Beyond CROSSROADS

Chapter 4

Student Learning and the Learning Environment

Many factors influence the academic progress of students. The varied academic preparation of the diverse two-year college student population calls for the entire college community to work in concert to create a positive learning environment that will maximize student learning in mathematics, both inside and outside of the classroom. In a standards-based learning environment, students are viewed as partners in the learning experience. To nurture that partnership, faculty may need to help students identify their academic strengths and weaknesses, develop strategies to minimize mathematics anxiety, and learn how to take responsibility for their own learning. Faculty, departments, and institutions need to make available to students an effective mathematics placement program. Once a student has enrolled in an appropriate mathematics course, it is essential to provide a supportive learning environment consisting of the classroom, mathematics tutoring labs, learning centers, counselors, support for students with disabilities, and other support services.

Implementation Standard: Student Learning and the Learning Environment

Mathematics faculty and their institutions will create an environment that optimizes the learning of mathematics for all students.

Responding to the Needs of a Diverse Student Population

The diverse student population of two-year colleges discussed in Chapter 1 presents unique challenges for students, faculty, and institutions. Large numbers of mathematics students need institutional support such as tutoring, financial aid, and childcare. Many students have full- or part-time work responsibilities, as well as significant family and personal commitments. Students with disabilities often choose two-year colleges for their educational needs. Variations in students' mathematics achievement have long been associated with the demographic issues of socioeconomic status and race/ethnicity. First-generation, immigrant, and international students may face difficulty adjusting to a new educational environment. To address these challenges, students need to assume an active role in their learning. Faculty and institutions need to create a responsive mathematics learning environment that responds to the needs and characteristics of its students.

Socioeconomic status is the greatest determinant of enrollment and persistence in college for all students.

Heather Oesterreich, *Characteristics of Effective Urban College Preparation Programs,* 2000, p. 4

Each student is entitled to access and support for high-quality educational experiences and opportunities—regardless of age, gender, sexual orientation, race, ethnicity, socioeconomic factors, physical and cognitive abilities, or precollege experiences. Creating an appropriate and responsive learning environment for academic success in mathematics is a responsibility that needs to be shared by each person in the institution. The institution needs to provide leadership training and equity training, so that faculty and student support staff acquire the necessary skills to address students' needs.

Students will be expected to do the following:

- begin taking their mathematics courses early in their program
- set high mathematical expectations for themselves
- learn to balance work commitments and other responsibilities with the time needed to achieve course objectives
- recognize their physical and cognitive capabilities and apply strategies that maximize those capabilities, such as attending class regularly and completing homework assignments
- conscientiously persist in each mathematics course
- make use of all resources provided by the institution
- acquire the necessary communication skills to accomplish course goals.

Implementation recommendation: The institution will provide all students with quality educational experiences and mathematical opportunities, regardless of distinguishing characteristics or precollege experiences.

Actions to support this recommendation

Faculty actions:

- have high expectations of all students and clearly communicate those expectations to students
- be aware of and accommodate diverse student needs
- collaborate with appropriate support services personnel to respond to the needs of students with disabilities
- serve as student mentors and mathematics advisors
- advise students of the availability and appropriate use of academic support resources.

Departmental/institutional actions:

- provide mentors for students
- provide mathematics tutoring centers, tutor training, and academic counselors
- assure that students have access to needed technology, such as computer software and hardware, tape recorders, calculators, and videos
- provide appropriate support services for disabled students
- establish support structures for students who lack academic prerequisites.

Initial Placement into the Mathematics Curriculum

Appropriate placement into a mathematics course is critical to a student's success in mathematics. The outcome of that placement process influences not only the time to program completion but also the student's self-perception as a learner of mathematics. To assure the best student placement, an institutional

placement policy should consider multiple factors. While testing provides important information for placement into mathematics courses, a mandatory placement policy based only on standardized test scores may effectively deny access to necessary courses for some students.[1] Measures such as placement testing, high school preparation, prior exposure to course content, time since high school graduation, enrollment status, enrollment in a study skills course, mathematical self-concept, attitude toward mathematics, attendance, and educational goals have been shown to be pertinent to student success.[2] Mathematics placement policies should place students into the highest-level course in which they are likely to be successful. An appeal process should be in place to accommodate the possibility of inaccurate placement.

Mathematics faculty involvement is essential when developing institutional placement policies prescribing initial placement of students into mathematics courses. The majority of two-year colleges in the United States rely on standardized tests for placement into the mathematics curriculum,[3] but the validity of these tests as predictors of academic success varies.[4] Initial advising on placement into the mathematics curriculum, mathematics course selection, and the implications of these choices on degree attainment are important considerations for student success and for encouraging more students to enroll in mathematics courses and programs. An advisor can help a student construct a personal profile detailing what the learner knows, wants to know, and needs to know to ensure that the appropriate mathematics class or classes are selected. Students should be encouraged to practice their mathematics skills before taking a placement test, in order to review previously learned concepts. Conversations between students and advisors about course placement engage students as full partners in their education.

If the student is not initially placed into a mathematics class appropriately, then the student is at an immediate disadvantage before other factors have the opportunity to influence success.

Phyllis S. Shaw, *An Analysis and Evaluation of Policies and Practices of Student Placement into College Algebra Classes...,* Doctoral Dissertation, 1997, p. 6

Students will be expected to do the following:

- prepare to take a placement test by reviewing test preparation materials supplied by the college
- be aware of the implications of placement results.

Implementation recommendation: A college placement team that includes mathematics faculty will develop policies and procedures for the placement of students into the mathematics curriculum based on an analysis of multiple measures.

Actions to support this recommendation

Faculty actions:

- be familiar with mathematics placement procedures at their institution
- advise students of the placement testing process and the implications of placement into the mathematics curriculum
- assume a leadership role in the development of mathematics placement policies.

Departmental/institutional actions:

- assure that mathematics faculty are involved in the design of mathematics placement measures
- use multiple measures for initial placement of students into mathematics courses
- periodically determine the effectiveness of mathematics placement tests with an empirical study of cut-off scores and student success
- place students into the most advanced course appropriate for their program for which they have prerequisite skills.

Learning Styles

How students learn mathematics is influenced by their learning style, defined as "the preferences, tendencies, and strategies that individuals exhibit while learning."[5] An effective mathematics curriculum is one that provides students of every learning style an opportunity to engage in a topic, connect with the material, and then stretch their learning capacity in other learning modes.[6] Instructional strategies and activities that take cultural, personal interaction, and communication styles into consideration can also contribute to student success, particularly for new students and poorly prepared students, among whom most attrition occurs.[7]

… adults … need to be ready to learn in order to learn.

AMATYC, *Mathematics for the Emerging Technologies,* 2003, p. 9

Research in learning suggests that instructional approaches for children provide similar achievement results as those designed strictly for adults.[8] Though some assumptions about learning apply equally to adults and children, some researchers believe that adults and children learn differently.[9] There is evidence that adults tend to be more self-directed and prefer learning that is learner-centered,[10] than children, who have fewer experiences and pre-established beliefs. Instructors should choose methods that are appropriate for *their* students. The goal is to help each student understand why a mathematical concept is important to learn, how to navigate information to be learned, and how the topic relates to his/her experiences.[11]

In general, learning styles can be categorized according to different personality or cognitive trait characteristics. There are three sensory types of learning styles: auditory (*hearing*), tactile (*doing*), and visual (*seeing*). Other learning styles are extensions of these three basic styles. Most mathematics instructors are visual, abstract, and individual learners. Learning styles for developmental mathematics students are visual, tactile concrete, auditory, and social.[12] Students may exhibit all or many of the characteristics at any one time. Preferences for one style or another may be strong, moderate, or mild.

An individual's learning style can be identified using available instruments. Some students have a different learning style for mathematics than for other academic subjects, such as English or history. Therefore, to identify a student's mathematics learning style, it is important to identify and use an inventory specifically designed for mathematics.[13] Once a mathematics learning style has been identified, faculty can help students employ one or more of the strategies outlined in Table 3 to maximize their learning of mathematics.

Students and faculty need to work together to understand and address a student's learning style(s) and be open to trying multiple instructional strategies to maximize each student's learning in mathematics. Mathematics education should focus not only on reinforcing areas of student strengths, but also on effective learning strategies to enhance student performance in less dominant areas.[15] Professional development in how to use multiple approaches in instruction that address the complete range of learning styles should be provided to faculty. Once faculty are knowledgeable about learning styles and trained to respond to them, they often feel more comfortable using multiple instructional strategies in their classrooms. Students who discover, understand, and apply study skills and learning strategies to complement their learning style are more likely to become more efficient in learning mathematics and making sense of new information.

Table 3 Selected Learning Styles Characteristics and Strategies for Students[14]

Learning Style Characteristics		Strategies for Students
Active/ Tactile/ Concrete	Retains and understands information as a result of doing something manual or involving the sense of touch.	• Use mathematics manipulatives as a concrete demonstration to make sense of a problem situation. • Draw a picture, make a table, build a physical model of a problem. • Have students act out a concept.
Active/ Social	Retains and understands information as a result of discussing or explaining to others.	• Participate in study groups. • Discuss concepts with the instructor and other students.
Analytic	Learns concepts and rules from experts.	• Listen to lectures. • Watch a demonstration.
Dynamic	Learns by exploring and looking for other possibilities for solving problems.	• Create and complete mathematics projects • Use trial and error to find mathematics patterns.
Global	Learns in large jumps, absorbs material randomly, is able to solve complex problems quickly and in novel ways.	• Relate new mathematics topics to previous knowledge.
Innovative	Learns mathematics by personally relating mathematics to himself/herself using feelings.	• Discuss mathematics ideas with others • Look for personal meaning in mathematics.
Intuitive	Discovers possibilities and relationships, is comfortable with abstractions and mathematical formulations, dislikes memorization and routine calculations.	• Seek interpretations and theories that provide proofs for theorems or formulas.
Reflective	Thinks about information quietly first and prefers to work alone.	• Incorporate reflection time as a part of study time. • Practice problems using computer software.
Sensing/ Common Sense	Learns facts by connecting concepts to real-world situations; prefers to see the usefulness and practical application of mathematics.	• Consult other sources for specific real-world examples of mathematics concepts and procedures • Seek hands-on learning experiences.
Sequential	Understands linear steps and follows logical paths to find solutions.	• Ask instructor to supply steps to solutions for problems.
Verbal	Prefers written and spoken explanations.	• Make summaries or outlines of course material. • Listen to classmates' explanations. • Read written explanations aloud. • Explain how to solve a problem to a tutor or classmate.
Visual	Remembers pictures, diagrams, flowcharts, formulas, and procedures.	• Seek diagrams, schematics, course material that can be viewed. • Create concept maps. • Color-code notes with highlighters. • Make flash cards with color coding.

Students will be expected to do the following:

- accept responsibility for their own learning
- apply strategies to complement their dominant learning style
- create, think, and reflect about mathematics concepts
- engage in multiple instructional and learning strategies to maximize their learning
- respect the different learning styles of other students.

Implementation recommendation: Students and faculty will be aware of different learning styles and implement supportive strategies to maximize student learning in mathematics.

Actions to support this recommendation

Faculty actions:

- understand student learning styles and become aware of one's own learning style
- help students identify their mathematics learning style(s)
- implement multiple instructional strategies to address multiple learning styles.

Departmental/institutional actions:

- provide academic resources to develop and support multiple instructional strategies
- provide professional development opportunities on learning styles for mathematics faculty and student support staff.

Learning to Be Problem Solvers

Becoming an efficient, independent problem solver should be a goal of every mathematics student. But for many students, mathematics is viewed as a "string of procedures to be memorized, where right answers count more than right thinking."[16] Authentic problem solving does not necessarily involve memorizing procedures and usually involves being motivated to solve the problems.[17]

…a teacher of mathematics has a great opportunity. If he fills his allotted time with drilling his students in routine operations he kills their interest, hampers their intellectual development, and misuses his opportunity…if he challenges the curiosity of his students… and helps them to solve their problems with stimulating questions, he may give them a taste for, and some means of, independent thinking.

George Polya, *How to Solve It,* 1973, p. v

> *"...good problem-solving behavior usually is not fostered by having students imitate how teachers solve problems. Because teachers typically demonstrate only correct moves, students often come to view problem solving as that of delving into a mysterious bag of tricks to which only a select few are privy."*[18]

To build problem-solving skills, faculty need to engage students actively in the learning process, create opportunities for exploration, and help them recognize that there may not be a rule to memorize or algorithm to follow for a given problem.

Expert problem solvers have access to rich, well-connected knowledge of mathematical concepts and possess confidence following a long history of successful problem solving. They also have an ability to imagine and conjecture possible solution paths, to monitor their progress and dynamically revise or abandon solution paths, and to verify that a solution is reasonable and makes sense. In contrast, developmental mathematics college students rarely plan a solution in advance, may demonstrate an inability to consistently monitor their progress, and have varying degrees of success recognizing that a solution attempt is not progressing toward the desired goal.[19] When their initial strategy is not productive, these students have difficulty switching to an alternative strategy. Faculty and students need to take these

characteristics into consideration and employ and engage in classroom activities that focus on boosting students' confidence and building a reservoir of problem-solving strategies. When students are given opportunities to use multiple approaches to solve problems, they come to recognize that mathematics is more than computation or getting the single right answer—it is a balance of process and product—a combination of good thinking and meaningful answers.

Students will be expected to do the following:

- recognize that problem solving is an essential skill to be developed or improved in any mathematics course
- understand and use a variety of problem-solving strategies.

Implementation recommendation: Faculty will be intentional and persistent throughout every mathematics course in helping students improve their problem-solving skills.

Actions to support this recommendation

Faculty actions:

- plan and model classroom experiences using multiple problem-solving approaches
- provide students with adequate time for planning, monitoring, reflecting, and understanding multiple approaches to solving problems.

Departmental/institutional actions:

- provide professional development for faculty and tutors to learn how to incorporate multiple problem-solving instructional strategies into their presentations.

Mathematics Anxiety and Other Factors That Influence Learning

The beliefs and attitudes that students bring with them to the classroom play a major role in how they learn mathematics. Some students believe that mathematics is about computation and that they are to find *the* correct answer in five minutes or less. They believe that they are to be passive in the learning process. They may also view mathematics as a collection of rules, facts, skills, and algorithms that need to be memorized. Some students think that mathematics is meaningless when there is a lack of context.[20] College mathematics students often believe that they should accept procedures without trying to understand the concepts, because they feel they are not capable of creating mathematics themselves.[21]

Attitudes toward mathematics can create either a feeling of confidence or anxiety that may have a positive or negative effect on mathematical behavior.[22] "Math anxiety" is described as a feeling of dread that is experienced when a person attempts to understand and solve mathematics problems. Factors such as age or maturational level, relationship between student and teacher, and the nature of the learning environment, including instructional methods used and learning resources available, influence why mathematics anxiety occurs.[23] Prior experiences in mathematics often play an important role. This anxiety is a major concern for many college students, particularly females and those with weak mathematics backgrounds.

Your goal…should be to guarantee every student math mental health, namely, the willingness to learn the math they need when they need it.

Sheila Tobias, Math Mental Health, *College Teaching* 39(3), 1991, p. 93.

Depending on the degree of mathematics anxiety, the student's fears can develop into "learned helplessness," the belief that one is unable to do mathematics at all.[24] Learning style issues can increase anxiety. A student who is predominantly a tactile learner may feel bewildered when mathematics is presented as strictly symbol manipulation. As a result, faculty and students should work together to identify

mathematics anxiety and manage the learning process. Strategies for students to cope with mathematics anxiety can be grouped into four categories as noted in Table 4. All four categories are beneficial, but approach strategies have been shown to be most successful.[25] Faculty can assist students in overcoming and managing their anxiety by suggesting that students engage in one or more of the following actions.

Table 4 Strategies for Coping with and Helping to Alleviate Mathematics Anxiety[26]

Strategy	Student Actions
Approach strategies involve the active learning of mathematics.	• Complete homework on time so as not to fall behind. • Maintain a regular study schedule and set aside extra study time before examinations. • Ask questions in class. • Talk with the instructor outside of class when concepts are unclear. • Form study groups with other students. • Visit a mathematics resource center or tutoring center for extra help. • Use supplemental resources, books, Web sites, or computer-based instruction.
Avoidance strategies involve taking a temporary break from studying mathematics to alleviate distress.	• When frustrated, maintain positive attitudes and remind themselves that they are good students. • Participate in sports or exercise to relieve stress.
Social support strategies involve sharing common experiences with others.	• Discuss mathematics concepts and experiences with other students. • Discuss mathematics concepts and experiences with the instructor, counselor, or advisor.
Relaxation strategies involve reducing stress through relaxation and self-control techniques.	• Practice systematic relaxation techniques such as deep breathing, tensing and relaxation, and visualization. • Practice long-term relaxation techniques. • Replace negative self-talk during homework or test-taking with positive self-talk.

Students will be expected to do the following:

- play an active role in the learning of mathematics
- understand that learning often involves effort, frustration, and struggle
- understand the impact of mathematics anxiety on their learning
- employ a variety of strategies to cope with and alleviate mathematics anxiety.

Implementation recommendation: Students, faculty and support staff will understand the influence of students' attitudes toward learning mathematics and employ strategies to help alleviate mathematics anxiety, build confidence in solving problems, and maximize student learning in mathematics.

Actions to support this recommendation

Faculty actions:

- be aware of the diverse mathematics backgrounds of their students and be sensitive to the impact that mathematics anxiety has on students
- answer questions and explain material carefully and clearly
- assign and review homework regularly to provide periodic and timely feedback

- be patient, supportive, and available to help when students are frustrated or confused
- refer students to appropriate support services for help in reducing mathematics anxiety
- be sensitive to the fact that students' family and job responsibilities may occasionally impact on their ability to complete course requirements
- use multiple assessment measures.

Departmental/institutional actions:

- offer mathematics study skills workshops for students
- provide a sufficient number of qualified, well-trained tutors who are available during the day, evening, and weekend
- provide training for counselors and other student support staff to address students' mathematics anxiety.

Inside and Outside the Mathematics Classroom

The physical environment of the classroom and the support services available outside of the classroom influence student success in mathematics. Every classroom develops its own social characteristics.[27] The institution needs to create the best environment for the learning of mathematics and support the characteristics of social interaction. The classroom layout, furniture, and the ease of bringing technology into the classroom all contribute to the learning of mathematics. As an example, classroom lighting needs to be flexible to support the use of technology and may require multiple light switches and the ability to dim the lights.

While most formal mathematics instruction takes place in a physical classroom, the boundaries and practices of the traditional classroom are being redefined. In the virtual classroom of distance education, the roles of the student and faculty are changing. Because students and faculty may be separated by time and location, students need to accept even more responsibility for their learning. In turn, faculty need to be even more available and responsive to students, utilizing alternative communication tools such as voice mail, e-mail, fax, electronic blackboards, and discussion groups.

Communication of mathematical ideas can extend beyond the classroom door. Learning "occurs within the broader social system that pervades the campus."[28] Thus, mathematics departments need to look for ways to encourage faculty-student and student-student interaction outside of the mathematics through mathematics clubs, local internships, speakers, mathematics-related field days, mathematics contests, study groups, and peer tutoring.

…the classroom environment communicates subtle messages about what is valued in learning and doing mathematics.

National Council of Teachers of Mathematics, *Principles and Standards for School Mathematics*, 2000, p. 18

Students can also benefit from a college tutoring center or mathematics resource center, staffed by qualified, trained tutors who themselves are students or employees of the college. Successful mathematics centers provide the following:

- multiple and varied resources for students
- peer and professional tutoring
- computers and other technology that supplement instruction
- student workshops focusing on learning styles and reducing mathematics anxiety
- opportunities for students to work individually and in groups
- adequate space for mathematics tutoring.

An academic testing center can supplement classroom activities by offering out-of-class testing, make-up testing, and placement testing. From the classroom to the testing center, from the math club to

the tutoring center, a successful environment is the result of careful planning and input from mathematics faculty and cooperation and commitment of everyone within the institution.

Students will be expected to do the following:

- use mathematics learning resources available outside of the classroom
- work with other students, tutors, and faculty outside of the classroom.

Implementation recommendation: Institutions will provide appropriate physical facilities and academic support resources to promote student success in mathematics and complement learning experiences.

Actions to support this recommendation

Faculty actions:

- be involved in the design of and decision-making about physical spaces that support mathematics instruction
- identify and recommend needed technology
- encourage interaction with students and between students inside and outside of the classroom
- be available outside of the classroom to assist individual students.

Departmental/institutional actions:

- supply the necessary equipment, including technology, to create classroom environments and mathematics learning centers that maximize the learning of mathematics
- provide adequate space and resources for peer and professional tutoring and mathematics resource centers
- provide adequate office space, computers, and access to student data for full-time and adjunct faculty.

Conclusion

Students, faculty, and institutions play important roles in creating productive learning environments to learn mathematics. Strategies for addressing initial placement into mathematics courses, the needs of the diverse student population, differences in student learning styles and problem solving skills, the impact of mathematics anxiety, ever-changing instructional formats, and planning for facilities and resources are best managed when all stakeholders actively participate and are guided by research. Mathematics faculty should set high academic goals for all students, complemented by programs and processes that help students achieve those goals.

The Implementation Standard for Student Learning and the Learning Environment, along with the recommendations presented in this chapter, can help to put the Standards for Intellectual Development from *Crossroads in Mathematics* into practice. Students *can* be successful in mathematics when students, faculty, and institutions collaboratively develop strategies, constructively confront the changing mathematics environment, and work to implement the actions in this and the following chapters. However, institutions need to provide the academic resources for faculty and student support personnel necessary to sustain and improve learning in mathematics. The results of research summarized in this chapter, as well as lessons learned by experienced practitioners, provide guidance to students, faculty, departments, and institutions for improving mathematics instruction in the first two years of college.

HIGHLIGHTS Implementing the Standard for Student Learning and the Learning Environment

Student Learning and the Learning Environment

Faculty and their institutions will create an environment that optimizes the learning of mathematics for all students.

At a standards-based institution, the *faculty*

- ☑ clearly define high expectations and communicate these to all students.
- ☑ are actively involved in understanding and recommending improvements to institutional policies for mathematics placement.
- ☑ use a variety of instructional methods to address the learning styles of all students.
- ☑ play an active role in planning and creating the learning environment.

At a standards-based institution, the *mathematics department* and the *institution*

- ☑ provide a learning environment that supports, values, and affirms the diverse needs of all learners.
- ☑ provide facilities, tutors and staff for mathematics resource centers.
- ☑ use multiple measures to place students in mathematics courses.
- ☑ provide professional development regarding learning styles, mathematics anxiety, and multiple problem-solving strategies so that faculty and instructional staff have the skills needed to address the diverse student population and dynamic curriculum.
- ☑ design and equip classrooms that encourage active learning and use of technology.

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1 Marwick, J. (2002). Charting a Path to Success: How Alternative Methods of Mathematics Placement Impact the Academic Success of Community College Students. *Community College Enterprise*, 8(2), pp. 41–50.

2 Apter, J. R. (1975). *The Development of a Community College Mathematics Placement Examination*. Unpublished doctoral dissertation, University of Illinois at Urbana-Champaign, Urbana, IL.

Armstrong, W. B. (1999). *Explaining Community College Outcomes by Analyzing Student Data and Instructor Effects*. Unpublished doctoral dissertation, University of California Los Angeles, Los Angeles, CA.

Robinson, S. H. (1998). *An Analysis of Placement Systems for New and Returning Community College Students, Specifically in College Preparatory and Entry-Level College-Level Mathematics Courses*. Unpublished doctoral dissertation, University of Central Florida, Orlando, FL. Dissertation Abstracts International, pp. 59–63, A0707.

3 Lewis, L., Farris, E., & Greene, B. (1996). *Remedial Education at Higher Education Institutions in Fall 1995*. Washington, DC: National Center for Education Statistics. (Statistical analysis report NCES 97–584).

4 Grubb, W. N., Worthen, H., Byrd, B., Webb, E., Badway, N., Case, C., Goto, S., & Villeneuve, J. C. (1999). *Honored But Invisible: An Inside Look at Teaching at Community Colleges*. New York, NY: Routledge, p. 5.

5 Thomson, B. S. & Mascazine, J. R. (1997). *Attending to Learning Styles in Mathematics and Science Classrooms*. ERIC Digests. Columbus, OH: ERIC Clearinghouse for Science, Mathematics and Environmental Education. Retrieved 4/3/2006 from http://www.ericdigests.org/2000-1/attending.html, p. 1.

6 Brown, B. L. (2003). Teaching Style vs. Learning Style. *Myths and Realities*, No. 26, ACVE Publications, p. 2. ERIC document ED 482329.

7 Sims, R. R. & Sims, S. J. (1995). *The Importance of Learning Styles: Understanding the Implications for Learning, Course Design, and Education*. Contributions to the Study of Education, No. 64. Westport, CT: Greenwood Press, p. 76.

Claxton, C. S. & Murrell, P. H. (1987). Learning Styles: Implications for Improving Educational Practices. *ASHE-ERIC Higher Education Report No. 4*. Washington, DC: Association for the Study of Higher Education.

8 Rachal, J. R. (1994). *Andragogical and Pedagogical Methods Compared: A Review of the Experimental Literature* (Informational Analysis). Hattisburg, MI: University of Southern Mississippi. ERIC document ED380566.

9 The term "andragogy" was defined as "the art and science of helping adults learn" by M. Knowles. Knowles, M. (1984). *The Adult Learner: A Neglected Species*. Houston, TX: Gulf Publishing. Retrieved 4/3/2006 from http://agelesslearner.com/intros/andragogy.html.

10 Harriman, G. *E-Learning Resources*. Retrieved 4/3/2006 from http://www.grayharriman.com/adult_learning.htm.

11 Conner, M. L. Andragogy and Pedagogy. *Ageless Learner*, 1997–2004. Retrieved 4/3/2006 from http://agelesslearner.com/intros/andragogy.html.

[12] Nolting, P. (2005). *Learning Styles of Developmental Math Students*. Title III Research. Retrieved 4/3/2006 from www.mccfl.edu/pages/2158.asp. *Comparing Student Learning Styles of Developmental Math Students to Faculty Learning Styles*. Title III Research. Retrieved 4/3/2006 from www.mccfl.edu/pages/2160.asp.

[13] Myers-Briggs Type Indicator (Briggs, Myers & McCaulley, 1985), The Kiersey Temperment Sorter (Kiersey & Bates, 1984), Dunn Model (Dunn, 1996), The Kolb Learning Style Inventory for Mathematics (Kolb, 1976), Felder-Silverman Index of Learning Styles (Felder, 1993).

[14] Felder, R. M. (1993). Reaching the Second Tier: Learning and Teaching Styles in College Science Education. *Journal of College Science Teaching*, 22(5), pp. 286–290.

Nolting, P. (2002). *Winning at Math: Your Guide to Learning Mathematics through Successful Study Skills*. Bradenton, FL: Academic Success Press, Inc.

[15] Sims & Sims (1995).

[16] National Research Council (1989). *Everybody Counts: A Report to the Nation on the Future of Mathematics Education*. Washington, DC: National Academy Press, p. 10.

[17] Kloosterman, P. & Stage, F. (1992). Measuring Beliefs about Mathematical Problem Solving. *School Science and Mathematics*, 92(3), p. 109–115.

[18] Lester, F. (1983). *Trends and Issues in Mathematical Problem-Solving Research*. In R. Lesh and M. Landau (Eds.). *Acquisition of Mathematics Concepts and Processes*. New York, NY: Academic Press, Inc., p. 229.

[19] Vicich, J. (2002). *Mathematical Problem-Solving Behaviors of Undergraduate Developmental Algebra Students*. Unpublished doctoral dissertation, Arizona State University, Tempe, AZ.

[20] Carlson, M. (1997). Obstacles for College Algebra Students in Understanding Functions: What Do High-Performing Students Really Know? *AMATYC Review*, 19(1), pp. 48–59.

Schoenfeld, A.H. (1985). *Students' Beliefs about Mathematics and Their Effects on Mathematical Performance: A Questionnaire Analysis*. ERIC document ED259950.

Spangler, D. A. (1992). Assessing Students' Beliefs about Mathematics. *The Mathematics Educator*, 3(1), pp. 19–23.

Yusof, M. & Tall, D. (1999). Changing Attitudes to University Mathematics through Problem Solving. *Educational Studies in Mathematics*, 37, pp. 67–82.

[21] Schoenfeld, A. (1988). When Good Teaching Leads to Bad Results: The Disasters of "Well Taught" Mathematics Courses. *Educational Psychologist*, 23(2), pp. 145–166.

[22] Schoenfeld, A. (1987). *What's All the Fuss about Metacognition?* In A. H. Schoenfeld (Ed.), *Cognitive Science and Mathematics Education*. Hillsdale, NJ: Lawrence Erlbaum Associates, pp. 189–215.

De Corte, E. & Op't Eynde, P. (2003). *Students' Mathematics-Related Belief Systems: Design and Analysis of a Questionnaire*. Paper presented at the Annual Meeting of the American Educational Research Association, Chicago, IL, 2003. ERIC document ED475708.

[23] Fiore, G. (1999). Math-Abused Students: Are We Prepared to Teach Them? *Mathematics Teacher*, v. 92, pp. 403–406.

Arem, C. (2003). *Conquering Math Anxiety: A Self-Help Workbook*. Pacific Grove, CA: Brooks-Cole.

[24] Tobias, S. (1993). *Overcoming Math Anxiety: Revised and Expanded*. New York, NY: W. W. Norton & Co.

[25] Peskoff, F. (2001). Mathematics Anxiety and the Adult Student: An Analysis of Successful Coping Strategies. In Schmitt, M. J. & Safford-Ramus, K. (Eds.), *Adults Learning Mathematics—7: A Conversation Between Researchers and Practitioners*. Proceedings of ALM—7, July 6–8, 2000, at Tufts University, Cambridge, MA: National Center for the Study of Adult Learning and Literacy, Harvard Graduate School of Education.

[26] Peskoff (2001). Nolting (2002).

[27] Yackel, E. & Rasmussen, C. (2002). *Beliefs and Norms in the Mathematics Classroom*. In G. Leder, E. Pehkonen, & G. Toerner (Eds.), *Beliefs: A Hidden Variable in Mathematics Education*. Dordrecht, The Netherlands: Kluwer, pp. 313–330.

[28] Tinto, V. (1997). Classrooms as Communities: Exploring the Educational Character of Student Persistence. *The Journal of Higher Education*, 68(6), p. 619.