black nor White, but descendant from White Afrikaans and Blacks, attended school up to the eighth grade and then received 2 additional years of teacher education. The Black person received the least amount of education; she or he attended school only to the sixth grade and then received 2 additional years of teacher education to qualify her or him for teaching. It is easy to see that these separate systems for preparing teachers for the classroom were incredibly unequal and could only result in disproportionate success and failure across racial groups.

Class size is also an indicator of the inequitable educational system in place during Apartheid. For example, in the Eastern Cape of SA, the student-teacher ratio in 1994 was 56:1 for the Black, 39:1 for the Indian, 28:1 for the Coloured, and 21:1 for the White populations (Gilmour, 2001). Given that funding to each of these four school systems has been inequitable, that language has been made a barrier to learning, that non-White teachers have been insufficiently prepared to teach in terms of both content knowledge and pedagogy; the added burden of large class sizes only further exasperates the possibility of learner success for the non-White.

Situation of South Africa after 1994

The new government of SA has made great strides in their effort to re-create their country into a model of democracy. A new constitution was drafted that clearly aimed at equality for *all* racial groups in SA and laid the foundation for the future by guaranteeing fair and accessible education for *all* South Africans. The constitution makes redress to the language barrier created by Apartheid and attempts to honor *all* of the languages of SA by declaring 11 of them official languages. This declaration by SA government makes access to education possible for all citizens and provides opportunities for learning to occur in the language most natural to the student. The new SA is still struggling with severe unemployment that affects 44% of Black peoples, among others 50% of young men compared to 7% for the Whites (L'Encyclopédie de l'Agora, Dossier : Afrique du Sud, 2005).

The government has also established the Equitable Shares Formula (ESF), which is intended to make just the division of national revenue among the nine separate provinces created in SA after the elections of 1994 (Equity in Education Expenditure, n.d.). This process is designed to make funds available to provinces on the basis of need in order to bolster the poorest of areas first before the funding of the wealthiest areas. This redistribution will no doubt help but problems still exist in the making of this redress a reality. Currently, due to lack of money in local schools, fees are being applied to students desiring to attend certain schools. Although schools are now free and open to all students, local fees are making enrollment prohibitive and in some cases are being applied in order to keep certain students barred from attendance (Spreen & Vally, 2006).

Likewise, an understanding of the difficulties confronting educators in SA as they work to reform their educational system, and specifically mathematics education, must include an explanation of the unique circumstances created by the

Apartheid regime; which, up to 1994 when the country's first democratic elections occurred, dominated and severely restricted the development and growth of the country's peoples and cultures. In the context of school reform, history books, mathematics schoolbooks, English books, Afrikaans books, social studies books, and others have been revised in order to celebrate the cultural diversity and the contribution of *all* South Africans from any racial background.

In the Eastern Cape of SA, where our study was conducted, the language spoken in most Black homes is Xhosa. The language spoken in most Coloured home is Afrikaans. The tendency in South African Black and Coloured communities, however, is to want to learn English and be able to communicate fluently in English. According to the 1993 Constitutional law, each citizen up to the age of 16 has the right to be educated in her or his native language. But, Black parents, who speak limited English, as well as Coloured parents, believe that their children will be better educated if they use English as the Language of Teaching and Learning (LTL). Some Black parents believe that their children will be better prepared for future careers if they attend White public schools and are taught by White teachers.

It has been left up to the individual schools to decide on the LTL for the particular community that they serve. For example, in the Eastern Cape of SA they have chosen English, Afrikaans (main language of Coloured people), and Xhosa (main language of Black people). The English language however is "becoming the lingua franca of the new South Africa" (Gilmartin, 2004, p. 415). Because of this reality, most Black and Coloured people tend to use English as the LTL in their schools. In Black township schools where 100% of students are Black, the LTL is mainly Xhosa for early childhood grades (grade k–3), gradually changing to English in middle childhood grades (grade 4–7), and then completely to English at the secondary level. Black and Coloured parents and their communities believe that the English language is the language of power and opportunity for success in SA; therefore, they strongly encourage their children to master English while they are at school.

In our study, which was conducted in a Coloured township school, class sizes were, on average, 38 pupils to one teacher, even higher than the 1994 figure for Coloured schools. Although research has shown that there is no direct correlation between class size and student performance (O'Sullivan, 2006); it has also been shown that available resources and teacher qualification have *significant* impact on the effectiveness of instruction (Howie, 2003).

With this historic inadequacy and inequity regarding teacher education programs, particularly for Black Xhosa speaking and Coloured Afrikaans speaking teachers in the Eastern Cape of SA, transforming mathematics education in the classroom remains a daunting task. In keeping with making funding and language accessible for all of the provinces is the hope that teacher preparation will follow.

As our study suggests, this is not yet the case. The teachers that we observed and interviewed expressed concern for their chances of success in an environment that is, while hopeful, not yet perfect. They remain under resourced and under prepared. In the next section we will define the context of the current study.

Context

The 2002 Revised National Curriculum Statement (RNCS) sets forth impressive objectives for the future of education in SA. Its scope covers a breadth of content areas and clearly objectifies what mathematics content is to be taught, learned, and assessed for grades K–9. The RNCS intends to expand school mathematics beyond arithmetic to include mathematical meaning consistent with the needs of the new society. In addition, the RNCS aims to establish equitable instructional and assessment practices compatible with current research on teaching and learning mathematics. These goals are interesting and encouraging. However, there is little research on how educators implement the RNCS in their day-to-day classroom mathematical discourses and whether such goals are actually being met. Likewise, at the current stage of transformation, there is limited curriculum material consistent with the RNCS agendas. This lack of research and supplemental learning materials continues to place teachers in a vulnerable and precarious situation.

In this study, we describe the voices and practices of four mathematics teachers in a grade K–7 Coloured township school in the Eastern Cape of SA. The four teachers' ages ranged from late 30s to early 50s. All four teachers and their students were Coloured and from the same township community. In this sense, the teachers were serving their own community. The four teachers' teaching experience ranged from 10 to 25 years. We describe four mathematics classroom discourses; two from the Foundation Phase (K–3) and two from the Intermediate Phase (4–7). Our descriptions illustrate the relationship between the participating teachers' voices and practices within their socio-cultural and socio-historical context.

Theoretical Framework

Here, we define *mathematical discourses* as mathematical discussions and social interactions occurring in a mathematics classroom between the teacher and students and among students as they attempt to solve problems and communicate their thinking and reasoning. To understand the complex interplay between a teacher's pedagogy and practice, we incorporated Hufferd-Ackles, Fuson, and Sherin's (2004) model for observing and describing four participating teachers' classroom practices. Hufferd-Ackles et al. (2004) observed and identified four levels of discourses that exist in a Math-Talk learning community that describe the relationships between teachers' beliefs and practices. Through a professional development project, they observed several primary school teachers' practices in a bilingual setting. Hufferd-Ackles et al. identified four transitional stages in mathematical discourse ranging from a traditional teacher-centered classroom (level 0) toward a classroom in which the students and teacher participated in and contributed to the activities of the community (level 3):

> Level 0 in the framework represents a traditional, teacher-directed classroom. In the level 1 classroom, the teacher in the study began to pursue students' mathematical thinking, but still played the leading role in the math-talk learning community. In level 2, the teacher began to stimulate students to take on important roles in the learning community and backed away from the central role in the math talk. In level 3, the teacher coached and assisted her students as they took on leading roles in the math-talk learning community. (p. 91)

One must recognize that these four levels of classroom discourses are not linear and sequential. For example, at each particular classroom activity, a teacher may incorporate two or more of these levels depending upon the classroom dynamics and the classroom learning situations. However, based on the teacher's content knowledge, beliefs, and pedagogical values, one of these four levels may play dominant role in the classroom mathematical discourses. An example of each level is presented below.

Consider the following problem: *Kim bought six movie tickets for her six friends. She spent 48 dollars total. How much did each ticket cost?* In a level 0 classroom, the focus of classroom discourse is on the teacher's question, the student's short numerical response, and the teacher's evaluation of the right answer. The classroom teacher is the sole authority for asking questions and validating students' responses. The social interactions occur only between the teacher and individual students. If a student responds "the answer is eight dollars," then the teacher validates the correct response and continues posing similar routine problems. In a level 1 classroom, in addition to focusing on the right answer, the teacher shows an interest in her or his students thinking and reasoning. She or he may ask, "How did you figure out the answer?" or "Is there any other way to solve this problem?" Nevertheless, she or he still plays a dominant role relative to the classroom mathematics discourse.

In a level 2 classroom, the teacher may pose the question to the classroom and provide students with opportunities to work in their small groups for problem solving and communication. Then she or he may invite students to defend their ideas in front of the class. Students' solutions are subject to change by other students or by the teacher through classroom dialogues. The teacher facilitates classroom mathematical discourse via her or his questioning strategies. Problem solving, reasoning and proofs, communications, mathematical connections, and mathematical representations are a central part of the classroom discourse. Multiple solution strategies are discussed. The students are treated as members of the classroom community. For example, one student may solve the problem algebraically by showing $6 \times x = \$48$, $x = \$8$. Another student may solve the problem geometrically by drawing a 6 by 8 rectangular figure, and yet another student may use her or his manipulatives materials such as base-10 blocks for mathematical modeling and visual representation. In a level 3 classroom, the teacher may invite students to pose similar problems for their peers and challenge them to find solutions. In this kind of classroom mathematical discourse, co-teaching and co-learning occurs among members of the classroom community. The classroom teacher acts as a learner with her or his students. She or he still plays the role of a facilitator and guide. She or he, however, provides the students more leadership opportunities.

Methods

This observational and descriptive research was grounded in constructivist inquiry (Lincoln & Guba, 1985, 1994). The study is context specific (i.e. four classrooms from a Coloured township school). In this sense, the study intends to share the ideas and experiences of the four participating teachers and hopes that others will identify with the research context and apply the findings to their own particular settings. Our data collection started in mid-January 2004 and ended mid-April 2004. It consisted of preliminary and active phases. The purpose of the preliminary phase was to establish a research framework and to discuss and decide the following issues: (a) defining the research goals, (b) establishing a timeline for research activities, (c) contacting the school community and sharing our intentions for the research, (d) targeting potential classrooms for observation (i. e., Foundation and Intermediate Phases), and (e) clarifying the role of the research team.

The active phase included conducting 14 mathematics classroom observations and 6 interviews with four participating teachers. The four teachers volunteered to participate in the study; two were women and two were men. The two women's ages ranged from mid 40s to early 50s. They taught second- and third-grade classrooms respectively. The two men's ages ranged from late 30s to mid 40s. They taught in sixth- and seventh-grade classrooms. Mathematics classroom observations occurred once a week, every Monday between 8:00 a.m. and 2:00 p.m. During the observations, the researchers focused on the teacher-students and student-student mathematics discourses; field notes were taken during the mathematics classroom observations. The subsequent interviews were audio-taped and transcribed verbatim. The criteria for the selection of teachers included: (a) their willingness to participate, (b) their ability to articulate who they are, (c) the diversity of their background (i. e., gender, age, home language), (c) their diverse mathematical content knowledge and qualification, and (d) their teaching experiences.

Data collection and data analysis occurred simultaneously during the course of the study. Constant comparative data analysis (Lincoln & Guba, 1985, 1994; McCracken, 1988) was used for making sense of data. Data was reviewed and analyzed independently by each member of the research team. This method was a form of triangulation among the researchers (Denzin, 1984). Triangulation also occurred when the research report was shared with the participants (i.e. the principal, deputy-principal, and teachers). The compatibility between the researchers' interpretation and the participants' stated beliefs and actions evinced the trustworthiness of the data analysis.

Consistent with the Hufferd-Ackles et al. (2004) model, we described classroom mathematics teaching and learning as well as teachers' voices towards mathematics education. We used the term *teaching strategies 1–4* instead of *levels 0–3* to demonstrate mathematics classroom discourses. This change in terminology occurred during our research report to the participating teachers. The teachers mentioned that the word "level" was too rigid. They also mentioned that the term *level 0* can be interpreted as the teacher's incompetence in teaching. We agreed with the participating teachers and modified the terminology.

Teachers' Background, Voices, and Classroom Practices

To demonstrate the kind of mathematics instructions occurring at this school in both the Foundation and Intermediate Phases, we selected four classrooms: a second grade, a third grade, a sixth grade, and a seventh grade. Based on analysis of the 14 classroom observations, these four representations of Foundation and Intermediate Phases as episodes were selected.

The physical structure of the classrooms in both Foundation and Intermediate Phases was very similar. Students were sitting around their tables in pairs. Two, or sometimes three, tables were joined together to make a cluster of four to six learners sitting together as a group. The number of pupils in each classroom was between 36 and 40. In the following section, we describe each teacher's background, voice, and her or his mathematics classroom practices in an effort to highlight the particular difficulties these teachers face and to explain the effect these difficulties have on students' learning and classroom discourses. In the following section, we describe each teacher's background, beliefs, and classroom mathematics practices. We aim to explain the challenges that these teachers faced in teaching mathematics, the decisions they made during their classroom mathematical discourses, the strategies they used, and the (probable) consequences of these strategies on students' learning and classroom discourses.

Teacher 1: Second-grade teacher's background, voice, and classroom practices

The second-grade teacher was from the Foundation Phase (k–3) background. She was in her mid 40s, Coloured, with 15 years of teaching experience. She obtained a diploma up to the eighth grade plus 2 years of teacher preparation in 1989, before liberation. She spoke Afrikaans as her mother tongue and English as a second official language. During her first 10 years of teaching, she used Afrikaans as the LTL. For the last 5 or 6 years, however, because of parental demand, she used English as the LTL in her class. The teacher stated that she suffered from scarce funding for professional development. Her pupils learned mathematics and other subjects in English although they were speaking Afrikaans as their mother tongue at home. The teacher lived in the same community in which her students lived. In this sense, she was serving her own community's pupils.

Her voice

The second-grade teacher mentioned that the three most important things for her were: (a) to see progression in her learners' academic growth and to acknowledge their achievement, (b) to provide her learners ample opportunities to excel, and (c) to assist struggling learners to reach an average level and to become confident in their own abilities. She asserted that for learners to understand and have a better appreciation of mathematics, she would integrate the subject with other learning areas: "If you look at Maths, it's all-encompassing, it's everywhere. If you look at the child as a whole then there is a connection."

To make her teaching interesting, she would give her learners apparatus such as a counting-chart or a hundred-chart. The teacher mentioned that using the children's environments for number operation and mathematical patterns and relationship was one of her instructional goals. Her biggest challenge was her class size and dealing with learners who were qualitatively slower: "When the class is so big, 39 children, you can't focus on your class as a whole and on those you really must focus on." In order to cope with this challenge, she used a heterogeneous, small-group, cooperative learning strategy:

> We have cooperative learning in the class. This year I am taking my weaker learners and focusing more on them. My first group, the clever ones, I can give more work for them to carry on with, like enrichment activities in Maths.

According to her, using this type of cooperative learning strategy, all children would benefit. The higher achievers learn by teaching and assisting lower achievers. The higher achievers also do the peer-assessment and group assessment: "We had an open session where they gave their views of the learners' work and also encouraged them to do better." She also mentioned the need for professional development through ongoing school-based workshops. She believed that by empowering herself she could make her mathematics classroom more enjoyable and meaningful for her students:

> I would like to learn more too, by attending more workshops so that I can equip myself to assist them in the classroom. Sometimes you sit there and become stereotyped doing the same thing over and over, when there are other little things you can do, when you go to the workshops, your spirit is just uplifted…there is a big need for Maths workshops. There are not many workshops that are held for the Foundation Phase teachers.

She acknowledged that working with her colleagues in the Foundation Phase was very meaningful for her professional development: "Sharing our portfolios help us a lot, getting information from the first grade and then moving on. So, we keep reports of the children and pass it on." We found the second-grade teacher's attitudes towards relearning mathematics interesting and encouraging. Although she mentioned the limitation her poor teacher preparation program created, she was hopeful that through her dedication and commitment towards her own professional growth, she could provide her learners better educational opportunities. The second-grade teacher's beliefs correspond to two important equity issues: (a) the issue of her students' achievement in mathematics; and (b) the issue of access for her underrepresented students to do significant mathematics.

Her practices

[Note: In subsequent sections, T = Teacher, L = Learner, and Ls = Learners.]

> T: How many fingers do we have? How could we make sure that we have 10 fingers? [She called a learner.]
> L1: [He counted 1 through 10 using his fingers. The teacher had her 100-chart on the board and asked learners to read various numbers on the chart.]
> T: [She called a learner.] Show me the number 10 on the board.
> L2: [She went to the board and showed number 10.]
> T: Which number comes before 10? [Learners raised their hands for response. The teacher called a learner.]
> L3: [He showed number nine on the board.]
> T: Which number comes after 10? [Learners raised their hands for response. The teacher called another learner.]
> L4: Eleven.

The counting activity continued with the teacher questioning the students to recognize the number before a given number, after a given number, below or above a given number. Learners would raise their hands for responses and the teacher would call a learner for a response (i.e., strategy 1 or level 0).

> T: How can I make 6 with my fingers? Can somebody come and write me six on the board? [The learners raised their hands. She called a learner.]

The student wrote the word "six" on the board. The teacher called another student to draw or model number six. The student drew six small circles, side-by-side on the board. The teacher called a different student to group the six circles by 2s. Students were listening and participating in the activity.

The teacher attempted to combine literacy and numeracy in her teaching by asking children to write numbers in English. In order to make counting by 2s more relevant to students' prior experience she used the students' bodies (i.e., counting six pairs of eyes). The activity was consistent with her statement about using children's natural environment for teaching mathematics. She encouraged her students to write and model mathematical symbols (i.e., drawing). The mathematical discourse, however, was dominated by teacher questioning, students' responses, and teacher evaluation (strategies 1 and 2, or level 0 and 1). Although providing her students with opportunities to make sense of numbers and operations was one of her priorities, in practice she focused only on some routine problems for students to answer. The level of mathematics discourse was at or below first grade. The teacher acknowledged that the way she taught was relative to the way she was "trained." She mentioned that she was the product of an educational system that historically treated teachers inequitably, thus she is ill-prepared in terms of content and pedagogy for teaching mathematics with understanding. However, she wanted to better prepare herself through ongoing school-based professional development activities. In our other classroom observations, the teacher followed the similar patterns of teaching and classroom discourses throughout the course of the study.

Teacher 2: Third-grade teacher's background, voice, and classroom practices

The third-grade teacher was from the Foundation Phase (k–3) background. She was in her early 50s, Coloured, with 25 years of teaching experience. Similar to the second-grade teacher, she obtained a diploma up to eighth grade plus 2 years of teacher preparation in 1978, long before liberation. She spoke Afrikaans as her mother tongue and English as a second official language. During her first 20 years of teaching, she used Afrikaans as the LTL. For the last 5 or 6 years, however, because of parents demand, she used English as LTL in her class. Similar to the second-grade teacher, this teacher stated that she suffered from scarce funding for professional development. The teacher lived in the same community in which her students lived. In this sense, she was serving her own community's pupils.

Her voice

She said it was important for her to know her learners. According to her, by the end of the first week of school, she would have already assessed her learners in order to see where the problems were in terms of learning mathematics, reading, and phonics. She stated that she wanted to get to know her learners not only by name but also by the way they worked: "I do a lot of observation, I observe five or six children at a time." She would observe the same children again the following day just to see if her observation and assessment were adequate. She asserted that one of her strategies was to challenge all children including "at-risk" learners: "I push them very hard during the first two-three weeks of the year to find out what their limitations and boundaries are, and then I can get my pace." For her, planning was very important. When she did her planning, she paid particular attention to the integration of mathematical contents and themes. She also focused on how her learners understood the mathematical ideas presented to them:

> For example, when I do time and then fractions, obviously fractions must also be quarters, halves, three-quarters because we talk about time which is about quarters and halves. So, I cannot do my planning for 10 days in advance. The child sets the pace and determines the next day's work.

As a result, she constantly adjusts her planning and her "pace" based on where her learners are:

> Every year is different, especially with the New Revised Curriculum Statement, with no guidelines for implementation from the Department of Education, no support from them; I am constantly changing because children are exposed to many things now, obviously methods change, and the subject or content changes.

Living in the same community where her learners lived provided her with ample opportunities to get to know her students' backgrounds and to build relationships with them and their parents. One of her biggest challenges was the implementation of the RNCS into her day-to-day mathematics instruction. She said that she had not figured it out yet.

Her practices

[Note: The focus of mathematics instruction was time measurement.]

> T: How many minutes are in an hour?
> Ls: 60
> T: 60 minutes. Can you tell me what the purpose of long hand is?
> Ls: It tells the hours.

T: Hours or minutes?
Ls: Minutes
T: How about short hand?
Ls: It tells the hours.
T: [She had a manual clock in front of her and she modeled the movement of the long hand for one complete revolution.] What do we call that?
Ls: Clockwise. [Then she modeled counter-clockwise.]
T: Now I want all of you to put your clock on the time that school starts. What time is the break? [She waited and observed.]
Ls: 10 o'clock. [They modeled it.]
T: When do we go home?
Ls: 12 o'clock.
T: What time do you come back?
Ls: One o'clock. [The teacher and learners continued their discussion about various time of day and events. They also would write the words such as morning/light, afternoon, evening, dusk, night/dark, a.m. and p.m. The teacher encouraged multiple perspectives.]

The students were expected to communicate their thinking and reasoning. The teacher asked the students to work on similar problems from the book. She circulated around the room, encouraging students to work together cooperatively and responsibly. Concurrently, she gave additional time to lower-achieving students (i.e., strategies 1, 2, and 3; with strategy 2 being dominant during the classroom discourses).

The classroom observation revealed several important issues such as: the teacher's pedagogical content knowledge, her questioning strategies for understanding and assessing students' understanding, her wait-time for students' responses, and her knowledge of her students and targeting of those children who were qualitatively slow. The teacher put mathematics content into context that made relevant sense to all students. The questioning strategies and wait-time afforded all students an opportunity to participate in and contribute to the activities of the classroom community. Nevertheless, the teacher mentioned the lack of adequate resources for teaching mathematics in a culturally responsive manner.

Teacher 3: Sixth-grade teacher's background, voice, and classroom practices

The sixth-grade teacher was from the Intermediate phase (4–7) background. He was in his early 40s, Coloured, with 12 years of teaching experience. Similar to the second-grade and third-grade teachers, he obtained a diploma up to eighth grade plus 2 years of teacher preparation before the liberation. He spoke Afrikaans as his mother tongue and English as a second official language. During his first 6 years of teaching, he used Afrikaans as LTL. For the last 5 or 6 years, however, because of parental demand, he used English as the LTL in his class. The teacher lived in the same community in which his students lived. In this sense, he was serving his own community's pupils.

His voice

Similar to the second-grade teacher, the sixth-grade teacher mentioned that teachers teach the way they were "trained." He said his biggest concern was for children to see the connection between what they do in the classroom and real life. As a mathematics teacher, however, he wants to help his learners to make the connection between school mathematics and its application in the real world. He believes that if teachers put mathematics in context then children will learn more easily. It was important for him to find a way that teachers would be able to recognize that a child has shown more progress when he is compared to previous years because he was challenged within her or his ability: "As mathematics teachers, if I and the other teachers look at mathematics teaching and learning this way, we will hopefully improve in the long term, and the children's level of Maths will grow."

His second concern was with the school's professional development activities. He stated that, although many teachers have been teaching mathematics for many years, not much has been done to upgrade their skills and methods. He suggested that one way to encourage teachers to empower themselves was through ongoing school-based professional development and workshops: "Getting people in the school may just touch that spark a bit, so that they can rejuvenate that interest again." He believed that even if teachers receive new methods of what to teach and assess, they are not necessarily ready to implement these ideas in their day-to-day classrooms.

His practices

On the board, the teacher wrote various units of metric measurements such as millimetre, centimetre, metre, and kilometre. The teacher started his instruction in a calm and peaceful voice.

T: Today we are going to focus on the introduction of measurement and conversion. How many millimetres are in a half of a metre?
L1: 500 millimetres, teacher.
T: 500 millimetres. It is written? Nought [zero] comma [decimal] 500 m. [He wrote on the board 0,500m.] How about half of a kilometre? How do we show that in terms of metres? What is the relationship between a quarter of metre and half of a metre? [He wrote on the board 1/4 m and 1/2 m.]
L2: It is a half of a half, teacher.
T: It is a half of a half metre. Okay, if I have a quarter of a metre, how do I show that?
L3: It is nought, comma 250 m. [The teacher wrote on the board 0,250 m.]

> T: Now, pick up your notebook. [Learners had their rulers, pens or pencils, notebooks, and textbooks in front of them. Then the teacher went from table to table giving different assignments to different groups of learners. The task was for each group to measure certain objects such as the length of a pencil, the length of a table, the length of an open hand, the length of a pencil case.] You will decide in your group whether you want to use millimetre, centimetre, or metre. I don't want one person doing all the measuring. I want one person be the reporter. [Classroom was noisy; however, the learners were on task.]

The activity on measurement was interesting and engaging. Students wanted to find the solutions for various objects. The teacher used strategies 1, 2 and 3 (i.e., levels 0, 1 and 2) for mathematical discourses. Our systematic observations of classroom discourses, however, suggest that the strategy 2 (level 1) was the dominant one in most cases.

There were several interesting points that emerged from the observation of this classroom discourse. First, the teacher's calm and peaceful manner created a safe environment, conducive to learning. Second, although the teacher's instructional approach was mostly conventional (i.e., teacher-directed instruction, teacher questions, students' short answers, and teacher evaluation), the latter portion of his instructional strategy afforded his students opportunities to engage in meaningful mathematical discourse among themselves. In this sense, his instructional approach was less teacher-directed and more student-centered. Third, the activity was contextualised and it had a real life mathematical application.

Teacher 4: Seventh-grade teacher's background, voice, and classroom practices

The seventh-grade teacher was from the Intermediate phase (4–7) background. He was in his late 30s, Coloured, with 10 years of teaching experience. Similar to the other teachers in this study, he obtained a diploma up to eighth grade plus 2 years of teacher preparation before the liberation. He spoke Afrikaans as his mother tongue and English as a second official language. During his first 4 years of teaching, he used Afrikaans as the LTL. For the last 5 or 6 years, however, because of parental demand, he used English as the LTL in his class. The teacher lived in the same community in which his students lived. In this sense, he was serving his own community's pupils.

His voice

Reflecting on his practices, the seventh-grade teacher believed that his way of teaching has to be transformed: "The frame of mind I am in will have to change as far as integrating is concerned." He stated, "This is definitely the area that I must improve in because it is something that I have been struggling with since the start of OBE [Outcome-Based Education]." From his perspective, teachers were taught to teach mathematics in three steps: (1) teacher teaching and learners following, (2) asking some learners to repeat what was taught, and (3) individual seatwork and homework: "They have to follow the procedure or the teaching methods. Teachers first do this, and then they do that. But it has changed. Because of that change, I feel that I personally need more guidance." His personal reflection and the new national requirements for effective teaching afforded him an opportunity to recognize the limitations of his method of direct instruction.

The teacher asserted that one of his personal responsibilities was to make sure that once the learners leave grade seven they are confident and competent to compete with other learners from more privileged schools. He wanted his learners to see the application of mathematics in the real world and be empowered mathematically: "I would like them to stand up and be counted amongst others as someone who has really progressed as far as Maths is concerned." The seventh-grade teacher was sensitive to the notions of access and equity in mathematics education. He wanted his students to be able to use technological tools for learning mathematics, the tools that he was denied having when he was at school.

His practices

After greeting, the teacher started his instruction on number patterns, number relations, and squaring numbers. On the board he wrote "number patterns." Below that title, he wrote two rows of numbers.

1	2	3	4	5	6	7	8
0	2	6	12	20	30	42	

T: Can we establish a rule? [Pause] Can we establish a rule in order to determine the relationship between the two rows of the numbers? What would be the next number? [He was referring to the number below 8.]

L1: Number 8 will be 56, teacher.

T: How did you get it? [The teacher paused. L1 is thinking while L2 raised his hand.]

L2: The number of the next term multiplied by the previous one? [He was referring to the numbers in the first row and multiplying two consecutive numbers 7 and 8 in order to get his answer 56. The learners observed the patterns on previous numbers such as $1 \times 2 = 2$; $2 \times 3 = 6$; $3 \times 4 = 12$; $4 \times 5 = 20$; $5 \times 6 = 30$; $6 \times 7 = 42$; and $7 \times 8 = 56$.]

T: Right. Now, I have these two rows of numbers. [He wrote on the board.] What is the rule? [He paused.]

1	2	3	4	5	6	7	8	9
3	5	7	9	11	13	15	17	19

L3: The rule is $n \times 2 + 1 =$

T: If I continue the first row up to 15, what would be the corresponding number for 15?
L4: 31, teacher.
T: How did you get it?
L4: $15 \times 2 + 1 =$
T: Square numbers. Who can give me a square number?
Ls: [Several voices.] 16, 9, 4 …
T: How do I get a square number? I get a square number by multiplying a number by itself. [Then he called different learners to give square numbers.]
L5: [One girl who was sitting quietly all of a sudden raised her hand and said:] I can make a square with a picture. If each side of a square is 4 centimetres then we get an area of 16 centimetres. [The class became very quiet. Learners were thinking about the girl's reasoning. However, the teacher did not follow up the learner's observation. Instead, he told her that she was answering a different question.]
T: But, what you are saying is geometry. We are not talking about geometry. We are talking about square numbers. Okay. We are talking about numbers not geometry. [The learner quietly accepted the teacher's response to her observation.] What number pattern do you see on these numbers? [Referring to $1 = 1 \times 1 = 1^2$; $4 = 2 \times 2 = 2^2$; $9 = 3 \times 3 = 3^2$; $16 = 4 \times 4 = 4^2$.]
L6: Teacher, I see a pattern there. I see 1, 2, 3, 4, [Referring to the bases for 1^2; 2^2; 3^2; 4^2.]
T: Yes. But, what is the square of that? [The student responded 1, 4, 9, and 16.]

The mathematics discourse continued with the teacher's questioning, students' responses, and the teacher's validations.

There are several important observations from this classroom episode. First, although the mathematics instruction was dominated by the teacher's talk, mathematical content was focused on conceptual understanding of number patterns (i.e. strategies 1 and 2). Second, in most cases, the teacher's wait-time for students' responses was very helpful. There were, however, two critical moments for mathematical learning that the teacher missed (a) the connection between geometry, measurement, and square numbers, and (b) the relationships between the square root of a number and its square. One might wonder, perhaps, if the teacher's uncertainty to see the connection prevented him from taking advantage of this learning opportunity. Asking for elaboration would encourage active listening to multiple perspectives for conceptual understanding of mathematics and modeling a "teacher as learner" in his classroom.

In our one-on-one interview with the teacher we asked him about these critical incidents:

R: In your mathematics lesson of squaring numbers, a student observed a squared geometric figure. Your response to the student's observation was that, "we are talking about number patterns not geometry." Why did you respond this way?
T: I was just focusing at that stage on my presentation, but I did reflect afterwards. I need to be guided more because I tend to focus only on whatever aspect I am doing. I did not pay much attention to what they were saying at that moment. I am just grateful for the observation about the squared numbers; it has opened my mind to be aware of other perspectives and other instances where the same principle can be applied. When I teach

> Maths, I must be aware of what else can be interlinked, so that when pupils come up with something, I can focus on that as well to empower myself and the students.

Through the process of dialogue with the researchers and his reflection on his classroom mathematical discourses, the teacher began to understand the limitations of his direct instruction. From our perspective, this type of confrontation is a positive step toward teacher transformation in terms of content knowledge and pedagogical content knowledge. The seventh-grade teacher mentioned that he needed to empower himself in terms of mathematical content and pedagogy so that he could help his students. He also realized the importance of actively listening to students and facilitating classroom dialogues through redirecting, probing, and prompting questions.

Discussion

In our study of these four teachers, we observed that mathematics instruction varied from mostly teacher-centered (strategy 1 or level 0) and teacher-directed combined with questioning for answers (strategy 2 or level 1), to small-group, cooperative learning and learner-centered (strategy 3 or level 2) in both Foundation and Intermediate Phases. Strategy 2 (level 1) was dominant in most classroom discourses. Strategy 4 was not observed in any classroom. Communication about mathematics ideas in all classes occurred mostly between the teacher and the learners. The nature of those interactions focused mainly on how to calculate and produce a correct answer. The reason for calculating and interpreting a given answer was observed in some of the classes in both phases. Our classroom observations suggest that the main focus of mathematics instruction was not to afford students with a conceptual understanding of the lesson presented by teacher but purposed only to impart the mechanical procedures necessary to achieve the correct answer.

In the aforementioned four classrooms episodes, we attempted to illustrate the dialectic relationships between the participating teachers' stated beliefs and practices. These reflexive relationships must be understood within the socio-cultural and socio-historical context in which these teachers were educated long before the 1994 election. The nature of these teachers' enactments is inherently socio-historical and experiential. They expressed the challenges they face teaching mathematics compatible with the new OBE of the RNCS. For these teachers to be successful in administering the RNCS, they will have to improve their content knowledge and their pedagogical approaches for teaching mathematics, thereby equipping their students with necessary knowledge, skills, and dispossessions. These teachers will need professional development support if they are to become the kind of teachers that the RNCS envisions; teachers who are "qualified, competent, dedicated and caring," and who are "mediators of learning, interpreters and designers of Learning Programmes and materials, leaders, administrators and managers, scholars, researchers and lifelong learners, community members, citizens and pastors, assessors and learning area/phase specialists" (RNCS, 2002, p. 8). The RNCS does not provide any specific methods for achieving these stated outcomes. Rather, it lays down a broad vision for the future of education and attempts to delineate what the new teacher, the new learner, and the future citizen of a united SA is desired to become and possess. The RNCS states that the "South African version of outcomes-based education is aimed at stimulating the minds of young people so that they are able to participate fully in economic and social life" (RNCS, 2002, p. 12). How the teacher in the classroom accomplishes these goals must become the responsibility of teacher preparation programs.

Our participating teachers themselves suggested common sense ways that they may begin to achieve these goals. They suggested that collaborative planning among their school colleagues and school-based professional development would be beneficial and useful. These teachers face the daunting task of implementing the new OBE in their day-to-day classrooms. In the East Cape of SA, rural schools are facing large student-teacher ratios, administrative failure, lack of financial and material resources, and the lack of adequate teacher preparation necessary to meet the goals of the new standards. Blanton and Harmon (2005) have shown that these obstacles can be overcome through the provision of organizational support of teachers at the school level. This support will help teachers to assume leadership responsibilities in their schools and facilitate the creation of curricula that are aligned with RNCS standards. Teachers can be educated how to design and implement professional development activities for their colleagues, and to revise lesson planning and delivery to better achieve the desired outcomes for learning. Professional partnership and development along these lines is possible for SA teachers and schools.

In a review of literature concerning teachers' values and presuppositions about mathematics instruction it has been concluded that teachers generally approach the teaching of mathematics as rule driven and formula based, and as a content area that is best taught through text-book problems and memorization (Zevenburgen, 2005). This literature also shows that these sorts of views are difficult to change without proper professional support (Zevenburgen, 2005). The teachers in our study, however, expressed their desire to do just that. They expressed the desire to connect their teaching with their students' socio-cultural backgrounds and to make their teaching contextually relevant to their students' lives. A first step in doing so would be to create a classroom environment where dialogue is treasured and students' voices are encouraged to be heard. This recommendation is consistent with the Math-Talk community climate discussed by Hufferd-Ackles et al. (2004) where the conducive learning milieu is one where the student contributes largely to the discussion of mathematics and is allowed to frame an understanding of specific content and concepts in her or his own terminology. Traditional mathematics instruction intends only to impart the skills required to solve mathematical problems; the new outcomes desired to be met by our South African teachers intend for students to *understand* mathematical concepts and the myriad of ways of representing them.

Participation in the larger global society, another one of the outcomes desired by the RNCS, requires that students not only be able to understand but also to learn to construct new knowledge, to explain, conjecture, organize, predict, and to collaborate with others toward a common goal (English & Watters, 2004). Traditional approaches to teaching mathematics have focused only on following procedures for arriving at an answer (English & Watters, p. 336). English and Watters note that the problem with this approach is that a child does not then have to understand or interpret the mathematics problem involved, she or he has only to be able to follow the proper sequence of steps towards a specific goal. This sequence of steps is problematic because this approach does "not address adequately the mathematical knowledge, processes, representational fluency, and social skills that our children need for the 21st century" (English & Watters, p.336) nor does it equip the student with any real sense of understanding of the language of mathematics. It is through the dialectic interplay between student–teacher and student–student that clarification and consolidation of conceptual understandings of mathematical ideas is fostered (National Council of Teachers of Mathematics, 2000).

Additionally, the participating teachers reflected on their teaching methods in mathematics, about the need to get to know all students, and about putting mathematics content in relevant contexts that connects with students' prior knowledge and their socio-cultural experiences. Students are more successful in their learning when their socio-cultural heritage is visible and reflected in the classroom. Teachers can create learning opportunities for all students by establishing socio-mathematical norms in the classroom relative to their students' cultural backgrounds (E. Yackel & P. Cobb, as cited in Frempong, 2005).

Moreover, the teachers we interviewed discussed the importance of active listening to students' voices, which is vital if students are to feel that they have a secure and welcoming place within the classroom and an opportunity to succeed. Students hold distinctive perceptions of learning and possess individual knowledge bases that are available for teachers to access if teachers learn to take the time required to foster these teacher-student relationships (A. Cook-Sather, as cited in Boyer & Bishop, 2004).

The teachers also talked about the need to commit themselves to allowing extra time for targeting attention on their lower achieving students, to affording all students sufficient opportunity to work together cooperatively and responsibly, and to using multiple strategies for assessing students' understanding of mathematical procedures. These ideas and strategies are compatible with the RNCS requirements but are understandably difficult given the current inequitable funding of schools and large class sizes.

Concluding Remarks

The intention of this study was not to question the professional integrity of these teachers. These educators took their teaching responsibilities very seriously. With inadequate resources and limited practical guidelines from the Department of Education, these educators tried hard to provide their students with the best possible educational opportunities. We also recognize that what these teachers enacted in their classrooms was/is connected to the larger socio-political and socio-historical movement that discriminated against them and intentionally prepared them poorly so that they would function minimally within their local settings. Nevertheless, we must express our constructive criticism regarding the inadequacy of most of the classroom practices we observed and the consequences of such practices for educating pupils.

In this study, we described the complexity of transforming mathematics education. Resulting from this observational and descriptive process we would suggest that the implementation of the RNCS requires an epistemological shift in teaching, learning, and assessing learning. Most of the participating teachers taught the way they were "trained" to teach. They clearly stated how their teacher education programs were structured. They also reflected on the last 10 years of education in SA. They were supportive of the RNCS in terms of what to teach, learn, and assess in mathematics. They were, however, unclear and uncertain regarding *how* to implement these national requirements in their day-to-day classrooms: "Because of that change, I feel that I personally need more guidance" (seventh-grade teacher).

Our study highlights similar concerns expressed elsewhere in studies of this sort. Research has shown that teachers often prefer "a more favourable learning environment than the one perceived to be present" (Aldridge, Laugksch, & Fraser, 2006, p. 137). Research has also shown that teacher preparation in outcome-based education has been significantly small when compared to the expectation of the educational reforms in SA (Aldridge, Laugksch, & Fraser, 2006). Teachers desire to have better resources, more preparation, better relations with colleagues, and stronger parental support (Aldridge, Laugksch, & Fraser, 2006). These desires echo the desires of our four teachers. In addition to these concerns the large class sizes found in these provinces combined with a lack of professional support makes it "difficult to use progressive teaching methods in the classroom" (Aldridge, Laugksch, & Fraser, 2006, p. 138).

For teachers to be competent in teaching mathematics in SA, they must be prepared more thoroughly in terms of mathematical content and pedagogy in grade appropriate contexts. The teachers we interviewed clearly expressed that they were aware of their own professional deficiencies and they worried about the consequences of these deficiencies for their students. Currently, SA has done much to further their educational reforms and to provide this preparation to their teachers equitably. The Department of Education has developed a number of resources in addition to the RNCS. The publication entitled "Toward Effective School Management" (TESM) exists as a series of manuals that provide a framework for the Department of Education to oversee their new educational reforms. Each manual covers a variety of issues related to the management of the diverse schools existing in SA and are designed to give individual school management teams the necessary guidance needed to manage their schools effectively (TESM, n.d.). In addition to this series the Department of Education has put together a web-portal that allows educators to access a wide variety of professional development resources, informational resources, and curricular resources (http://www.thutong.org.za). Notwithstanding these efforts, the system is still struggling to prepare its teachers effectively due to the slowness of these materials and funding to reach the poorest areas of SA. It is vitally important for these teachers to be prepared to teach mathematics in a way that is culturally and contextually relevant in order to meet the needs of their students. Teachers must be "provided with evidence of best practice that is based on solid research" so they can create the best learning environments possible for their students (Webster & Fisher, 2003, p. 324).

In 1999, SA mathematics achievement for eighth grade was the lowest of all participating countries, as reported in the Third International Mathematics and Science Study (TIMSS; Highlights from the TIMSS, 1999). This poor showing did not change after 4 years when students were tested again; in 2003 SA placed last of the 45 participating countries (TIMSS, 2003). South African educators continue to face heavy challenges as they struggle to overcome the tough realities facing them as teachers. After 15 years of reform, the funding of schools is still insufficient and inequitable, class sizes are still cumbersome, preparation remains inadequate, and language barriers still exist.

The legacy of the Apartheid system of education and its deep impact on denying equitable education for all citizens, keeps transforming mathematics education an uncertainty in the new multilingual classrooms of SA. Democratic education may not be realized if it does not reach the next stage of connectivity and relationship with the existing day-to-day classroom situation. At the present time, there is limited research-based curriculum material in mathematics. Therefore, more research is needed in this area.

It is important to transformative mathematics education that higher education institutions of learning take hold of their responsibility to provide effective teacher preparation programs. Future mathematics teachers need to be prepared to face the challenges of a new multilingual society. Will they be prepared for the new societal and educational demands that await them?

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