PATHWAYS TO IMPROVEMENT

USING PSYCHOLOGICAL STRATEGIES TO HELP COLLEGE STUDENTS MASTER DEVELOPMENTAL MATH

BY ELENA SILVA AND TAYLOR WHITE

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for the Advancement of Teaching

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MICHELLE BROCK'S CLASSROOM is small and unassuming, one of more than a hundred in the dozen brick buildings that make up Sacramento's largest two-year college, American River College. If she weren't standing in front of the class, it would be difficult to distinguish Brock from many of her 28 students who, like their community college peers nationally, come from many walks and stages of life, some straight out of high school with their futures ahead of them, others well into their work lives and seeking new opportunities.

Some 60 percent of the nation's 13 million community college students are unprepared for college-level courses and must enroll in at least one developmental course…[and] less than a quarter of students in developmental math courses earn a degree or credential within eight years.

FOUR DAYS A WEEK, they gather in this windowless room, its walls interrupted only by two whiteboards and a single bulletin board tacked with a diagram of math prerequisites and course options. The diagram is daunting, a dozen boxes connected by a web of lines and arrows that tell the tale of how an American River student might make it from the non-credit courses of basic arithmetic, through algebra, and on to a college-level mathematics course. This is what brings this class of students together: the hope that they can successfully navigate their way to and through college math.

They're not alone. Some 60 percent of the nation's 13 million community college students, one of the largest and fastest growing populations in higher education, are unprepared for college-level courses and must enroll in at least one developmental course.[1] Faced with a long sequence of pre-college-level, non-credit courses, often repeating math material they've failed before, half of them quit within the first few weeks of enrolling in the courses.[2] They quit because they believe they aren't smart enough to do math, that the class itself has little relevance to their personal or academic goals, and that they don't really belong in the course or in college at all.

And because such students cannot get to graduation if they cannot get past mathematics, the result is not just a dropped class, but the end of college and the economic insecurity that often results from not earning a degree. Nationally, less than a quarter of students in developmental mathematics courses earn a degree or credential within eight years.[3]

But Brock's class is different and promises different results. It is part of a nationwide initiative of 28 community colleges exploring a new

The [Carnegie Pathways] are designed to challenge certain beliefs that many developmental math students share: that they are not "math people," that "people like me don't belong here," and that the class is really not about or for them.

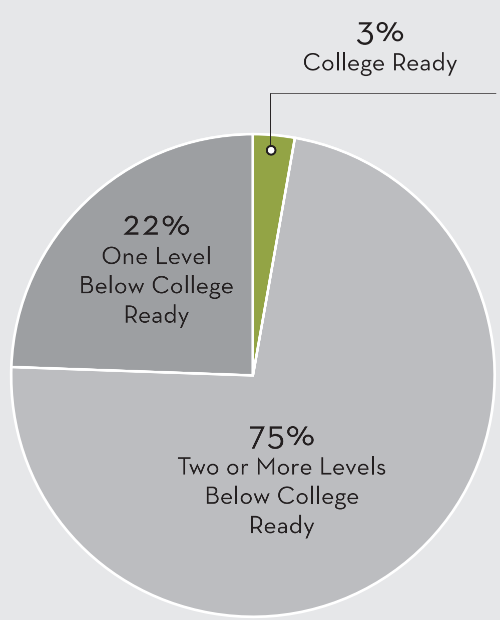
model of developmental mathematics instruction.[4] Developed by the Carnegie Foundation for the Advancement of Teaching with assistance from the Charles A. Dana Center at the University of Texas–Austin, the initiative includes two distinct course pathways, a statistics pathway and a quantitative reasoning pathway, that serve as alternatives to the typical multi-course sequence of developmental mathematics. The Pathways, called Statway™ and Quantway™, are yearlong academic courses that earn students college credit, with fewer students dropping out, most earning college credit toward graduation, and some even discovering a predilection for mathematics.

To be sure, the Pathways effort is not the only one to address the developmental math crisis, a problem estimated to cost the nation billions of dollars in lost earning potential.[5] At Jackson Community College in Tennessee, for example, students enroll in SMART math, a program organized around discrete mastery-based developmental math modules designed in partnership with the National Center for Academic Transformation. And at the Community College of Denver, students can enroll in a FastStart program and accelerate through two semesters of remediation in just one. Across the country, there are dozens more initiatives designed to revamp how and how quickly students complete developmental requirements.

But Carnegie's Pathways are unique in several ways. They integrate developmental and college-level math into the curriculum. Faculty encourage students to make explicit connections between higher math concepts and their understanding of the world around them. And the organization of teaching and learning is different too, with students tackling real-world problems and instructors focused not just on teaching mathematics, but also on teaching these students how to become successful learners.

Importantly, Carnegie's Pathways model addresses not just the structural and curricular problems of traditional developmental math

READY OR NOT
PATHWAYS STUDENT READINESS IN MATH AT ENROLLMENT

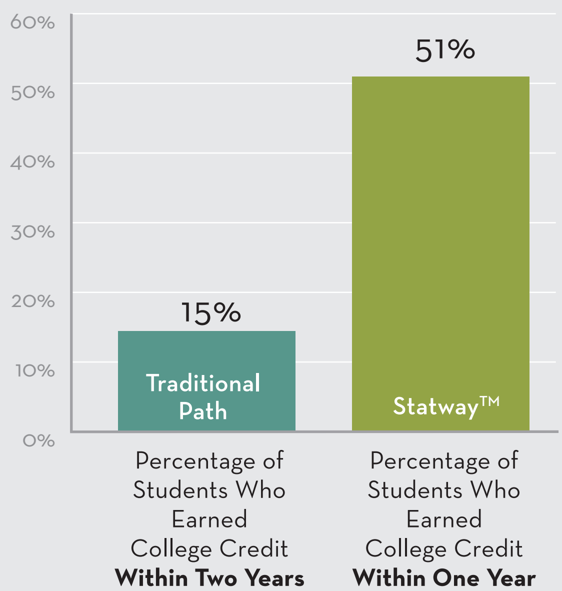


SOURCE: Strother et al., 2013

courses, but also the substantial socio-emotional and psychological hurdles many students face. The courses are designed to challenge certain beliefs that many developmental math students share: that they are not "math people," that "people like me don't belong here," and that the class is

TRIPLE THE SUCCESS IN HALF THE TIME

COMPLETION RATES WITHIN STATWAY™ INSTITUTIONS



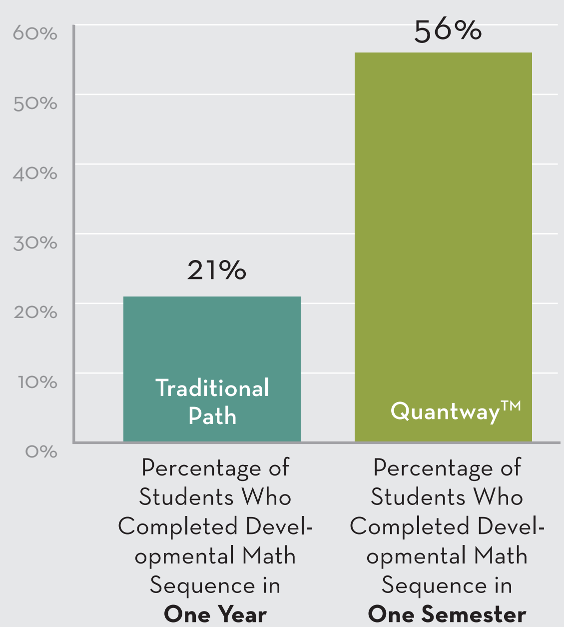
SOURCE: Strother et al., 2013

not about or for them. Drawing on a research base developed over many years in education, Carnegie is testing a set of strategies to help students—especially the traditionally underserved students in the Pathways courses—persevere and succeed academically. This kind of persistence, what the researchers and faculty who developed the Pathways call "productive persistence," is a key driver of Quantway and Statway.[6] Broadly defined, productive persistence is the package of skills and tenacity that students need to succeed in an academic setting.

Carnegie's aim is ambitious: Among the Foundation's network of colleges, only 6 percent of developmental mathematics students have traditionally been able to earn college math credit within a year of continuous enrollment.[7] Carnegie set out to raise that rate to 50 percent, even knowing that the vast majority of Pathways students would begin the class two or more levels below college-level math. Statway met this goal in the program's first year, when 51 percent of 1,077 students entering the course in fall 2011 successfully completed the sequence,[8] earning college credit in just one year.[9] Quantway

PROMISING PERFORMANCE

COMPLETION RATES WITHIN QUANTWAY™ INSTITUTIONS



SOURCE: Strother et al., 2013

students, who have only completed one semester of the two-semester sequence (due to Quantway's later launch date), have been similarly successful, with 56 percent fulfilling their developmental math requirement in just one semester. In contrast, only 21 percent of students in other developmental math options available on those campuses completed their requirements, and it took them twice as long to do so.[10]

PATHWAYS TO IMPROVEMENT

Despite its early signs of success, Carnegie's Pathways model is still a work in progress, and deliberately so. It began as part of the Foundation's commitment to studying and solving a wide range of educational problems in a new way. Known in the technology and healthcare industries as "improvement science," the approach starts with an evidence-based hypothesis, tests it in practice using a disciplined method of documenting successes (and failures), and then scales what works. It is a fairly simple and logical way to approach research and reform in any industry: have researchers and practitioners work together, using their collective knowledge to test, refine, and then scale improvements. But this improvement strategy represents a major shift in the education field, where researchers and educators rarely work together to frame and solve problems, and where there are very few systems to collect, study, and share information about the complicated work of teaching and learning.

The Pathways embody the improvement-science approach in education. Carnegie has developed Quantway and Statway as a program of simultaneous research and reform that is designed to study itself, to test and refine changes. With the support of Carnegie researchers, teams of faculty from across the network of colleges collect data on students and on their own instructional practice. Using this data, the faculty try to figure out what's working and what's not, and engage in rapid cycles of inquiry and improvement. One of these teams, which Carnegie calls "subnetworks," focuses entirely on productive persistence, with faculty sharing and testing strategies to increase student retention and success. For faculty, being part of a subnetwork means they aren't just teaching a different type of course with a new curriculum, but are doing so with a commitment to understanding and solving the developmental mathematics crisis in community colleges.

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The Pathways have evolved considerably since their beginnings in 2008, when newly-appointed Foundation President Anthony Bryk announced the Foundation's commitment to improve community college developmental mathematics.

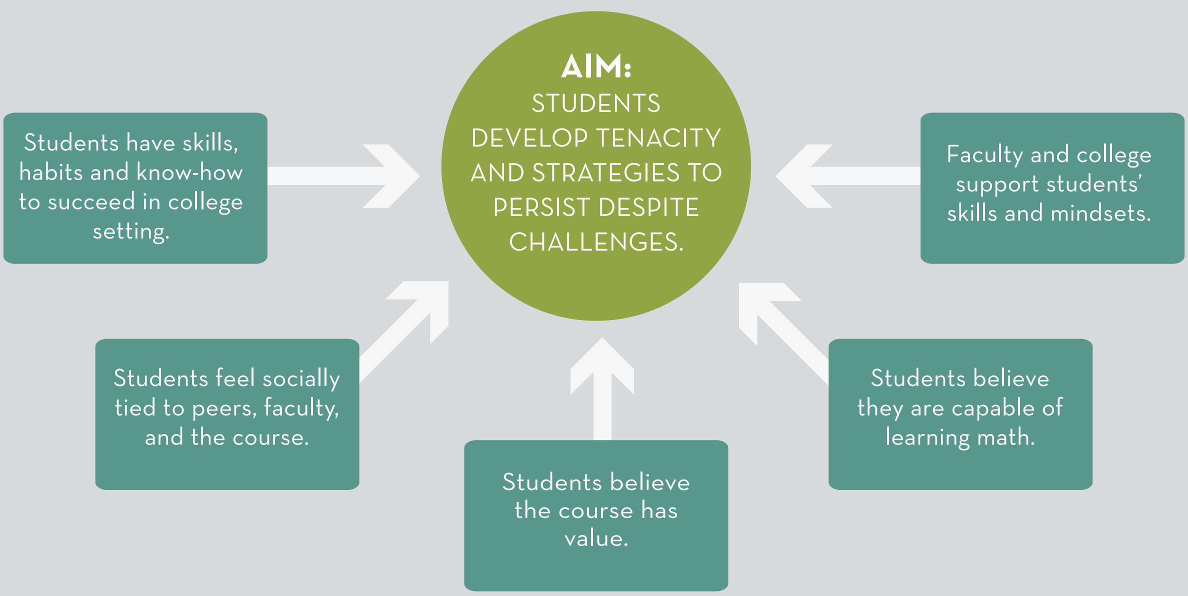
Over nearly two years, the Carnegie Foundation convened a group of nationally recognized experts in mathematics, statistics, quantitative reasoning, and developmental education to create a more coherent and intensive math pathway. By the fall of 2011, they were ready to introduce Statway at 19 community colleges and two four-year universities in five states.[11] Having refined the instructional system for months, they felt confident that the Pathways would, at least structurally, address the shortcomings of traditional developmental math sequences. But decades of experience and research on student disengagement and failure suggested that structural changes alone would not be enough to help many students. Pathways also needed to offer something else to support student success. But what?

The launch of the courses, Statway and Quantway, provided the perfect opportunity to begin tackling that crucial question. In the spirit of improvement science, Pathways researchers opted to start their inquiry as close to the problem as possible by surveying community college math faculty.[12] What factors, they asked, lead students to succeed in developmental math? What factors commonly lead to failure? Which of these factors can we influence?

The faculty identified a lengthy list of personal and psychological attributes of students who navigate developmental math successfully. Successful students, the faculty reported, have faith in their potential as math students. They are undeterred by challenges or failure. They set goals, ask questions, and build relationships with their classmates.

Armed with these insights, Carnegie researchers led by Jane Muhich, director of Carnegie's productive persistence initiative and a former developmental math instructor, and David Yeager, now a professor of psychology at University of Texas-Austin, poured through the literature on student motivation, self-regulation, persistence, and more. To combine this academic research with practitioners' expertise, Muhich and Yeager—themselves a purposeful combination of these perspectives—engaged instructors in the research, examining developmental education programs and approaches. They were struck by the fact that most of the research and practice on improving students' study skills paid no

DRIVING TOWARD PRODUCTIVE PERSISTENCE
PSYCHOLOGICAL STRATEGIES FOR STUDENT SUCCESS



SOURCE: These drivers are excerpted from the January 2013 version of Carnegie's Productive Persistence Driver Diagram. To see the complete diagram, please visit www.carnegiefoundation.org/productive-persistence.

attention to students' underlying beliefs about and motivation for learning. Muhich and Yeager suspected that efforts to improve study skills would only help students if they also addressed these socio-emotional and psychological factors that had not yet been studied extensively in community college settings.

Research conducted by Carol Dweck, a Stanford psychologist who also served as Yeager's doctoral advisor, supported their hypothesis. In a study of New York middle school students, Dweck and her colleagues found that an eight-session course in study skills had virtually no effect on students' academic performance. But, when the course added lessons to address specific psychological factors of learning—namely, students' mindsets about whether intelligence is innate or developed through effort—the results were startlingly different. The workshop not only changed the way students understood intelligence and its relationship to effort, but also boosted their motivation, participation, and academic performance. Dweck and her colleagues concluded that because the students in the control group "were not taught to think differently about their minds, they were not motivated to put the skills into practice."[13]

Yeager and Muhich moved ahead, outlining a practical theory—an actionable, evidence-based and testable framework—for how faculty and colleges could help students develop both the study skills and the mindsets to be academically successful. Using what improvement science calls a "driver diagram"[14] they documented key contributors (so-called "drivers") of student success and completion, paired each with interventions ("change ideas") drawn from practice and research, and developed measures to gauge the success of each intervention. Together, the drivers sought to correct key obstacles to students' success: their negative perceptions of themselves as math students, their doubts about the relevance of the material, and their lack of personal connection to classmates and faculty. Though the drivers themselves were not novel, the practical framework that wove them together and tested them in practice—by now known as the "productive persistence" framework—certainly was.

Muhich, Yeager, and their colleagues throughout the network have continued to refine the framework, continuously piloting and testing classroom strategies to improve students' experiences and, ultimately, their success in the courses. Those that prove effective can be scaled and tested as interventions with all Pathways students. As this evolution has occurred, the framework has become a defining aspect of the Pathways. Its strategies to help students persist and succeed in math—changing students' mindsets, adding relevance to the rigor of mathematics, and diminishing students' sense that they don't belong—are credited as a significant source of the Pathways success to date.

[T]his improvement strategy represents a major shift in the education field, where researchers and educators rarely work together to frame and solve problems, and where there are very few systems to collect, study, and share information about the complicated work of teaching and learning.

SHIFTING STUDENTS' MINDSETS

"Can't you just tell me?" Gary Berns, a former Marine and aspiring public relations major who finished high school in the 1980s, asks Brock in her Statway class at America River. He waits for Brock to respond, picking at the pills on his grey Old Navy fleece and tapping his foot impatiently against his blue JanSport backpack.

"You don't want me to tell you," says Brock, glancing back from the whiteboard where she's busy writing.

"Yes, I do!" Berns says, brightening at the attention. Brock smiles and looks away. Berns sighs and refocuses on his work. He asks a question to another member of his small group and then nods and recalculates. "For every protein it goes up 6. Is that it?" he asks. That's it, he realizes, before his group responds. "Hey," he calls out to Brock. "You couldn't just tell me that!?" He is clearly pleased with himself, as is Brock, who turns toward Berns but addresses the entire class: "It's your learning, not mine."

From the outside, this may not seem like a major moment. But for Brock and her students, it epitomizes the type of teaching and learning that the Pathways program is all about. Key to the Pathways instructional system is this process of struggling through difficulty or, as Brock puts it, "fighting through the pain." Through moments like this one—moments where students must rely on themselves and each other, not on their instructors—Pathways students come to see that learning math is not about guessing what the teacher wants to hear or about finding a particular answer. It is about the process of thinking, making sense of a topic, and persevering in the face of not knowing exactly how to proceed or whether a particular approach will work. It's about struggling effectively, or "getting dirty," as Brock puts it—taking time to explore, investigating multiple methods, and articulating a chain of reasoning behind the approaches.[15] Carnegie calls this process "productive struggle."

But "getting dirty" is easier for some students than for others. Some come to the Pathways courses with the skills and mindsets to tackle challenges head on, but most lack part of that critical combination. And this is where productive persistence comes in: by improving students' work habits and developing their tenacity, productive persistence helps ensure that "fighting through the pain" results in progress rather than discouragement. Armed with the tools of productive persistence, students come to see that struggle—something that has defeated many of them in the past—is an important part of the learning process.

The notion that struggle can lead to success is foreign to many Pathways students. Indeed, according to UCLA psychologist and Carnegie Senior Fellow James Stigler, this lack of confidence in the value of hard work may be imbedded deep in American culture. In the early 1990s, while researching Japanese and Chinese education systems, Stigler and his colleagues conducted an experiment to gauge how 1st graders in Japan and the U.S. reacted to academic challenges. Faced with an impossible math problem designed by the researchers, the American students "worked on it less than 30 seconds on average and then they basically looked at us and said, 'We haven't had this'."[16] But the Japanese students worked for the entire hour on the problem unfazed, seemingly inspired by the challenge.

From this study and subsequent research, Stigler concludes that two cultures interpret effort and struggle differently. Students in Asian and Eastern cultures learn that struggle is not only natural, but a chance to demonstrate that they have what it takes to persevere through even the most daunting challenges. This "effort model" contrasts starkly with the "ability model"—more common in the U.S.—in which "errors may be interpreted as an indication of failure, and may imply that the potential to learn is lacking."[17] Put simply, Stigler says, American students "see struggle as an indicator that [they're] just not very smart … . It's a sign of low ability—people who are smart don't struggle, they just naturally get it, that's our folk theory."[18]

A key part of productive persistence is trying to change that folk theory and, quite literally, change students' minds about themselves as math students so they'll push themselves through the course content. More than 70 percent of incoming Pathways students report doubts about their ability to learn math, but this number drops significantly after students participate in the courses' three-week "starting strong package," a compilation of activities and discussions adapted from research and expert practitioners' knowledge. While only a handful of the activities in the package are designed specifically to address students' mindsets, early data indicate they may be among the most effective.

At Santa Monica College, for example, Yeager and his Stanford-based collaborators, Dave Paunesku and Carissa Romero, found that having students read and write a response to an article on how the adult brain can grow through effort and practice improved their persistence and overall performance. The article, adapted from Carol Dweck's research, was designed to introduce students to the growth-mindset concept. "Scientists have found that learning to juggle is a lot like getting better at math," the article explains. "When people learn and practice new ways of doing algebra or statistics, it can grow their brains—even if they haven't done well in math in the past." In a randomized experiment done collaboratively with Carnegie researchers and Roberta Brown, then a Pathways instructor at Santa Monica,[19] half of a group of students read the article about growth and half read a control article that only explained the parts and functions of the brain. Three months later, students' records were collected from the registrar. Students who read the growth article were twice as likely as those in the control group to complete the course. What's more, those who participated in the activity saw an increase in their GPA—about 0.26 points, on average.[20]

[S]trategies to help students persist and succeed in math [include] changing students' mindsets, adding relevance to the rigor of math, and diminishing students' sense that they don't belong.

Survey results from students in the Pathways further confirm that the mindset activities can change students' beliefs about math—and quickly. Just weeks after the "Grow Your Brain" activity, students reported increased enthusiasm and greater confidence in their ability to persevere through the course, a mindset that has translated into higher course-completion rates.

RIGOR AND RELEVANCE

Two thousand miles away from Brock's Statway class, in a suburb of Cleveland, Ohio, Aaron Altose is teaching a Quantway class at Cuyahoga Community College. While Statway and Quantway are different in some ways from one another, with Statway focused on general statistics and Quantway on quantitative reasoning, they both differ dramatically from the traditional developmental math courses offered at most community colleges in the nation.

Altose, who teaches Beginning Algebra as well as Quantway, says the difference is pretty simple: Quantway works because it delivers challenging math concepts in a real-world context. As a former engineer with a master's degree in mathematics, Altose doesn't want his developmental math students to sidestep tough math, but he realizes that many of his students, who hope to go into law enforcement, pharmacy tech, or early childhood education, don't need a long sequence of algebra to be successful. Instead, they need a rigorous college-level math course that's relevant to them.

Altose describes a lesson on linear equations, where he teaches the concepts of slope and intercepts by having his students graph life expectancy as part of a discussion on the consequences of raising the eligibility age for social security. "Especially for my older students," he explains, "this means something to them. It matters for their lives that they can understand this."

Making these kinds of connections is essential for students, according to researchers and Pathways faculty. When the work is relevant, students are often more motivated and more likely to persist in the face of difficulty. Arleen Arnsparger, who heads up the Center for Community College Survey for Student Engagement, says students usually end up in developmental classes based on placement test scores, with no input from the individual students about whether the class fits their academic goals.[21] They assume from the start that the classes, while necessary to move ahead in college, will not likely be relevant to their long-term or even short-term goals. As part of a recent study published in *Science* magazine, researchers Christopher Hulleman at James Madison University and Judith Harackeiwicz of the University of Wisconsin-Madison asked students to write about the relevance of a weekly assignment on their lives or for the life of someone they know.[22] Just the exercise of connecting the assignment to their lives had a positive effect on their interest levels and course grades. The increase in grades for these students was dramatic, representing more than two-thirds of a letter grade (0.8 grade points).

In another study by University of Wisconsin psychology professor Hyungshim Jang, college students were given a 20-minute math lesson after either receiving or not receiving a rationale. Those who heard that the relatively uninteresting lesson about correlation coefficients would make them better teachers and improve students' lives worked longer on learning the content than other students who were not given the rationale. Importantly, those who recognized the relevance of the lesson came to understand the mathematical concept

Networked Improvement Communities are designed to get Pathways faculty and researchers working together to test hypotheses, analyze changes to practice and, over time, modify and improve the Pathway courses.

more deeply than other students who were not given this rationale and were able to apply it later to new problems.[23]

"Many [students] are convinced they can't do well at math," says Brock. "They avoid it and hope it won't matter for their lives." But it does, of course. When they figure that out, there is a "spark," explains Brock, and that spark triggers something different in them. Knowing the course has value for them personally "energizes" them, she says.

A SENSE OF BELONGING

Rowan Lindley teaches Quantway classes at Westchester Community College outside of New York City, where she has worked for the past 20 years. Like their counterparts throughout the Carnegie community college network, Lindley's students often work in small groups, sharing ideas about strategies, justifying answers, questioning each other, and looking at each other's papers. Lindley believes this collaborative approach is "a tenet of how people really should learn math." Students say the teamwork is motivating, pushing them to participate more actively in their classes.

But for students in the Pathways, the importance of working in groups isn't just about collaboration. It's also an opportunity to feel they are an important part of a learning team, taking collective responsibility for their education. "They influence each other," says Lindley, who explains that it's not always in a good way. Like yawning, social behaviors are contagious. So if one student in a group gives up, sometimes others will follow suit. But, Lindley says, "they are mostly feeding off each other in positive ways. They are changing the way they think about things, the way they think about a math problem and whether they can really get through it."

Stanford professors Gregory Walton and Geoffrey Cohen have advanced the psychological study of belonging in college, another important aspect of productive persistence. In a study conducted with colleagues from the University of Wisconsin, the psychologists found that small, even trivial connections to peers increased students' sense of social belonging and their motivation to achieve.[24] Importantly, Walton and Cohen have also demonstrated that carefully designed exercises to increase students' sense of belonging can have dramatic effects, particularly on students most likely to face stereotypes and a sense that they don't "fit in" to academic settings.[25]

Notably, based on analyses of student surveys, "social belonging" is the strongest predictor of persistence and completion among students in the Pathways courses. Knowing this allows a subnetwork of Pathways faculty and researchers to develop, through disciplined methodology, particular strategies to enhance social belonging.

Altose in Cleveland, for example, has been testing a particular strategy to enhance student participation—a key indicator of how comfortable students feel as members of the class. "I was using an approach where students took an index card and used it as a question card. I would inconspicuously take the card and hold it and then tally how many students asked questions. I went through lots of cycles of trying and adjusting. At first it was difficult, it was distracting and disrupting group conversation. So I made adjustments—very small adjustments—to the process. I would remind them to take out their card and have it ready so it's a seamless part of the course." The work paid off. "Eventually I saw that students who did ask a lot would encourage others—try to get them to do the asking. They'd cheer each other on." But the bigger success, he says, is that these small tests of change will identify and spread good practice, a key dimension of Carnegie's improvement-science approach.

SCALING IMPROVEMENT

Being part of what Carnegie calls a "networked improvement community," or a NIC, a key feature of the Pathways strategy to sustain and expand the program's success, helps faculty think about how to improve the course in what Altose calls "a calculated and precise way."

NICs are designed to get Pathways faculty and researchers working together to test hypotheses, analyze changes to practice and, over time, modify and improve the Pathways courses. This is an important part of Carnegie's overall improvement strategy, which seeks to accelerate the pace of improvements and scale them with consistently strong results. An analytics "hub" at the Carnegie Foundation coordinates and supports the Pathways NIC in the collecting, managing, analyzing, and sharing of data across the community college network. These data allow the NICs to probe differences across classes, faculty, colleges, and different sub-groups of students; to share what's working; and to set an agenda for subsequent improvement on what's not.

To be sure, gathering evidence of what's happening, while it's happening and with those who are making it happen, isn't easy. It can be frustrating and exhausting. Quantway and Statway faculty are the first to admit that studying their own practice while they're engaged in it is a harder way to teach. It takes more time and more focus and a willingness to keep at it, says Brock. But she thinks it's making her a better instructor. "It's feeding me," she says. And she's sure that it's better for her students. Altose has a similar take on it. "Students have a whole different way of doing things," he says. "They know they can do it, and they know how to do it."

This approach is translating into greater success than developmental math students have typically known. Among Pathways institutions in 2010-11, students in the Pathways pass their courses at triple the rate of other developmental math students, in half the time. At American River College, 83 percent of the students who enrolled in Statway in the fall of 2011 successfully finished the entire year-long course sequence. Except for those who have decided to pursue math or a related major—and several, surprising themselves, do want to pursue math now—these students are done with their college math requirements. With weeks left in the course, Gary Berns can already see beyond it. "I'm going to Sac State, and I'm going to graduate. If I hit a bump, I'll call Michelle [Brock]. Just kidding," he adds. "She wouldn't answer anyway. I'd figure it out myself."

ENDNOTES

[1] American Association of Community College, *Community College Fact Sheet 2013*, accessed March 13, 2013, http://www.aacc.nche.edu/AboutCC/Documents/2013facts_fold_revised.pdf; College Board, Trends in Higher Education: Trends in Community College Education: Enrollment, Prices, Student Aid, and Debt Levels (2011), accessed March 13, 2013, http://advocacy.collegeboard.org/sites/default/files/11b_3741_CC_Trends_Brief_WEB_110620.pdf.

[2] Thomas Bailey, *Rethinking Remedial Education in Community College*, CCRC Brief No. 40 (New York: Community College Research Center, Teachers College, Columbia University, 2009). Also see Thomas, Bailey, Dong Wook Jeong, and Sung-Woo Cho. "Referral, Enrollment and Completion in Developmental Education Sequences in Community Colleges." *Economics of Education Review* 29, no. 2 (2010): 255-270.

[3] Ibid.

[4] During the 2010-11 school year, a total of 28 institutions across eight states taught either Statway™ or Quantway™. As of January, 2013, 43 institutions in 10 states offered Pathways courses.

[5] Juan Carlos Calcagno and Bridget Terry Long, "The Impact of Postsecondary Remediation Using a Regression Discontinuity Approach: Addressing Endogenous Sorting and Noncompliance," NBER Working Paper 14194 (2009), accessed March 13, 2013 http://www.nber.org/papers/w14194.

[6] The term productive persistence was coined by Uri Treisman, a former senior partner at the Carnegie Foundation who is the director of the Charles A. Dana Center and a professor of mathematics at the University of Texas–Austin.

[7] Scott Strother, James Van Campen and Alicia Grunow. *Community College Pathways: 2011-2012 Descriptive Report, 6,* accessed March 14, 2013, http://www.carnegiefoundation.org/sites/default/files/CCP_Descriptive_Report_Year_1.pdf. Carnegie established baseline performance across its network of participating colleges and found that only 5.9 percent of developmental math students receive credit in a college-level math course within one year, and only 20.4 percent achieve this goal within three years.

[8] Ibid. To successfully complete the Statway course sequence, students must receive a C or better in their final term.

[9] Ibid., 5-6.

[10] Ibid., 5-6.

[11] Ibid., 3.

[12] Specifically, Carnegie researchers surveyed community college faculty attending the Foundation's Statway™ Summer Institute in July 2010.

[13] Carol Dweck, *Mindset* (New York: Ballantine Books, 2006), 221.

ENDNOTES

[14] Driver diagrams organize knowledge around a particular issue and represent a practical theory for achieving a specified outcome. It generally consists of several key elements: an aim, primary and secondary drivers, and change ideas.

[15] Katherine Merseth, "The Carnegie Foundation for the Advancement of Teaching: Learning Opportunities for Pathway Classrooms," 2, accessed March 13, 2013, http://rethinking-precollege-math.wikispaces.com/file/view/Merseth+on+Productive+Struggle.pdf

[16] James W. Stigler, quoted in Alix Spiegel, "Struggle for Smarts? How Eastern and Western Cultures Tackle Learning," *NPR,* November 12, 2012, http://www.npr.org/blogs/health/2012/11/12/164793058/struggle-for-smarts-how-eastern-and-western-cultures-tackle-learning

[17] Harold W. Stevenson and James W. Stigler, *The Learning Gap: Why Our Schools are Failing and What We Can Learn From Japanese and Chinese Education* (New York: Summit Books.), 103.

[18] James W. Stigler, quoted in Alix Spiegel.

[19] Roberta Brown now teaches Statway as a Professor of Mathematics at Valencia College in Orlando, Florida.

[20] David Yeager, David Paunesku, Carissa Romero, Roberta Brown, Jane Muhich, and Greg Walton, "Engineering psychological interventions for scale: The case of the 'growth mindset.'" Unpublished Manuscript, University of Texas–Austin, 2013.

[21] David S. Yeager, Jane Muhich, Laura Torres, and Rose Asera, "Productive Persistence: A Practical Theory of Community College Student Success." Unpublished Manuscript, Carnegie Foundation, 2012.

[22] Christoper S. Hulleman and Judith M. Harackiewicz, "Making education relevant: Increasing interest and performance in high school science classes," *Science 326 (2009):* 1410-1412.

[23] Jane Hyungshim, "Supporting students' motivation, engagement and learning during an uninteresting activity," *Journal of Educational Psychology* 100, no. 4 (2008): 798-811.

[24] Gregory M. Walton, Geoffrey L. Cohen, David Cwir, and Steven Spencer. 2012. "Mere belonging: The power of social connections." *Journal of Personality and Social Psychology*. 102 (3): 513-532.

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