CHANGING **EQUATIONS**

How Community Colleges Are Re-thinking College Readiness in Math

PAMELA **BURDMAN**

LearningWorks

about

THE **AUTHOR**

Pamela Burdman is a Berkeley-based consultant working with foundations and nonprofits on efforts to improve college readiness and success. She has served as a journalist, foundation officer, and policy analyst, with an emphasis on higher education policy in California and nationally. In her previous role as a program officer for the William and Flora Hewlett Foundation, she developed and implemented the foundation's grant-making strategy to improve student success in California's community colleges. She began her career as a journalist. Her articles have appeared in the *The New York Times, San Jose Mercury News, San Francisco Chronicle, Sacramento Bee, Salon, Lingua Franca, Change,* and *National Crosstalk*.

LEARNING**WORKS**

LearningWorks was founded by the Career Ladders Project for California Community Colleges, the Research and Planning Group for California Community Colleges, and the California Community Colleges Success Network to facilitate, disseminate and fund practitioner-informed recommendations for changes at the community college system and classroom levels, infusing these strategies with statewide and national insights. LearningWorks seeks to strengthen the relationships that offer the greatest potential for accelerating action, including those between policy makers and practitioners, among overlapping initiatives, and across the 112 colleges. LearningWorks is supported by the William and Flora Hewlett Foundation and the Walter S. Johnson Foundation.

ADDRESS 678 13th Street, Suite 103 | Oakland, CA 94612
WEB www.LearningWorksCA.org

> **I would love to learn more** about art, philosophy, literature, and history in a college setting. Math requirements will prevent that. Should they?

Those are the closing words of Javier Cabral's May 2013 article "How I Almost Didn't Fail Algebra." In it, Cabral recounts his experience at a Southern California community college, where he took remedial algebra eight times before concluding that he would never pass the subsequent "gatekeeper" math class required to transfer or earn a college degree. "I don't think my inability to solve quadratic equations should be a deal-breaker for any further education," wrote Cabral, now a Los Angeles-based journalist.[1]

Cabral framed his predicament as the result of an unjust system that requires many college students to repeat high school math classes based on their scores on placement tests. Others would fault not the requirements, but the instruction that failed to help him master them. Those who defend the requirements hold that only two years of algebra can teach the problem-solving and critical thinking skills that all students need for success in college. But Cabral's story resonates with a growing chorus of education leaders who question that assumption, maintaining that math skills such as statistics help provide an excellent foundation for college and are more relevant than algebra for most fields of study. They predict that, for most students, a second year of algebra eventually will follow Latin into obsolescence as a requirement for all students.

It's hard to say exactly how the debate over community college math requirements will play out in California or across the nation. What is clear is that community colleges are emerging as a new theater for the long-running dispute over what math students need, when they need it, and why. At least a quarter of the state's community colleges are now experimenting with new remedial math curricula that place less emphasis on the second year of algebra and more on preparing students for statistics and quantitative reasoning. In a few states, entire community college systems are engaged in redesigning their math curricula, replacing the traditional monolithic sequence of required courses culminating in intermediate algebra with new math pathways tailored to students' different academic goals.

Feeding the trend to redesign remedial education is the recent focus by education leaders, policymakers, and foundations on increasing college completion, as well as the prevalence of first-person stories like Cabral's. Because of their high enrollment and generally low completion rates, community colleges are central to many initiatives to improve higher education outcomes. And increasingly, it's becoming clear that improvement won't be realized unless more students succeed in math: Together, the high proportion of community college students requiring math remediation, and the relatively low proportion who succeed in required remedial sequences, make placement in developmental math[2] one of the single greatest barriers to college completion[3].

The added attention to lowering that barrier has spawned a range of experiments aimed at improving, reforming, or even eliminating math remediation in community colleges. An increasing number of colleges in California and the nation are involved in such experiments, ranging from new instructional strategies to new placement policies to alternative curricula. Through LearningWorks' efforts to strengthen student achievement in the California Community Colleges, it has become clear that practitioners involved in such experiments are eager to learn about parallel efforts, and those not yet involved are curious about the work underway, whether in California or elsewhere in the nation.

LearningWorks commissioned this report, *Changing Equations*, to address those needs. Based on interviews with researchers and practitioners, it explores the reasons some colleges and college systems are altering their approaches to remedial math, how they are doing it, their outcomes to date, and the implications for the future.

[1] *Javier Cabral, "How I Almost Didn't Fail Algebra," May 9, 2013, Javier Cabral, Zocalo Public Square, accessed August 5, 2013.*

[2] *While some college systems prefer one term over the other, "remedial" and "developmental" education are used interchangeably in this report.*

[3] *While this policy brief focuses on reforms taking place at the community college level, the concern about completion relates to both A.A. and B.A. degrees for two reasons: (1) The remedial courses that are the subject of reforms are also offered at many four-year institutions, though only a few are currently pursuing such reforms, and (2) A significant proportion of students at public universities in many states are community college transfer students, so community college reforms may affect a significant proportion of students receiving B.A.'s, especially from public universities.*

NEW **FORMULAS**

Moving Beyond Developmental Math

It has long been recognized that strong high school math preparation correlates with college success, and various initiatives have focused on improving K-12 math curriculum and better aligning it with the expectations of postsecondary institutions. While education reformers have prioritized such efforts, a set of new community college experiments recognizes that those endeavors have not yielded dramatic reductions in the need for math remediation for recent high school graduates. What's more, attempts to improve traditional remediation for students who don't pass placement tests have yet to produce major improvements in community college completion rates.

Viewed with an eye on completion, remedial courses intended to help students become "college-ready" are looking, for too many community college students, like barricades. This is especially true in math: Only 20 percent of students who place into developmental math courses ultimately complete the developmental sequence and pass a college-level gatekeeper course such as college algebra, or in some states, statistics.[4] By definition, that means the other 80 percent cannot graduate or transfer to a four-year school. This dismal success rate is causing some in academia to ask whether it's the traditional definition of math readiness – rather than every student who doesn't meet it – that has to go.

"You look at those numbers and you think, 'We have to be able to do better than this,'" says Anthony Bryk, president of the Carnegie Foundation for the Advancement of Teaching. "It's hard to believe that a system writing off three out of four kids is the best we can do."

[4] *Thomas Bailey, Dong Wook Jeong, Sung-woo Cho, 2010, "Referral, Enrollment, and Completion in Developmental Education Sequences in Community Colleges,"* Economics of Education Review, volume 29.

Indeed, the three postsecondary courses with the lowest rates of success nationally are all remedial math courses.[5] And sequences of three or four remedial math courses that some community college students are required to take are an even greater barrier to completion, with studies uncovering no evidence that they improve those students' chances of graduating.[6] The situation is particularly stark for students of color, who are disproportionately placed into remedial math courses.[7] The critics call this an extreme injustice, claiming the sequences don't develop the math skills most students need for success in college, their chosen careers, or civic participation.

Mathematician Uri Treisman of the University of Texas-Austin is among the critics. "The developmental enterprise, built in the 1950s, is a burial ground," he recently told an audience of community college leaders, referring to the large numbers of students whose college aspirations are blocked when they don't succeed in required remedial math courses. "Millions of people are taking stuff that I think, as a mathematician, is a waste of time."

Rather than simply criticize the mainstream, Treisman and Bryk are among the leaders of a new movement to construct alternative pathways to college-level courses for community college students whose educational goals, they argue, don't require two years of algebra. The second year – referred to in high school as Algebra 2 and in college as intermediate algebra – was long considered essential for college success. In many states it's the highest-level remedial math course before a student can take a required gatekeeper course.

But both intermediate algebra and college algebra are primarily stepping stones toward calculus, and that is why they are coming into question. Some 80 percent or more of students don't ever take calculus, because they are not pursuing courses in STEM (science, technology, engineering, or math) fields. The question now is whether intermediate algebra unnecessarily hinders some students pursuing degrees in drama, culinary arts, foreign languages, and other fields from ever graduating. Even if these students passed Algebra 2 in high school, they still could fail a college placement exam and find themselves, like Cabral, stuck in intermediate algebra. The thinking behind the alternative sequences rejects this one-size-fits-all approach. Instead, it shifts the emphasis from course completion to competencies, saying that a student's pathway through math should be designed to teach the competencies required for his or her intended field of study.

The new pathways for non-STEM students are course sequences that encompass both remedial-level courses as well as the credit-bearing gatekeeper courses that students must pass to earn an associate degree or transfer. Many of these new sequences stress skills in statistics or quantitative reasoning rather than algebra and calculus. While the de-emphasis on intermediate algebra remains controversial, the math pathways movement resonates with other initiatives to focus community college education around structured pathways leading toward careers.

The experiments to redesign math pathways are varied and far-flung, but they are centered in the community college sector:

- The Carnegie Foundation is piloting alternate sequences called Statway and Quantway in California and 10 other states.
- The California Acceleration Project (CAP) has assisted about 21 colleges in implementing statistics-oriented pathways.
- Treisman, who helped Carnegie launch its efforts, is now collaborating with all of Texas' community colleges on a redesign called the New Mathways Project (NMP).
- Other approaches to improving student success, including statewide modularized curriculum reforms in North Carolina and Virginia, are influenced by the pathways work in that students' math requirements are dependent on their intended program of study.

Some of these endeavors to chip away at the standard definition of math readiness are beginning to show impressive, if preliminary, results. Others are still too new to have visible

[5] *Jenna Cullinane & Philip Uri Treisman, 2010,* Improving Developmental Mathematics Education in Community Colleges: Prospectus and Early Progress Report on the Statway Initiative, *National Center for Postsecondary Research Working Paper.*

[6] *For a summary of some of the research in this area, see Thomas Bailey, Shanna Smith-Jaggars, and Judith Scott-Clayton, 2013,* Characterizing the Effectiveness of Developmental Education: A Response to Recent Criticism, *Community College Research Center.*

[7] *Mary Perry, Peter R. Bahr, et al, 2010,* Course-taking patterns, policies, and practices in developmental education in the California Community Colleges. Ed Source. Bailey et al, 2010. *Ed Source.*

outcomes. All arose out of impatience among policymakers and education leaders for developmental education reforms that ensure that more under-prepared students have opportunities to succeed in college. The various efforts were spawned nationally through Achieving the Dream and the Developmental Education Initiative, as well as through a host of state-level initiatives, including California's Basic Skills Initiative. At the start of these projects, curricular change was not a central focus.

In fact, efforts to redesign the math pathways students pursue are not the only approach used by educators re-thinking how to help students who come to college insufficiently prepared in math. They were also not the first. For educators considering their menu of options, the first column might include instructional innovations that leave the curricular content largely intact. Examples include compressing two semesters of math into one or contextualizing math instruction based on students' fields of study. If such fixed-curriculum innovations constitute the first column of options on this menu of reforms, a second might offer new strategies for using placement tests to direct individual students into math courses. The third column would be comprised of ways to redesign the pathways students pursue through math and align them with programs of study. More and more, community college educators are integrating two or three of these reforms, and as a result, some are changing curriculum, revising placement exams, and adding new pedagogical approaches all at once.

This new math reform menu can also help to chronicle colleges' routes to pathways redesign. For example, a college might begin by accelerating the standard math curriculum through compressed courses or other innovations, then experiment with new placement tests or policies, and finally start to ask whether the assumptions beneath the math curriculum and assessments apply to all its students, ultimately leading the school to an interest in alternative pathways. Whatever a college's trajectory, it is not uncommon for practitioners and policymakers initially driven to improve instruction or assessments within the standard math curriculum to eventually conclude that such changes don't go far enough.

Math instructor Myra Snell of Los Medanos College in the San Francisco Bay Area is a case in point. After five years working on a federal grant to improve student outcomes in developmental math, Snell and her colleagues were dismayed to learn that only 17 percent of Los Medanos students who began their remedial studies with elementary algebra ever completed the sequence by taking a transferable math course. Snell's resulting inquiry into ways to speed students' progress to gatekeeper math courses ultimately resulted in a new course called Path2Stats, which became a model course for the California Acceleration Project. The premise for the Los Medanos course was that statistics, which is accepted as a transfer-level math class, does not require a background in intermediate algebra, but does require math preparation that may be equally rigorous.

It is too soon to say whether new pathways or other strategies, alone or in combination, will "crack the code" and yield better college and career success for students who traditionally struggle with math. But early evidence on Path2Stats and other pathways attempts suggests they are worthy experiments and that their continuation should yield a more comprehensive understanding of how math intersects with college and career success.

If they do prove successful, not just community colleges, but also high schools and universities, will need to study them. To the extent that students learning math through new pathways do well in college and beyond, the implications could cascade throughout the education system. Since many broad-access public universities, such as California State University, base their remedial standards on the very assumptions that community colleges are starting to question, the new pathways have the potential to influence university remedial programs, too. They could also cause a re-thinking of the new Common Core State Standards for K-12 math, as well as agreements about how two-year college courses articulate, or transfer, to four-year universities. Currently, both still emphasize the standard algebra-heavy math pathways. Those discussions are already under way in California and other states where experiments are ongoing among educators looking to lower the barricades represented by remedial math. At issue is whether readiness should connote a mastery of the high school math skills that traditionally have been deemed necessary for college – or a more forward-looking view of the competencies students need for college success.

MATH *READINESS* = **EVOLVING** EQUATION

Underlying these experiments is a new sense of urgency around improving college attainment, with research identifying remedial math sequences as one of the major obstacles blocking students from completing a degree. That, in turn, has led to a concerted focus on how best to prepare students in math, with findings emerging from both research and practice that are starting to shift the understanding of math readiness. At the heart of that evolution are four key insights:

1. Math is a hurdle for the majority of community college students.
2. Most students deemed "unready" in math will never graduate.
3. The tests used to determine readiness are not accurate enough to predict whether students can succeed in college-level math courses.
4. The math sequence required by most colleges is irrelevant for many students' career aspirations.

Math Is A Hurdle For The Majority Of Community College Students

In fact, at community colleges, college readiness in math is the exception, not the norm. Nationally, according to a 2009 study by the Community College Research Center, 59 percent of community college students are placed in developmental math, compared to 33 percent placed in developmental reading.[8] In addition, according to a study in California, black and Latino students are overrepresented in the lowest levels of math remediation, with more than 50 percent of those who are required to take any remedial courses needing three or more courses before they can attempt college-level math.[9] The reason math is such an impediment is less clear, and thus the solutions range from improving high school instruction and college remedial courses to changing the math requirements themselves.

[8] *Bailey et al, 2010.*
[9] *Perry et al, 2010.*

Most Students Deemed "Unready" in Math Will Never Graduate

According to a national study, only one third of students referred to developmental math complete the required sequence, and only 20 percent who place into developmental math complete a college-level math course required for graduation. In effect, of every 100 students, math challenges may be blocking up to 40 of them from graduating.[10] Among students who are required to take math sequences of three or more courses, fewer than 10 percent complete the gatekeeper math class.[11] Evaluations from different higher education settings suggest that developmental math has largely insignificant and sometimes negative effects on students' educational outcomes."[12]

Tests Of Math Readiness Are Not Terribly Accurate

Research reveals that low accuracy levels of math placement tests could be creating an unnecessary hurdle for as many as a fifth of students who are placed into remedial courses. These are students who, despite failing the exams, could have earned a B or better in a college-level course without first taking a remedial course, according to an estimate by the Community College Research Center. In fact, wrote the author, "Using placement exams as a screen actually results in substantially lower accuracy rates than using nothing at all; in other words, the increase in the number of qualified students who are prevented from accessing college-level [courses] with the exams outweighs the decrease in the number of unqualified students who are admitted into college-level courses."[13] Using other measures, such as high school grades, in addition to test scores improves the accuracy of placement decisions, the study found.[14]

The Standard Math Sequence Aligns With Few Students' Career Aspirations

Increasingly, colleges are questioning the default assumption that all students need to take the traditional calculus-oriented math sequence, and some research is starting to address that question. "Although little systematic work has been published in this area, some studies suggest that less than a quarter of all majors require rigorous preparation in calculus," wrote Treisman and Cullinane.[15] A more recent analysis by Anthony Carnevale of the Georgetown Center on Education and the Workforce found that only 6 percent of workers use Algebra 2 and beyond in their careers – and only about 11 percent may require the high level of critical thinking, problem solving, and math reasoning that is taught in intermediate algebra. Among B.A. holders, somewhere between 18 and 31 percent require intermediate algebra in their careers, while up to 42 percent may require higher order reasoning skills.[16] Per Carnevale, there is no reason to assume that statistics or other math courses cannot teach these skills. The absence of empirical evidence to date leaves the causal links largely unexamined.

In sum, the reformers argue that, on the basis of a weakly predictive test, large numbers of students are being prevented from completing college unless they pass a challenging course that may be irrelevant to their future success. "The path to higher education and upward mobility is no longer open to hundreds of thousands of students due to high failure rates in developmental and gateway mathematics courses," reads the introduction to curricular materials for one of the alternative pathway initiatives, Texas' New Mathways Project. "Far too many students are unsuccessful in these courses, and the course content does not build the mathematical skills needed for many jobs and for informed citizenship."

Instead of simply pressing for better high school preparation, the critics are asking what those students are being prepared for and whether all students need the same preparation. While not challenging the importance of math, they quarrel with the type of math typically required, saying that the majority of students would be better served in their lives and careers by learning statistics and quantitative reasoning rather than high-level algebra. According to Treisman, only a couple of concepts in intermediate algebra, about three weeks of material, are important for all students – even those who aren't interested in fields like engineering or physics. And that, he says, can be taught in a way that is relevant for students: "I will die on the hill saying that doesn't have to only be represented by doing long strings of meaningless procedures," he says.

[10] *If about 60 percent of students require developmental math, and 2/3 of them fail to complete the sequence, that's fully 40 percent of students.*
[11] *Bailey et al, 2010*
[12] *Michelle Hodara, 2013.* Improving Students' College Math Readiness: A Review of the Evidence on Postsecondary Interventions and Reforms, *Center for Analysis of Postsecondary Education and Employment.*
[13] *Judith Scott-Clayton, 2012,* Do High-Stakes Placement Exams Predict College Success? *Community College Research Center Working Paper No. 41.*
[14] *For more about how research on placement exams is influencing policy and practice, see Pamela Burdman,* Where to Begin: The Evolving Role of Placement Exams for Students Starting College, *Jobs for the Future, August 2012.*
[15] *Cullinane & Treisman, 2010.*
[16] *Georgetown University Center on Education and the Workforce calculations of O*NET 17.0 and* American Community Survey (ACS) *data.*

If Treisman weren't a nationally recognized mathematician and an authority on math education, his argument likely would get little attention. Similarly, if Statway and Quantway had not been spawned by the venerable Carnegie Foundation, their backers might have struggled to convince colleges to sign up and funders to write checks – even with allies among college math faculty.

Countering decades of reports linking traditional math preparation with better postsecondary and workforce outcomes is a heavy lift, because the validity of the standard pathway has been taken for granted. But it turns out that much of the research is confounded by the gatekeeper role that the traditional math sequence has long played. Do algebra skills actually matter across the board? Or do they matter simply because colleges and universities have for decades required them for graduation, if not for admission, thereby ensuring that virtually no one finishes college without them? Increasingly, policy leaders are asking these questions and looking in new places for answers.

Carnevale, too, whose research first made the link between two years of algebra and job success, is urging the field not to confuse the correlation with causation, saying the evidence for causation is very weak. While no one challenges the idea that two years of algebra followed by calculus are important for majors such as physics and engineering, it is harder to say why that sequence would predict life success more generally for majors in history, English, or political science. And in fact, he noted, requiring it may be unnecessarily narrowing opportunity.

"If you're going to be a surgeon, why do you need Algebra 2? You've definitely got to take Algebra 2 or else you won't make the cut, so to speak," says Carnevale. "We've narrowed the pathway down. The curriculum is becoming national, and the assessments are becoming national. American education reform is crashing on the shoals of Algebra 2. There needs to be more than one way to get these kinds of broad skills."

NEW *CLIMATE* = **EXPERIMENTAL** ZONE

The new insights about remedial math sequences have helped to shape a climate in which experimentation is encouraged. Numerous national policy and disciplinary organizations, aware of the gravity of the remedial math dilemma, are urging colleges and college systems to re-think their math requirements and try out alternatives. Consider these examples:

- In 2012, the Developmental Math Committee of the American Mathematical Association of Two-Year Colleges approved a statement saying that intermediate algebra is "an appropriate prerequisite to algebra-based courses in a calculus-based pathway ... but not a universal prerequisite for all college level mathematics courses. Courses outside of the calculus-based pathway can be better served by other prerequisite courses."

- Also last year, Complete College America and three other organizations released a statement on remedial education reforms that said, in part, "Institutions need to focus on getting students into the right math and the right English ... Of particular concern is mathematics, which is generally considered the most significant barrier to college success for remedial education students. At many campuses, remedial math is geared toward student preparation for college algebra. However, for many programs of study, college algebra should not be a required gateway course when a course in statistics or quantitative literacy would be more appropriate."[17]

- A recent report by the National Center on Education and the Economy reached a similar conclusion in analyzing the relationship between high school mathematics, community college introductory math courses, and introductory courses in other majors. "Are we turning away otherwise qualified youth from good jobs because they fail to meet irrelevant requirements?" asked the authors. "And for the students successful in reaching two-year programs, are the currently required high school mathematics courses wasting time and effort on the wrong mathematical priorities instead of spending it on more relevant mathematics?" They suggest that success in college requires different math concepts and skills than are currently being emphasized by most high schools.

- Even the Common Core State Standards for Mathematics make a gesture in the direction of differentiated pathways, acknowledging that students pursuing majors in STEM (science, technology, engineering, and math) fields require more calculus-oriented math than other students. They do not, however, go as far as abandoning the two-year algebra requirement for all high school students.

[17] Core Principles for Transforming Remedial Education: A Joint Statement, *Charles A. Dana Center, Complete College America, Inc., Education Commission of the States, Jobs for the Future, December 2012.*

It is possible that courses in statistics or quantitative reasoning could prepare the majority of students as well as or better than algebra. Unfortunately, existing research validates only the gatekeeper function of algebra, not the content. Likewise, there has been no empirical research on other math sequences -- until recently there have been no sequences to research. Two years of algebra remains the norm, especially at the K-12 and university levels. The Common Core State Standards for Math, which will take effect in some 45 states by 2015, include the equivalent of two years of algebra (although, so far, there are differences of opinion on how to implement those standards). Most universities also adhere to the idea that college graduates need to have mastered intermediate algebra, with more elite campuses requiring it of their admits, and broader-access institutions, including most community colleges, requiring it as a remedial course for some students.

In fact, intermediate algebra has effectively become a proxy for determining whether students are "college material," a sorting mechanism used by selective institutions that need criteria for determining which students make the grade. "My sense of intermediate algebra as the prerequisite is to provide the university with some confidence that the students have a modest level of quantitative literacy," notes George Johnson, a mechanical engineer at the University of California, Berkeley, who heads a system-wide faculty committee on admissions standards.

Others view the intermediate algebra requirement as obsolete, recalling the slow death of Latin and Greek requirements in the curriculum for college-bound students. "It's the new Latin," says David Plank of Policy Analysis for California Education. "It's hard to master, but easy to measure." Treisman says that rather than insist on intermediate algebra, which, after all, may vary from college to college or high school to high school anyway, universities should specify the sort of mathematical competencies they expect. "I think we need to not put in place some ambiguous course. We need to force ourselves to say what the mathematics is that constitutes maturity," he says. When he worked with a group of mathematicians on alternative pathways and pushed them to answer the question, he says, "We agreed that there were two particular areas of algebra that we thought all graduates should know, and that's linearity and something about exponential growth. Those things come up in financial mathematics, in mortgages, in health care decisions."

Part of the problem is that, despite acknowledging that advanced algebra itself may not be essential, some educators and policymakers are loath to abandon it. Its importance in the curriculum is taken as received wisdom, so few focus on the fact that it is based on correlation, not causation. "The risky thing for legislators and other people is, if you throw away the math because everybody doesn't use it on the job, what do you have that's going to teach those critical thinking and problem-solving and math reasoning skills?" wonders Carnevale. "We think math does it. But we're not positive. The (standard algebra-based) math curriculum is the gymnasium we're using to build those muscles. Is there another way to do it? We do know that statistics teaches those skills. What we don't know is the head-to-head comparison."

Treisman and Bryk are pretty sure that statistics can do as good a job as algebra, if not better. So are many individual math instructors. "I spent 15 years of my professional life teaching algebra in a very intensive, research-based way," notes Snell of Los Medanos College. "I think the kind of thinking that students are learning in a statistics pathway is actually much better aligned with the kind of quantitative reasoning skills that we want all students to have."

But empirical evidence that compares the alternative pathways to the traditional sequence can't be generated unless the alternatives are allowed to exist, at least in experimental form. "Right now, the argument isn't about evidence," says Carnevale. "We just make sure everybody goes through the same channel. Inherently, you limit opportunities and you limit learning."

New Math Strategies = Experiments

Empirical research is relatively consistent in concluding that developmental math is not improving students' college outcomes. However, the research doesn't reveal the source of the problem or its solution, paving the way for a plethora of developmental mathematics innovations and experiments at community colleges around the country that hopefully will identify strategies to better serve students. The experiments range from new state policies sanctioning differentiated math pathways to faculty-driven redesign of math courses and course sequences. In many instances, the efforts parallel work to accelerate students' progress through developmental English. And they exist as part of a menu of approaches for improving students' math preparation in college, with pathways efforts featuring some of the most extensive and, at times, the most divisive changes:

MATH **READINESS** *REFORM* MENU

Colleges and practitioners effectively choose approaches within at least one column, but some are pursuing all three:

Instructional Reforms
Modifications to instruction or course sequences within the standard curriculum:

- Compressed courses
- Modularized courses
- Contextualized courses
- Non-academic supports

Placement Reforms
Modifications to placement exams or placement policies:

- New placement tests
- New placement policies

Pathways Reforms
Modifications to standard curricular sequences that tailor requirements to students' fields of study:

- Statistics-based pathways
- Quantitative literacy-based pathways

While community colleges are the main locus of the three types of reforms, each has potential implications for instruction at high schools and universities. Given the importance of K-16 alignment, pathways modifications present the most challenges because curricular changes could lead to misalignment if not accompanied by parallel shifts at the high school and university levels. This causes some observers to view them as the most disruptive of the three types of reforms, but others say that meaningful developmental mathematics reform cannot be accomplished without a serious look at the curriculum.

In general, though, the reforms can be complementary, and some colleges and college systems are implementing math innovations across the continuum. Professional development and faculty engagement play an important role in each – whether in designing, implementing, or studying the reforms. That process ideally should be ongoing, with data being collected and used to identify the most promising practices, ultimately informing the development of the next phase of reforms.

BREAKING *GROUND* FOR **PATHWAYS** REDESIGN

A MATH INSTRUCTOR at Los Medanos College in the San Francisco area's East Bay, Myra Snell for years worked with a team of faculty looking for ways to strengthen student success in college. As co-coordinator, along with an English instructor, of the college's developmental education program, she spent five years working on a federal grant to strengthen the algebra sequence. Instructors met weekly, observed each other's classes, re-wrote curriculum, created common exams, and revised classroom activities. The efforts were quite successful in the narrow sense: the college reached its goal of increasing course success rates by 10 percent.

"We were very happy and self-congratulatory," Snell recalled. Until, that is, they saw the pipeline study that the school's institutional research office had spent six months completing. It showed that only 17 percent of students beginning in elementary algebra (a remedial course) had subsequently completed a transferable math course.

"I was devastated," she recalled. "We have phenomenal course success rates, in the top quartile in the state. We still have teaching communities that meet every semester. We still have a designated person with release time who is a lead for those professional development efforts. All of that effort did not improve the completion rate of college-level math. Seventeen percent is terrible."

With a researcher at the Carnegie Foundation, Snell started looking at data from various colleges in California and discovered that students' success rates could be projected simply by assuming 30 percent attrition at every juncture in the developmental math sequence. "You could predict very closely what any completion rate would be at any college, regardless of what the colleges were doing," she said.

Snell's "stu-piphany," as she calls it, was to figure out what scholarly research would eventually confirm: That the lengthy remedial math sequences, regardless of content, were themselves an impediment to completion of college, with more courses meaning more opportunities for students to exit the sequence. "That said to me this was a structural issue," she said. "The length of the pipeline was predictive. The length of the sequence had to be shortened. If we didn't do that, we would never see improvements in completion rates, ever."

Her own department, Snell realized, was offering five times as many sections of statistics as of precalculus, either of which is accepted for transfer credit in math. But she also knew that although intermediate algebra is listed as a prerequisite for statistics, in practice, very little algebra content is necessary to learn statistics. So, she set to work on a new course.

In the fall of 2009, Snell began offering "Accelerated Algebra for Statistics," better known as "Path2Stats." The college listed the course as a prerequisite for statistics, in addition to intermediate algebra.

Path2Stats was designed to prepare students for statistics, and while it taught some intermediate algebra, it left out much of the algebra that Snell and others say isn't needed. The course was open to all students, no matter their placement score.

The results validated Snell's hunch that students could meet their transfer requirement without taking a typical intermediate algebra course. Regardless of placement level, students performed dramatically better, and with an average of 60 percent completion of a college-level course (statistics) within one year – far better than the 21 percent three-year completion rate for any college-level math course in the traditional pathway.

"Our responsibility in the community college system is to experiment," said Snell. "Let's do it, see what we can learn, get third-party evaluators to keep track of the data. Let's begin to try some things and document them, so we have a real compelling argument, that it's across colleges with multiple teachers, with many forms and that students have been helped."

Snell went on to co-found the California Acceleration Project, and her course became a model for other community college math instructors looking for ways to increase student success in developmental math. And yet, her own course has been in jeopardy because of a University of California requirement saying that, to meet the university's requirements for a transfer student, math courses must not just be college-level courses, they must have intermediate algebra, or its equivalent, as a prerequisite.

Listed as an alternative prerequisite in 2009, the Los Medanos course operated that way until 2012, when a University of California official notified the college that approval of the course for transfer purposes had been removed. After other colleges started attempting to develop similar courses, a vocal community college math instructor complained to the university's Academic Senate that the content didn't align with intermediate algebra. "It had gotten too much publicity," lamented Snell.

Despite the considerable increase in student success that the course had offered, the college couldn't afford to jeopardize students' ability to transfer. Los Medanos eliminated Path2Stats as a prerequisite for the statistics course, leaving intermediate algebra as the only prerequisite. Transfer-bound students who are interested in taking Path2Stats can still do so through an existing mechanism, which allows students to challenge prerequisites if they are able to succeed in the subsequent course without taking the prerequisite.

In July 2013, much to Snell's frustration, a University of California faculty committee affirmed its position that incoming transfer students are expected to complete the same math sequence as recent high school graduates enrolling as freshmen. "These transferring juniors are coming in with 60 transferable units!" she said. "It's a little hard to argue that they're not college ready."

INSTRUCTIONAL REFORMS

Partly in response to a growing awareness of the obstacles created by lengthy remedial sequences, community colleges have been experimenting with various changes to the sequencing, pacing and delivery of remedial courses that leave existing curriculum intact. There are several varieties of modification, with some combining more than one feature. Preliminary research suggests several avenues of instructional innovation that may be effective:

Compressed Courses. Compressed courses are one of the most common developmental innovations.[18] Compression uses traditional curriculum, but moves students through it more quickly to minimize opportunities for students to drop out. One of the earliest examples of this is the Community College of Denver's FastStart program. Launched in 2005, the program squeezes two three-hour courses into one six-hour-per-week format. Considered successful at that college, the program has been growing, with 14 sections offered per semester as of 2012.

An analysis found that FastStart students were "more likely than otherwise similar students to pass the highest developmental math course as well as to enroll in and pass gatekeeper math courses." While researchers weren't able to fully separate the effects of compression and other program features, they wrote, "It appears that the course compression structure may be the catalyst driving superior course performance outcomes." However, no relationship was found with student retention, transfer or completion.[19]

In a recent report, the research firm MDRC found that Broward College's Math Redesign, which compressed a 16-week developmental course into eight weeks, also showed promise, though it has yet to undergo a rigorous evaluation.[20]

Co-requisite models. Another approach to speeding students' pathways into a program of study is co-requisite developmental education, also known as

[18] *Hodara, 2013.*
[19] *Nikki Edgecombe, Shanna Smith Jaggars, Elaine DeLott Baker, Thomas Bailey, 2013,* Acceleration Through a Holistic Support Model: An Implementation and Outcomes Analysis of FastStart@CCD, *Community College Research Center.*

mainstreaming, in which students simultaneously enroll in a remedial and a college-level course in the same subject. While the Community College of Baltimore has a successful program in English, most of the examples in math come from four-year universities, including Austin Peay State University in Tennessee, with its Developmental Studies Redesign Initiative. Austin Peay eliminated two remedial math courses -- elementary algebra and intermediate algebra -- and replaced them with enhanced sections of its two core college-level math courses. Instead of just the math course, students simultaneously take a linked workshop that offers additional instruction in weaknesses identified by initial assessments. The course pattern has more than doubled the success rate in college-level math, compared with the standard sequence.[21]The university also reported that more students are returning to school the following year. However, there has been no rigorous evaluation of the program to date.

Modularized courses. As mentioned in the section on placement, modularized courses are designed to help pinpoint students' developmental needs in order to minimize the time they spend in developmental courses. In some colleges, the courses also are used to tailor students' math requirements to their intended programs of study. For example, in Texas, Tarrant County College's ModMath program divides the school's three semester-long developmental math courses into three five-week modules. Students work at their own pace on computers using the MyMathLab software package, with instructors available to assist them. They can complete up to three modules per semester. In looking at the program, MDRC found a promising trend, but has yet to conduct a rigorous evaluation of the program. The only rigorous study of modularization, which focused on two Tennessee colleges, found that students in modularized sequences performed the same as or worse than those in the traditional sequence.[22]

Contextualization. Contextualized math courses tend to teach math in the context of specific occupations or career pathways, to make the material relevant and easier to grasp. These courses have names such as "Math for Healthcare" and "Technical Math for Airframe Mechanics." Aligned with specific career pathways, contextualized math courses like these often employ pedagogical approaches, such as mastery-based learning and project-based learning, that distinguish them from the typical remedial course. A California-based study published in 2011 found that community college students in contextual developmental math courses passed them at much higher rates (86 percent) than students taking traditional developmental math (59 percent), and that the students had higher success rates in other non-math courses as well.[23] But the study also found that changes to the associate degree math requirements in the state reduced the availability of contextualized math courses, and furthermore, that some contextualized math courses are not accepted for transfer by the California State University system, even if they include more advanced math topics than the transferable courses. And a study in Washington state found that I-BEST -- a state-funded program for adult education students that integrates basic skills instruction into occupational classes -- was associated with higher rates of credit accumulation and persistence.[24]

Non-academic supports. The increased attention to college completion also is revealing a concern about students' non-academic needs, such as their confidence, motivation, and persistence. Some of the new math programs incorporate services or strategies to support these needs and help strengthen students' "non-cognitive" skills that increasingly are being identified as important components of college-readiness.[25] FastStart, for example, offers students case managers, and guides them in career exploration and educational planning. Students also co-enroll in a student success course.

As part of its work on alternative math pathways (discussed below), the Carnegie Foundation also is experimenting with approaches to yield what it calls "productive persistence." One such strategy is to have students read and respond to an article about how the adult brain can grow through effort and practice. Carnegie researchers found that students who read the article were twice as likely as other students to complete the course, and that their grade point average increased by 0.26 points.[26] In that vein, the New Mathways Project has integrated student support courses. Likewise, the California Acceleration Project, in assisting colleges in creating shorter pipelines to statistics, requires instructors to learn instructional strategies that promote students' tenacity and teach behaviors conducive to school success.

[20] *Kelley Fong and Mary Visher, 2013,* Fast Forward: A Case Study of Two Community College Programs Designed to Accelerate Students Through Developmental Math, *MDRC.*
[21] Core Principles for Transforming Remedial Education, *2013, Charles A. Dana Center, Complete College America, Inc., Education Commission of the States, Jobs for the Future.*
[22] *Hodara, 2013*
[23] *W. Charles Wiseley, 2011,* "Effective Basic Skills Instruction: The Case for Contextualized Developmental Math," *PACE Policy Brief.*
[24] *Davis Jenkins, Matt Zeidenberg, and Gregory Kienzl, 2009,* Educational Outcomes of I-BEST, Washington State Community and Technical College System's Integrated Basic Education and Skills Training Program: Findings from a multivariate analysis, *Community College Research Center Working Paper No. 16.*
[25] *See, for example, David Conley, 2013,* A Complete Definition of College and Career Readiness, Educational Policy Improvement Center.
[26] *Elena Silva and Taylor White, 2013,* Pathways to Improvement: Psychological Strategies to Help Students Master Developmental Math, *Carnegie Foundation for the Advancement of Teaching.*

PLACEMENT REFORMS

In some states, new placement tests or placement policies for incoming community college students have been central, from the beginning, to developmental reforms. In other cases, the need for new placement approaches has emerged in the course of other reforms.[27] While there is research (mentioned above) about the validity of common placement exams, there is limited research to date about the effectiveness of the new exams and new placement policies.

New placement tests. At least five states' college systems have developed customized placement exams that are intended to align better with college math curricula. These include diagnostic exams in Virginia and North Carolina that divide curricula into eight or nine content modules. Instead of a test score above or below a prescribed cut-off, a student is simply given a breakdown as to which of the modules he or she has mastered. This innovation is intended to better pinpoint students' deficiencies in order to minimize their time in developmental courses. (But it also lends itself to program-specific placement, as explained below.)

New placement policies. Colleges and college systems also are experimenting with a wide range of policies to improve the effectiveness of placement exams. These include offering refresher courses for students who fail the tests and relaxing re-testing policies. These policies are being implemented with an eye toward minimizing the amount of time students spend in developmental courses, given new understanding that long sequences serve as a barrier to college completion. Of particular note are program-specific placement policies in college systems, such as those in North Carolina and Virginia. Modularization in those systems, besides serving to pinpoint students' developmental needs in order to address them more efficiently, also allows colleges to align students' math preparation with their intended major. In North Carolina, for example, liberal arts majors need to take or pass out of only five modules; engineering majors require all nine.

The use of high school grades instead of or in addition to test cut-offs is also gaining traction as a way to place incoming students. For example, North Carolina's system now waives testing for recent high school graduates with a GPA of 2.6 if they took the prescribed high school math courses, including two years of algebra. Long Beach City College conducted a study to see what variables best predict student performance in math courses there, and found that the GPA was by far the best predictor. Long Beach has since begun basing placement decisions on high school transcripts, waiving placement testing for most recent high school graduates.[28]

Increasingly, colleges also are offering brush-up courses and other resources. Santa Monica College has an online orientation program called Prep2Test. The college claims that students who familiarized themselves with test content and reviewed test preparation materials were 36 percent more likely to place into college-level math.

PATHWAYS REFORMS

While there is much enthusiasm in the field for placement reforms as well as for instructional innovations, some leaders are concerned that these changes don't go far enough to yield the improvements warranted in college completion. In particular, they worry that existing intermediate algebra requirements are irrelevant for many students' educational pursuits and will continue to stymie their progress in college. In addition, they argue that many students would be better served by a curriculum that emphasizes statistics and quantitative reasoning rather than the two years of algebra that cause so many students to struggle.

"It's time to ask fundamental questions about why people who care about student learning, despite Herculean efforts, are still not able to help these students realize success," wrote Bryk and Treisman in the Chronicle of Higher Education in 2010. "The math pathway for students pursuing majors in the math-oriented disciplines is well established: Students work their way through algebra to calculus. However, many students in the social sciences, arts, and humanities, and those seeking careers in business, applied technologies, health sciences, and other fields, could be served just as well by another pathway. The skills in those professions can require rigorous preparation in statistics. Statistical reason-

[27] *Burdman, 2012.*

[28] *For research based on the Long Beach City College study being conducted by the Research and Planning Group, see Terrence, Willett,* The Potential of Transcript-Based Placement, *March 2013 presentation to California Community Colleges Chief Student Services Administrators Association.*

ing supports decision making under conditions of uncertainty, an inescapable condition of modern life. This is math that will help these students understand the world around them, and it's the math they can use right now."[29]

In the three years since that piece appeared, pathways-oriented reforms have sprouted up in various manifestations:

- The *Carnegie Foundation* launched its Statway project in 2010, with 19 colleges in five states. Now, 43 colleges in 11 states are implementing Statway or a newer quantitative literacy pathway called Quantway. Each pathway includes two courses: a developmental course and a college-level course designed to be completed in a student's first year.

- In *California*, about 27 colleges have attempted some type of statistics pathway. In addition to those implementing Statway, many of the math faculty who are implementing alternatives receive support from either the *California Acceleration Project*[30] (a project of California's Basic Skills Initiative) or *Acceleration in Context*. Los Medanos College's Path2Stats course – a one-semester, six-unit course open to students regardless of their placement score – serves as an exemplar for the California Acceleration Project, with colleges inside and outside of California developing their own versions, using its design principles.[31]

- The use of modularized curricula in *North Carolina* and *Virginia* reflects pathways thinking, in that the content required of students depends on their educational goals. North Carolina has since gone farther down the pathways route, creating five gateway math courses, each aligned with different areas of study and different developmental education modules. For majors with college algebra as the gateway math course (primarily students transferring to a four-year university in business or STEM fields), students are expected to master all eight modules. Students pursuing programs that lead to a diploma in a field such as welding typically need to take or place out of only three modules. Most students pursuing STEM-oriented associate degrees require an applied Algebra 2 class as their gateway course, which they are eligible for after completing or passing out of five modules. Those five modules are also the maximum required for students in transfer fields that do not require Algebra 2 who choose a statistics or quantitative literacy gateway course.

- In *Colorado,* the State Board for Community Colleges and Occupational Education adopted in February 2013 recommendations by the system's developmental education task force. In addition to the traditional STEM-oriented math pathway, the state's community colleges will offer a quantitative literacy pathway for transfer students, as well as one for students who don't intend to transfer. For students placing below high school level, options for improving their score include test preparation programs, boot camps, tutoring, adult basic education, and massive open online courses (MOOCs). The plan is for the new pathways to be fully implemented by Fall 2014, and $7 million from a federal grant will help make that happen.

- *Texas*' 50 community colleges are partnering with the University of Texas' Dana Center to develop and implement two alternative math pathways, as well as a STEM pathway for students who require some remediation. The starting point for each of the pathways is a remedial level foundations course that covers numeracy, proportional reasoning, algebraic reasoning, descriptive statistics, basic probability and modeling. The course is taken in conjunction with a student success course that emphasizes building the skills and tenacity to succeed in math and other college courses. Students in the STEM pathway are required to take an additional remedial course, equivalent to intermediate algebra, before taking a college-level pre-calculus course. But students in the other two pathways can proceed directly to a college-level math course in statistics or quantitative literacy.

- At Illinois' *Rock Valley College*, two math instructors developed a six-unit quantitative reasoning course called

[29] *Anthony S. Bryk and Uri Treisman, April 2010, "Make Math a Gateway, Not a Gatekeeper,"* Chronicle of Higher Education.
[30] *The California Acceleration Project has been a grantee of Learning Works.*
[31] *Katie Hern, with Myra Snell, forthcoming,* Toward a Vision of Accelerated Curriculum and Pedagogy: High Challenge, High Support Classrooms for Under-Prepared Students., *Learning Works.*

Math Literacy for College Students. It has been taught since Fall 2011. Emphasizing critical thinking and problem solving, the course was designed for liberal arts majors. The City Colleges of Chicago plan to pilot the course in Fall 2013, with an interest in scaling it. A book based on the course, Math Lit,will be published later in 2013 by Pearson. Rock Valley also offers an accelerated math pathway, which compresses beginning and intermediate algebra into one six-unit course, and a modular pathway with four modules offered every eight weeks that covers all of beginning and intermediate algebra.

- *Florida* implemented a new assessment, the Postsecondary Education Readiness Test (PERT), in 2010.[32] The PERT math assessment assumes that community college students need intermediate algebra before they enroll in one of three gateway courses: college algebra, statistics, or liberal arts math. However, under recently passed legislation, all public high school graduates will be assumed college-ready and exempt from placement testing. Three Florida colleges are participating in Statway. In addition, for students still enrolling in developmental education (i.e., those who did not enroll in a Florida high school in the last 10 years or those who opt to take developmental courses), other colleges are considering opening alternative pathways to statistics and liberal arts math. "We have been encouraging any college that wants to explore options to accelerate student entry to do so," says Julie Alexander, vice chancellor for academic and student affairs for the Florida Division of Colleges.

- More sophisticated approaches to contextualizing developmental math, such as those utilized by the *Career Advancement Academies* in California, may involve re-designing courses or sequences to reflect the math demands of the particular career pathway in question.

Whether they are local efforts or multi-state initiatives, each of these projects is anchored by community college math faculty. In Texas, for example, faculty at nine of the state's 50 community colleges are working to "co-develop" the curriculum with the University of Texas' Dana Center staff. "They are preparing for implementation and doing faculty training and review of material," says Jenna Cullinane, a policy expert at the center. "They're planning for how to recruit students, how to communicate broadly across the institution, and the implications beyond developmental math faculty. There are faculty that aren't totally sold, but we want them to be engaged at least at the level of joining conversations and seeing the data."

Early Results. Because the first of the new pathways experiments began in 2009, there is still relatively little research on the new curricular pathways, but early results are strong. With some programs seeing double to triple the success rates in less time than the traditional sequences, reformers are anticipating change more transformational than the incremental improvements yielded by prior reforms.

Carnegie's first report showed that 51 percent of students in the statistics pathway (or Statway) completed a college-level math course in their first year of college, compared to only 6 percent of students pursuing the standard pathway. In the quantitative literacy pathway (or Quantway), 56 percent of students completed developmental math during their first semester, compared to the 21 percent of students in the standard pathway who took two semesters to complete it.[33] Bryk is not yet congratulating himself on these achievements, saying that the next goal is to use improvement science – best known for its use to improve patient outcomes in health care-- to analyze variability of performance across classrooms within the same college, in order to learn how to achieve quality teaching at scale across campuses nationally.

Los Medanos' Path2Stats course similarly has posted encouraging results: Among students placing into intermediate algebra who instead took Path2Stats, 82 percent completed the college-level statistics class within one year, whereas only 33 percent of those in the traditional pathway completed college-level math within three years. At the elementary algebra placement level, 78 percent of Path2Stats students were successful in the statistics course in their first year, compared with 17 percent of comparably placed students after three years in the traditional pathway. Likewise, at the lowest placement level, 38 percent of students taking Path2Stats passed college-level math after one year, compared with 9 percent of those in the traditional path after three years.[34]

Based on the positive outcomes of these descriptive studies and the proliferation of new alternative pathways, it may be possible within a few years to conduct a more rigorous study. Likewise, Texas and Colorado's reforms are just being implemented, so no data is available there yet, but both should have rich data resources before long. Casey Sacks, a project manager leading the Colorado redesign, estimates that about 20 percent of students who place at the lowest level (traditionally, this has meant four semesters of remedial courses before a student can enroll in a college-level math course) will pass college-level math, compared to just 3 percent who take the traditional sequence. Twenty percent is still a low number, but a dramatic improvement.

[32] *For more about this assessment, see Pamela Burdman, September 2011,* Testing Ground: How Florida Schools and Colleges Are Using a New Assessment to Increase College Readiness, *Jobs for the Future.*

[33] *Scott Strother, James Van Campen, Alicia Grunow,* Community College Pathways: 2011-2012 Descriptive Report, *Carnegie Foundation for the Advancement of Teaching, March 2013.*

[34] *Katie Hern, "Acceleration across California: Shorter pathways in developmental English and math," Change:* The Magazine of Higher Learning, *June 2012. For the prior year's findings, see Myra Snell and Lucy Michal,* Statistics-Based Approaches to Developmental Education Reform, *PowerPoint Presentation, National Center for Postsecondary Research meeting, June 2012.*

ALIGNMENT = **CONUNDRUM**

Of course, the possibility of sustaining and replicating these improvements is contingent on the ability of practitioners to implement such reforms. K-16 alignment is proving to be a key challenge. While the understanding of math readiness is evolving at the community college level, these new experiments are colliding with more traditional approaches at both the K-12 and university levels.

K12. With the participation of 45 states, efforts to implement the Common Core State Standards by 2015 are by far the most visible strategy being pursued nationally to improve students' college readiness during high school. What Common Core math shares with some of the community college pathway reforms is an emphasis on development of higher-order skills, such as critical thinking and problem solving, and a de-emphasis on memorizing mathematical procedures.

But there is a major difference: while some community colleges are migrating toward different standards based on students' individual programs of study, de-emphasizing the notion of two years of algebra for all, the Common Care math standards are moving toward a single standard of math readiness, with the two-year algebra sequence effectively intact. This raises obvious questions, such as: If a second year of algebra truly is not relevant for most students, and colleges are starting to relax that requirement, should high schools still insist on it?

One view that is gaining adherents is that the requirements don't have to be identical, and that high schools should not foreclose any options for students. Jacqueline King, director of higher education collaboration at the Smarter Balanced Assessment Consortium, one of two groups creating tests aligned with the Common Core, explains: "When kids are 14, our goal should be to keep as many options open to them as possible. It's a little different story when they're 18, and they're paying for college."

Others argue that in order to send clear and consistent signals, colleges should align with the Common Core standards and not seek ways to circumvent the two years of algebra. "We're between the high schools that have a common set of

standards with Common Core and California State University, with its own common set of standards," says Beth Smith, a math instructor and incoming president of the statewide Academic Senate for the California Community Colleges. "We have to have messages that go up and down that say we're holding students to comparable standards."

Still others predict that the Common Core standards will eventually move in the direction of alternative pathways. "There is a tacit agreement among a large number of people that the high school math standards will have to be revisited," notes Bryk. "There was just a political compromise, and there is a lot more intermediate algebra than a significant number of people really think all kids need to be able to know and do. As a consequence, it's going to put needless hurdles in the way of large numbers of students."

To further complicate matters, some states that have signed on to Common Core are not mandating two years of algebra for high school students. For example, in Florida, students will be able to graduate from high school without a second year of algebra, although four years of math are required.

Transfer and Articulation. At the other end of the pipeline, the expectations of four-year universities in many ways drive curriculum for both K-12 and community colleges. Currently, the need to make sure that community college students' lower division coursework can transfer to a four-year university is also a stumbling block for those laboring to design alternative pathways. The transfer edifice is built around a set of assumptions about how two-year college courses articulate with four-year colleges, even though many of those courses also are taken by students who will not transfer. And in some states – including California – those assumptions include the expectation that students have passed intermediate algebra in high school or as a remedial course in community college.

Some university faculty are reluctant to abandon the expectation that students learn intermediate algebra, even when faced with evidence that students can pass a math course accepted for transfer – statistics – without Algebra 2. That creates a challenge for alternative pathways, as well as any relaxation of the algebra requirement in Common Core.

"I'm coming to the conclusion that we're not really using Algebra 2 as something that says, 'We know you have to have this in order to succeed in statistics,'" says Johnson at UC Berkeley. "There's an awful lot of material in intermediate algebra and Algebra 2 that points in the direction of precalculus, so it's a great prerequisite for calculus, but may not be all that important for somebody who's into humanities and going to be taking statistics. Is it a real prerequisite, or is it a proxy that says students who have passed it have demonstrated the level of competence that would be expected of incoming freshmen?"

Even if the answer is the latter, Johnson says, many university faculty are loath to allow students to transfer without the minimum requirements expected of incoming freshmen. "One hundred years ago, Latin was the filter," he notes. "If you didn't know Latin, you couldn't possibly succeed at the university. I think we've gone a little bit beyond that, but maybe mathematics is still stuck in that frame."

Johnson's committee, the Board of Admissions and Relations with Schools, recently issued a statement standing by its historical requirement that students entering any campus in the system as juniors have taken and passed intermediate algebra. Notwithstanding evidence that students don't need to learn intermediate algebra to succeed in statistics, committee members felt that transfer students should have the same math background required of incoming freshmen. However, the committee left open the possibility of re-defining the content of intermediate algebra to align more closely with the Common Core, which they say includes fewer topics than the intermediate algebra now expected of transfer students.[35]

This and similar requirements in the California State University system chafe at some community college leaders. "This situation amounts to the use of intermediate algebra as an entrance filter to a four-year university, rather than a validated prerequisite," wrote Ian Walton, a former president of the community colleges' statewide Academic Senate, in a Senate publication. He noted that during a public vetting process for the statistics course, more than 30 colleges requested an alternative prerequisite. "These requests could not be accommodated because of the CSU/UC regulations," he said.

California State University has, in fact, opened its door a little farther than the University of California, because five of its campuses are participating in a Statway study that will

[35] *There is still some debate about the amount of algebra required in Common Core, with some observers arguing that it is no less than current intermediate algebra courses contain.*

end in 2014. The results of that study are expected to offer a clearer way forward on the articulation question. While some participants, including administrator Ken O'Donnell, are optimistic that the study will validate the alternative pathways, some faculty expect the experiment will only expose the weaknesses of the statistics alternative. "Some faculty say that there's something in intermediate algebra about being a well-educated person and functioning in society," says O'Donnell. "Algebra gives you a way to symbolically represent unknowns, they say, and adults should be able to do that, and it doesn't matter if you can pass a statistics course without it."

Outside of California. Elsewhere, the transfer and articulation challenges are being worked out in different ways.

- The pathways redesign in *Colorado* focused on quantitative reasoning instead of statistics because of articulation challenges. Unlike some states, statistics is not a guaranteed transfer class for any of Colorado's four-year universities, so designing a pathway around it didn't make sense because advisors would only steer students away from it, notes Casey Sacks of the state's community college system. While there are good arguments for changing the articulation requirements, faculty are still largely wedded to them.

"The psychology faculty absolutely want algebra as a sorting mechanism," she says. "It's an over-populated major. They want to use it to weed out students who aren't as strong. It doesn't matter if they actually need that content in the major. Having gone through this whole redesign, I think it's really unfair to put math in that position. We have a horrible habit of confusing inputs with outputs."

- In *Illinois*, a statewide articulation committee approved Math Literacy for College Students as an acceptable prerequisite, along with Prep Math for General Education and an intermediate algebra course for non-STEM majors.

- In *Texas*, new pathways will articulate at all public universities, per state rules, but institutions will determine which pathways will be accepted by which majors. Articulation requirements vary quite a bit. While University of Texas-Austin considers statistics the requirement for nursing, Texas State University still requires college algebra. At some Texas institutions, college algebra is a prerequisite to statistics. "In that case, it wouldn't save people any time to go through a statistics pathway," notes Cullinane of the Dana Center.

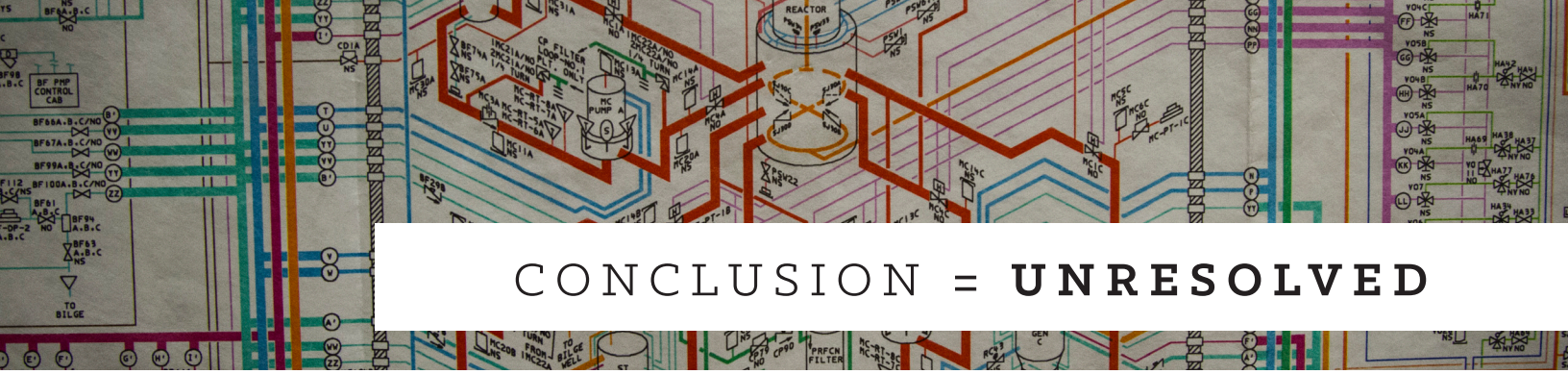
- In *Florida*, Julie Alexander doesn't anticipate that universities will protest if some two-year colleges alter the pathways into statistics and liberal arts math, both of which are already articulated. "We have the statewide course numbering system, which guarantees articulation," she says. "I think we have a structure in place that will allow us to do what we feel is in the best interest of the students."

- The *Carnegie Foundation* perhaps has a greater challenge around articulation, in that colleges implementing Statway and Quantway are replacing not just the prerequisite remedial course, but the transfer-level course as well. "This has been a political terrain that we've been able to walk through, but it's certainly not resolved nationally," notes Bryk.

One faculty critic said that pre-statistics courses were missing such content as how to calculate the area of a circle, and that much of the material was at a middle-school level insufficient for university admissions. Treisman responds that this type of analysis emphasizes standards setting at the expense of helping students progress toward a degree.[36]

"If you start at the level of particulars, you can make an infinite list of defensible items," he says. "I cannot imagine someone not knowing how to find the volume of a cone – the problem is I have 1.4 million items that I believe are indispensable. The evidentiary standards for what is a gateway and what is a prerequisite should be major themes of academic governance and academic policymaking. I'm proposing to governance boards that there be an automatic audit triggered if system-wide failure rates in a course exceed 35 percent. Then it's not about students or individual faculty, it's a structural problem. You'll find that for college algebra and pre-calculus, investigations would be triggered."

[36] *For an interesting discussion of the tension between enforcing standards and promoting student progress, see Shanna Smith Jaggars and Michelle Hodara, 2013, "The Opposing Forces That Shape Developmental Education: Assessment, Placement, and Progression at CUNY Community Colleges,"* Community College Journal of Research and Practice, *Volume 37, Issue 7.*



CONCLUSION = **UNRESOLVED**

The conversations and questions about math requirements often sound highly technical: For example, what percentage of college graduates will need to factor polynomials in their future careers? But the stakes are very high and very personal from the perspective of the millions of students referred to remedial education each year, many of whom are low-income or students of color. If the current math requirements seemingly preventing those students from progressing become indefensible, a change could open doors for many of them, holding out prospects for narrowing achievement gaps and boosting U.S. competitiveness. Furthermore, it also might increase the productivity of colleges, which is sure to interest many policymakers. One analysis suggests that, despite the perception that innovative programs cost colleges more, programs such as Statway and Quantway can likely help colleges produce graduates at lower cost and, in most states, generate a positive return on the initial investment.[37]

Still, the programs remain highly controversial because of a longstanding reliance on the current algebra-oriented math sequences. In the short-term, stand-offs -- between, for example, alternative pathways proponents in community colleges and those setting transfer requirements at universities – may persist. Even skeptics agree that any resolution to the tension will depend on additional experimentation. Community college math instructor and faculty leader Beth Smith, for example, is wary of removing intermediate algebra from the curriculum. But she is the first to say that the decision ultimately should be based on evidence.

"People in higher education want to see if we can find something that works," says Smith. "We should be able to try some things in a pilot form, track the students carefully, watch their success, not only in the math sequence, but in other courses as well, as they transfer and have opportunities to do upper division work and possibly change majors."

And that is where the defenders of the standard math curriculum see eye to eye with reformers like Treisman, Bryk and Snell. The various experiments began just a few years ago, based on educated guesses, and early findings are starting to accrue. If those promising results can be sustained and replicated, and students pursuing the alternate pathways are equally or more qualified for upper-division coursework and the workplace, it might end the debate about how to define math readiness. But it would likely signal only the beginning of the effort to re-structure math programs nationally and ensure they maximize students' ability to enter and complete college.

[37] *Robert Johnstone, September 2013,* Statway-Quantway & Fiscal Considerations: We Should Be Doing This Anyway, But Here's How It May Help the Bottom Line, *National Center for Inquiry & Improvement.*

ACKNOWLEDGMENTS

This report was shaped largely by the insightful observations of numerous practitioners, researchers, and education leaders who made themselves available for interviews and/or to comment on drafts of this report. We gratefully acknowledge the thoughtful input of those named below. The author also wishes to thank Linda Collins and the LearningWorks team for the vision to commission a report highlighting math pathways redesign.

Julie Alexander
Vice Chancellor for Academic and Student Affairs, Division of Florida Colleges

Kathleen Almy
Mathematics Instructor, Rock Valley College

Rose Asera
Independent Researcher and Evaluator

Anthony Bryk
President, Carnegie Foundation for the Advancement of Teaching

Anthony Carnevale
Research Professor and Director, Georgetown University Center on Education and the Workforce

Jenna Cullinane
Higher Education Policy and Strategy Lead, The Charles A. Dana Center, University of Texas at Austin

Bernadine Chuck Fong
Senior Managing Partner for Community College Programs, Carnegie Foundation for the Advancement of Teaching

Michelle Hodara
Senior Researcher, Education Northwest

George Johnson
Professor, Mechanical Engineering, University of California, Berkeley, and Chair, Board of Admissions and Relations with Schools (BOARS)

Rob Johnstone
Founder and President, National Center for Inquiry and Improvement

Jacqueline King
Director, Higher Education Collaboration, Smarter Balanced Assessment Consortium

Lars Kjeseth
Mathematics Instructor, El Camino College

Cynthia Liston
Associate Vice President for Policy Research and Special Projects, North Carolina Community College System

Ken O'Donnell
Senior Director, Student Engagement and Academic Initiatives & Partnerships, California State University

David Plank
Executive Director, Policy Analysis for California Education

Casey Sacks
Project Manager, Trade Adjustment Assistance Community College and Career Training, Colorado Community College System

Beth Smith
Mathematics Instructor, Grossmont College and President, Academic Senate for California Community Colleges

Myra Snell
Mathematics Instructor, Los Medanos College and Cofounder, California Acceleration Project

Uri Treisman
Professor of Mathematics, Professor of Public Affairs, and Director, The Charles A. Dana Center, University of Texas at Austin

Ian Walton
Former Mathematics Instructor, Mission College and former President, Academic Senate for California Community Colleges

design **DONNA CHOI**
photography **DAN FIGUEROA**

LearningWorks
linking knowledge, policy and practice

LearningWorks was founded by the Career Ladders Project for California Community Colleges, the Research and Planning Group for California Community Colleges, and the California Community Colleges Success Network to facilitate, disseminate and fund practitioner-informed recommendations for changes at the community college system and classroom levels, infusing these strategies with statewide and national insights. LearningWorks seeks to strengthen the relationships that offer the greatest potential for accelerating action, including those between policy makers and practitioners, among overlapping initiatives, and across the 112 colleges. LearningWorks is supported by the William and Flora Hewlett Foundation and the Walter S. Johnson Foundation.

ADDRESS 678 13th Street, Suite 103 | Oakland, CA 94612
WEB www.LearningWorksCA.org