EXPLORING TEACHER PERCEPTIONS OF THE DEVELOPMENT OF RESILIENCE IN A PROBLEM-SOLVING MATHEMATICS CLASSROOM

Pavneet Braich & Joyce Mgombelo

Faculty of Education, Brock University, Canada

This paper draws from an exploratory study of how mathematics teachers perceive the development of characteristics of resilience in mathematics students, as it is facilitated through a problem-solving teaching approach. Qualitative research approach was used to gain further understanding of how and why teachers decided to implement problem solving in their classrooms. A key objective was to understand types of strategies which teachers used in their classroom, as well as their understanding of developing resilience characteristics in students.

Keywords: Problem solving, resilience in mathematics, mathematics teaching

INTRODUCTION

In 2004, The Report of the Expert Panel on Student Success in Ontario, titled Leading Math Success (Ontario Ministry of Education, 2004), stated the following:

> Too often, society has accepted the stereotype that mathematics is for the few, not the many. The reality is that mathematics is deeply embedded in the modern workplace and in everyday life. It is time to dispel the myth that mathematics is for some and to demand mathematics success for all. (p. 9)

This statement alludes to a dualistic notion which exists within mathematics education: you either can or cannot be a successful mathematics student, depending upon an innate ability which allows for less or more mathematical understanding. This false conception reinforces negative self-perceptions for students, hindering or completely ceasing their motivation to understand mathematics. This underlines the need for a shift in perspectives and understandings of teaching and learning mathematics, as well as the need for strategies that encourage students to remain persistent in understanding mathematics. Educators are continuously attempting to understand teaching approaches for helping students who are "at risk." The At Risk Working Group (2004) in part defined 'students at risk' as "students who are disengaged, with very poor attendance" (p. 16). These are the students who find no purpose in attending a mathematics classroom, and have probably internalized the notion that mathematics is not a subject which correlates with their skills and abilities. Ross, Hogaboam-Gray, and McDougall (2002) state that "one of the chief elements of mathematics education reform is teachers who make the development of student self-confidence in mathematics as important as achievement" (as cited in Ontario Ministry of Education, 2004, p. 26). According to the National Council of Teachers of Mathematics (2000), "solving problems is not only a goal of learning mathematics but also a major means of doing so" (p. 52). Findings from Vatter

(1992) suggest that at-risk students can be more successful if: "(1) school work is hands-on; (2) students' feelings of worth and accomplishment are nurtured by the work itself; and (3) the work is tied to real work in the real world" (as cited in Ontario Ministry of Education, 2004, p. 38).

The problem-solving approach could possibly help develop characteristics of resilience, since it is emphasized and promoted. Teachers need to understand and identify strategies which can help in building students' mathematical understanding, as well as their resilience, so that they improve as mathematicians. This paper draws from a study that was aimed at exploring how mathematics teachers perceive the development of characteristics of resilience in students, as it is facilitated through a problem-solving teaching approach. The study was guided by the following questions: 1) To what extent are teachers aware of the development of characteristics of resilience within students in a problem-solving classroom? 2) How do teachers create conditions for students to succeed, through strategies and approaches, in a mathematics classroom, when solving problems? 3) What are the challenges for teachers, if any, in creating a problem-solving environment? and, 4) What successful factors/qualities have they seen develop in students, through implementing problem solving in classrooms?

THEORETICAL FRAMEWORK

The research was framed by the following ideas: Resilience, Problem Solving, Outcomes of Problem-Solving Approach and Development of Resilience.

Resilience

'Resilience' describes "a set of qualities that foster a process of successful adaptation and transformation despite risk and adversity" (Benard, 1995, p. 2). According to Borman and Overman (2004), characteristics underlying resilient children typically include high self-esteem, high self-efficacy, and autonomy. The development of resilience is seen as a process. Research focusing on adolescent resilience as a process, "aims to understand the mechanisms or processes that act to modify the impact of a risk setting, and the developmental process by which young people successfully adapt" (Bond, Burns, Olsson, Sawyer, & Vella-Brodrick, 2003, p. 2).

Henderson and Milstein (1996) found that the capacity for resilience varies from one individual to another, and can grow or decline based upon "protective factors within the person that might prevent or mitigate the negative effects of stressful situations or conditions" (as cited in Borman & Overman, 2004, p. 178). Findings have been consistent in showing types of protective mechanisms that are important in the process of successful adaptation at three main levels: individual level, family level, and community level (Bond et. al, 2003). Borman and Overman (2004) conducted a study, in which they found that the most powerful model for promoting characteristics of resiliency was the *supportive school environment model*, which stressed fostering healthy social and personal adjustment of students. Three variables were the focus of this model: (a) safe and orderly environment, (b) positive teacher-

student relations, and (c) support for parent involvement. It was comprehensively found that the most powerful school models for promoting resilience included "elements that actively shield children from adversity" (p.192). This illustrates the importance of identifying and regulating protective mechanisms, since these have shown associations with academic resilience.

Problem Solving

A focus on problem solving seems to be a key component of sound mathematics teaching and learning. There are various definitions of problem solving; these have been limited for the purpose of the paper. Lovin and Van de Walle (2006) define a *problem* by citing the definition of Hiebert et al. (1997): "any task or activity for which students have no prescribed or memorized rules or methods, nor is there a perception by students that there is a specific correct solution" (p. 11). Another definition used for the purpose of the study is given by Kantowski (1980):

> A task is said to be a problem if its solution requires that an individual combines previously known data in a way that is new. If he can immediately recognize measures that are needed to complete the task, it is a routine task (or a standard task or an exercise) for him. (as cited in Pehkonen, 2007, p. 1)

Within the problem-solving process, the lesson begins with the teachers posing a problem question or story, which contextualizes the learning, and then afterwards concepts and procedures are derived and understood by students (Small, 2008). Students should be engaging in tasks posed by the teacher, which allow them to engage in the mathematics that they are expected to learn through interactions, and struggle with the mathematics, by "using their ideas and their strategies" (Lovin & Van de Walle, 2006, p. ix).

Additionally, research by Vatter (1992) suggests that at-risk students' success has been attributed to a more hands-on, project-based approach to curriculum involving increased student choice, flexibility, and connections with students' everyday lives (as cited in Ministry of Education, 2004).

Outcomes of Problem-Solving Approach and Development of Resilience

The idea of resilience being important to the study of mathematics is understood and better realized when educators value a holistic view of education, along with the constructivist understanding of learning. Students bring their values, beliefs, and prior experiences into the classroom, which affect their learning. Conversely, the way in which they learn in the classroom affects the way that they construct their knowledge, and the meaning which they give to their surroundings and experiences. By viewing mathematics education from this viewpoint, the study of resilience can help in supplementing educators, to emphasize the need for students to be successful despite feeling that they are not a good mathematics learner.

The Ontario Ministry of Education (2004) also encourages the idea that students need a certain amount of stress-producing conditions in order for learning to occur, based upon its research and stated belief:

Students must regularly be given the opportunity to struggle with mathematics problems. By denying them these experiences, or by providing excessive assistance to shelter them from what is perceived as mental pain, teachers and parents can end up 'crippling kids with kindness' (Chatterley & Peck, 1995). (p. 39)

Glendis and Strassfeld (n.d.) understand that "students' mathematical development occurs within the social context of the classroom (Cobb, 1996), in an environment where the emotional experiences of students 'have the potential to influence teaching and learning processes' (Schultz & DeCuir, 2002)" (as cited in Glendis & Strassfeld, n.d., p. 4). Thus, it is important to learn strategies to help students regulate their emotions of low self-confidence and low self-esteem. Glendis and Strassfeld (n.d.) further state that "negative emotions cause students to require increased extrinsic motivating factors, such as teacher guidance and attention" (p. 5). Therefore, teachers need to explore and learn strategies to help students in overcoming their emotions of inferiority towards learning mathematics.

METHODOLOGY

An exploratory, qualitative research design was used in order to further explore problem solving, and allow further learning about this phenomenon (Creswell, 2008). Purposeful sampling (Creswell, 2008) was used to explore perceptions of teachers who were already using problem solving. Teachers were selected through participation in mathematics education forums. They were given a *Letter of Invitation*, outlining a brief purpose of the study, and a *consent form* to verify their participation in the study. An interview guide with questions was the primary data collection instrument. Interviews were approximately one hour long; they were audio-recorded and transcribed. Following were the interview questions:

1. How long have you been implementing problem solving in the classroom, and how did you begin to explore teaching problem solving more in depth?

2. What is your understanding of problem solving as a mathematics teaching and learning approach, and what is the need for it in a current mathematics classroom?

3. What approaches and strategies do you use to help your students understand mathematical concepts through problem solving? (Examples can be provided)

4. When students begin learning mathematics in your classroom, in general, have you had to deal with situations that challenge your teaching, or seem to be challenges for students' learning? If so, could you explain further with examples, and how you have dealt with them.

5. In your experiences with problem based learning, how do you think students deal with their frustrations, struggles, confusions, failure, etc. when learning through

problem solving? (Examples can be provided). What are strategies or structures that you use to help your students?

6. What successful outcomes and results have you observed in your classroom, through implementing problem solving?

7. How important, do you believe, is the development of certain students' character traits or disposition in a mathematics classrooms? In your experience, do you think problem solving promotes these character traits? Explain.

8. Do you think that students can build perseverance by learning mathematics through a problem-solving approach? If yes, could you explain your understanding of 'perseverance' and examples in which you have seen it?

In order to have an exploratory and non-restricted discussion, a semi-structured interview format was chosen, with open-ended questions; this would allow for additional questions to be asked, letting teachers have more dialogue, and voice their experiences (Creswell, 2008). To establish credibility of results, member checking was used to allow the participants to validate the data collection procedures (Creswell & Miller, 2000). Participants were able to view the audio transcriptions of the interviews. To analyze the interviews, an intrinsic case study analysis (Creswell, 2008) was used to separately understand each teacher's case. This put focus on the uniqueness of a single case, since a key objective of the study was to gain knowledge of specific strategies used by teachers; strategies could be similar or vary in ways, yet, have similar objectives and outcomes for teachers. Afterwards, a cross-cases analysis (Stake, 1995) was conducted to compare results from the two teachers by understanding commonalities and differences in teaching practice, as well as the understanding of developing resilience characteristics in students. These were examined by understanding common themes amongst the cases. Triangulation (Creswell & Miller, 2000) was used in conducting the cross-case analysis to form themes from the two case studies, since only the researcher's lens was used in the data analysis.

FINDINGS

For the purpose of this paper, findings from the cross-case analysis of the two cases, named Mrs. A and Mrs. B, will be discussed in the following themes which emerged from analysis: Assessment providing relevance of mathematics curriculum in problem solving; Questioning; Successful instructional strategies in a problem solving environment; and Development of characteristics of resilience in problem solving.

Mrs. A is currently teaching third grade. She described her personal journey, which lead her to implement "true, meaningful problem solving" in her classroom, over the last 5 years. Mrs. A had felt that the way she had been previously teaching was not the best approach, and there "had to be a better way to teach and develop true mathematical understanding in my students." As a result of feeling the need to learn a

more suitable and successful approach for teaching mathematics, she turned to the Math Curriculum document, and was struck by the process skills discussed; specifically the statement that asserted "mathematical problem solving should be the mainstay of all math programs." She was beginning to understand that problem solving deserved more eminence; while teaching skills and concepts directly is also important, "problem solving should be folded into a teacher's approach in order to compliment the learning that is taking place." Mrs. B currently teaches grades 7 and 8. She has taught math as a core subject for 19 years. About 8 years ago she began to explore and teach math through the problem-solving approach. Mrs. B believes that mathematics needs to be taught in the real world context, and not "individually or singularly out of the blue," so students understand that it applies to the real world. She further states that "the more that you can bring it into their life or something they understand, is better, so that they can more grasp the concepts that you're doing."

Assessment Providing Relevance of Mathematics Curriculum in Problem Solving

The teachers described a crucial reason for implementing problem solving to be that they felt there was disconnect in the way that the mathematics curriculum was being taught to students, thus, creating a lack of relevance for them. A decisive link to be recognized is that in order to make mathematics learning more relevant for students, and to pose appropriate problem questions, assessment for learning is essential. Teachers must have an understanding of their students' level of mathematical knowledge in order to begin from a context which students can relate to, and sequence the lesson in a way that all students can make connections. Mrs. B discussed the use of diagnostic assessments as a form of assessment for learning. In order to choose an appropriate question which allows for multiple entry points to solve it, teachers must know their students' zone of proximal development. Using diagnostic assessments also allows teachers to anticipate the range of solutions which students might present, thus. Mrs. A discussed how formative assessment, as a form of assessment for learning, is also advantageous for teachers. Since problem solving allows for more dialogue and communication, as students are solving the problem, teachers are able to help students in recognizing the relevance of their mathematics learning by questioning them, and further activating their prior knowledge and ability to make connections. Teachers are able to make more balanced, written and oral assessments of their own students as well.

Questioning

Questioning is a key strategy in facilitating the development of resilient characteristics in students, as teachers motivate students to remain persistent in solving problems. Asking students to explain their thinking, or why they chose the strategy were examples of the types of questions which could be asked. Mrs. B sometimes answers students' questions with a question, knowing that the students will be frustrated for some time, but she also assures them to keep struggling. This can be reassuring for students since they feel that the teacher understands that the

students have the ability to meet the challenges presented to them. Findings by Gaye Williams (2007), an Australian researcher, also suggested that in some cases, giving students time to struggle and stress, and refraining from telling them how to solve problems will build more resilient children. Educators need to foster the characteristic of adolescents to meet challenges. Mrs. A asks open-ended questions such as: Why did you choose that strategy?; How does drawing the groups help you with your thinking?

These types of questions further the thinking of the students, and sometimes they realize that their strategy may not be on the right track, or the most efficient. While doing so, it is important for Mrs. A to ensure that students understand that there is no "right" way to solve a problem, since everyone has a different level of understanding, and some may prefer a methodical approach, whereas another may have a more creative approach to solving a problem. She reiterates that "no child is told they are not doing it right."

Successful Instructional Strategies in a Problem-Solving Environment

During the time when students are struggling, strategies that teachers use to facilitate a problem solving classroom can be useful. These include group work and *gallery walks*, where students go around and observe solutions of peers with sticky notes; they put any questions on one colour of sticky notes, and comments on another colour. Mrs. A has also discussed how she challenges her stronger students to try different problems or work with more difficult numbers. The *congress*, or extended discussion that occurs once all students have had time to work on the problem, is also a successful strategy in the problem-solving approach used by Mrs. A and Mrs. B. Students gain comfort and confidence in their learning as they explain their solutions to the class, and are able to justify and defend their understanding to their peers by being questioned or asked to reaffirm their thinking. As this occurs, simultaneously the rest of the class is able to learn from their peers and value the diversity in thinking within their class. In relation, Mrs. A also discussed how students who are weaker in their mathematical understanding may not participate in the mathematical conversations, but they will still be exposed to ideas and skills. Gradually, all students can gain confidence in themselves as they realize that others are thinking along the same terrain; those who have approached the problem in either a very distinct or less efficient, sophisticated way are valued members of the class. Allowing students to learn from one another helps them connect their thinking with the ideas of others.

Mrs. A and Mrs. B have both witnessed positive development of qualities in students, and become aware of how the problem-solving approach creates a sense of community in the classroom. This, in turn, helps students become more confident in their learning, as they feel a sense of belonging. Mrs. A gave the example of a comment she had heard: "I want to try the strategy that _____ used next time I do a problem." This type of comment can be powerful for students, since they feel as if

they are a contributing member of their class. Mrs. B also spoke to this point by discussing one of the positive outcomes of the learning community: students are able to learn from peers that they might not normally interact with. Within the relationship dynamics of a classroom, this is influential for students who may feel that they are not noticed or may have low self-esteem as a learner. Tools, such as the *bansho*, have also shown to be a source of pride for the entire class as well. The Japanese term *bansho* means board writing (Kubota-Zarivnij & Kestell, 2010), and is used in a very systematic manner, in order to keep record of all parts of the problem solving lesson and show various approaches used by students to solve a problem.

Students learn to use their peers as a source of help, if they feel that they are failing individually; this is acceptable and advocated in a safe classroom. Students are able to use the strategy of *tailgaiting* or doing a *spywalk*, where they are allowed to move around the room, looking at or questioning how others are solving the problem. This can help students become more resilient since they learn to ask peers for help in their learning, and not feel isolated. Also, they are able to clear misconceptions that they may have, through extended mathematical talk with others, and being able to fuse the ideas or suggestions of others with their own. This relates to Margaret Glendis and Strassfelds' (n.d.) findings from their action based research, in which it was observed that students had begun to rely on one another when they worked through their 'crucial points,' and felt a sense of pride in their work as a group. Another finding, stated by Mrs. A, was that the problem-solving approach strengthened friendships between students, as the feeling of inclusiveness developed in the classroom. These relationships extend beyond the subject, and into other curriculum areas.

Development of Characteristics of Resilience in Problem Solving

Mrs. A and Mrs. B discussed the importance of allowing students to solve problems in their own ways, and build self-confidence in them. This also concurs with Small (2008), who believes that allowing students to approach problems in their own way, builds confidence and maximizes the potential for further understanding. When students are able to succeed in solving problems through their chosen approach, then they feel ownership of their learning. If they struggle during the process of finding a solution, teachers are able to help accordingly. Strategies, such as spy walks, tail gaiting, gallery walks, group work, extended discussion or congress, and guided questioning all help in acting as protective mechanisms against failure. Allowing students to struggle, and helping them understand that it is a natural part of the problem-solving process is important.

Another significant type of protective mechanism which Mrs. A and Mrs. B advocated, was the development of a safe community in the classroom. This is done through the various strategies mentioned above. Using peers as resources around the classroom, and discussing with them to clear misconceptions; these are qualities of resilient mathematics learners. Mrs. A and Mrs. B have identified that these are achieved through extended discussion, and time given to discuss with peers. Creating

a supportive atmosphere is the key to creating a safe classroom in which students can progress and become resilient in overcoming the struggle which they face.

Being a resilient mathematician describes a learner who has "a set of qualities that foster a process of successful adaptation and transformation despite risk and adversity" (Benard, 1995, p. 2) that they may face in the process of working on problem solving in a mathematics classroom. The perceptions of Mrs. A and Mrs. B, in discussing their awareness of the development of resilience, shows students want to be successful mathematics learners. Although some students may come into the classroom believing that they are not good at math, or they dislike math, Mrs. A and Mrs. B have observed positive outcomes in teaching through the problem-solving approach. It can be assumed that all humans want to feel successful and good about themselves, therefore, naturally, they would be open to developing characteristics of resilience. This coincides with the understanding of Benard (1995), as it is explained that "we are all born with an innate capacity for resilience, by which we are able to develop social competence, problem-solving skills, a critical consciousness, autonomy, and a sense of purpose" (p. 2).

The cases of Mrs. A and Mrs. B have shown that students are able to succeed and become resilient mathematics learners. This is enabled through structured strategies for problem solving which are used to create an environment in which students can develop characteristics of resilience. This is very important in the teaching of mathematics, since the subject has been stereotypically known to only be understood by some students, not all.

CONCLUSION

Findings of this study highlight the importance of the problem-solving approach in teaching mathematics, and the development of resilient characteristics in students. This study extends the conceptualization of resilience within mathematics education, claiming that the definition is based upon the context and types of risks which are under study. For the purpose of this study, the risk was students failing in understanding mathematics, and believing that they are not good at mathematics. The conceptualization of resilience remains open to interpretation, since there is no unified theory or definition. Findings are useful for educators who are interested in supporting students to gain specific characteristics of a resilient mathematics learner, which include: (a) developing self-confidence, (b) regulating emotions of mathematical anxiety and struggling to succeed, (c) remaining persistent by struggling in solving problems, (d) using resources around the classroom, (e) and clearing misconceptions and incorrect solutions. The findings from the case studies show that the strategies that teachers use when teaching problem solving promote the above characteristics for students.

REFERENCES

Benard, B. (1995). Fostering resilience in children. ERIC Clearinghouse on

Elementary and Early Childhood Education in ERIC Digest: Urbana, IL.
Bond, L., Burns, J., Olsson, C., Sawyer, S., & Vella-Brodrick, D. (2003). Adolescent resilience: A concept analysis. Journal of Adolescence, 26(1), 1-11.
Borman, G., & Overman, L. (2004). Academic resilience in mathematics among poor and minority students. The Elementary School Journal, 104(3), 177–195.
Creswell, J. (2008). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (3rd ed.). Upper Saddle River, NJ: Pearson.
Creswell, J., & Miller, D. (2000). Determining validity in qualitative inquiry. *Theory Into Practice*, *39*(3), 124-130.
Glendis, M., & Strassfeld, B. (n.d.). Emotions and motivation: Changing avoidance goals into achievement goals by giving students positive emotional experiences in the mathematics classroom. Unpublished manuscript, New York University at New York. Retrieved from http://www.icme-organisers.dk/tsg24/Documents/GlendisStrassfeld.doc
Kubota-Zarivnij, K., & Kestell, M. (2010, May). Bandsho: A collective thinkpad. Symposium conducted at the meeting of Ontario Association of Mathematics Education, Brock University, St. Catharines, ON.
Lovin, L., & Van de Walle, J. (2006). Teaching student-centered mathematics: Grades 5 – 8 (The Van de Walle Professional Mathematics Series: Volume 3). Boston, MA: Pearson.
National Council of Teachers of Mathematics (NCTM). (2000). Principles and standards of school mathematics: An overview. Reston, VA: NCTM.
Ontario Ministry of Education. (2004). Leading math success: Mathematical literacy, grades 7-12 (The Report of the Expert Panel on Student Success in Ontario). Toronto, ON: Queen's Printer for Ontario.
Pehkonen, E. (2007). *Problem solving in mathematics education in Finland*. Unpublished manuscript, University of Helsinki at Finland. Retrieved from http://www.unige.ch/math/EnsMath/Rome2008/ALL/Papers/PEHKON.pdf
Small, M. (2008). Making math meaningful for Canadian students, K-8. Toronto, ON: Nelson.
Stake, R. E. (1995). *The art of case study research*. Thousand Oaks, CA: Sage.
Williams, G. (2007). Abstracting in the context of spontaneous learning. Mathematics Education Research Journal, 19(2), 69-88.