Developments

Reflections on Developmental Mathematics—Building New Pathways

By Rose Asera

Overview of Projects

Developmental education is a pedagogical challenge, especially since students are grappling with academic material they have seen before (some recently). Perhaps they had mastered this material and forgotten it or not mastered it the first time around. Sometimes those earlier educational experiences left faint traces or even scars. We were excited to work in this area because developmental education is a place where the quality of teaching really matters.

Starting in 2005, we designed an action research project, Strengthening Pre-collegiate Education in Community Colleges (SPECC; Carnegie Foundation for the Advancement of Teaching, 2011). We invited 11 California community colleges to join us in this endeavor. These campuses already had some developmental programmatic interventions in place. As part of SPECC, colleges could expand and enhance their current developmental efforts and also work with us to study the effects of those efforts. In addition, we fostered a sense of community among the participating colleges and made opportunities for them to learn from each other's experiences so that ideas and models had the chance to move and grow. In terms of knowledge building, the project had 11 locally-shaped laboratories actively working on all aspects of developmental education.

Not surprisingly, the SPECC campuses offered the range of the intervention programs that are common across community colleges: different configurations of learning communities; first-year experiences; various uses of technology in both mathematics and English classrooms; as well as use of tutors and instructional aides in the classroom, in scheduled study sessions, and in labs. Many of these interventions were small programs, nurtured by the faculty and staff responsible for them.

It is a challenge to sum up the outcomes of 3 years in one or two paragraphs. We certainly gained more insight into the nature of the problems in developmental education, from the broad policy and systemic barriers to the students' protective behaviors. In terms of student outcomes, there was a general moderate positive trend across the campuses, with a few highly visible successes. A strength of the action research design—the local variability—became more of a liability in measuring outcomes. It was hard to know across sites if the nature of the intervention was the same–a learning community in one setting is not the same as a learning community in another—or if the measurement of learning was similar across sites.

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As is commonly the case, we also had unexpected and less measurable outcomes. Although SPECC was not framed as a leadership project, the very nature of the design and opportunities afforded let some faculty develop as leaders on their campuses, and some grew into leadership roles in the state. A second serendipitous outcome was the critical mass of experiences that gave faculty inquiry an identity as a recognized form of professional development. We introduced Carnegie's signature work in the Scholarship of Teaching and Learning and the faculty ran with the idea. Faculty translated the concept of examining teaching practice and student learning to the community college setting. In contrast to many Scholarship of Teaching and Learning studies which are conducted individually, faculty organized the work collaboratively as Faculty Inquiry Groups (FIGS), reflecting the culture of community colleges. In those FIGS, faculty shaped questions about student learning and gathered a wide range of evidence—campus data, examples of student work, student interviews and focus groups, and "think-alouds"—to answer those questions. Their findings came back to the classroom as content, pedagogy, and assessments, all of which were subjects for further inquiry.

Developmental Mathematics

We were lucky that there were no blazing failures but saddened by the quiet disappointments. Among the disappointments were the high failure rate of students in developmental mathematics and the realization of how hard it is to change that rate. There were some modest successes in improving student performance, but they could only chip away at the magnitude of the problem. Technology in the classroom was useful, but had moderate effects, as was generally true of tutoring. Common assignments and assessments proved to be a powerful tool for building a more coherent developmental mathematics program but did not have a direct effect on student outcomes. The models that were more effective were immersive and intensive—for example, summer learning communities or programs in which students were enrolled simultaneously in two sequential mathematics courses taught as a single course—were coincidentally expensive not only in resources and time, but also in human capital. For all those reasons, those models were hard to scale.

At the same time that SPECC was ending, there was a change at the Carnegie Foundation. A new president, Tony Bryk, brought a vision of educational research that brings together researchers, practitioners, curriculum developers, and commercial designers. The overall intent was to have a research infrastructure, knitted together by data and evidence of learning, making it possible to aggregate and build on research findings. In addition, the entire endeavor has been built to support the ongoing development and improvement of practice and to be able to go to scale. Looking for the first problem to address, Bryk recognized that working on developmental mathematics in community colleges could affect many students' lives.

The Carnegie Foundation is not alone in choosing developmental mathematics. Many others across the country have come to a similar conclusion: It is a core community college challenge. Data from Achieving the Dream (2011), both local campus data and a study of the program-wide database by Tom Bailey and colleagues at CCRC (Community College Research Center), clearly identify developmental education, and particularly mathematics as a major barrier. Initiatives in the field include Achieving the Dream Developmental Education Initiative (Achieving the Dream & MDC, 2009), National Center for Academic Transformation (2005)

Changing the Equation, the California State Basic Skills Initiative (2009), and Global Skills for College Completion (2011), to name a few. These programs have different approaches, varying theories of action, and different starting points. The challenges are great enough and the field big enough that it can benefit from this diversity of approaches.

Developmental Mathematics Sequence

The typical developmental mathematics sequence, which retraces the K-12 curricular pathway from arithmetic through algebra, is designed to lead students to calculus. All students, regardless of educational intentions go through the same developmental sequence, although some programs let students move through at their own pace. The CCRC studies (Bailey, Jeong, & Cho, 2008) reframed the question by analyzing data about completion across the developmental sequence as a whole, rather than studying success rates in a particular course. The studies pointed out the low percentage of students who complete the sequence (overall 31% of students who start anywhere in development mathematics) and the somewhat counterintuitive finding that more students are lost before initial enrollment and between courses than from courses. The very length of the sequence is problematic because the longer the sequence, the more chances there are—in every course and between courses—for students to leave.

The SPECC approach is to map new pathways through the developmental mathematics landscape in ways that move students directly towards their educational and career goals. Certainly one core pathway would still lead to, and possibly accelerate, progress towards calculus and STEM (Science, Technology, Engineering, and Mathematics) fields. What if, there were also pathways for students pursuing careers in allied health or public safety, or planning to transfer and major in humanities or social sciences? Introductory statistics seems to be a useful goal for these students. An increasing number of fields require statistics; one estimate is that statistics is now the quantitative requirement for 40% of undergraduate majors (Schield, 2008). Could there also be pathways that would move more directly to statistics or another transfer-level mathematics course that fulfills the quantitative reasoning requirement?

Mathway/Statway

In response to this question The Carnegie Foundation, working in collaboration with the Charles A. Dana Center at the University of Texas at Austin and the American Mathematical Association of Two-Year Colleges (AMATYC), will design and build two initial pathways. Small tweaks to the existing system will not be enough to construct these pathways: It is time to reconsider every dimension, including content, instruction, structure and class organization, assessment, and policy.

The Mathway will start with a 1-semester experience of integrated problem solving and critical thinking called Mathematical Literacy for College Students (MLCS) that focuses on numeracy, equations and functions, proportional reasoning, and probability and statistics. Successful completion of the Mathway will include MLCS in the first semester plus a transfer-level quantitative reasoning course, mathematics for liberal arts, or non-STEM college algebra course. The Statway will be an integrated pathway from developmental mathematics (starting with students who place into elementary algebra) to and through college-level statistics in 1 year. Drawing on the power of learning in context, the arithmetic and algebra needed for statistics will be taught and applied in the service of learning statistics. Content and examples within these pathways could be locally customized so that students with common career goals could learn the mathematics and solve the types of problems they will see in their future work.

> *More students are lost before initial enrollment and between courses than from courses.*

There are also potential risks in creating alternate pathways through developmental mathematics. Of great concern is a danger of "tracking" students too early, particularly because when students enter college their goals may not be clear, or their goals may change as they learn about new possibilities. Three components of the project design are intended to avoid the pitfall of creating a limiting pathway.

The first is mathematical rigor: the content of the curriculum needs to be defined by rigor of mathematical and statistical reasoning. Thus we began by bringing together a group of university and community college faculty who are active in the national mathematical and statistical professional associations to generate the learning outcomes, building on the established work in the field, including documents such as *Guidelines for Assessment and Instruction in Statistics Education* (ASA, 2011) and *Beyond Crossroads* (AMATYC, 2006). The Statway outcomes will be reviewed by relevant professional associations: the American Mathematical Society, the American Statistical Society, the American Mathematical Association of Two-Year Colleges, Consortium for the Advancement of Undergraduate Statistics, the Mathematical Association of America, the National Association for Developmental Education, and the National Council of Teachers of Mathematics. Professional review not only ensures quality but is also valuable in seeking to establish transfer agreements between community colleges and four-year institutions.

The second strategy is to create bridges between pathways. Of course, many students are not sure about their directions when they enter college; part of the educational experience should be to try on and explore possible majors and careers. The field needs both new pathways and portals that give students a chance to explore different destinations. If students decide to change directions, there should be bridges between the pathways. It may well be that students who successfully complete the Statway find—perhaps surprisingly—that they like the challenges of quantitative reasoning and want to do more. With new-found confidence, such students could take a bridge course that brings them into the pre-calculus sequence and towards a STEM major.

The third antidote to the threat of a compromised pathway is a relentless focus on data and evidence of student learning. Initially, analysis of campus data would trace patterns of student flow into and out of the developmental sequence to see when students leave, who completes the sequence, and what transfer-level mathematics class completers take. In other words, data will help the campus identify the pool of students that these pathways could serve.

The major use of data will be to focus on evidence of student learning in order to inform instruction. The bottom line is increased student success and progress, but the currency is evidence of student learning. To clearly demonstrate learning, faculty need to depend on an agreed set of outcomes, common measures, and common assessment instruments. These outcomes and assessments have been shaped by mathematical rigor and created during a year-long design process with faculty and researchers. A strong resource will be the experience with the Comprehensive Assessment of Outcomes in a First Statistics course (CAOS; Web Artist, 2006) test, which has been used voluntarily and provides comparison with normative data from a multistate undergraduate sample. Over time, comparative analysis of data across sites could contribute to the ongoing improvement of the pathways content and assessments.

As vital as evidence is, it can also become an obstacle. The field of education has made great strides towards looking to research and evidence to validate work. Increasingly, when ideas arise now, educators will ask, "What is the evidence base for this?" The field is gradually moving toward a greater reliance on research and evidence. But it's important to recognize that this view has limitations as well. Can an over-reliance on existing research—or on a particular kind of research—paint us into a corner? The need for evidence should not preclude the ability to innovate. These pathways, for example, are based on a new hypothesis, rooted in a combination of research, experience, observation, and possibilities. It's impossible to have data about the effects before trying it. We need the space to systematically test a thought-out hypothesis and generate real data.

Making the change from the current configuration of developmental mathematics to a landscape shaped by a number of well-marked pathways will not be particularly easy. The new pathways are disruptive in many ways: they cut across boundaries of content, structure, and policy. But change is never easy. There are, in fact, good reasons to move carefully when making changes, and due diligence should be applied to all innovation.

We will build new pathways with a central focus on students and conscientious attention to evidence of learning. More importantly, pathways are not built in isolation. Pathways implementation starts with a small number of colleges working intensely to codevelop the instructional materials, and the materials will continually be refined based on use, data, and feedback.

Conclusion

The Statway and the Mathway are not THE answer for developmental mathematics, although each may be an answer for the right group of students in the right setting. More than that, we believe that proposing new pathways asks the right questions: Can we design pathways that support student success in mathematics that are directly connected to their educational and career goals?

References

Achieving the Dream, Inc. (2011). *How we work.* Silver Spring, MD: Author. Retrieved from http://www.achievingthedream.org

Achieving the Dream, Inc., & MDC. (2009). *Developmental Education Initiative: Accelerating achievement*. Retrieved from http://www.deionline.org/

AMATYC. (2006). *Beyond crossroads. Implementing mathematics standards in the first two years of college*. Memphis, TN: AMATYC, Southwest Texas Community College.

ASA. (2011). *GAISE reports*. Alexandria, VA: Author. Retrieved from http://www.amstat.org/education/gaise/

Bailey, T., Jeong, D., & Cho, S. (2008). *Referral, enrollment, and completion in developmental education sequences in community colleges* (CCRC Working Paper No. 15). New York, NY: Community College Research Center, Teachers College, Columbia University.

Basic Skills Initiative. (2009). *Are your students prepared?* Sacramento, CA: Academic Senate

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College Students' Perceptions of the Impact of Developmental Courses on Their Academic Performance and Persistence

By Lucille A. Green

An extensive amount of faculty time and institutional financial resources have been committed to the formulation and delivery of developmental courses at the college level. According to research by the National Center for Education Statistics (2003), a large number of college students are underprepared for college-level coursework and are required to take at least one or more developmental courses. Although the design and delivery of developmental courses has been documented, limited research has been done to assess the perceived academic benefit of these courses – especially from the perspective of the student. Therefore, this research was designed to fill this void. This report examines the perceptions of college students about the impact of required developmental courses on their academic performance and persistence in college.

Rao (2005) noted that faculty members teaching college-level courses lament the fact that many students are not able to read and understand the required course materials, which can lead to failure of classes. Boylan and Saxon (1999) asserted that the vast majority of first-time college freshmen are administered prescribed placement tests in reading, writing, and mathematics, yet there is no mechanism in place that requires students to complete the sequence of remedial courses. Bettinger (2009) stated that many students who do choose to complete the remedial sequence may continue to struggle in college-level courses. Bailey, Jeong, and Cho (2010) showed that many students who failed to complete their developmental sequence did so because they never enrolled in a developmental course to begin with.

The need for remedial or developmental coursework is not new. In the 1700s, entrance requirements at some well-known institutions were based on students' knowledge of foreign language and their moral character. However, these early colleges found very few applicants academically qualified to enter college and, as a result, initiated remedial coursework for underprepared students in order to increase enrollment enough to keep their doors open. It was during the early nineteenth century that many colleges admitted the sons of wealthy alumni regardless of their level of preparation. They also began admitting economically disadvantaged but academically bright students on scholarships to boost enrollment numbers (Stephens, 2001).

Meanwhile, by the mid-nineteenth century, entrance requirements had been elevated substantially. An example was the change in requirements in mathematics at Yale between 1720 and 1835. In 1720, arithmetic was not required for admittance and Euclidean geometry was a senior-level course. However, by 1743 geometry was a sophomore-level course. In 1825 it became a freshmen course and by 1845, it was an entrance requirement along with algebra (Stephens, 2001). These increases in the rigor of college curricula and the number of students arriving without the necessary preparation led to the creation of preparatory departments within colleges. The most noted of these was the University of Wisconsin during the period of 1849 to 1880 (Stephens, 2001).

The Morrill Act, and opportunities for the education of women, later increased access to higher education but also heightened the number of underprepared college students. By 1892, the concern over underprepared students entering college sparked a report by the Committee of Ten, commissioned by the National Education Association, to call for the strengthening of secondary schools and to allow only fully prepared students to apply to college. However, by 1907 students applying to Yale, Princeton, and Columbia were still not prepared to meet the entrance requirements (Stephens, 2001).

In recent times, research has indicated that with so many students participating in developmental coursework, adequate performance and retention through the college-level is a major concern. However, disparities exist with regard to underpreparedness across subject areas and skill levels. For example, students needing remediation in writing or intermediate algebra were more successful at attaining college-level success than those needing remediation in other subject areas and levels. When students need developmental coursework in reading, basic mathematics, or a combination of subjects, their risk of failing to achieve their academic goals increases significantly. Statistics have shown that one in eight students needs remediation in reading. Of those students, 65% need remedial courses in at least three additional areas, including mathematics (Adelman, 1998). Fifty-five percent of students who needed no remedial coursework, and 47% of students who needed only one remedial course, persisted to complete their degree. However, only 24% of students who needed three or more remedial courses completed their degree. Given these statistics, students who understand and believe in the purpose of developmental courses and the benefits they may provide may be more highly motivated to proceed with and excel in them.

Research Questions

The following questions were used to guide this research:

1. To what extent do students believe that participating in developmental courses enhances their academic performance in subsequent courses at the college level?
2. To what extent do students believe that participating in developmental courses enhances their persistence to remain in college until graduation?
3. To what extent do students believe that participating in

for California Community Colleges. Retrieved from http://www.cccbsi.org/

Carnegie Foundation for the Advancement of Teaching. (2011). *Undergraduate education: Strengthening pre-collegiate education in community colleges* (SPECC). Retrieved from http://www.carnegiefoundation.org/previous-work/undergraduate-education

Global Skills for College Completion. (2011). *Pedagogy matters*. Retrieved from http://www.globalskillscc.org/

National Center for Academic Transformation. (2011). *Changing the equation: Redesigning developmental math*. Saratoga Springs, NY: Author. Retrieved from http://www.thencat.org/Mathematics/CTE/CTE.htm

Schield, M. (2008). Quantitative literacy and school mathematics: Percentages and fractions. In B. Madison & L. Steen (Eds.), *Calculation versus context: Quantitative literacy and its implications for teacher education* (pp. 87–107). Washington, DC: Mathematical Association of America.

Web Artist. (2006). *The CAOS test*. Minneapolis, MN: Regents of the University of Minnesota. Retrieved from https://app.gen.umn.edu/artist/caos.html

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