A Linear Combination of Traditional Instruction and TPSWriC for Math-Anxious Students

Thomas Varghese and Elizabeth Pace

Introduction

Everyone in a classroom is unique. Some students like mathematics; others do not. Mathematics comes easily for some; others struggle with it every step. For others, mathematics is a stress inducer, and others even see it as a punishment. Mathematics anxiety has been discussed periodically in the professional literature for several decades. In 2001, the No Child Left Behind legislation was passed in the United States to ensure that every child meets high standards of mathematical proficiency, and this has required educators to give increased attention to the study of mathematics anxiety. Fotoples (2000) noted that, while the United States and the rest of the world have caught up in the growth of communications and electronics, expertise in mathematics has suffered. Many employers find employees' math expertise inadequate and their skills in basic arithmetic insufficient. Along with proficiency in number sense and computational skills, other domains of mathematics are also essential for educational advancement and career opportunity. Many jobs require substantial mathematics, such as forecasting, budgeting, modelling and statistical analysis. A lack of mathematical understanding can affect career-selection options and advancement. It can also make it difficult to respond positively to changes in the workplace environment. The mathematics competency of every student is a matter of worldwide concern. We have noticed through our classroom experience that math-anxious students have the greatest difficulty in learning mathematics skills. Hence, as teachers, we should endeavour to more effectively teach math-anxious students.

Mathematics Anxiety

Wood (1988) defined mathematics anxiety as the general lack of comfort when required to perform mathematically. Ma (1999) noted that mathematics anxiety can take multidimensional forms, such as dislike (an attitudinal element), worry (a cognitive element) and fear (an emotional element). He also reported the negative consequences of being anxious about mathematics. These consequences include the inability to do mathematics, a decline in mathematics achievement, the avoidance of mathematics courses, and associated feelings of guilt and shame. Limiting one's participation in mathematics courses potentially limits future course selection and career paths.

Research studies (Fiore 1999; Handler 1990; Norwood 1994) have indicated that teachers play a major role in contributing to mathematics anxiety in their students. Tobias (1978) and Stodolsky (1985) noted that the beginning of math anxiety can be traced to negative classroom experiences. Greenwood (1984) suggested that mathematics anxiety results more from the way the subject matter is presented than from the subject matter itself. Teachers can create anxiety by placing too much emphasis on the memorizing formulae, learning mathematics through drill-and-practice and applying rote memorized rules (Greenwood 1984). Rote memorized rules and manipulation of symbols can be stumbling blocks to a child's learning (Skemp 1986). Mathematics anxiety can therefore be considered a function of teaching methodology.

Instructional Strategies

Given the effect of negative classroom experiences on the development of math anxiety, it is critical to examine classroom practices and modify instructional methods to ensure quality mathematics teaching. It is important that students experience success in the classroom. If students experience success in learning mathematics, they will be inclined to like the subject and the teacher. Success and motivation depend on self-efficacy, and self-efficacy is based on positive past learning experiences. There are a variety of nontraditional (or alternative) instructional strategies that promote success and thereby mitigate mathematics anxiety (Newstead 1998; Norwood 1994; Vacc 1993; von Glasersfeld 1991).

Nontraditional instructional approaches that involve more personal and process-oriented teaching and that emphasize understanding rather than drill-and-practice are believed to reduce mathematics anxiety (Newstead 1998). It has also been suggested that encouraging students to work with peers in small, cooperative groups may have important, affective consequences, including a reduction of anxiety (Vacc 1993; von Glasersfeld 1991). Problem solving and discussing strategies for problem solving may also reduce mathematics anxiety (Skiba 1990; Vacc 1993).

In contrast, emphasis on discussion, explanation and justification of strategies can cause anxiety in children. These children often prefer a classroom in which they are given strong direction from a teacher (Newstead 1998). Perception of strong direction from a teacher lessens previously formed anxiety and discomfort (Clute 1984; Newstead 1998; Norwood 1994).

Berliner and Rosenshine (1987) reported that it is most effective to teach in a systematic manner, providing instructional support for the students at each stage of learning. Guided practice followed by independent practice fosters fluency. This strategy involves reviewing material and then presenting new material with diverse and concrete examples, which the students solve with the teacher's guidance.

According to Newstead (1998), it is difficult to conclude that traditional teaching approaches always lead to math anxiety while alternative classroom approaches (which emphasize discussion, understanding and problem solving) do not. Some pupils thrive in the security and structure of a formal classroom while others are interested in the responsibility and creativity associated with problem solving and discussion. Both approaches can cause mathematics anxiety. Hence, a combination of both traditional and nontraditional approaches may help different types of learners.

The following section suggests an instructional strategy that is a combination of both traditional and nontraditional approaches.

A Linear Combination of Traditional Mathematics Instruction and TPSWriC

Bandura (1982) believed that people's perception of their own effectiveness plays a major role in their behaviour. We propose an instructional strategy that will cultivate in students a positive perception of ability in a mathematics classroom. This strategy begins with a structured lesson in which procedures and rules are clearly explained through guided practice, followed by independent practice in which students verbalize their thought process and write down what they understand. This strategy is a combination of traditional instruction (direct teaching) and an alternative method (TPSWriC—pronounced *T-P-S-Rick*—the *W* is silent).

Norwood (1994) found that students with mathematics anxiety are more comfortable in highly structured classrooms than less-structured classrooms. Math-anxious students do not trust their instincts or intuitions, and therefore do not prefer to work with a discovery approach to learning mathematics. The proposed strategy therefore begins with a structured, direct-instruction component.

Direct Instruction

The role of direct instruction (or lecture method) in a mathematics classroom has been clearly documented. Many authors (Gunter, Estes and Schwab 1995; Krantz 1998; Wu 1998) have pointed out that lecturing is an effective way of teaching mathematics. When teachers give specific instructions and take students through a task step-by-step, students can master the skill. Krantz noted that the lecture is a powerful teaching device that has stood the test of time. It has been used to "good effect for more than 3,000 years" (Krantz 1998, 12). Although this method has received much criticism from contemporary educators, the survival of the lecture is itself evidence that it has unique strengths as a teaching method (Freiberg and Driscoll 1996; Henson 1988). Borich (2004) indicated that a lecture should neither be a lengthy monologue nor an open, free-wheeling discussion. It should be a quickly paced, highly organized set of interchanges controlled by the teacher and focused on acquiring a limited set of predetermined facts, rules or action sequences. By adding wit and humour in a presentation, a teacher can arouse curiosity and amusement in the listener.

Teaching the first part of a lesson systematically (through direct instruction) and the second part through guided practice is a strategy based on the research by Berliner and Rosenshine (1987). Students who prefer a systematic, structured classroom to a nonstructured classroom will benefit from this instructional methodology (Vinner 1994).

Having a discussion at the beginning of a new chapter or concept alienates certain students. Norwood (1994) also remarked that math-anxious students feel uncomfortable while being taught with nontraditional methods. Once they have had success in a structured classroom, math-anxious students will be more open to nonstructured classrooms. Vinner

(1994) suggests that procedures and rules (which are cognitively simpler, clearer and easier to handle) give math-anxious students an emotional security. Math-anxious students should initially be given something to help them solve a problem, rather than having them create their own solution procedure (Vinner 1994). However, once they get the problem-solving skills, math-anxious students are more willing to begin discussing problems at a deeper level.

Hence, we propose beginning with a direct instruction component. The underlying assumption is that with direct instruction, "all students can learn to think mathematically when carefully taught" (Marchand-Martella, Slocum and Martella 2004, 209).

Marchand-Martella, Slocum and Martella (2004) noted that many educators equate child-centred instructional strategies (such as discovery learning) with conceptual understanding, and teacher-directed methods with rote learning and mindless computation. However, "this view promotes a false dichotomy between basic skills and conceptual understanding" (Marchand-Martella, Slocum and Martella 2004, 210).

We should not "conveniently forget" that not all mathematical concepts lend themselves to discovery (Carnine 1990, as cited in Marchand-Martella, Slocum and Martella 2004). Carnine indicated that many students, particularly low-performing students, learn more quickly when given a clear, concise explanation of what to do and how to do it. When explicit strategies are not provided, students often make up their own mathematical rules, which are often creative but incorrect. Moreover, discovery learning does not provide a gradual transition from structured to independent work (Marchand-Martella, Slocum and Martella 2004). In mathematics, skills and understanding are completely intertwined. Precision and fluency in the execution of skills are the requisites for conceptual understanding (Wu 1999). "From the intuitive to the abstract, and primitive skills to sophisticated ones; such is the normal progression in mathematics" (Wu 1999, 16). Once students understand a topic or concept, and attain fluency in the required skills through the guidance of their teacher, they can confidently move on to discussion and questioning. They will also be more inclined at this point to explore the concepts using alternative strategies. Hence, the second part of this strategy is nonstructured.

TPSWriC

During the second part of the lesson, students move from structured practice to more open (or independent) practice. This phase emphasizes thought processes and their verbalization, and a written response. This is based on a five-step process called TPSWriC (T—think, P—pair, S—share, Wri—write and C—compare). *Pair and share* is an old technique to which we suggest adding the components *think*, *write* and *compare*.

Math-anxious learners should be allowed to continually move ahead and make progress. Through appropriate instructional strategies, teachers can help math-anxious students continue to think, write and try, even when the students feel they can't proceed.

T (Think)

Students think about every question and develop an idea or strategy to solve the problem. This enables them to briefly work on their own without the pressure to arrive at the right answer. Students reflect on the new concept or topic introduced in the class and explore alternative strategies based on the knowledge they acquired in the first part of the lesson.

P (Pair) and S (Share)

Students form groups and share their ideas for solving the problem. Cooperative learning is an excellent tool for helping those who suffer from mathematics anxiety (Vacc 1993). Two to four students can share responsibility for solving a problem instead of just one, and it becomes okay to make mistakes and ask questions. There is less pressure to find one method or one right answer, and different approaches are more likely to be proposed and explored. This helps develop a richer understanding of the topic. Group interaction or cooperative learning promotes female and minority students' self-esteem, motivation and achievement (Croom 1995). Also, when students participate in cooperative learning, their attitudes toward their classmates improve, particularly toward those from different ethnic backgrounds (Slavin 1986). Thus, students will learn to respect the point of view and accept the differences of other students.

Wri (Write)

Students may have arrived at an answer or a way of solving a problem by their own thought processes, group work or both. Writing helps students make sense of mathematics and helps them practise inferring, communicating, symbolizing, organizing, interpreting, linking, explaining, planning and reflecting (Countryman 1992). Verbalizing during the discussion and then writing down the methodology (or thought process) activates the mind and reinforces the problem-solving strategy.

C (Compare)

The Russian psychologist Vygotsky pointed out that students accomplish different things when they work on their own rather than with the guidance of a teacher. The work students do under the guidance of a teacher enables them to succeed on their own later on (Vygotsky 1978, as cited in Epp 1998). Once students develop their written response through their own thought processes and/or through discussion, they need to verify that they are on the right track. Students can compare the methodology and/or answer given by a teacher with their own methodology and/or answer. This step paves the way for classroom discussion. Discussion allows students to justify their own answer and gain insight into the thought processes of others. As well, Vygotsky (1978, as cited in Croom 1995) suggested that group interaction helps develop mental operations or processes in children because they tend to internalize what is discussed.

Summary

Wu (1999) noted that some mathematics educators want to stop teaching basic skills and instead teach mathematical understanding. However, precision and fluency in basic skills form the basis for conceptual understanding (Wu 1999). This instructional strategy is intended to help math-anxious learners by providing them with a firm foundation in the required concepts and then encouraging them to attain higher-level thinking skills. We are aware that even mentioning procedures and rules can cause open hostility in some mathematics education circles. Some educators believe that having math-anxious students invent their own algorithms promotes conceptual understanding. However, correctness and generality become two major concerns when students are allowed to make up their own algorithms (Wu 1999). As Wu noted, it is also a Herculean task to examine 30 different algorithms in a class of 30 students and then work with each student on their own understanding. Open-ended problems can be used to build confidence in mathematical problem solving, but only after students have learned the required skills to tackle the problem. The advantage of the proposed strategy is that it helps students achieve a firm foundation in a concept, topic or skill and then encourages them to work both independently and cooperatively at various stages.

Direct instruction helps teachers present new content by breaking it into smaller segments. During this part of the lesson, teachers can ask direct questions to get an idea of students' understanding of new concepts or skills. TPSWriC transforms the class into an environment with a nonstructured pace. This strategy encourages students to get involved in their own thought processes, verbalize these processes and reflect on their written responses through a comparison with the teacher's suggested answer. This overt verbalization (especially through group discussions) not only helps students attend to their own strategies but also boosts their self-confidence. Students who cannot find an answer on their own can listen to others in the group. Through this strategy, teachers are responsible not only for the intellectual development of students but also for emotional support. Rather than complaining that the students lack ability, teachers can teach effectively by building confidence in their students. This has a positive effect on both the social and academic skills of students.

Classrooms that work in this way lessen the anxiety and discomfort for some students (Vinner 1994). The security and structure of a lesson are initially maintained. Once a student knows the content, his anxiety is lessened. At the same time, pupils who want to understand better by asking "why" and "how" are given opportunity to do so through discussion and through developing their own thought processes. Classroom discussion helps students develop an understanding of themselves and others. Social skills—such as showing encouragement, giving direction and asking for help—are facilitated by both the teacher and other students. This not only reduces subject-related anxiety but also shows students that their peers possess both strengths and weaknesses, which boosts the morale of math-anxious students.

Many of the authors cited in this article have successfully used this strategy as a dominant form of instruction in their classrooms. The advantage of this strategy is that the strengths of traditional instruction are supplemented by the strengths of nontraditional instruction.

Through this strategy, students are more likely to achieve the goals of the National Council of Teachers of Mathematics (NCTM 1989): to value mathematics and develop confidence, to reason and communicate mathematically and to solve problems. Thus, no child is left behind.

> Let us teach our children mathematics the honest way by teaching both skills and understanding.
>
> —Wu 1999, 52

The authors would like to thank Gladys Sterenberg and two anonymous reviewers for their helpful suggestions. Their input made this a better article.

References

Bandura, A. 1982. "Self-Efficacy Mechanism in Human Agency." *American Psychologist* 37, 122–47.

Berliner, D C, and B V Rosenshine, eds. 1987. *Talks to Teachers: A Festschrift for N L Gag*. New York, NY: Random House.

Borich, G D. 2004. *Effective Teaching Methods*, 5th ed. Upper Saddle River, NJ: Pearson/Merrill Prentice Hall.

Carnine, D W. 1990. "Reforming Mathematics Instruction." *ADI News* 10, no 4: 1–4.

Clute, P S. 1984. "Mathematics Anxiety, Instructional Method and Achievement in a Survey Course in College Mathematics." *Journal for Research in Mathematics Education* 15, no 1: 50–58.

Countryman, J. 1992. *Writing to Learn Mathematics: Strategies That Work*. Portsmouth, NH: Heinemann.

Croom, L. 1995. "Mathematics for All Students: Access, Excellence and Equity." In *Multicultural and Gender Equity in the Mathematics Classroom: The Gift of Diversity—1995 Yearbook*, eds J Trentacosta and M J Kenney, 1–9. Reston, Va: National Council of Teachers of Mathematics.

Epp, S S. 1998. "A Unified Framework for Proof and Disproof." *Mathematics Teacher* 91, no 8: 708–13.

Fiore, G. 1999. "Math-Abused Students: Are We Prepared to Teach Them?" *Mathematics Teacher* 92, no 5: 403–06.

Fotoples, R M. 2000. "In My View: Overcoming Math Anxiety." *Kappa Delta Pi Record* 36, no 4: 149–51.

Freiberg, J H, and A Driscoll. 1996. *Universal Teaching Strategies*, 2nd ed. Boston, Mass: Allyn & Bacon.

Greenwood, J. 1984. "Sound Off: My Anxieties About Math Anxiety." *Mathematics Teacher* 77, no 6: 662–63.

Gunter, M A, T H Estes, and J Schwab. 1995. *Instruction: A Models Approach*. Boston, Mass: Allyn & Bacon.

Handler, J R. 1990. "Math Anxiety in Adult Learning." *Adult Learning* 1, no 6: 20–23.

Henson, K T. 1988. *Methods and Strategies for Teaching in Secondary and Middle Schools*. New York, NY: Longman.

Krantz, S G, ed. 1998. *How to Teach Mathematics*. Providence, RI: American Mathematical Society.

Ma, X. 1999. "A Meta-Analysis of the Relationship Between Anxiety Toward Mathematics and Mathematics Achievement in Mathematics." *Journal for Research in Mathematics Education* 30, no 5: 520–40.

Marchand-Martella, N E, T A Slocum and R C Martella. 2004. *Introduction to Direct Instruction*. Boston, Mass: Pearson Education.

National Council of Teachers of Mathematics (NCTM). 1989. *Curriculum and Evaluation Standards for School Mathematics*. Reston, Va: NCTM.

Newstead, K. 1998. "Aspects of Children's Mathematics Anxiety." *Educational Studies in Mathematics* 36, no 1: 53–71.

Norwood, K S. 1994. "The Effect of Instructional Approach on Mathematics Anxiety and Achievement." *School Science and Mathematics* 94, no 5: 248–54.

Skemp, R R. 1986. *The Psychology of Learning Mathematics*. 2nd ed. Middlesex, UK: Penguin Books.

Skiba, A E. 1990. "Reviewing an Old Subject: Math Anxiety." *Mathematics Teacher* 83, no 3: 188–89.

Slavin, R E. 1986. "Learning Together: Cooperative Groups and Peer Tutoring Produce Significant Academic Gains." *American Educator* 10, no 2: 6–11.

Stodolsky, S S. 1985. "Telling Math: Origin of Math Aversion and Anxiety." *Educational Psychologist* 20, no 3: 125–33.

Tobias, S. 1978. *Overcoming Math Anxiety*. Boston, Mass: Houghton Mifflin.

Vacc, N. 1993. "Teaching and Learning Mathematics Through Classroom Discussion." *Arithmetic Teacher* 41: 225–27.

Vinner, S. 1994. "Traditional Mathematics Classrooms: Some Seemingly Unavoidable Features." *Proceedings of the Eighteenth International Conference for the Psychology of Mathematics Education* 4: 353–60.

von Glasersfeld, E, ed. 1991. *Radical Constructivism in Mathematics Education*. Dordrecht, Netherlands: Kluwer Academic Publishers.

Vygotsky, L S. 1978. *Mind in Society: The Development of Higher Psychological Processes*. Cambridge, Mass: Harvard University Press.

Wood, E F. 1988. "Math Anxiety and Elementary Teachers: What Does Research Tell Us?" *For the Learning of Mathematics* 8, no 1: 8–13.

Wu, H. 1998. "The Joy of Lecturing: With a Critique of the Romantic Tradition in Education Writing." In *How to Teach Mathematics*, ed S G Krantz, 261–71. Providence, RI: American Mathematical Society.

———. 1999. "Basic Skills Versus Conceptual Understanding: A Bogus Dichotomy in Mathematics Education. *American Educator* 23, no 3: 14–19; 50–52.

Thomas Varghese is a graduate student in the Department of Secondary Education at the University of Alberta. Elizabeth Pace is a graduate student in the Department of Educational Psychology at the University of Alberta.