Improving Success in Developmental Mathematics: An Interview with Paul Nolting

By Hunter R. Boylan

Think of math as a foreign language:If you do not use it, you will lose it.

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Dr. Paul Nolting is a national expert in assessing individual math learning problems, developing effective student learning strategies, and assessing institutional variables that affect math success. Since his dissertation in 1986 on improving math success with study skills he has consulted with over 100 college, university, and high school campuses on math success. He has written journal articles; consulted on Quality Enhancement Plans; conducted live PBS and other broadcasts; presented at numerous national conferences; and written several texts, tutor manuals, handbooks, DVDs, and computer assessment programs to improve math success. His* Winning at Math *text won book of the year award from the National Association of Independent Publishers for best text of the association and is the only research-based math study skills text published in the U.S. He is employed at the State College of Florida in Bradenton, FL and has been an institutional test administrator, learning specialist, director of Title III Programs, Student Support Services director, and disability coordinator. He has also been a graduate school adjunct instructor at the University of South Florida and Florida Gulf Coast University. His life has been dedicated to improving the success of math students.

Hunter Boylan (H.B.): According to the National Center for Education Statistics (NCES, 2003), more college students place into developmental mathematics than any other subject area in developmental education. Why do you think so many incoming students place into developmental math?

Paul Nolting (P.N.): First, it is important to define developmental math. The levels of developmental math courses can be different, depending on the state, college, or university. Usually there are only two levels of developmental English and reading, but there could be four or even five levels of developmental math, making it more likely for students to be placed into developmental math. Placement test scores can also vary from college to college and state to state. This means that in one state or college a test score places students into a college-level course and in another college or state the same score would put them into a developmental course.

One reason that many students are placed into developmental math is that cut scores for college-level math may be higher than for college-level reading and English. For example if the ACT cut score to be placed into college level math is 20 and the ACT cut score to be placed into college-level English is 17 and reading is 18, then institutions would likely have more students in developmental math.

In addition, the amount of elapsed time since a student has taken their last math course has significant consequences on placement into college-level math courses. Think of math as a foreign language: If you do not use it, you will lose it. However, even after completing high school English or courses that required reading, students still use those skills in everyday life. In almost every case this is not true for math. The delay between taking the last math course and taking the placement test has a significant influence on math placement scores. This delay could be caused by taking the last math course in the junior year; also, returning students who have not taken math in many years will lose most of their algebra knowledge and some of their arithmetic skills due to calculators, cell phones, and other technology. For example, students are using calculators, math functions, and web accesses on their cell phones to solve arithmetic problems such as multiplication, calculating tips, and algebra problems by putting formulas into math solving web sites. Also, in many cases calculators have taken the place of memorizing math facts, resulting in decreased automaticity of generating math facts and solving problems with pencil and paper. However, during the ACCUPLACER and COMPASS placement tests used by many community colleges, students are not allowed to use calculators or cell phones to solve problems. Due to a loss of basic math facts, students may score poorly on the arithmetic portion of the test and be placed into arithmetic or prealgebra courses. Other students taking placement tests that allow calculators but are timed, may have reduced automaticity with the result that fewer problems are solved.

Many students are obtaining their GEDs and then attending college. Students can pass the GED by only having good arithmetic skills and having little or no algebra skills, which means almost all of these students could be taking developmental math.

In fact many high schools only require students to take Algebra I to graduate which, in almost every case, guarantees placement into a developmental math course. Even students taking Algebra II place into Elementary/Basic Algebra college courses. High school math grading systems can measure algebra skills, but they are also often a measure of effort and extra credit as an indicator of success, compared to the placement test which measures only pure algebra knowledge.

Anxiety could be another issue contributing to high developmental math placement rates because more students have reported test anxiety in math than English or reading. Students' test anxiety could also increase since the placement test is their first college test. Since anxiety can decrease test performance, these students may be placed into a developmental math course instead of a credit course.

There are various causes for students to be placed into developmental math (Latterell & Frauenholtz, 2007). However, one solution to decreasing the number of developmental math students is making sure that students are properly prepared to take math placement tests so they can be correctly placed and, if justified, have the opportunity to take credit math courses.

H.B.: The Community College Outreach Center (Bailey, Jeong, & Cho, 2010) reports that only a handful of those who place into the lower levels of developmental mathematics ever pass college-level algebra. Why do you think so many fail to complete developmental math?

P.K.: There are a variety of reasons for this including that the developmental math course sequence is long, the courses have high failure rates, students must master the algebra skills before moving on to the next level, the courses require abstract reasoning, students have anxiety which translates into avoiding math courses, students do not know how to study math, it is socially acceptable to fail math, students with personal problems usually withdraw from math first, and repeating students usually get the same type of instruction that originally led to their failure.

There are more predominate variables that affect mathematics success than in English, reading, and most other courses. First, college students could take up to three or four developmental math courses before entering a college-level math course. Mathematics courses at most institutions are considered the high enrollment and high risk courses with 50% pass rates being common. This means that only 12% of the students would get through a three-course sequence without failing one of the math courses. We also know that students who repeat algebra courses have less of a chance to pass it the second and third time (unless the curriculum and support is changed). Students then question their math ability, which lowers their persistence, and may develop learned helplessness. Students then do not persist due to their previous failures, don't repeat or take the next math course, or drop out of college entirely.

A second reason few students complete the developmental mathematics sequence is that it is extremely linear: earning a C in a current algebra course most likely translates to failing the next algebra course. Missing one concept in Chapter 2 can lead to not being successful in Chapter 3. Many students may never find out which skills they need to develop and, consequently, continue to make the same mistakes. Some of these students keep repeating the same algebra course three or four times because they never master the prerequisite algebra skills to be successful and do not finish the math sequence.

"How many times does a student fail a developmental math course before dropping out of college?"

Math phobia and math anxiety can also influence the completion of developmental math courses. Students who have phobias or anxiety may avoid retaking a math course they failed and never get to the next level math course. This delay in taking math courses can have a negative effect on course success. Also, some students may not pass the math course due to anxiety even though they actually know the material.

Procrastination may be more prevalent for developmental math students than other students. A procrastinating student waits too long to complete homework or waits until it is too late to get tutoring help. Procrastination is a defense mechanism so that, if students fail, they will not feel that bad because they can attribute failure to lack of effort. Procrastination in other courses may not have as severe consequence as in math.

Students with personal or work problems have told me that they are more likely to withdraw from math than their other courses. This may be because the students do not have math study skills to help support their learning.

Last, mathematics learning is based on abstract reasoning, and some students have difficulty in these areas, even students with over a 3.0 GPA. These students often do well in every course but math and, after repeating the developmental math course several times, they may drop out of college or transfer to another college. However, some of these students may actually be able to pass a liberal arts or statistics math course.

The math department alone cannot solve all the problems due to the numerous variables affecting math success. A college-wide math summit is needed to establish a team to address all the variables affecting math success. The real question is, "How many times does a student fail a developmental math course before dropping out of college, and what can colleges do about that?"

H.B.: At most colleges the only option for a student who fails developmental math is to retake the same course. What other strategies would you recommend for students who fail a developmental math course?

P.K.: This is true at both colleges and universities. The most common options are retaking the placement test to score out of the developmental math course or retaking the final exam. These alternatives bring up three questions: (a) Is the placement test a better predictor of knowledge than the previous math course grade, (b) is the final exam a good predictor of success, and (c) which students are most likely to score high enough on the placement test or final exam to take the next math course? At almost all the colleges/universities where we have worked, the placement test was a better predictor for math success than the previous algebra course grade. The final exam score may also be a better predictor of success than the course grade (Nolting, 1986). The third possibility is to work with students who were passing the course toward the end of the semester but did poorly on the last test and/or the final exam. Math learning specialists could diagnose academic and math study skills problems and help these students receive academic support through college tutoring, professional tutoring, web-based math programs, and TV math programs to learn their missing math skills along with math study skills. Students could use the opportunity between semesters to build up these skills and retake the placement test. Some other students may opt out of taking math for the next semester, get professional tutoring, and then take the placement test. Institutions could set up academic support programs, especially between the spring and fall semester, to help these students over the summer and enable them to succeed in a credit math course. However, if the student failed intermediate algebra for the first or second time it might be possible for these students to take a college-level math course, such as liberal arts or statistics, and be just as successful as the students who passed intermediate algebra (Waycaster, 2002). I would suggest that institutions conduct their own research in these areas to improve the success of developmental students.

H.B.: What specific, practical suggestions do you have for math instructors to help developmental math students be successful?

P.K.: Developmental math instructors can play a major role in math student success but, again, the math department itself cannot be held totally responsible for math student success. According to Bloom (1976), the variance contributing to math success is 50% for cognitive entry skill and intelligence, 25% for quality of instruction, and 25% for affective characteristics. Instructors can evaluate the predictive validity of the placement test, improve quality of instruction, teach students math study skills and test anxiety reduction techniques, as well as help students improve their math self-efficacy. Developmental students need a multimodality instructional approach which means integrating the lecture with manipultives, math study skills, and group work; learning math vocabulary words; using web-based support; tutoring students based on their learning style; giving frequent quizzes and practice tests; and inviting counselors into the class to discuss anxiety issues and provide a referral for personal problems.

Instructors can also use the strategies suggested in *Beyond Crossroads* (Blair, 2006). Articles from the *Journal of Developmental Education* and *The AMAYTC Review* can also be helpful. To teach students math study skills and anxiety reduction instructors can review *Winning at Math* (Nolting, 2008b) and the *Math Study Skills Workbook* (Nolting, 2008a). Instructors who know their students' math background, math study skills level, and learning styles are in a better position to help students succeed in mathematics. Instructors who want to change instructional strategies need to be given the flexibility and support by the math chair to discover the best learning strategies for their students.

H.B.: Some faculty believe that developmental students who do not do well in mathematics have learning disabilities. What suggestions do you have for identifying or working with such students?

P.K.: In my 25 years of consulting with math departments this comment has always come up. It is true that some developmental math students have learning disabilities (LD; Nolting, 2000). Also students may be ADHD (Attention Deficit Hyperactivity Disorder) or have traumatic brain injuries (TBI). However, these problems are not encountered in the majority of the students who are failing their math courses. Nonetheless, besides conducting testing for LD, ADHD, or TBIs, faculty should be aware of characteristics that students with learning disabilities may exhibit, such as: notes that look like "chicken scratches," reversal of letters or numbers, mixing up symbols, responding correctly in class to questions but failing the tests, or asking you to repeat steps (when it appears they are paying attention). Also, students who can work a problem correctly one day but totally forget how to work it the next day or cannot perform abstract reasoning problems may have learning disabilities (Nolting, 2000).

A little anxiety can motivate learning and improve test scores.

To enhance students with LD's opportunities for success, it's important to know students' processing deficits in order to better instruct/tutor them and provide appropriate classroom and testing accommodations. Based on their processing deficits, students will have difficulty in one or more of these areas: auditory processing, processing speed (visual), short-term memory (auditory), visual-spatial thinking, long-term retrieval, working memory, comprehension-knowledge (long-term memory), or fluid reasoning (abstract). Fluid reasoning is the processing deficit that causes the most math learning problems and is the most difficult to accommodate. Instruction to address processing deficits should include multimodality strategies, manipulatives, math study skills, and reductions of test anxiety along with appropriate accommodations. The best student success results can be obtained by a collaborative effort among the campus office for students with disabilities, the learning resource center, and the math department. However, in some rare cases students with LD or TBIs may not have the cognitive skills to pass algebra courses even though they have average to above average intelligence and have good GPAs. This is becoming more apparent with the veterans returning from Afghanistan and Iraq with TBIs and posttraumatic stress disorders (PTSD; Church, 2009; Grossman, 2009). Still, these students may be able to pass a Liberal Arts or Statistics math course.

H.B.: Where does math anxiety fit into all of this?

P.K.: Math anxiety and math test anxiety fall right in the middle of developmental mathematics. Math anxiety and math test anxiety are real and cause major problems for many students. However, the concept of math anxiety is relatively new in the education field, with research beginning in the early 1970s (Richardson & Suinn, 1973) when researchers coined the phrase "matheophobia" and indicated that this phobia causes childrens' unwillingness to learn math. Then Shelia Tobias (1978) came along with her research on women and math and indicated that math anxiety is a state of panic, helplessness, paralysis, and mental disorientation that occurs when trying to solve math problems. The focus then shifted from math anxiety being a skill deficiency to it being a state of mind. Tobias and Weissbrod (1980) continue the research on math anxiety and indicate that teaching students relaxation techniques, self-awareness, and good study skills has decreased math text anxiety and improved academic performance.

Today we know that math anxiety is a fear of math which may include a fear or procrastination in doing homework or even going to class. Math test anxiety consists of emotionality (somatic response) and worry (cognitive response) during a test. These reflect how students feel and what they are telling themselves during a test. Students with high test anxiety have both emotionality (rapid heart rate, sweaty palms, shallow breathing) and worry (telling themselves that they will fail). More recent research has pinpointed the effects of anxiety on learning and testing. This effect can be explained by reviewing the Stages of Memory: Sensory Input, Short-term Memory, Working Memory, Long-term Memory, Abstract Reasoning, and Memory Output. Anxiety decreases Working Memory, and anxiety limits information going into and coming out of Long-term Memory and Abstract Reasoning. Thus it can affect math learning in a classroom, on homework, and when taking tests. Although a little anxiety can motivate learning and improve test scores, too much anxiety decreases learning and recall during tests (Nolting, 2008a, 2008b).

Another interesting concept about test anxiety is that many students complain about not having enough time for their math tests even

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though almost all the students have left during the last 5 to 10 minutes of the testing period. I have asked thousands of students the reasons for leaving early and the two major reasons are: "The test anxiety became so high that I could not stay in the room any longer," and" I noticed all the students leaving ahead of me and decided that I would not be the last student or next to last student to turn in my test because that means I am dumb and stupid."

Instructors, tutors, and learning lab assistants can help students reduce their anxiety by recognizing that anxiety is real (Shields, 2007), having counselors and guest speakers on this subject, teaching the students short- and long-term relaxation techniques (Bitner, Austin, & Wadlington, 1994; Nolting, 1987, 2007, 2008b), teaching students test-taking procedures (Nolting, 2007), giving practice tests, sponsoring anxiety workshops, having students take the test in a separate room with the same amount of time, and referring students with high test anxiety to counselors and the disability resource office. Although test anxiety alone does not constitute a disability at this time, having a general anxiety syndrome may be a disability.

H.B.: Do you believe that the assessment instruments used to place students into developmental courses are appropriate?

P.K.: First, colleges must have mandatory assessment and mandatory placement policies for all developmental courses and all students (Boylan, 2002; McCabe, 2003). However, I believe that the assessment instruments can be improved to better predict math success. This can be done with at least four different strategies. As I noted earlier, student achievement can be predicted from three different areas: cognitive entry skills (50%), quality of instruction (25%), and affective student characteristics (25%; Bloom, 1976). Thus, the best predictive model should include all three areas. However, most colleges only focus on cognitive entry skills by using cognitive skills placement tests such as the SAT, ACT, ACCUPLACER, and COMPASS. Assessing student affective characteristics such as self-efficacy (House, 1995; Nolting, 2006; Rodriguez, 2002), motivation, anxiety, math study skills, learning styles, and others (Boylan, 2008, 2009; Hill, 2004; Levine-Brown, Saxon, & Boylan, 2008; McCabe, 2003; Saxon, Levine-Brown, & Boylan, 2008) should also be included for placement. Assessing learning styles and matching them with teaching styles (Higbee, Lundell, & Arendale, 2005) could impact quality of instruction. Based on these variables, the following strategies are suggested. The first strategy would be to give students a second math cognitive skills measurement test the first or second day of class because their placement test scores or last math course could be several years ago. Math success is based on current math knowledge. Based on the scores students may be able to move up a course level or move down a course level. Even if policies prohibit such movement, it will give the students and instructors immediate feedback on math readiness. That way students can seek help earlier or the instructor can immediately refer students for help instead of waiting for their first exam score.

The second strategy is to have students take a diagnostic cognitive math test. This test would indicate which math skills need to be improved; the student could then be referred to web-based programs or specific tutoring. The best time to conduct this assessment and treatment is prior to the beginning of the semester. In some cases the first and second strategy could be combined.

The third strategy is to include affective assessments as part of the placement process and also take into account the length of time since a student's last algebra course (Miami Dade College, 2004). Measuring affective characteristics is important because study skills, anxiety, and locus of control have a significant effect on math success (Nolting, 1986). Colleges need to conduct research using different affective assessments (Saxon et al., 2008) to discover which ones provide the best prediction for success.

We do not want adult learners engulfed in a digital divide.

The fourth strategy is to assess the students' learning styles and the instructor's teaching styles to find the best match. Based on learning styles research, about two-thirds of the math instructors teach to about one-third of the students' preferred learning styles (Nolting & Nolting, 2008) leading to a mismatch. Challenges to this strategy include scheduling problems and the fact that math instructors often have similar teaching styles that may not match with the developmental math students.

Using multiple predictors can allow students to be more accurately placed and may decrease the amount of time students are in developmental math courses. This may lead to a higher graduation rate.

H.B.: Do you think that existing texts, software programs, and other developmental mathematical resources are appropriate for adult developmental students?

P.K.: Texts, software programs and materials have been improving. Mathematics assistance can now be a 24/7 learning experience, although some of the sources of assistance work best for visual learners. However, in my experience many adult learners are kinesthetic (hands on learners), auditory, or group learners. These students exert more control over learning math than they did in high school by attending lectures, reading the text, taking notes, completing text-based homework, meeting with a tutor, or meeting in groups to discuss their homework. It is difficult enough for many adult students to learn mathematics let alone change their learning styles to access technology-based math information and materials. These students also have difficulty locating and managing support resources and may become frustrated trying to use the new technology.

There is a movement to eliminate math text books, due to their high cost, and use web-based materials instead. The assumption is that students will have equivalent learning experiences and the same pass rates without printed texts. This may be an erroneous assumption for adult learners. Eliminating math text books for developmental students may be more cost effective than paying for texts but repeating the math course is more costly. Publishers need to continue their technology-based upgrades but also need to focus on the adult learners' needs by integrating group work, manipulatives, math study skills, test anxiety reduction strategies, learning management programs, and self-efficacy support as they are adapting to the new learning technology. We do not want adult learners engulfed in a digital divide. Adult learners may first need to become successful math learners and then adapt to the new learning technology. In fact, all learners need to be taught using various strategies to improve math success (Blair, 2006; Higbee, Lundell, & Arendale, 2005; Muro & Terry, 2007; Zavarella & Ignash, 2009).

H.B.: The current developmental mathematics curriculum at most institutions includes a combination of arithmetic and introductory and intermediate algebra, thus preparing students to become successful in college algebra. Does this prepare students appropriately for 21st century careers?

P.K.: There are two main movements in the math world that address this question. One movement supports reducing the number of developmental math courses to improve the course success rates. This movement could result in reducing the number of levels in the developmental math course sequence prior to specific credit

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math courses. It could also result in higher math course pass rates. The other movement supports students taking higher levels of mathematics in preparation for the expanding need of math-dependent careers in science, engineering, and computers.

Mathematicians are also asking themselves two curriculum questions: What are the real prerequisite course requirements for noncollege algebra courses that meet graduation requirements? And, what prerequisite arithmetic/algebra skills are essential to be successful in the next algebra course? Essentially, the traditional course sequence should match the real math needs of students' majors. For example, there is a high demand for nurses but many colleges and universities require college algebra as an entrance requirement for nursing programs. However, most college algebra skills are not necessary for nursing, and a statistics course would be more appropriate. Are all prequisite algebra skills—such as dividing polynomials—essential for the next algebra course? Now may be the best time to focus on consistency pertaining to necessary prerequisite developmental algebra courses and algebra skills: The Carnegie Foundation, American Association of Two Year Colleges, National Developmental Education Association along with Achieving the Dream and other mathematics organizations are now focusing on these issues.

Uri Treisman (Achieving the Dream) points out that one goal of the organizations' meetings is to identify new course ways without watering down the curriculum. President of NADE, Marcella Davis, has stated,

> NADE leaders and practitioners have long realized the truth of research data which show that mathematics is the academic area of most difficulty for the greatest percentage of underprepared postsecondary students. These practitioners also support study skills courses which deal with student motivation, math anxiety, and methods of math study. NADE welcomes collaboration with and offers support of innovative mathematics initiatives. (M. Davis, personal communication, March 15, 2011)

With this collaborative effort and the information strategies from articles in this journal the future is the brightest ever to improve the success of developmental math students.

H.B.: Can you tell us a bit about your own research and its implications for teaching developmental students?

P.K.: I have been conducting math research—with my wife, Kimberly Nolting, and colleagues Dr. Craig Hardesty and Bill Thomas—for the last 25 years. The research has been conducted at my college, other college and university math departments, and as part of college QEP development. Even though each college is different some common themes have emerged which can help institutions improve math success.

1. Institutions need to conduct a correlation analysis to determine if the placement test scores are significant.
2. Institutions need to make sure their cut scores are predicting success not failure.
3. Students placed into a math course for the first time have a higher pass rate than students who successfully completed the previous algebra course and are taking the next algebra course for the first time. If this is true at your institution, you may have a curriculum gap or a high number of students who had Cs in the last algebra course.
4. A final grade of C or lower in an algebra course usually means the student will not succeed in the next algebra course. 5. The amount of time elapsed since the last algebra course is related to math course success.

Math success is an institutional responsibility.

6. Students taking the lowest level math course who score in about the bottom 25% on the placement test usually don't pass the course. Other instructional strategies should be offered to these students.
7. Raising the placement cut score for intermediate algebra can improve math success.
8. The algebra skills in intermediate algebra are not prerequisite skills needed for liberal arts math or elementary statistics.
9. Teaching students math study skills does improve their math success (Nolting, 1986; Tobias & Weissbrod, 1980).
10. The more times students take the same algebra courses the less likely they are to pass it. Institutions need to develop sections especially for repeating students and students with disabilities.

These are some of themes from our research that have been discussed in more detail in the interview. I would advise colleges to collect their own data and implement strategies that best match the college's strengths in order to improve student success. Math success is an institutional responsibility that needs to be addressed by the college's president and other administrative officers in order to induce institutional change that will not only help developmental math students but all students.

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