Teaching Unheard Voices: Students At-Risk in Mathematics

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To examine the mathematics classroom experiences of students considered to be "at-risk," we conducted case studies of four students in grades 7, 8, and 9 in Northwestern Ontario. The case studies revealed that their mathematics classes offered few opportunities for active, engaging learning or activities that students experienced as being relevant. Their teachers, who generally used traditional practices, seemed reluctant or unable to adopt reform-based teaching methodologies. Based on the diversity of the observed students' characteristics and learning needs, and the challenges these impose on classroom dynamics, we suggest earlier intervention for at-risk students as well as more substantial professional development for teachers.

Key words: mathematics learning, mathematics education, classroom environments

Afin d'analyser durant les cours de mathématiques les expériences d'élèves jugés à risque, les auteurs ont effectué des études de cas portant sur quatre élèves en 7e, 8e et 9e années dans le nord-ouest de l'Ontario. Ces études de cas ont révélé que leurs cours de mathématiques leur offraient peu d'occasions d'apprentissage actif ou d'activités pertinentes que les élèves pouvaient trouver intéressantes. Leurs enseignants, qui en règle générale utilisaient des méthodes pédagogiques traditionnelles, semblaient peu enclins ou incapables d'adopter des méthodes dérivant de la réforme. Compte tenu de la diversité des caractéristiques et des besoins des élèves observés quant à l'apprentissage et des défis que ceux-ci imposent à la dynamique de la classe, les auteurs suggèrent une intervention plus précoce auprès des élèves à risque ainsi que des activités de perfectionnement professionnel plus systématiques pour les enseignants.

Mots clés : apprentissage des mathématiques, cours de mathématiques, prestation en classe

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Mathematics reform is often viewed as particularly crucial for students who are struggling in mathematics, and best practices for working with such students are well defined. For example, recent publications from the Ontario Ministry of Education focus on recommendations for teaching students who are considered to be *at-risk* in mathematics for not meeting the expectations of mathematics course curricula (Expert Panel on Student Success in Ontario, 2004; Expert Panel on Literacy and Numeracy Instruction for Students with Special Education Needs, kindergarten to grade 6, 2005). Research on implementing the reforms described by the National Council of Teachers of Mathematics (NCTM) (2000) in schools with a large at-risk population does exist (see Balfanz, MacIver, & Byrnes, 2006) but research relating to students in Canada and particularly in northwestern Ontario is limited. For example, Kajander (2002), who interviewed grade-10 mathematics students and found many with critical gaps in their understanding, argued for the need to also study students in younger grades.

The current project began with a group of grades-7 to -10 (i.e., intermediate) teachers expressing interest in better understanding the needs of their students who were performing at low levels in mathematics. The teachers' discussion took place during a monthly half-day Professional Learning Group meeting, organized and administered by their school board. A further description of this activity may be found elsewhere (see Kajander & Mason, 2007). The research reported here forms part of a larger project that was conducted in three school districts in the region and included a written survey of over 70 teachers (Kajander & Zuke, 2007). To learn more about individual experiences and perceptions of students and their teachers, we conducted case studies in four class-rooms in four schools in northwestern Ontario. Our awareness of research related to at-risk students in mathematics and the recommendations from recent reform efforts such as those of the NCTM (2000) guided our analysis. These recommendations include the documents known as *The Standards* (NCTM, 1989, 2000), which describe best prac-tices in mathematics, as well as the *Expert Panel on Student Success in Ontario* (2004), and the *Expert Panel on Literacy and Numeracy Instruction for Students with Special Education Needs in Kindergarten to Grade 6* (2005), also in Ontario.

We used case study methodology for the research described here. We asked teachers who completed the survey to volunteer their classrooms if they were interested in participating in the case study portion of the project; four teachers were selected to participate, providing a class at

each of the grade 7, 8 and 9 levels. The study began with an initial sample of 15 students that these teachers identified as at-risk. After working in each classroom with these students individually or in small groups for about six to eight weeks, we narrowed the sample to one student in each of four classrooms. Students were chosen to maximize the diversity of learning needs in the sample to bring to light the many different student profiles that we were seeing, underscoring the notion that no one set of defining student characteristics exists (McFeetors & Mason, 2005). We conducted the case studies of the four students observ-ing their mathematics classroom experiences over a four-month semester, with a researcher (second author) working three times a week in each classroom. The teacher-participants guided our choice of method because they did not want students removed from the mathematics classrooms to any extent. We took the stance of participant-observers, interacting individually in the class with those students studied during the work periods. Observations of the classroom environment including teacher practices were also of interest in the case studies. Detailed field notes of observations and samples of student work served as the data for the study.

The designation *at-risk*, as described by the Ontario Ministry of Education and Training (2005), applies to students who perform at achievement levels 1 or 2, where level 1 is described typically as "limited" understanding on an achievement chart, which translates into a grade in the range of 50 per cent to 59 per cent, and level 2 is described typically as "some" understanding, translating to a grade of 60 per cent to 69 per cent. However, the characteristics of students at risk may vary greatly, providing a central challenge to describe them (McFeetors & Mason, 2005). Students' level of cognitive development (Geary 1994, 2000) may influence mathematics achievement, as well as a teacher's knowledge and teaching methods (Balfanz et al., 2006). Factors influencing student success may also include motivation, attitude, and confidence related to mathematical ability (Augustyniak, Murphy, & Phillips, 2005; Hannula, 2006; Sullivan, Tobias, & McDonough, 2006). Typically continued poor performance may reinforce students' low self-concept. In this way, a student's self-perception becomes self-sustaining, creating a cycle that is difficult to break (Marchesi, 1998). On the other hand, when at-risk students learn in environments designed according to their interests and levels of knowledge, they may become more engaged and motivated and increased mathematics learning will be possible (Daniels & Arapostathis, 2005; Hannula, 2006; Sullivan et al., 2006).

The National Council of Teachers of Mathematics' *Principles and Standards for School Mathematics* document has inspired many of the recent mathematics curriculum changes in Ontario (NCTM, 2000). In the NCTM (2000) vision, teachers provide rich learning experiences for students and help them to work through mathematical problems (NCTM, 2000). The Equity Principle of the NCTM underscores the idea that all students should be exposed to appropriate and rich mathematical experiences and problem-based learning, regardless of their levels of procedural skill (Van de Walle & Folk, 2005). Students are encouraged to develop their own solutions to problems rather than strictly following procedures that teachers prescribe, and students share multiple solutions to support the development of a thorough understanding.

In support of the Equity Principle, much research indicates that students at-risk will not benefit from rote learning or procedural practice alone (Fleener, Westbrook, & Rogers, 1995; Huhn, Huhn, & Lamb, 2006; Van de Walle & Folk, 2005). Because students at-risk may find learning basic fundamental skills to be boring, this will add to the negativity associated with the subject matter (Expert Panel on Student Success in Ontario, 2004). As well, students are more likely to practise incorrect methods when they rely on individual rote learning, thus more practice and volume alone does not necessitate success in mathematics (Woodward & Brown, 2006).

Because students are typically required in reform-based classroom environments to support their answers and defend the strategies they have chosen, they need to communicate effectively and interact in a social setting (Wood, Williams & McNeal, 2006). A teacher must be able to not only disseminate mathematical knowledge but also support all students' communication of mathematical ideas. Students are not able to switch back and forth between a student-centred and teacher-centred classroom. Thus, the transition to a student-centred learning environment must be gradual and consistent (Huhn et al., 2006).

In sum, students at-risk will benefit the most from hands on, active learning where they are free to explore and manipulate objects (known as manipulatives) while problem solving (Fleener et al., 1995; Van de Walle & Folk, 2005). In fact, practices that have been identified as best from a number of sources indicate that all students, particularly those at-risk, need to be actively involved in their learning through many hands-on, relevant, and engaging learning experiences to better support the development and retention of knowledge (Expert Panel on Student Suc-

cess in Ontario, 2004; NCTM, 2000; The Ontario Ministry of Education and Training, 2005). These learning experiences should be relevant and connect to students' worlds (Boaler, 1999). Hence traditional mathematics classroom practices might be particularly damaging for students at-risk, while reform-based practices can be particularly beneficial.

METHOD

We employed a qualitative, case study approach (McMillan, 2004) to explore and discern the perceptions, attitudes, and experiences of students at-risk to learning mathematics. We also wanted to describe students' experiences in the contexts of their actual mathematics classrooms.

The study involved teachers and students from four classrooms in four schools in a medium-sized urban area of northwestern Ontario. All the teachers had been participants the previous year in a Professional Learning Group for mathematics (Kajander & Mason, 2007), and willingly volunteered their classrooms for the study.

Teachers were chosen for the study from a grade-7 and grade-8 class, and from two grade-9 applied classes.[1] The grades-7 and -8 teachers were subject generalists; the grade-9 teachers taught only mathematics classes. We initially chose fifteen students in grade 7 to 9 for our study based on their teachers' identification. After working with all the students individually or in small groups for the first six to eight weeks of the study, we narrowed the sample to one student in each of the four classrooms to concentrate fully on one student at a time. We chose students from the initial sample with diverse characteristics to investigate as broad a range of behaviours and issues as possible: reading difficulties, attendance issues, behaviour issues, and issues related to mathematical understanding.

Data Collection

From September to December of 2006, we (a graduate student, second author, working closely with a faculty member, first author) observed the four classes for the entire length of the class three times each week, which we felt was enough to discern the climate of the classroom and patterns of interactions among students and teachers, while trying to avoid being obtrusive. As well as watching and documenting the actual lesson, we worked each day with selected students as they completed their assigned work.

Extensive discussions took place with participating teachers prior to the study to define the role of the researchers. Although we all agreed that the researcher-as-observer stance would prevent student-researcher interaction from influencing the data, we needed a way to probe students' thinking and understanding. In addition, teachers justifiably felt that the students in question should not be pulled out of class for interviews. Hence, we adopted a participant-observer stance, and gathered data about student understanding by interacting with students individually as they worked on homework tasks. As well the students were observed during formal lessons. We documented all these observations in field notes, and also examined copies of student work. Because teachers felt that recording the classroom interactions would be too obtrusive, we did not use audio or videotaping.

We analyzed field notes, which included observations from any formal lessons that teachers taught as well as notes regarding the observations of the case-study students and our interactions with them, to look for important themes, and these were assembled into narratives of each of the four main case study students.

CASE STUDIES

All teachers involved expressed concern and compassion for their students. The physical classroom environments in the study appeared generally welcoming to students. Teachers used a similar format to teach most classes observed in the study: the teacher discussed any homework from the previous night, and then presented a teacher-directed lesson that varied in length from day to day and classroom to classroom. We did not observe any of the teachers using manipulatives frequently, although we observed one of the teachers using them slightly more often than were the others.

Although the students were chosen to illustrate a range of traits in terms of behaviour, motivation and attendance, a number of similarities can be described. All four students presented in this article expressed frustration to us with the mathematics they were learning, as well as their weak understanding of it. All described themselves as "dumb" or "bad" at mathematics, indicating their poor self-concepts. All had a tendency to stop working, rather than ask for help, when they did not understand. All students, except the youngest in the sample, described to varying degrees their perceptions from past experiences that their teacher would become frustrated if they showed their lack of understanding

by asking for help. The students demonstrated avoidance behaviours in mathematics class to varying degrees; none appeared even remotely engaged by the mathematical content offered.

The following case studies describe in more detail the classroom teaching and a selected student in each of the four classes. We have ordered the case studies by grade level and in each case, the general classroom observations and teacher observations will be described first, followed by a description of the particular student studied in that classroom. All teacher and student names are pseudonyms. All teachers are portrayed as female for the purpose of preserving anonymity, although in fact the sample included teachers of both genders.

Classroom A - Grade 7 (Ms. Adams)

Ms. Adams is an experienced, confident teacher who has been teaching for over 20 years. Her classroom appeared organized and was colourfully decorated. The students were seated in groups of three or four, with the desks in each group lined up horizontally so that the students all faced the blackboard. School supplies and math manipulatives were readily available to the students, but they had to leave their desks to get the manipulatives if they chose to use them because they were not kept at each student's desk.

Each of Ms. Adams's observed mathematics lessons followed a similar format. First, the students engaged in problem-solving exercises. For example, on one particular day, Ms. Adams gave her students about five minutes to write down as many strategies as possible to find the area of irregular figures. Then, she held a class discussion in which students shared their work, describing their different strategies to the entire group. After the exercise, she took up homework questions. When students gave an incorrect response to a homework question, Ms. Adams typically responded with "Does anyone have a better answer?"

Ms. Adams did not examine the method involved in arriving at answers that were incorrect; she emphasized correct answers rather than solution methods. For example, when examining a word problem and looking for hints within it, Ms. Adams had the class focus on the word "excluding." One student suggested that it meant "not including." Ms. Adams then told the class that excluding means they should subtract. Rarely did she wait for more than one student to raise her or his hand before selecting a student to give an answer.

In the majority of the lessons observed, Ms. Adams asked students to copy a short note that she wrote on the blackboard. She wrote examples on the board as she explained them; students copied these examples in their notebooks; Ms. Adams followed this activity by assigning homework questions to everyone to be worked on individually. However, on one occasion observed during the research period, she gave students a longer assignment to work on individually, which involved creating, conducting, and analyzing their own survey. Students primarily worked independently, but Ms. Adams told them that if they needed assistance they had two options: They could ask her or they could ask a friend for help, but again, only once.

Three students in the class, according to Ms. Adams, had been struggling with the material at the grade-7 level and receiving failing grades, one of whom was Brian. Ms. Adams decided early in the year to place these three students in a foundations curriculum where the students worked at a grade-5/6 level. The rationale given to us was that these three students had too many gaps in their prior knowledge and that this work would benefit them by filling in these gaps.

Ms. Adams gave these students a workbook of over 60 pages. For the most part, these three at-risk students worked independently on these workbook questions, with little assistance. They sat outside the classroom in a hallway area with tables to do this work. An Educational Assistant worked occasionally with the students, but she admitted to us that she struggled with the mathematics content of the material herself. We never observed Ms. Adams to come out while the students were working to ask them how they were progressing, or to offer them help with the mathematical ideas in the workbooks. However, she did collect the workbooks periodically, graded them, and then handed them back to the students. One of these three students, whom we refer to as Brian, was the case study student from this classroom. Our observations began with watching Brain participating in the regular classroom, and then moving with him to the hallway area once he was placed in the alternative program. Brian began the alternative program about a month into the term.

Brian's Case Study. Brian, well-behaved, attended school regularly, although he seemed unmotivated during mathematics classes. He did not seem to possess a great deal of self-confidence and frequently suggested to us that he equated getting the right answer with being "smart." For example, when working independently on a question, we often heard him muttering under his breath, "Is that right? Am I smart?"

It appeared to us that Brian's difficulty with reading was one of the greatest factors inhibiting his success in mathematics. An obvious factor when he worked on word problems in class, his reading ability became a major issue when he tried to read the instructions for his workbook questions. For example, he read a workbook question that began with, "A *patio* will be made with square stones. . ." as, "A *potato* will be made with square stones…". We pointed out his reading error by saying the mispronounced word out loud and had Brian repeat the question. After he understood the directions, we discussed the problem in the patio example with him, and helped him create a visual image. Brian then completed the problem with few prompts. On another day, once we read a question aloud to him that he could not answer, and he discussed what it was really saying, he drew a picture on his own and said, "This question is easy!" When asked why he could not complete it in the first place, he said it was because he ". . . did not understand it."

It may well have been that it was the written text (rather than the mathematical ideas) that he did not understand. It is possible that remediation in reading might have been sufficient to support higher achievement in mathematics as well because other similar evidence exists in our field notes to indicate that Brian negotiated the mathematics once he understood the written text.

Classroom B – Grade 8 (Ms. Brown)

Ms. Brown has been teaching for over five years. In her classroom, the students' desks were arranged in rows of pairs that faced the blackboard. The walls were decorated with motivating posters. She showed compassion toward students as she tried to assist them in any way she could. She made students aware of what they needed for a particular lesson and provided them with the necessary supplies.

Ms. Brown was an organized teacher who expressed the initial desire to expose her students to a variety of methods to learn mathematics. She had just been moved to this elementary school in the fall, which had a different demographic from her previous school. Although the board in question did not have a self-identification program for Aboriginal students, our informal visual observation indicated that 30 to 50 per cent of the students in this classroom were of Aboriginal heritage.

Early in the fall, Ms. Brown related her enthusiasm to us for the ideas of mathematics reform, some of which had been discussed the previous year during meetings of her Professional Learning Group. She ex-

pressed wanting to use a discovery style of learning with her students as much as possible, and was knowledgeable about the use of manipulatives.

Ms. Brown often started her lessons by welcoming the students and telling a math-related story or anecdote, attempting to use examples connected to student interest, such as the recently announced salary of a well-known baseball player. She followed this verbal introduction by writing a short note on the blackboard, possibly with examples. She then gave a task or assigned work to the students. In the earlier part of the fall, Ms. Brown sometimes used manipulatives in her lessons, for example, using integer chips as well as snap cubes for some of the students' tasks. Although the first part of the lessons was relatively teacher directed, Ms. Brown sometimes asked students to work on hands-on tasks during class.

Ms. Brown also used methods of assessment other than tests. During the course of the research, she used two culminating unit problem tasks: one that students worked on individually, and the other, in groups.

Generally, we observed a significant number of behaviour problems in this classroom. Many students appeared highly disinterested with the subject matter. It appeared difficult for her to collect assigned questions from students. The students were not at all eager to do their assigned work or participate in class. Ms. Brown frequently asked them if they had questions with the material and paused during her lessons to ensure that everyone was able to follow. We observed that many students were reluctant to ask questions or to speak when given the chance. It appeared very difficult for Ms. Brown to get students actively involved in her lessons in any way; behaviour-related disruptions were frequent such as students calling out or pounding on their desks. Because this classroom was in an open-concept school in which the classrooms were separated by moveable panels, this fact added to the noise level. We often observed that voices clearly heard from other classes distracted students.

From the beginning of the school year, we noticed a change in Ms. Brown's optimism. She described to us the feeling that the environment at this current school was very different from her previous school; this school was becoming a disheartening experience for her. By the end of the classroom observation period in December, she had become very discouraged in general, and had lost some of her initially expressed enthusiasm for reform-based learning because of the students' poor responses to her lessons. For example, when using the snap cubes for an

activity, students made guns out of them and played inappropriately with them. After a number of warnings, Ms. Brown took the manipulatives away. This situation resulted in further frustration for Ms. Brown and the students because students complained they could not do the activity without the cubes. After that indicent, Ms. Brown avoided the use of manipulatives. Ms. Brown expressed frustration to us about the potential for implementing reform-based methods and stated that they were unrealistic in her current classroom, although she described her awareness of the need of the students at-risk for hands-on learning and manipulative use.

Diane's Case Study. Diane's example illustrates how a disruptive classroom environment can have a potentially debilitating effect both on students and teacher.[2] Diane was a student who, unfortunately, exemplified such demoralization. She identified herself as Aboriginal, and had attended school on a reserve about 300 kilometers away from her present school from kindergarten to grade 3. She said that she missed a lot of grade 3 because she was visiting her sister. She attended a new school for grades 3 and 4, followed by a move to another reserve for grades 4 to 6. She cannot recall why but knew that she "missed a few months of school" in grade 6. During grade 6 her family moved again and she has attended her current school since. Diane had attended four different schools in fewer than nine years. As well, she was absent from school nearly 30 per cent of the fall term. She told us that she had experimented with drugs, and had been suspended from school for two days.

Diane described enjoying mathematics at the primary level, liking her teachers, and enjoying playing with hands-on materials. She said she had good grades in mathematics then. Now, she said she "hates math." We observed that she was easily frustrated by some of the assigned work, and would simply put a task down and stop working, rather than asking for help. However, on one occasion when we explained that some tasks are challenging and are not clear right away, she began working again and managed to finish the task without help. Diane said she could sense that past and present teachers were frustrated with her when she asked for help, and that was why she did not bother to ask any more. She commented that concepts were "not explained" well enough for her to understand.

Diane expressed the feeling she would not succeed even before she attempted particular mathematics problems. She almost never asked questions. Although her work was often not completed or attempted, she

said she did not understand how to do it or feared that she might get questions wrong. As well, she said she did not feel prepared for tests and quizzes and "forgets" what to do. Even when Diane had completed a question correctly, she typically said that it was "probably wrong." For example, in a question involving solving for an unknown in a linear equation using a balance analogy, Diane chose trial and error as her strategy. Although her answer was correct, she was convinced that she was wrong because she thought that some type of procedure that she did not use was needed to figure it out correctly.

When the researcher sat next to her and offered words of encouragement (not necessarily help on the mathematical ideas), Diane was able to work longer without becoming frustrated. Although an Educational Assistant was in the room, we did not observer her working one on one with Diane during the duration of the research. Although Diane's background and current poor attendance likely affected the continuity of her learning, we felt her poor self-concept and reluctance to ask questions were contributing factors to her difficulties as well.

Classroom C – Grade-9 Applied (Ms. Chase)

Ms. Chase has been teaching at this particular high school for fewer than five years. She arranged her classroom with the desks in rows. She was very tolerant on many occasions of less than perfect behavior. She attempted to stay positive and to keep the students in good spirits despite the fact that many of them were struggling with the material. She also offered school supplies such as pencils or rulers to those students who needed them.

Typically, Ms. Chase's lessons involved well organized but extremely lengthy formal lessons (up to 45 or 50 minutes of a 75 minute period). When the students had an opportunity to give answers and contribute to a lesson, the response time given was generally only as long as it took for the first student to raise his or her hand and participate. Ms. Chase gave many step-wise procedures to the students. The students themselves did not have a chance to investigate or develop these procedures independently and may have had to rely on memorizing them if they did not understand them conceptually. Homework practice also tended to be mostly procedural practice, with few contexts of any sort evident.

The students most often were not attentive throughout the lengthy lesson and we observed them talking to other students and not copying

notes as they were instructed. Following the formal lesson, Ms. Chase assigned seatwork. The students usually had an ample amount of class time to complete it, although they did not always use this time to do so. It seemed as though many were just waiting for the lesson to be over so they could ask to use the washroom. In fact, we never witnessed the homework questions being taken up in class. Homework checks did not take place to keep the students accountable, and they were responsible for completing homework on their own (or not) and asking for help if needed. In reality, many of them were simply not doing the homework, and almost no one asked for help during homework time.

Ms. Chase attempted once during the research to try a reform-style group task. Because she did not lead up to notions of group work, manipulative use, or problem solving in any way before the lesson, her lesson was an abrupt change of style, which is difficult for students (Huhn et al., 2006). She was dissatisfied with the lesson because many students were off task, did not complete it, and misused the manipulatives. This lesson was the first time she had used manipulatives with the class. After that experience, she did not use any form of manipulatives again.

We witnessed Ms. Chase using a real world context only once, when explaining the concepts of area and perimeter. She related perimeter to home improvements, like measuring baseboards, and used area concepts to discuss painting walls and to know how much carpet to buy. On this particular day, we observed the classroom behavior to be much better than other days. Perhaps this observation was not coincidental and that there was a link between the relevance in the lesson and at least somewhat improved behaviour.

Susan's Case Study. We chose Susan as a case study student because she exemplified a number of typical issues observed with several other students. Susan appeared in fact not to be lacking in mathematical ability. Nevertheless Ms. Chase identified her as at-risk because of her poor grades.

A typical day with Susan was as follows:

> Susan is in the hallway as soon as class begins, just minutes after the bell has rung at 1:00 pm, and is apparently going to the washroom. The lesson continues and Susan comes back to class at 1:25 pm. She leaves again for whatever reason and returns about 10 minutes later. Upon her third arrival to the class, she is not paying attention as the lesson goes on and continues to make conversation with the students around her. [researcher field notes]

Susan was comfortable sharing some of her personal history with us. She has had many challenging experiences at quite a young age, and she was currently struggling with many issues. She attended kindergarten through grade 6 in a large city, living in a dangerous area of an American city for a portion of grade 6. She talked about two gangs in particular, and told stories involving children of violence in the streets. In grade 7 she moved to a very small northern town and began grade 8 there. Eventually, she moved to the town in which the research took place where she completed grade 8. She came to the high school where the research was taking place for grade 9. We conjecture that such disruptions would compromise her learning, perhaps underlying her statement that she did not see the point of mathematics and did not understand why the students needed to go through all of this "stuff." She said that students should just learn what they need for a particular job. Susan also said that she did not want to go to college or university and that she did not care if she were ever employed. Her solution was that she would collect Employment Insurance (EI) benefits.

Many instances demonstrated Suan's ability and potential. For example, instead of using the formula sheet, she intuitively came up with the formula for the area of a triangle, which happened to be right-angled. She used her understanding of the area of a rectangle and recognized that two of the triangles made a rectangle. By dividing the area of a rectangle by two she was able to find the area of the triangle. On another day, not having a calculator prompted her to find her own strategy for dividing. Instead of dividing by 4 when given the perimeter of a square and asked to find the dimensions, Susan divided by 2, twice. She realized this was the same thing and, although inefficient, was correct. Again, a deep understanding was apparent.

Susan demonstrated some ability but lacked interest and focus, often appearing highly distracted. For multiple reasons, Susan failed to see the value in mathematics or in education in general. However, she managed to pass the course. Ms. Chase felt that Susan's achievement would not have been possible without support of our research team for such a substantial period of time.

Classroom D – Grade-9 Applied (Ms. Daniels)

Because Ms. Daniels's classroom style was similar to that of Ms. Chase, for the purposes of brevity, we have not described classroom activities in

detail. Suffice to say that the descriptions of Classroom C and D are highly similar.

Kelly's Case Study. Kelly, a grade-9 student, was painfully shy with very weak self-esteem. A positive sign of her awareness and agency, however, was that she was a member of a school-based self-esteem club. Nevertheless, she also had much difficulty communicating and we found her hard to understand at times because of her tendency to use disjointed sentences, repeatedly using words such as "like" or "or something." However, she appeared to develop a certain trust in us over time, and began to ask frequently if she were on the right track with questions. When we asked if she thought her answer or method were correct, Kelly would often say it was wrong.

During Ms. Daniels's regular lesson, Kelly often passed notes when the teacher's back was turned. Because Kelly was very discrete about it, the researcher did not believe that Ms. Daniels was aware of the extent of this activity.

Kelly failed the first two formal tests in the course. However, her marks steadily improved after that, and not only did she pass the next three tests with increasingly higher marks, she did excellent work on a number of assignments in the latter half of the course, including receiving three "A" grades. However, a lot of evidence suggests that Kelly was still operating with a basically procedural understanding thus making problem solving difficult. Kelly made a lot of careless errors, for example, forgetting to divide by 2 when applying the area of a triangle formula. This error, like many of the other minor errors, resulted in lost marks, and perhaps lost confidence. In addition to careless errors, Kelly did not readily use the resources that were available to her. Formula sheets, homework answers at the back of the book, as well as a calculator were accessible and often on her desk, although she would often take a great deal of time trying to recall formulas and mathematics facts from memory. She frequently showed signs of frustration by hanging her head and becoming quiet.

Specifically, certain types of questions were difficult for her to complete as illustrated in Figure 1. Kelly's responses from her notebook are transcribed for illustrative purposes in capital letters below each question in Figure 1. Some of her handwritten notes are visible to the right, and Ms. Daniels wrote the grade on each question, as shown on the left, as well as more notes partially visible to the right. Ms. Daniels had

graded these questions using a numeric score, rather than using levels of achievement based on a rubric.

In previous assessments and homework questions, Kelly was able to compute unit rates as well as create equivalent ratios. However, Kelly appeared to find the questions in Figure 1 difficult and we believe that she was working procedurally, without deep understanding. There is an attempt at the top right of the page to make an equivalent fraction but she was not able to successfully do so.

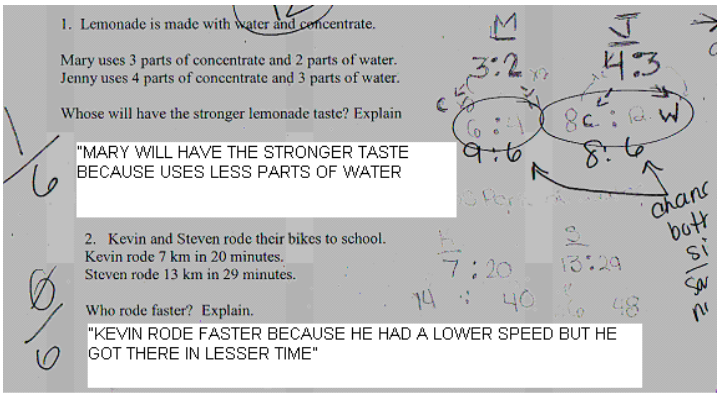

Figure 1. In both examples, the student appears to use a single value, rather than the ratio, to determine the answer.

Figure 2 provides another example in which Kelly could not apply a concept. Again, she did not appear to have the conceptual knowledge of the parallel line and angle relationships and therefore was unsuccessful. In question one, the students were supposed to figure out the unknown angles for parallel lines by using the "Z pattern, F pattern, and C pattern." As an aside, we could not help but notice the extreme dryness and lack of context in these sample questions, especially for at-risk students.

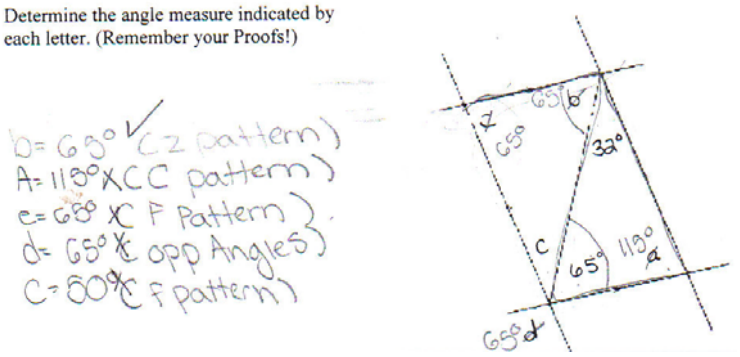

Figure 2. The inter-dependence of the angle measures makes it unclear which error was the first in this example.

We are assuming Kelly understood that the pairs of lines were parallel, although the diagram is inconclusive. She seems to have an incomplete idea of the patterns. For example, she attempted to determine angle *a* on the bottom right corner, possibly from the idea that it would be the supplement of 65 degrees (Kelly has written 115 degrees above angle *a*, based, we think, on the idea that 115 + 65 = 180). In fact the "C" pattern refers to angles enclosed by parallel lines (i.e. angle *c* + 65 degrees + angle *a* must add to 180 degrees). Kelly appears to have a partial understanding because she chose the angles enclosed by the right side and the diagonal, rather than enclosed by the parallel lines. In the very next question (see Figure 3), students were given another example in the form of a quadrilateral and required to apply the concepts and proofs to determine the angles. As shown in Figure 3, Kelly was unable to complete the question although she attempted an answer. It is not surprising that she was unsuccessful with her attempt based on her work on the question shown in Figure 2.

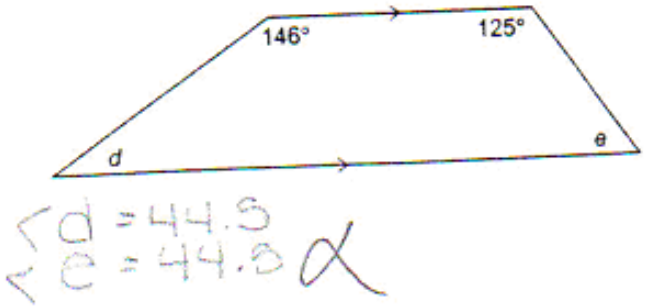

Figure 3. In this example, the student is pairing the supplemental angles incorrectly.

We felt that the abstract nature of these questions for students in the applied level and the feedback of "X" by the teacher in Figures 2 and 3 did not support deepened student understanding.

In addition to application questions, Kelly found that recalling definitions and meanings of math-related terms was also a problem. Her difficulty was true for test situations, in completing seatwork, and in discussions with us. For example, she was unable to do a homework question asking for the dimensions of a rectangle because she said she did not know what these were. When we explained that this statement meant the length and the width she was able to respond easily. There were also many instances on the tests where she was unable to provide answers for definition questions. She could not define terms like *binomial* and *variable*, yet the majority of test questions involved such terms and used them repeatedly. She was not able to define the phrase *obtuse angle* on her geometry test, nor was she able to identify obtuse angles in her test problems. Students were required to give definitions of mathematical words on the test, which they needed to understand the instructions for other test questions. Kelly was unaware of many of these crucial definitions, but attempted to work with the concepts associated with them. Her work in Figure 4 illustrates another example of this crucial learning issue, showing Kelly's work on the highly procedural and definition-oriented questions that were typical of the homework.

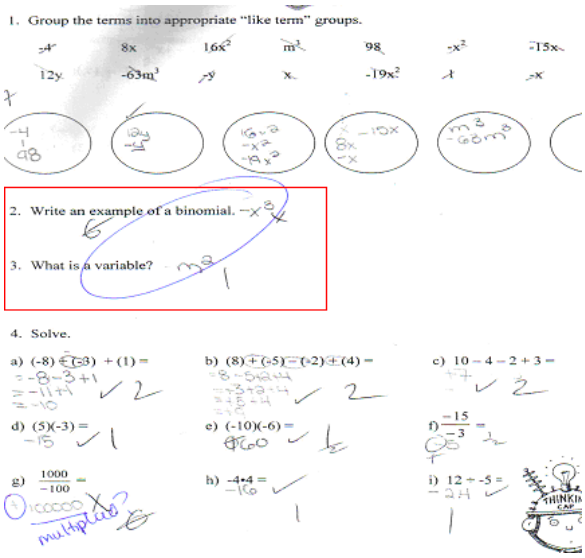

Figure 4. This typical question illustrates difficulties with both definitions and procedures.

Hands-on or concrete materials were not used to convey the geometric ideas, and real-world connections were not apparent during our observation periods. Kelly had much difficulty understanding terms and determining what was being asked. She was also inhibited by a lack of a belief in her ability, had difficulty communicating orally, and showed some very clear gaps in her learning that contributed to a deficiency in conceptual knowledge.

DISCUSSION

The four students demonstrate many different characteristics in their relationship with learning mathematics. Brian, well behaved, was inhibited by his reading difficulty. Diane, who expressed strong dislike for mathematics and her recent teachers, had poor behaviour and attendance. She was easily frustrated and very reticent to express the need for help even if it were offered. Susan was unmotivated, avoided doing her work, and was often inattentive, yet she had moments of conceptual insight. Kelly, painfully shy, had difficulty with both expressing herself verbally and understanding instructions and terminology. Because her

procedural work was often not accompanied by conceptual understanding, she found problem solving difficult.

Scholars such as Hannula (2006) and Woodward and Brown (2006) have identified what have become known as *best practices* for teaching students who are labeled as *at-risk*. Such practices include fostering social acceptance, independence, communication, and control over learning; developing a connection between mathematics concepts and students' actual lives; and enhancing opportunities to develop skills needed to learn in an investigative or problem-solving mode. Although it may be important to include targeting areas of specific content-related weakness, individual rote practice alone is deemed insufficient, and may even be detrimental to address misconceptions and deepen understanding in the absence of other learning opportunities.

The students in the study demonstrated varying characteristics and levels of mathematical understanding. However, most were significantly disengaged from the mathematics classroom activities; attendance and attention span were problems for some. All appeared shy, unmotivated, and/or hesitant to ask questions. All appeared to be significantly lacking in self-confidence. In some cases, these underlying issues and frustrations had manifested themselves into substantial behaviour problems: they were completely off task. Indeed, such disengagement seems connected to the most striking general observation from the case studies: teachers did not appear to have, or were unable to create, opportunities to significantly address students' mathematical misconceptions and weaknesses. We have a strong suspicion that the development of these situations over the course of students' schooling experiences may have related to inappropriate past and current opportunities to learn mathematics, ultimately leading to students becoming frustrated and disengaged from the content. However, we were able to observe only students' current behaviours and responses. The disengagement and behaviour issues observed in the case studies would appear to provide a difficult starting point for teachers wishing to shift to a more reform-oriented classroom environment. Hence, most of the classroom teaching observed in the case studies appeared to be highly traditional, procedural, and teacher directed, particularly in Classrooms A, C and D. Students were generally expected to work on decontextualized tasks without social interaction or other motivating aspects, particularly in the grade-9 classes. Teachers made few connections to their world and interests, with the exception of the few attempts by Ms. Brown.

Despite the importance of including active, hands-on, engaging, interactive, and involved learning, three of the teachers in the case studies had a strong preference for formal, teacher-directed instruction. Although the teachers made a few attempts to use manipulatives, they appeared unable to make reform-based methods work effectively with students not used to non-directive teaching. Although the grade-9 students we observed could not focus for long periods, they were subjected to a significant amount teacher-directed instruction. Such environments potentially continue to perpetuate the cycle of disinterest, boredom, and frustration, eventually manifested in the significant class-room misbehavior that we also observed. Overall, many students in the study were disengaged from their mathematical learning, unmotivated or frustrated, and were unable to see the point of the topics being studied. Their disengagement was evident in their being loath to ask questions when they did not understand mathematical concepts and procedures. Some also had reading difficulties, and shyer students virtually never sought assistance from their teachers. It is likely that this discouragement, lack of interest in mathematics, and disengagement eventually became manifested in the observed off-task behaviour that tended to put at-risk students further behind, further decreasing their performance and self-confidence, and thus perpetuating the cycle of poor achievement in math.

Implications

The data presented in this article consistently point to a significant disconnect between *best practices* for students at-risk as described in the literature, and what we observed in the interactions between teachers and students in the classrooms. Rich and engaging reform-based environments that cater to students' learning needs were described in the literature as having the most potential to motivate and support the learning of students at-risk. However, we did not generally observe in the classes involved in the study interesting tasks that students saw as worthwhile and contextually important to their lives. Practice questions, particularly in the grade-9 classes, were mostly formal textbook tasks that were abstract and not engaging to students. Teachers appeared reluctant to use investigations, tasks, and other student-centred or reform-based techniques, and the few attempts to use manipulatives often resulted in chaos. We believe that, all told, these issues are of grave and significant concern to warrant further study and point to a crucial need for ongoing professional development and support.

Examining these classrooms from the teachers' point of view, we note that some of the study classrooms were highly discouraging environments in which to teach. Engaging students with significant weaknesses in content knowledge, many of whom were absent frequently and who were typically unmotivated and regularly misbehaved, would be daunting for even the most skilled teacher. The case studies indicate that the teachers who we observed in their classroom settings were coping with students at-risk by falling back on familiar practices that afforded them the most control, namely, teacher-directed instruction accompanied by extra help on individual homework. Although most teachers expressed a strong desire to help their at-risk students, they appeared to be ill equipped to meet the many challenges of engaging students who felt alienated and disengaged from learning mathematics. Teachers thus seemed inhibited from shifting out of a traditional pedagogical mode and could not embrace approaches that would better serve at-risk students in their class-rooms.

Although we suspect that many of the situations we observed would generalize to other geographic areas, the students bearing the additional burden of moving frequently, especially in the case of students from First Nations reserves, have additional challenges in learning largely sequential subjects such as mathematics. We suggest that interventions for students who are beginning to fall behind (and/or beginning to disengage) need to happen much earlier in their schooling. These interventions would require, we believe, significant professional development opportunities. Strong administrative support and adoption of school-wide reforms coupled with professional development have been shown to support teachers' development and improve achievement for at-risk students (Balfanz et al, 2006). We believe the data presented in this article attest to the desperate need for the widespread provision of such training and support.

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NOTES

[1] Grade-9 mathematics classes in Ontario are offered at the "academic" level for students intending to study math-related subjects at university, and the "applied" level for other students.

[2] The potentially demoralizing effect of such demanding classrooms on even the most enthusiastic teachers may be important to consider for the focus of another research study.

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