

## **Students at-risk: What can they tell us about teaching and learning mathematics?**

### **Abstract:**

This paper presents the perspective of adolescent students at-risk in mathematics. The paper provides a venue for students' voices; an opportunity for them to outline how educators might improve mathematics teaching and learning for this underrepresented group. The students in this study suggested that learning opportunities could be improved if they were provided with additional instructional time; more one-on-one assistance with either a teacher or more able peer; and manipulative-based activities which focused on developing conceptual and procedural knowledge as well as mathematics communication skills. Thus, the study findings support the creation of a mathematics learning environment that balances both small group collaboration and teacher directed explicit instruction provided to at-risk students either one-on-one or in homogeneous small groups.

### **Purpose**

The purpose of this paper is to present one component of the research findings from a study conducted in partnership with ten district school boards in northern Ontario. The intervention provided Grade 7 – 10 mathematics and special education teachers with professional development opportunities to assist them in creating appropriate learning experiences for their students identified as 'at-risk' in mathematics. The project combined multiple professional development experiences, including: collegial support within a community of learners; specific training on the use of the *Nelson PRIME*<sup>1</sup> developmental continuum; opportunities to implement new knowledge and skills; and time to reflect on mathematics beliefs and practices. However, within the context of this paper, I present only the students' perspective of how they were impacted by the professional development offered to their teachers and what they suggest teachers do to improve learning experiences for this group of students.

### **Theoretical Framework**

#### ***Students at Risk and Mathematics Reform***

Although many studies provide evidence which support the positive outcomes of Standards-based mathematics teaching practices on student achievement for average and high achieving students (Boaler, 1998; Fennema, Franke, & Carpenter, 1993; Romberg, 1997), some studies (Kroesbergen, Van Luit & Mass, 2004; Baxter, Woodward, & Olson, 2001; Woodward & Baxter, 1997) have found that reform teaching practices had negligible benefits for the least able students. Although explanations for these findings vary, most focus on the lack of support for struggling students during knowledge construction activities. Moreover, as a result of repeated failures with mathematics, many struggling students are intimidated by it and, eventually develop a belief that mathematical competency is acquired by only a few gifted individuals. Furthermore, these same students view the abstract nature of mathematics as serving no real purpose in their everyday lives. Such experiences result in student frustration and fear of mathematics. These negative experiences lead to the development of a low perceived self-efficacy (Bandura, 1997). Therefore, if a person's past experiences in mathematics are negative and laden with failure, this will result in a lack of confidence in any future encounters with the subject. Pajares' (1996) extensive literature review on students' mathematical achievements supports the assertion that students' beliefs about their mathematical abilities are strong predictors of students' future achievements.

By contrast, Middleton and Spanias' (1999) review of the research on motivation in education highlight the significant influence of instructional design on student achievement motivations in mathematics. Specifically,

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<sup>1</sup> PRIME is the acronym for *Professional Resources and Instruction for Mathematics Educators*. PRIME is a Canadian research-based initiative developed through Thomson-Nelson publications. It is continuum describing the developmental phases (skills and knowledge) that students progress through as they develop conceptual understanding in mathematics.

they assert that "achievement motivation in mathematics is highly influenced by instructional practices, and if appropriate practices are consistent over a long period of time, children can and do learn to enjoy and value mathematics" (p. 82). Positive results of Standards-based mathematics teaching on low achieving students have also been reported by Riordan and Noyce (2001) and Hickey, Moore, and Pellegrino (2001).

The findings from the study presented in this paper support the significant influence of instructional design on student motivation; specifically the findings suggest positive student outcomes through the combined use of the *Nelson PRIME* developmental continuum and other in-service supports, including professional learning communities. The study provides evidence of improved achievement for low achieving students who were provided explicit instruction focused on their learning needs and encouraged to use concrete materials to represent their mathematical ideas.

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## **Methodology**

The intervention design for this study focused on training teachers to differentiate their mathematics instruction such that they learned to create appropriate tasks for their struggling students. To support teachers in this endeavor, their students completed mathematics diagnostic tests from *PRIME* which placed students along a developmental continuum. The diagnostic tests and developmental continuum have been empirically validated using Canadian students (Small, McDougall, Ross, & Ben Jaafar, 2006). Once placed on the continuum, *PRIME* provided detailed information on developmentally appropriate instructional strategies to move students forward in specific concepts and skills (Small, 2005). Thus, through combining the *PRIME* materials with additional professional development supports, including professional learning communities, the study goal was to positively influence the achievement motivations for students struggling with mathematics.

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## ***Study Participants***

The project involved 57 Teachers (Grades 6 – 10) and 105 students from ten northern Ontario school boards that expressed interest in participating in the project. The teachers were asked to select appropriate student participants with the minimum selection criteria including students that were characterized as “at-risk” in mathematics yet had a good record of attendance.

## ***Data Collection Instruments***

The student data were obtained from two sources: a 16-item Likert attitude survey and an exit interview. The survey questions were structured in such a way as to delineate students’ attitudes and beliefs within four broad categories: importance and relevance of mathematics; efficacy and confidence in mathematics abilities; the role of rules and explanations; and communication and learning supports. The survey was modified from Siemon, Virgona & Corneille (2001).

Student exit interviews were conducted by the participating teachers with their respective students. The interview focused on students’ perceptions of change (cognitive and affective) as a result of involvement in the project. Additionally, the interviews garnered student feedback with respect to mathematics topics or concepts identified as problematic and effective teaching strategies for students identified as at-risk in mathematics.

## ***Treatment Design***

The professional development offered to the participating teachers included three days of *Nelson PRIME* training focused on the development of mathematical content and pedagogical content knowledge specific to Number Sense and Numeration. The three one-day workshops were offered by *Nelson* staff over a four month period. To further support each learning community, teachers were provided with opportunities to meet and discuss their classroom experiences.

## **Results and Discussion**

This paper outlines the influence of a professional development initiative on student attitudes and achievement, as well as provides information concerning how at-risk students perceive mathematics; their ability to learn mathematics; and their frustrations with the learning process. Thus, the question addressed in this paper is: *What can students identified as at-risk in mathematics teach us about their experiences in mathematics that will help us improve teaching for this group of students?*

### ***Summary of Findings: Student Attitudes and Beliefs***

The survey findings and the student exit interview indicate that, from the students' perspective, they are cognizant of their learning difficulties in mathematics. Yet, in spite of their negative histories with the subject, they view it as significant and relevant to their daily lives and their futures. The findings suggest that students at-risk are not disengaged learners; they accept some responsibility for their learning through a willingness to obtain support from their teacher or their peers. Moreover, the students attribute some of their difficulties in learning mathematics to their inability to communicate mathematically, either verbally or in written form. These findings suggest that students at-risk in mathematics would benefit from additional instructional time; one-on-one assistance with either a teacher or more able peer; and manipulative-based activities focused on developing conceptual and procedural knowledge as well as mathematics communication skills.

The student attitudinal findings from this study are consistent with the attitudinal findings from the large scale Australian Middle Years Numeracy Project (Siemon, Virgona, and Corneille, 2001). Although the student participants were from opposite hemispheres, they reported very similar internal and external factors contributing to their struggles with mathematics. Moreover, their recommendations to improve their learning experiences were also markedly similar. For example, both groups of students suggested more one-on-one support; better quality teacher explanations; less reliance on traditional textbook driven lessons; and additional assistance in improving their deficiencies in fundamental mathematics knowledge (i.e., basic operations with whole numbers and fractions; and identifying, describing and comparing fractions). Finally, a salient theme in both groups of students was their desire to learn mathematics, as they perceived it as significant and relevant to their lives and future success.

### ***Summary of Findings: Student Achievement***

The pre and post-test *PRIME* Diagnostic data provides additional insight into the effects of the intervention on student achievement. Specifically, the data indicates that the intervention positively influenced participating students' Number and Operations knowledge. However, in the absence of a control group for comparison, it is difficult to conclude with certainty that student achievement results would be significantly different than student achievement results from non-participating teachers' classrooms.

Although the study findings are positive and encouraging, of concern is the limited number of students (N = 12 or 11.4%) that reached Phase 5 (Flexible Thinking Phase) or Phase 4 (More Abstract Phase) (N = 28 or 26.6%) in their post-test *PRIME* Number Diagnostic. The post-test mean scores from the paired sample t-test for both the *PRIME* Number Diagnostic and the Operations Diagnostic were approximately 18.5, indicating that the majority of Grade 7 – 10 students at-risk in this study scored Phase 3 in their number sense development. According the Nelson *PRIME Guide to Using the Developmental Map* this correlates to students in Grades 3 – 5 (p. 12). The primary explanation for this Phase assignment is that relatively few of the participating students are facile with fractions and decimals nor operations with either. Thus, additional support and time is required to provide students with the requisite skills and understandings they are lacking in fractions and decimals.

## **Conclusions**

Although the teacher data was not presented in the context of this paper, the study findings indicate that participating teachers and their students maintain similar beliefs with respect to the most effective intervention strategies for supporting the teaching and learning of mathematics for adolescent at-risk students. In particular, the findings suggest that students at-risk in mathematics would benefit from additional instructional time; one-on-one or small group assistance targeted to specific requisite skills (e.g., basic operations with whole numbers and fractions; and identifying, describing and comparing fractions/decimals); and manipulative-based activities focused on real-life connections. Thus, the findings support the creation of a mathematics learning environment that balances both small group collaboration and teacher directed explicit instruction provided to at-risk students either one-on-one or in homogeneous small groups. A collaborative environment, with appropriately scaffolded activities, allows students to function within their “zone of proximal development” (Vygotsky, 1978), improve their communication skills, and expand their understanding of mathematics. While the one-on-one or small group explicit instruction provides students with opportunities to develop their confidence and competence in mathematics through observing the teacher or peers model strategies and effective communication, as well as allowing students to explore with manipulatives, ask questions, and review or practice specific concepts and skills.

Finally, the findings underscore students’ understanding of their learning needs and their willingness to engage in the learning process. The evidence presented in this study illustrates that at-risk students are not necessarily disengaged and disinterested learners; rather they have a desire to learn mathematics, and perceive it as significant and relevant to their lives and future success.

## **Connection to the themes of the congress**

The paper connects to this year’s congress theme and at least two of the four strands: *Transformation, Innovation, Networks* and *Equity and Quality*. Specifically, the paper focuses on presenting the voices of an underrepresented group in research: adolescent students at-risk in mathematics. This paper provides a venue for their voices; an opportunity for students to express their opinions on how to improve teaching and learning and, generally, for improving “learning for ALL learners”. Moreover, this research study grew from collaboration between ten district school boards and one faculty of education, with the common goal of fostering innovative practices to improve student motivation and the quality of students’ learning experiences.

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