The Anti-Anxiety Curriculum: Combating Math Anxiety in the Classroom

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Negative attitudes toward mathematics and what has come to be know as "math anxiety are serious obstacles for children in all levels of schooling today. In this paper, the literature is reviewed and critically assessed in regards to the roots of math anxiety and its especially detrimental effect on children in "at-risk" populations such as low socioeconomic status and females. The effects of teachers' and parents' assumptions, family support, and parents' level of educational attainment will be addressed. The paper also addresses the curricular issues that may lead to math anxiety such as high stress instructional methods and "timed testing".

A negative attitude toward mathematics is a growing barrier for many children to mathematics (Ashcraft, 2002; Popham, 2008; Rameau & Louime, 2007). For many children, negative attitudes toward mathematics begin early in life, sometimes even before they enter kindergarten (Arnold, Fisher, Doctoroff, & Dobbs, 2002). The child's educational context at home and at school can affect this attitude (Scarpello, 2007). Children from low socioeconomic backgrounds often have parents with less educational background and who often have negative attitudes toward mathematics themselves. Females are also often overlooked or socialized to dislike mathematics (Geist & King 2008; Titu, Gallian, Kane, & Mertz, 2008). While research supports that girls have the similar aptitude for mathematics, they are more susceptible to math anxiety due to their aversion to high stakes testing and social comparison (Haynes, Mullins, & Stein, 2004; Miller & Bichsel, 2004; Miller & Mitchell, 1994). For these groups and many other children, a fear of mathematics or what is commonly known a "math anxiety" it creating a disparity between levels of mathematics achievement. In some cases, the gap in achievement is not brought about by differing levels of potential and ability, but the chances of developing math anxiety or a negative attitude toward mathematics (Ashcraft, 2002; Hopko et al., 2003).

Children begin to construct the foundations for future mathematical concepts during the first few months of life (Geist, 2003a; Geist, 2003b). Before a child can add or even count, they must construct ideas about mathematics that cannot be directly taught. Many of these basic ideas are constructed through interaction with the surrounding environment and the adults in that environment. Ideas that will support formal mathematics later in life such as order and sequence, seriation, comparisons, classifying, addition and other more advanced mathematical skills have their genesis before the age of five. The seemingly simple understanding that numbers have a quantity attached to them is actually a complex relationship that children must construct.

As children enter formal schooling, the constructive process sometimes takes a turn for the worse, especially for girls and minorities (Ma, 2003; Scarpello, 2007; Turner et al., 2002). Studies have shown that at this time in children's learning of mathematics, textbooks take over the process of teaching and the focus on shifts from construction of

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concepts using children's own mathematical thinking to teacher imposed methods of getting the correct answer (Geist, 2000). Teachers begin to focus on repetition and speed or "timed tests" as important tools for improving mathematical prowess and skill which can undermine the child's natural thinking process and lead to a negative attitude toward mathematics (Popham, 2008; Scarpello, 2007; Thilmany, 2004; Tsui & Mazzocco, 2007).

This overreliance on timed tests and other high stakes approaches to teaching mathematics reinforce the negative attitude toward mathematics that many children have developed in the early years of life (Scarpello, 2007). For those children who had a positive mathematical experience in the early years, this new approach to learning mathematics is often very different from what they are used to (Popham, 2008). Children begin to associate mathematics with boring work that often does not relate to their everyday life. Teachers will sometimes have the perception that if children are enjoying the activities, it is not really learning (Lewis, 2005).

However, this attitude leads to schools not achieving the objectives that they are set out to achieve. Instead of helping children develop fluency at computation and become more efficient at problem solving, these policies have produced students that rely more on rote memorization and have increased the level of anxiety in young children by making mathematics a high-risk activity. This tends to produce more adults with "math anxiety" and discouraged children who understand the concept but work a little slower. It also may explain some of the disparities between girls and boys regarding attitudes toward mathematics and why minorities tend to perform poorly on mathematics achievement tests.

Recent studies show that roots of the gap in mathematics achievement begins well before the first NAEP assessment in 4th grade (Lewis, 2001; Waanders, Mendez, & Downer, 2007). Children entering Kindergarten have been shown to have disparities based on socioeconomic level. For girls, the disparity does not manifest itself until after 4th grade. The NAEP assessment in 4th grade shows that girls actually outperform boys on the math portion of the test. The same NAEP assessment in 8th and 12th grade show that the girls' advantage disappears as formal schooling, testing and socialization begin girls to create negative attitudes toward mathematics (which is also measured by the NAEP test).

Gender Effects on Negative Attitudes

Mathematics in many classrooms is based on a traditional "skills based" model. Too often, this means memorization and rote recitation rather than active concept based learning (Cates & Rhymer, 2003). Worse, it is often taught as if all the students are not just similar, but identical in terms of ability, preferred learning style, and pace of working (Boaler, 1997). Under achievement and non-representation of girls at the highest levels in mathematics may be linked to the method of instruction rather than ability because boys are more likely to adapt better to the traditional skills model (Boaler, 2002). Evidence also shows that times testing and other high stakes assessment effects girls attitude toward mathematics more than boys, leading to higher levels of mathematics anxiety in females (Beilock, 2008). However, even though boys may seem to adapt to this instructional model, it is important to note that boys are overly represented at the lowest and the highest levels in mathematics (Bielinski & Davison, 2001).

These gender differences are exacerbated by the homogenized approach to teaching in which all students are assumed to learn the same way and at the same pace. Imagine a classroom climate that acknowledges gender differences while considering individual styles and behaviors. This classroom climate would be supportive of the mathematical learning needs of boys and girls. An essential element in this approach is planning a curriculum that is developmentally appropriate, individualized, and gender responsive.

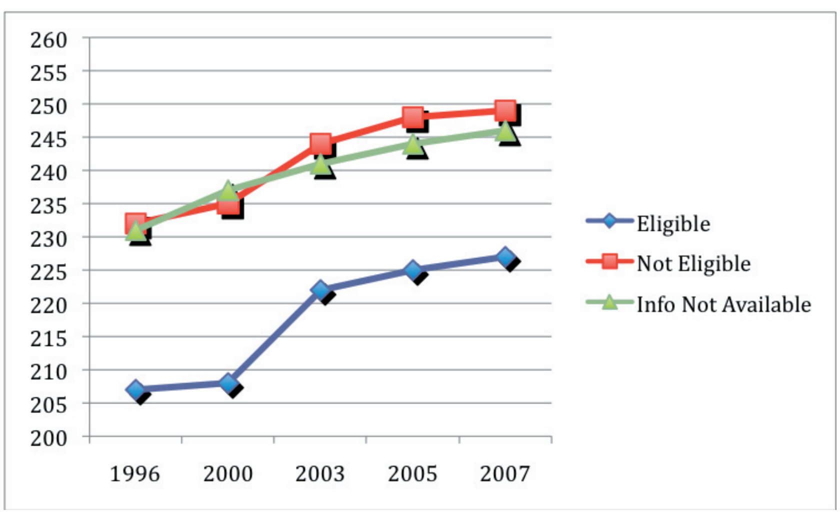
So, what does this mean for how we teach in our classrooms? It means that we have to be sensitive to the different needs of boys and girls. Their brains are different and more importantly, their approach to learning may be different (Geist & King, 2008; Gurian, 2005; Pinker & Spelke, 2005). Every child learns differently. They also respond differently to different instructional approaches (Leedy, LaLonde, & Runk, 2003). In general, there is little empirical research about the causes of mathematics anxiety and even less on the effects and efficacy of timed testing as an instructional approach. However, we do know that adding time requirements to tasks does increase anxiety, decrease accuracy and create a negative attitude toward the subject matter (Ashcraft, 2002; Popham, 2008; Tsui & Mazzocco, 2007). Research also shows that females are more susceptible to these effects than males (Beilock, 2008; Haynes et al., 2004; H. Miller & Bichsel, 2004; L. D. Miller & Mitchell, 1994).

Many teachers believe that girls achieve in mathematics due to their hard work while boy's achievement is attributed to talent (Jussim & Eccles, 1990; Jussim & Eccles, 1992). These differing expectations by teachers and parents may lead to boys often receiving preferential treatment when it comes to mathematics.

Children may internalize these attitudes and begin to believe what their teachers and parents believe. As a result, girls tend to feel less confident about their answers on tests and often express doubt about their performance. As children progress through school, girl's assessment of their enjoyment of mathematics falls much more drastically than boy's assessment. These attitudes may shape the experiences that children have as they are learning mathematics.

Poverty and Family Effects on Negative Attitudes

Research also demonstrates that the most consistent risk factor for low achievement in mathematics is family income level – the lower the family income, the lower the achievement (Jordan, Kaplan, Oláh, &



Note: Info not available refers to surveys that had no response in this category

Figure 1. Poverty groupings for 4th grade NAEP mathematics scores form 1996-2007

Locuniak, 2006; Stipek & Ryan, 1997). There is also a link between parental attitudes toward mathematics, educational level and their child's level of math anxiety (Scarpello, 2007; Turner et al., 2002). On the NAEP mathematics assessment, children who are eligible for the USDA's free or reduced cost lunch program, regardless of ethnicity, scored 13 points below the national average and 22 points below those students that did not qualify for the program (Figure 1, National Center for Educational Statistics, 2007). While the figures show steady increases in scores over the 10-year period, the gap between "eligible" and "not eligible" student remains steady. These data support the contention that poverty is a significant risk factor for early mathematics achievement.

If we can assume that these differences are not a result of native potential, or some sort of genetic mathematical ability, then we must look for environmental variables to explain the intertwining outcomes of poor achievement and negative attitude toward mathematics (Alsup, 2005; Hopko et al., 2003; Popham, 2008; Scarpello, 2007). The NAEP data also suggests that lower educational attainment of parents is a risk factor for lower achievement (Barbarin et al., 2006; Duncan, 2007; Duncan, Ludwig, & Magnuson, 2007). When parent educational level is examined, there is a positive correlational decline in NAEP scores on the mathematics portion of the test (Dobbs, Doctoroff, Fisher, & Arnold, 2006; National Center for Educational Statistics, 2007)

Similar results were found using the *Programme for International Student Assessment* (PISA) test administered by the *Organisation for Economic Co-operation and Development* (OECD) study (Figure 2) (Desruisseaux, 1995; Orginisation for Economic Co-operation and Development, 2007). The PISA is an internationally standardized assessment, jointly developed by participating countries and administered to 15-year-olds in schools in several countries including the U.S., Canada, Mexico, the U.K., Japan and most of Europe, to measure academic achievement of students.

Additionally, this data shows that the father's education level seems to have a greater effect in almost all groups. Yet studies have shown that a mother's attitude and encouragement toward mathematics was a significantly more important factor to children having a positive attitude toward mathematics and was liked to positive achievement in mathematics (Scarpello, 2007). The importance of family socialization and attitudes are evident in he research and the test scores on both the PISA and the NAEP.

It is hypothesized that both parents' educational attainment may have such a large effect on mathematical achievement because the mathematical environment in the home

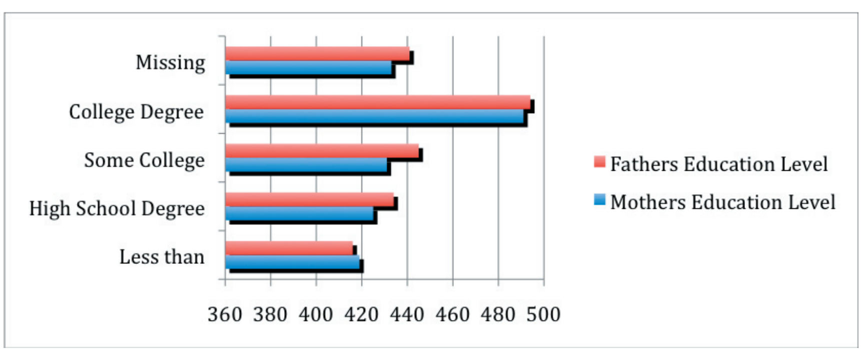


Figure 2. PISA Scores by Mother and Father's education level

may be less stimulating for families with low educational attainment (Jordan & Hanich, 2003; Jordan et al., 2006). The parents may have less knowledge of mathematical concepts, lower comfort level with mathematics and a negative attitude toward mathematics leading to math anxiety and an aversion to mathematics. This, in turn, could hinder their ability to encourage and support those concepts with their child. Parents may also not understand the importance of promoting emergent mathematics with their child in the early years, much as is done with literacy development (Geist, 2008).

In many rural locations in the United States, such as Appalachia, lower educational level and poverty is a double disadvantage for children and school districts. By contrast, statistics for inner city school districts show that although there is a large number of children in poverty, there is a higher mean educational attainment for their population within the school district. For example, six inner-city school districts (Columbus, Cincinnati, Cleveland, Toledo, Akron, and Dayton) have an average percentage of the population with a college degree or more of 23.7%, while an average of three representative school districts in Ohio's Appalachian region have an average of 13.1% with a college degree or more. (Ohio DOE Similar District Grouping, https://webapp2.ode.state.oh.us/similar_districts/Similar_Districts.asp).

The effect of high stakes methods such as timed tests on these "at-risk" groups are just some of the examples of how math anxiety and negative attitudes toward mathematics can effect achievement and progress in mathematics (Miller & Mitchell, 1994). Others who are not in these categories are also affected. Methods that emphasize the primacy of correct answers over concept development, competition and speed over understanding, and rote repetition over critical thinking will exacerbate the problems. Research has shown that these methods inherently create anxiety in children and adults. However, unlike general anxiety, mathematics anxiety has unique characteristics (Baloǧlu & Koçak, 2006) and can be traced back to some specific previous educational experiences (Ma, 2003).

Teacher Influences

One of the difficult problems to overcome is that by the time people become adults the damage is already done (Donelle, Hoffman-Goetz, & Arocha, 2007; Gresham, 2007; Liu, 2008). Our attitudes toward mathematics are set because of prior experiences. The early use of high stress techniques like timed tests instead of more developmentally appropriate and interactive approaches lead to a high incidence of math anxiety. Williams (2000), compared two methods of learning multiplication facts in order to develop speed and accuracy with a seventh grade enrichment class, which met for seven weeks during the school year. As part of the curriculum, students were provided with activities to refine their basic math skills. The class was divided into two groups with one group receiving paper and pencil practice with "Minute Madness" worksheets (control group), and the other group using the drill and practice software, "Multiplication Puzzles" (treatment group) computers. The results indicated that there was a significant increase in the number of problems correctly answered on the post-test by the treatment group that used "Multiplication Puzzles" on the computer, whereas mean scores for the pencil and paper group did not indicate a significant improvement in the development of their multiplication skills.

Jackson & Leffingwell (1999), investigated the types of instructor behavior that created or exacerbated mathematics anxiety in students. It also tried to assess the grade level at which mathematics anxiety first occurred in these students. They found was that teacher behavior was a prime determinant of math anxiety and that it is usually evident early on in the primary grades.

Many teachers of young people feel uncomfortable teaching mathematics because they do not like mathematics themselves. Many also feel that they are not good at mathematics and therefore feel uncomfortable teaching it to their students (Burns, 1998; Stuart, 2000). Many teachers who have math anxiety themselves inadvertently pass it on to their students.

Math anxiety does not come from the mathematics itself but rather from the way math is presented in school and may have been presented to teachers as a children (Stuart, 2000).

Conclusion

I can personally remember a chart posted prominently in the classroom with all the students names in a column down the right hand side of the chart. As we progressed through the year, we had daily timed mathematics tests on addition (or was it multiplication? I can't remember). If we completed all 20 problems in 1 minute, we got a star next to our name and got to move on the next level test. If you did not finish in time (with all the answers correct, of course), we got no star and had to retake the test the next day and subsequent days, until we passed it and finally earned our star. Near the middle of the year, everyone could see, by looking at the chart, which students had more stars and which students had the fewest stars. As you can imagine, those of us with the fewest stars began to really hate math and really stress out whenever it came time for the test.

Overcoming math anxiety means examining how we teach mathematics in our classrooms. This issue is of major concern to our economy, to a child's future employment and their success in higher education. Mathematics is seen as an important factor in a vital global economy. Creating a country of "mathophobes" does not bode well for us in the uncertain global economy of the future. Elementary and High School students may chose to take less mathematics or lower level mathematics because of a negative attitude toward mathematics. This could lead them to choose not to pursue higher education. For those that do pursue higher education, the research shows that college mathematics instructors are concerned by the high levels of aversion to mathematics that is seen (Gresham, 2007; Liu, 2008; Rameau & Louime, 2007; Ruffins, 2007; Walsh, 2008).

There are curricular alternatives that can lessen mathematics anxiety. Current and future teachers should seek out these methods and embrace them whole-heartedly. If we remember our experiences with mathematics as I have done above, it should motivate us to make a change. We must remember the words of the poet George Santayana: "Those who cannot remember the past are condemned to repeat it."

References

Alsup, J. (2005). A comparison of constructivist and traditional instruction in mathematics. *Educational Research Quarterly, 28*(4), 3-17.

Arnold, D. H., Fisher, P. H., Doctoroff, G. L., & Dobbs, J. (2002). Accelerating math development in head start classrooms. *Journal of Educational Psychology, 94*(4), 762.

Ashcraft, M. H. (2002). Math anxiety: Personal, educational, and cognitive consequences. *Current Directions in Psychological Science, 11*(5), 181-185.

Balog˘lu, M., & Koçak, R. (2006). A multivariate investigation of the differences in mathematics anxiety. *Personality & Individual Differences, 40*(7), 1325-1335.

Barbarin, O., Bryant, D., McCandies, T., Burchinal, M., Early, D., Clifford, R., et al. (2006). Children enrolled in public pre-K: The relation of family life, neighborhood quality, and socioeconomic resources to early competence. *American Journal of Orthopsychiatry, 76*(2), 265-276.

Beilock, S. L. (2008). Math performance in stressful situations. *Current Directions in Psychological Science, 17*(5), 339-343.

Bielinski, J., & Davison, M. L. (2001). A sex difference by item difficulty interaction in multiple-choice mathematics items administered to national probability samples. *Journal of Educational Measurement, 38*(1), 51.

Boaler, J. (2002). Paying the price for "sugar and spice": Shifting the analytical lens in equity research. *Mathematical Thinking and Learning, 4*(2/3), 127.

Burns, M. (1998). *Math facing an american phobia*. Sausalito, CA: Math Solutions Publications.

Cates, G. L., & Rhymer, K. N. (2003). Examining the relationship between mathematics anxiety and mathematics performance: An instructional hierarchy perspective. *Journal of Behavioral Education, 12*(1), 23-34.

Desruisseaux, P. (1995). OECD study shows disparity in education. *Chronicle of Higher Education, 41*(32), A50.

Dobbs, J., Doctoroff, G. L., Fisher, P. H., & Arnold, D. H. (2006). The association between preschool children's socio-emotional functioning and their mathematical skills. *Journal of Applied Developmental Psychology, 27*(2), 97-108.

Donelle, L., Hoffman-Goetz, L., & Arocha, J. F. (2007). Assessing health numeracy among community-dwelling older adults. *Journal of Health Communication, 12*(7), 651-665.

Duncan, G. J. (2007). High-quality preschool as antipoverty. *American Prospect, 18*(5), A20-A21.

Duncan, G. J., Ludwig, J., & Magnuson, K. A. (2007). Reducing poverty through preschool interventions. *Future of Children, 17*(2), 143-160.

Geist, E. (2008). *Children are born mathematicians: Encouraging and supporting development in young children* (1e ed.). Upper Salle River, NJ: Prentice Hall.

Geist, E. (2003a). Children are born mathematicians. *Young Children,*

Geist, E. (2003b). Infants and toddlers exploring mathematics. *Young Children, 58*(1), 10-12.

Geist, E. A. (2000). Lessons from the TIMSS videotape study. *Teaching Children Mathematics, 7*(3), 180.

Geist, E. A., & King, M. (2008). Different, not better: Gender differences in mathematics learning and achievement. *Journal of Instructional Psychology, 35*(1; 1), 43-52.

Gresham, G. (2007). A study of mathematics anxiety in pre-service teachers. *Early Childhood Education Journal, 35*(2), 181-188.

Gurian, M. (2005). *The minds of boys : Saving our sons from falling behind in school and life / michael gurian and kathy stevens* (1st ed ed.). San Francisco, CA : Jossey-Bass.

Haynes, A. F., Mullins, A. G., & Stein, B. S. (2004). Differential models for math anxiety in male and female college students. *Sociological Spectrum, 24*(3), 295-318.

Hopko, D. R., McNeil, D. W., Lejuez, C. W., Ashcraft, M. H., Eifert, G. H., & Riel, J. (2003). The effects of anxious responding on mental arithmetic and lexical decision task performance. *Journal of Anxiety Disorders, 17*(6), 647.

Jackson, C. D., & Leffingwell, R. J. (1999). The role of instructors in creating math anxiety in students from kindergarten through college. *Mathematics Teacher, 92*(7), 583.

Jordan, N. C., & Hanich, L. B. (2003). Characteristics of children with moderate mathematics deficiencies: A longitudinal perspective. *Learning Disabilities Research & Practice (Blackwell Publishing Limited), 18*(4), 213.

Jordan, N. C., Kaplan, D., Oláh, L. N., & Locuniak, M. N. (2006). Number sense growth in kindergarten: A longitudinal investigation of children at risk for mathematics difficulties. *Child Development, 77*(1), 153-175.

Jussim, L., & Eccles, J. S. (1990). *Expectancies and social issues*. New York: Plenum Pub. Corp. for the Society for the Psychological Study of Social Issues.

Jussim, L., & Eccles, J. S. (1992). *Teacher expectations II: Construction and reflection of student achievement* American Psychological Association.

Leedy, M. G., LaLonde, D., & Runk, K. (2003). Gender equity in mathematics: Beliefs of students, parents, and teachers. *School Science and Mathematics, 103*(6), 285.

Lewis, A. (2001). *Add it up: Using research to improve education for low-income and minority students*

Lewis, T. (2005). Facts + fun = fluency. *Teaching Children Mathematics, 12*(1), 8-11.

Liu, F. (2008). Impact of online discussion on elementary teacher candidates' anxiety towards teaching mathematics. *Education, 128*(4), 614-629.

Ma, X. (2003). Effects of early acceleration of students in mathematics on attitudes toward mathematics and mathematics anxiety. *Teachers College Record, 105*(3), 438-464.

Miller, H., & Bichsel, J. (2004). Anxiety, working memory, gender, and math performance. *Personality & Individual Differences, 37*(3), 591-606.

Miller, L. D., & Mitchell, C. E. (1994). Evaluation achievement in mathematics: Exploring the gender biases of timed testing. *Education, 114*(3), 436-438.

National Center for Educational Statistics. (2007). *NAEP data explorer*

Orginisation for Economic Co-operation and Development. (2007). *Education at a glance - 2007* OECD.

Pinker, S., & Spelke, E. (2005). Are gender differences in math and science innate? *CQ Researcher, 15*(19), 461-461.

Popham, W. J. (2008). Timed tests for tykes? *Educational Leadership, 65*(8), 86-87.

Rameau, P., & Louime, C. (2007). *Mathematics phobia: Are the mathematical sciences a pothole in the road of life?* Indian Academy of Sciences.

Ruffins, P. (2007). A real fear. *Diverse: Issues in Higher Education, 24*(2), 17-19.

Scarpello, G. (2007). Helping students get past math anxiety. *Techniques: Connecting Education & Careers, 82*(6), 34-35.

Stipek, D. J., & Ryan, R. H. (1997). Economically disadvantaged preschoolers: Ready to learn but further to go. *Developmental Psychology, 33*(4), 711.

Stuart, V. B. (2000). Math curse or math anxiety? *Teaching Children Mathematics, 6*(5), 330.

Thilmany, J. (2004). Beating math anxiety. *Mechanical Engineering, 126*(12), 18-18.

Titu, A., Gallian, J., Kane, J. & Mertz, J. (2008) Cross-Cultural Analysis of Students with Exceptional Talent in Mathematical Problem Solving. *Notices of the American Mathematical Society*, *55*(10), 1248-1260

Tsui, J. M., & Mazzocco, M. M. M. (2007). Effects of math anxiety and perfectionism on timed versus untimed math testing in mathematically gifted sixth graders. *Roeper Review, 29*(2), 132-139.

Turner, J. C., Meyer, D. K., Anderman, E. M., Midgley, C., Gheen, M., Yongjin Kang, et al. (2002). The classroom environment and students' reports of avoidance strategies in mathematics: A multimethod study. *Journal of Educational Psychology, 94*(1), 88.

Waanders, C., Mendez, J. L., & Downer, J. T. (2007). Parent characteristics, economic stress and neighborhood context as predictors of parent involvement in preschool children's education. *Journal of School Psychology, 45*(6), 619-636.

Walsh, K. A. (2008). The relationship among mathematics anxiety, beliefs about mathematics, mathematics self-efficacy, and mathematics performance in associate degree nursing students. *Nursing Education Perspectives, 29*(4), 226-229.

Williams, L. P. (2000). The effect of drill and practice software on multiplication skills: "multiplication puzzles" versus "the mad minute.".