An NCPR Working Paper

Improving Developmental Mathematics Education in Community Colleges: A Prospectus and Early Progress Report on the Statway Initiative

Prepared for the NCPR Developmental Education Conference:
What Policies and Practices Work for Students?
September 23–24, 2010
Teachers College, Columbia University

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The National Center for Postsecondary Education is a partnership of the
Community College Research Center, Teachers College, Columbia University;
MDRC; the Curry School of Education at the University of Virginia;
and faculty at Harvard University.

The contents of this paper were developed under a grant from the Department of Education. However, those contents do not necessarily represent the policy of the Department of Education, and you should not assume endorsement by the Federal Government.

This paper reflects the collective efforts of the many people and organizations working in the Statway[SM] Initiative, a statistics-intensive pathway that will enable community college developmental education students to successfully complete a transferable credit-bearing mathematics course. The Carnegie Foundation for the Advancement of Teaching is serving as the lead organization of a new Statistics Pathway Network that is harnessing the contributions and expertise of design partners including researchers, advisors, and community college faculty and staff, many but not all of whom are named in this paper. The Charles A Dana Center at the University of Texas at Austin is among these design partners. To learn more, visit www.carnegiefoundation.org and www.utdanacenter.org.

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Abstract

Developmental education has the mission of enabling underprepared students to acquire the capabilities necessary for college success. A growing number of research studies document its failure, however; specifically, approximately two thirds of community college students referred to a remedial mathematics sequence do not complete it. In response to these findings, The Carnegie Foundation for the Advancement of Teaching, with the Charles A. Dana Center as a principal design partner, is launching a comprehensive initiative to create two new pathways, the Statway and the Mathway, to enable developmental mathematics students to complete a credit-bearing, transferable mathematics course in one academic year while simultaneously building skills for long-term college success. The primary curricular goal of the Statway course sequence is to develop the mathematical proficiency of students pursuing non-STEM academic and occupational programs, with a special focus on statistical literacy. This paper describes the research-based Statway design and its intended learning outcomes, the processes and participants involved in its development, and the challenges of implementation.

Contents

1. Introduction

> Now is the time to build a firmer, stronger foundation for growth that will not only withstand future economic storms, but [will] help us thrive and compete in a global economy. It's time to reform our community colleges so that they provide Americans of all ages a chance to learn the skills and knowledge necessary to compete for the jobs of the future.
>
> —President Barack Obama

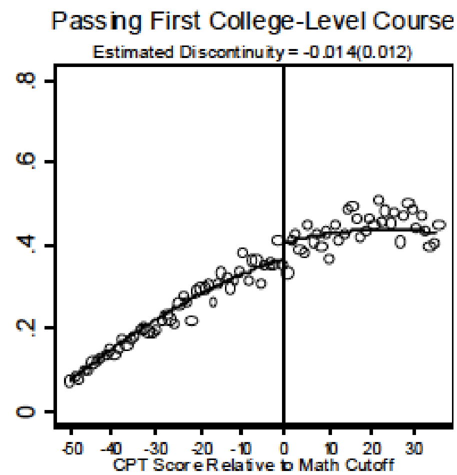
Developmental education is a central pillar of America's community college system. Its critical mission is to enable underprepared students to develop, quickly and inexpensively, the capabilities necessary for college success. The scope of this enterprise is massive. Nationally, about 60 percent of community college students are referred to one or several developmental courses (Attewell, Lavin, Domina, & Levey, 2006; Bailey, Jeong, & Cho, 2010). In some community colleges, more than 90 percent of entering students are deemed insufficiently prepared to start college-level work (Kerrigan & Slater, 2010).

In this time of growing workforce dislocation, the mission of developmental education is especially compelling. But a growing number of research studies document in stark terms the failure in execution of the developmental education enterprise, and the nature of this failure is increasingly well understood (Achieving the Dream, 2008, 2009; Bailey, 2009; Bailey et al., 2010; Bettinger & Long, 2005; Martorell & McFarlin, 2010). Mathematics, in particular, appears to be a nearly insurmountable barrier for a large proportion of the community college student population (Achieving the Dream, 2006c).

The Current State of Developmental Education

Approximately two of three community college students referred to a remedial mathematics sequence do not complete it, as shown in Figure 1 (Bailey et al., 2010). Further, a regression discontinuity study that drew from a large Florida dataset found little evidence of the effectiveness of developmental mathematics education (Calcagno, 2007; Calcagno & Long, 2008). But perhaps more alarming is that this data show that significantly fewer than half of the students with perfect or near-perfect mathematics scores enrolled in and successfully completed a credit-bearing college math course. Studies using Ohio and Texas data report roughly similar results (Bettinger & Long, 2005; Martorell & McFarlin, 2010).

Figure 1: Education Outcome by Math College Entry Level Placement Test Score and Estimated Discontinuity



Source: Bailey (2008).

According to a U.S. Department of Education study (Adelman, 2004), the three courses with the highest rates of failure and withdrawal in postsecondary education are all developmental mathematics courses. To make matters worse, Adelman also found, consonant with the Calcagno study, that the failure and withdrawal rates in the most common credit-bearing, transferable mathematics courses—college algebra and pre-calculus—exceeded 50 percent on many campuses. This is especially disheartening, given that the developmental course sequence is intended to be adequate preparation for these gateway courses. In effect, developmental education has become not an entryway but a burial ground for the aspirations of myriad community college students seeking to improve their lives through education.

Fortunately, improving developmental education is now a major priority of a growing number of federal and state policy-makers, influential foundations, and advocacy organizations. Several national policy organizations have developed comprehensive agendas focused on improving developmental education. In particular, Michael Collins of Jobs for the Future has laid out a compelling policy framework for addressing this challenge. Collins (2009) points to the need for prevention strategies that reduce demand for developmental education as well as strategies to improve placement and assessment practices, increase funding and other support for innovation, and enhance performance measurement and institutional incentives for program improvement. The Getting Past Go initiative of The Education Commission of the States and the Developmental Education Initiative (DEI) have similarly trenchant agendas that address the many dimensions of reforming developmental education (Jobs for the Future, 2010; Vandal, 2010).

Yet despite the multidimensionality of these policy agendas, our experience in working with state-level policy-makers is that these leaders typically have a strong preference for strategies that might obviate the need for developmental education, for example by raising high school graduation standards. In essence, their vision is of a world free from the need for remediation, one in which higher standards alone can successfully improve student achievement. This is a compelling goal, to be sure, but not, in our view, an attainable one. We believe that developmental education is here to stay and that the commitment to a viable second-chance system of higher education is one of our great national strengths—a strength that reflects the American creed of opportunity.

Although more effective preparation of students for college should reduce the need for developmental education, it is unlikely that developmental education will ever be rendered unnecessary by prevention strategies, for several reasons. First, the stakeholders who define requirements for high school graduation have different priorities from those who establish college-readiness standards. The practice of defining college readiness is disproportionately influenced by elite universities, and these institutions are becoming increasingly competitive. High school graduation requirements, conversely, are generally defined through local political processes. Political forces at the local level typically favor standards that most students will be able to meet, whereas the policies of elite universities are intended to identify and attract highly proficient students.

One indicator of the magnitude of this gap is that only 24 percent of ACT-tested 2010 high school graduates met or surpassed all four of the ACT College Readiness Benchmarks, whereas nearly 74 percent of U.S. students successfully matriculated from high school (ACT, 2010; Aud et al., 2010). Another indicator is that 56 percent of all new first-year students in the California State University System—students who successfully completed all high school graduation requirements—were referred to at least one remedial course (California State University, 2008). In short, the tension between elite and mass education suggests there may always be a gap between minimum high school graduation requirements and the effective requirements for college success.

Second, students who return to school after a period in the workforce will likely need to renew basic quantitative skills. This population, which is continually attempting to enhance skills and knowledge, should continue to be supported but would receive little immediate benefit from more stringent high school graduation requirements.

Third, if our country continues to be open to immigrants seeking means to improve their life prospects, some developmental education will, of necessity, be required to smooth the transition from foreign education systems.

Thus prevention strategies alone will not solve the developmental mathematics problem. The challenge, as we see it, is to redesign the developmental education system so that it is a powerful engine of upward mobility for the great majority of students whose economic futures depend in significant part on its effectiveness.

The Statway

In response to this challenge and consonant with its mission, The Carnegie Foundation for the Advancement of Teaching, with the Charles A. Dana Center at the University of Texas at Austin as a principal design partner, is launching a comprehensive initiative to create two new pathways, the Statway[1] and the Mathway, that will enable developmental mathematics students in community colleges to complete a credit-bearing, transferable mathematics course in one academic year while simultaneously building skills for long-term college success.

Work on the Statway, which focuses on statistics, data analysis, and quantitative reasoning, is already underway. Collaborating in the development of the Statway are 19 community college campuses and systems (see Appendix A). They constitute what is known as the “Collaboratory.” Community college faculty and staff participating in the Collaboratory are working with initiative design partners, researchers, and other advisors in a Networked Improvement Community to test and co-develop Statway materials. Additional details about the process of co-development will be described later in this paper. Work on Mathway, designed to take students through a credit-bearing transferable mathematics course focused on developing general quantitative reasoning skills, will be launched by The Carnegie Foundation for the Advancement of Teaching and the Dana Center in fall 2010 with eight community colleges as founding partners (see Appendix B). Carnegie’s work with the Collaboratory colleges is being led by Bernadine Chuck Fong, President Emerita of Foothill College.

What follows is a description of the Statway from the perspective of the authors, two designers centrally involved in its development. While a great deal of our thinking has emerged from work with partners at the Carnegie Foundation, the following prospectus reflects the thinking of the authors, and not the official position of the Foundation. The term “we” is used to denote the ideas of the authors, while the ideas of other members of the Networked Improvement Community are credited individually or as the community collectively.

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[1] Statway is a service mark of The Carnegie Foundation for the Advancement of Teaching.

We describe core portions of the work currently underway as well as our vision for its further development. The Statway is a work in progress, and its shape will be determined not only by the various partners in the Networked Improvement Community but also by the exigencies and vicissitudes of the complex work of educational reform. We begin by describing the mathematical, statistical, and college success goals of the new pathway and their rationales. We then describe the Community's novel improvement-driven approach to research and development that is the prime force shaping the Statway's design. The paper ends with a discussion of various threats to the success of the Statway and a strategy—the joyful conspiracy—that we hope will effectively address them.

2. The Design of the Statway

The primary curricular goal of the Statway course sequence is to develop students' proficiency in important core areas of mathematics with a special focus on statistical literacy. By statistical literacy, we mean not just the ability to execute standard statistical operations—for example, computing a mean or correlation coefficient—but also the ability to reason under conditions of uncertainty, an inescapable phenomenon of modern life. We see statistical literacy as a core skill for effective citizenship, which regularly calls on individuals to make informed inferences from data (Gal, 2002; Garfield & Ben-Zvi, 2007; Wallman, 1993).

Rationale for the Model

The Statway is not intended for individuals pursuing mathematics-intensive majors—for example, those in physical sciences and engineering programs. These STEM majors typically require that students complete an introduction to the calculus that requires, as a prerequisite, high levels of computational facility with algebraic and trigonometric expressions and functions along with sufficient conceptual understanding to use this facility efficaciously. STEM majors also require, at a minimum, that students complete differential equations, linear algebra, and an introduction to the calculus of several variables, as well as core science courses that make substantive use of the calculus.

The Statway, by comparison, is intended for the large population of learners pursuing occupational programs in such fields as the allied health sciences and public safety or academic programs in the liberal arts, business, and social sciences,[2] which frequently require students to complete only a single quantitative course to achieve a credential. In brief, we believe that the traditional algebra-intensive, pre-calculus-focused developmental sequence has the wrong goals for students not bound for STEM majors and thereby creates unnecessary impediments to their academic progress.

As currently taught, these developmental courses typically focus on the development of highly decontextualized procedural skills that the great majority of students will never use in the workplace or in other life endeavors (Grubb, 1999). Indeed, the evidence strongly indicates, as noted in the studies cited above in the Introduction, that success in these developmental sequences does not reliably beget successful performance in college algebra, let alone in introductory calculus. And the image of legions of developmental students learning to factor

[2] We recognize that some allied health sciences and business programs do require calculus, and for these students a more traditional STEM pathway may be more appropriate.

trinomials or rationalize binomial surd denominators absent of a setting in which the transcendent power of mathematics becomes apparent, or absent even of any motivation other than meeting a formal requirement, should be enough to rend the hearts of even the most hidebound mathematicians.

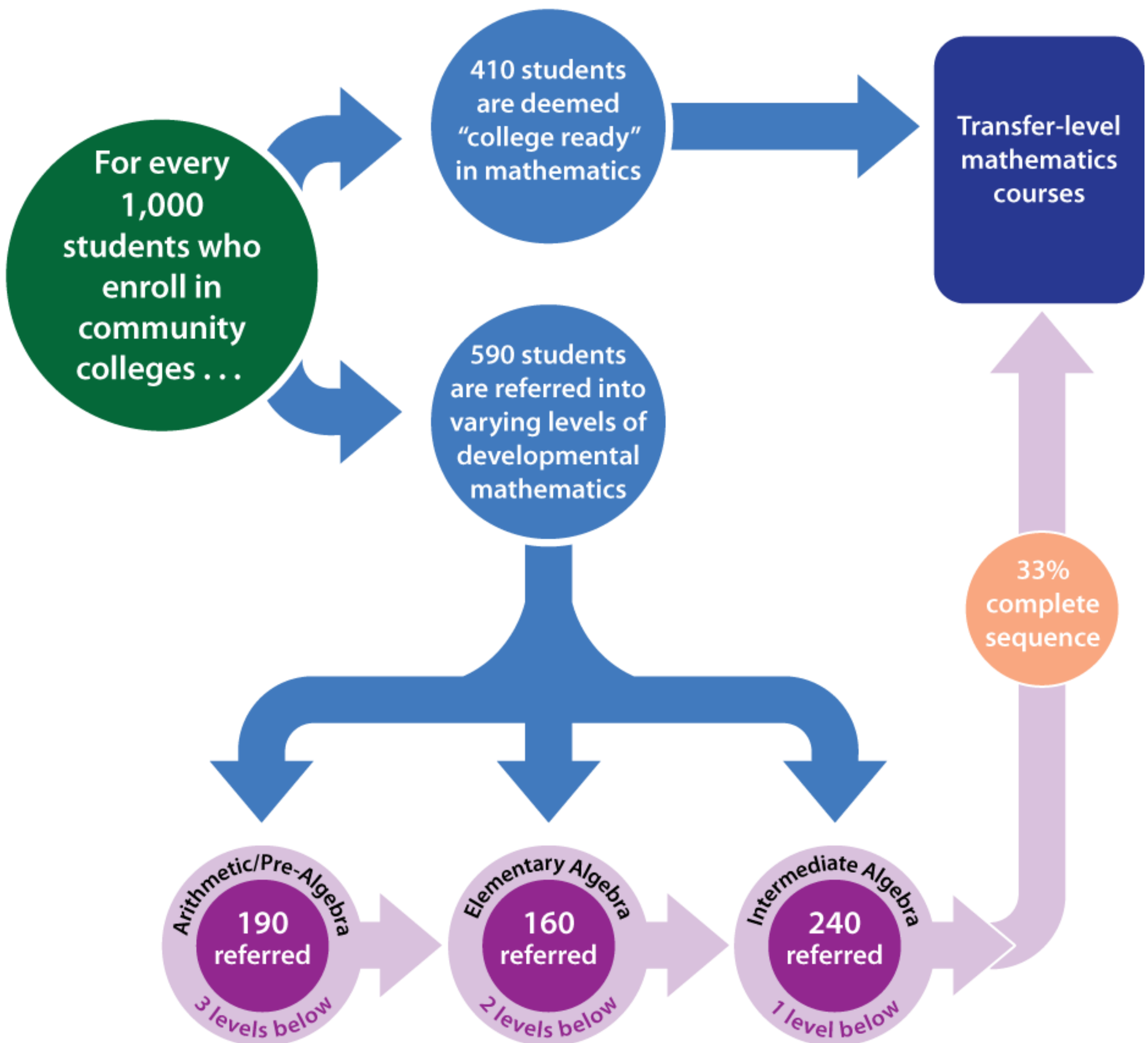
We assert that the great majority of students, whether in STEM majors or not, would benefit from taking statistics, and that the subject needs much greater emphasis in K–12 as well as in higher education. Conversely, calculus may be overemphasized in high school and college (despite the devotion of one of the authors to its subject matter). 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 (see, for example, Schield, 2008). Moreover, a recent study of the use of mathematics in the workplace found that only about one fifth of jobs—including high-paying white-collar jobs—require more than a deep knowledge of middle school mathematics (Carnegie Corporation of New York & Institute for Advanced Studies, 2009; Handel, 2007).

We note also that credit-bearing statistics course enrollments have been growing steadily, at least since the Conference Board of the Mathematical Sciences (CBMS) began surveying undergraduate programs in 1965. The most recent CBMS survey (2005) reported a total of 118,000 undergraduates taking statistics at two-year institutions, an increase of 59 percent since 2000. Of note is that less than 6.5 percent of the mathematics enrollment in community colleges in 2005 was in the first three semesters of calculus. Statistics enrollment in community colleges that year was already larger, at 7 percent. Recent data suggest that collegiate calculus enrollment has been steadily decreasing since at least 1990 (Lutzer, Rodi, Kirkman, & Maxwell, 2007).

The Statway Initiative seeks to further increase statistics enrollments by building an integrated, accelerated pathway that equips students with the mathematical supports necessary to master statistics content deemed worthy of transfer credit by local articulation authorities, and that has the broad support and sanction of the major professional societies of mathematicians and statisticians and of mathematics and statistics educators. The Statway is organized to enable students to complete their introductory mathematics course requirements as rapidly as possible (ideally in one year), and this accelerated timeline is one of its key innovations.

Developmental mathematics is typically taught in a multilevel sequence of courses (see Figure 2). Students may be referred to one, two, or three developmental courses (or even more on some campuses) based on their performance on a placement examination. The normative sequence begins with a basic arithmetic class, followed by pre-algebra, algebra, and intermediate algebra—a rough reflection of the traditional upper elementary to high school mathematics sequence except for the curious omission of geometry, despite its importance to success in calculus, physics, and other introductory STEM courses.

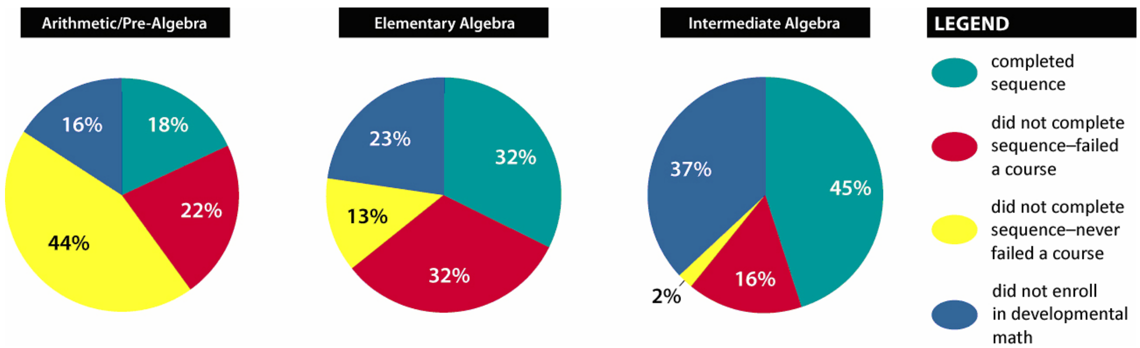
Figure 2: The Typical Developmental Math Sequence in Community Colleges



The multi-course structure of the traditional developmental mathematics sequence impedes student success rather than fostering it (Hern, 2010), as Figure 3 shows. After referral to a developmental sequence, some students fail to enroll in the first class (Achieving the

Dream, 2006b). Others who successfully complete one or more courses do not necessarily continue to the next class. In fact, more students “leak” out of the developmental pipeline because they do not enroll in the first or a subsequent course than because they actually fail a course (Achieving the Dream, 2006c; Bailey et al., 2010).

Figure 3: Proportion of Student Outcomes in the Developmental Math Sequence



Desired Learning Outcomes

To create a set of broadly sanctioned Statway outcomes, The Carnegie Foundation for the Advancement of Teaching created the Carnegie Committee on Statistics Learning Outcomes (CCSLO), composed of senior leaders of the major mathematics and statistics professional organizations as well as distinguished community college mathematics and statistics faculty members (see Appendix C for a list of participants and their affiliations). Early in the outcome-development discussions, four critical design issues arose.

The first is that if, as we suspect, the Statway will be the only collegiate mathematics experience for some students, the pathway must ensure that these students master not only important statistics content but also the basics of middle and early high school mathematics, which studies (such as the study by Handel [2007], referenced above) show are essential in the workplace. The CCSLO strongly recommended that such basic mathematical content should, whenever possible, be taught in the service of the statistics outcomes. But the committee also acknowledged that some exceptions would be necessary. For example, the basics of exponential functions might need to be introduced in a self-contained mathematics unit, perhaps emphasizing the essentials of financial literacy (Briggs, 2004).

The second issue, which presents a daunting design challenge, is the need to prepare students for the possibility that they might change their goals after completing the Statway and seek to switch to a math-intensive major that does require calculus. The new pathways must function to increase rather than restrict academic and career options. Planning for students' change of plans is especially crucial in the community college sector since, while a great majority of its students begin their studies with very high confidence in their ultimate success, many have a limited understanding of their possible academic and professional options (Center for Community College Student Engagement [CCCSE], 2009; Grubb, 1996). Indeed, one of the most important missions of community colleges is to help students determine the most productive uses of their lives in ways that are compatible with their personal preferences and values.

As part of a preliminary Statway blueprinting exercise, we interviewed mathematics and developmental mathematics faculty members on a dozen community college campuses. Their concern about possibly limiting new curricular options was paramount. Many faculty members reported that the moment when developmental mathematics students realize that they can truly succeed in mathematics can be transformative, emboldening them to raise their academic and professional aspirations.

During these early stages of developing the Statway, the strategy will be to selectively recruit only students who have declared, with high levels of certainty, a non-STEM major for which statistics is the appropriate quantitative preparation. Care is also being given to the choices of algebraic content within the Statway that are most critical for productive citizenship.

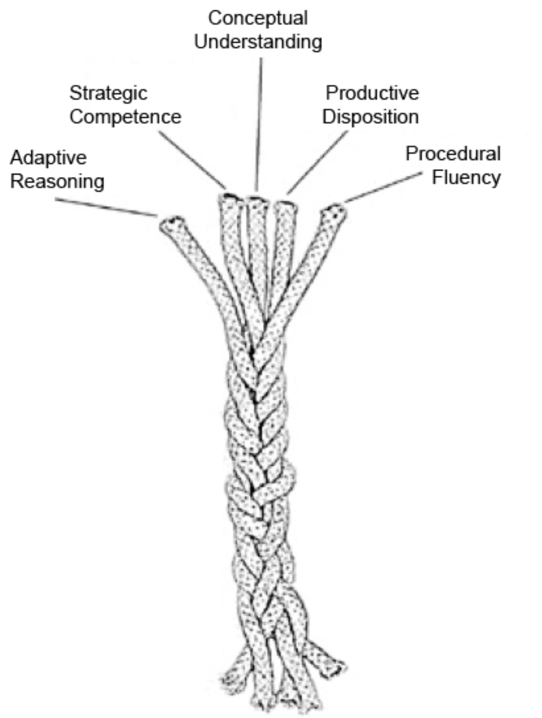
The third design challenge is the need to create a set of curricular outcomes that will ensure that the Statway will both pass muster with local articulation authorities and avoid igniting a "math war," such as happened in many K-12 state standard-setting exercises (Wilson, 2003). Fortunately, the CCSLO was able to build directly on both the AP Statistics framework and the Guidelines for Assessment and Instruction in Statistics Education, known as the GAISE standards (American Statistical Association, 2007). The AP and GAISE standards share much in common and have met articulation requirements in many higher education systems, including the large California State University System (see, for example, San Francisco State University [SFSU], 2010).

The fourth critical design issue is to assure that the new pathways do not lessen the rigor or intellectual challenge of the basic developmental sequence or, more broadly, of the students' collegiate mathematical experience. The challenge is to show that it is possible to create an intellectually demanding program that will likely enable more students to make a successful transition to college mathematics. While the choice of statistics as a focus of a new pathway was primarily motivated by the belief in its importance and centrality to the mathematical sciences (Steen, 1988), statistics also makes fewer demands on students' symbolic processing skills.

Our approach to addressing rigor has been to define explicitly what is meant by *mathematical proficiency*, and our approach to this challenge has been deeply influenced by the work of a Special Mathematics Learning Committee impaneled by the National Research Council of the National Academies in 2000. One of this paper's authors (Treisman) served on a special oversight commission guiding the committee's work. In its seminal report, *Adding It Up: Helping Students Learn Mathematics*, the committee defined proficiency as comprising five independent but intertwined strands: strategic competence, conceptual understanding, procedural fluency, adaptive reasoning, and productive disposition (see Figure 4). *Strategic competence* refers to the ability to formulate, represent, and solve mathematical problems. *Conceptual understanding* describes students' grasp of mathematical concepts, operations, and relations. *Procedural fluency* describes the ability to carry out procedures flexibly, accurately, efficiently, and appropriately. *Adaptive reasoning* refers to the capacity for logical thought, reflection, explanation, and justification. And, finally, *productive disposition* reflects a view of mathematics as sensible, useful, and worthwhile, together with a belief in diligence and self-efficacy (National Research Council, 2001).

Together, the five stands of proficiency encompass not only the specific mathematical skills that students will need for future coursework and employment but also the dispositions and characteristics that research suggests students must develop to succeed in using mathematics productively in their future coursework and professions. This notion of proficiency reflects advances in the learning sciences concerning how people develop general intellectual competence (Bransford, Brown, & Cocking, 2000) and, specifically, how students learn mathematics (Bransford & Donovan, 2005; Donovan & Bransford, 2005; Lester, 2007). It also draws upon now well-established principles of mathematics learning and instruction (Henningson & Stein, 1997; Weiss & Pasley, 2004) and, in particular, special challenges in learning statistical ideas (Garfield, 1995).

Figure 4: Intertwined Strands of Mathematical Proficiency



Source: National Research Council (2001).

Instructional Design

We recognize that many Statway students will have experienced repeated failure in earlier K-12 math courses and that some students will have special learning needs. Research suggests that these students will especially benefit from explicit Statway instructional routines that help them organize critical mathematics content (Bulgren & Schumaker, 2006; Deshler et al., 2001). Many will also benefit from a variety of instructional and programmatic strategies that explicitly challenge deep-seated, debilitating misconceptions about the nature of mathematical learning. Yet others will benefit from a careful effort to insure that Statway instructional materials are developed with the needs of English Language learners in mind. The Carnegie Foundation has enlisted Stanford professor Guadelupe Valdes as a senior partner to address the latter point.

This new work in the learning sciences points to a powerful set of principles that we believe should inform the Statway's instructional design. Among these are the importance of ensuring that students:

1. Engage in appropriately challenging and natural, authentic tasks that involve active meaning making;

2. Connect new learning with their prior knowledge in ways that address well-documented common misconceptions and that anchor new concepts in existing competencies;

3. Develop adequate conceptual understanding to support knowledge transfer and, in particular, the productive use of newly acquired skills to solve novel problems;

4. Develop the ability to communicate using mathematical and statistical language, which will require them to learn relevant vocabulary and language structures of the disciplines;

5. Receive timely feedback so they can revise their work, thought processes, and understandings;

6. Develop conceptual and procedural fluency by practicing important skills, concepts, and principles in a variety of contexts increasingly distant from the context in which they learned them; and

7. Develop metacognitive awareness of their performance—for example, by developing strategies that allow them to self-monitor when solving a problem.

The Carnegie Foundation is in the process of developing a final set of lesson design principles that align closely with many of the ideas presented above. The Dana Center has been charged with developing the initial set of instructional materials that will embody the design principles. These materials will then be refined by Collaboratory faculty members in a process influenced by Japanese lesson study (Fernandez & Chokshi, 2002; Lewis & Tsuchida, 1998; Stigler & Hiebert, 1997). The modified lesson study protocols are being developed by Carnegie senior partner James Stigler and Carnegie consultant William Saunders. Once tested, refined, and piloted during 2010–2011, the lessons will be made available to the public as open education resources.

The provisional outline delineating the course mathematics and statistics outcomes, a model lesson, and a preliminary scope and sequence were vetted at the Summer Institute—the first convening of the 19-member Statway Collaboratory in July 2010. In addition, the major professional society members of the CBMS were asked to provide structured feedback on the outcomes in ways that reflected their particular organizational traditions and operating procedures. Many professional societies convened formal Association Review Groups (ARGs) and submitted thoughtful and detailed critiques. Overall, the professional and campus Collaboratory feedback was exceptionally positive, and the feared divisions concerning a statistics-intensive introductory course sequence did not materialize. Revisions to the outcomes and scope and sequence are under way and will be posted on the Carnegie Foundation for the Advancement of Teaching and Dana Center websites in 2011.

The preliminary Statway scope and sequence are broadly consistent with the most common organizational approaches taken in introductory courses offered by mathematics and statistics departments across the country. There is growing standardization of these courses, with only a few differences concerning a handful of key topics—the most common being the point at which to introduce approaches to data collection, the level of mathematical formalism used in the introduction of probability measures and random variables, and whether inference for proportions or for means is covered first. Decisions about the Statway preliminary scope and sequence are being driven by a desire to make minimal demands on students' prior mathematical experience and to introduce core mathematical topics in ways that directly support mastery of the statistics content, as suggested by the CCSLO.

While we expect that the Statway will ease students' successful transition to college, we anticipate that it will raise the demands on faculty's pedagogical skills. Many Statway faculty members will need to learn, for example, how to use formative assessments and authentic problems to drive student learning. Many will need to cultivate skills to help students develop conceptual understanding. One of the central challenges of the Statway initiative is the development of a robust, respectful professional support system for the faculty who teach the new pathway. Work on this support system began in the Collaboratory's first summer meeting and will continue throughout the project. A survey of Collaboratory faculty members' professional learning histories and preferences is currently under development in a process led by Carnegie consultant Kay Merseth of the Harvard Graduate School of Education.

New Approaches to Student Success

The Networked Improvement Community hypothesizes that changing the mathematical content and organizational structure of developmental mathematics will have a substantial effect on student success rates, but its members understand that the Statway, when bundled with a robust approach to supporting student success, can have a much greater effect. Work on a definition of the Statway's college success outcomes and strategies for achieving them began in spring 2010, but a comprehensive strategy has yet to be developed.

The following ideas are the authors' and have been shaped by three factors: (1) their prior work with community colleges, (2) Treisman's earlier work in developing the Emerging Scholars Program, and (3) emerging findings from psychological and learning sciences research.

Close Collaboration between Faculty and Administrative Units

In our prior work with community colleges, we observed that many had well-established, complex ecologies of student support systems and innovative course sequences, often with local faculty and administrator constituencies that strongly supported them. But we commonly found a significant disconnect between activities aimed at supporting student success led by faculty and those led by administrative student services units. Few of the campuses we visited had a history of—or appetite for—trying to directly shape what happens between students and faculty members in mathematics classrooms, whether physical or virtual. As one community college governance leader put it succinctly, "campus leadership is often loathe to annoy the faculty." On most campuses, the major student support structures are the direct responsibility of administrative units, while the courses are, naturally, the province of the faculty. This has been the case since campuses began to professionalize student advising and support at least four decades ago.

There are, fortunately, important exceptions, where close collaboration between faculty and administrative units to increase student success is well established. The most outstanding examples, in our view, are connected to national organizations, such as the Achieving the Dream Initiative, the League of Innovation in the Community College, and the National Center for Academic Transformation (NCAT). Achieving the Dream in particular has worked successfully to raise the evidence standard for local improvement work on many campuses and has strengthened the culture of data-driven decision making in a wide variety of long-term strategic campus initiatives (Brock et al., 2007; Jenkins & Kerrigan, 2009).

In fact-finding visits to a dozen campuses well known for successful innovation, we were struck by the extraordinary creativity of local faculty and administrators in combining powerful ideas rooted in deep practice wisdom with idiosyncratic local particulars to create improved campus practices. Examples of local particulars include the systematic mobilization of faculty members with special and relevant interest and skills, the creative use of fungible campus resources, and the reanimation or repurposing of unique campus structures or programs. This highly specific combination of good ideas and local resources is one reason, we conjecture, that so few examples of local innovative practices are being replicated on other campuses. We were also surprised to observe that while many of the campuses we visited were proud of their learning communities, case management systems, college success courses, and other elements of what might be thought of as a standard student services armamentarium, the content of these practices varied enormously from place to place. Our preliminary review of college success courses and of academic boot camps, for example, found extraordinarily diverse structures and practices attached to these generic names.

In many ways, even the campuses working most actively to improve student success are doing so in a kind of solitary confinement, unaware of the progress and high-yield, detailed practices of others. There are far too few examples of a Campus B successfully building on the work of a Campus A. Moreover, many campus leaders told us that not only is it hard to learn from others, but the weak and poorly funded R&D structures on their campuses and the heavy compliance requirements that campus institutional research officers must address also make it hard for them to learn even from their own work, resulting in a form of induced institutional amnesia.

We believe that the Statway initiative provides an opportunity for campuses to work together not only on common solutions to common course-design needs but also on new, more effective, scientifically based approaches to supporting their students' academic success. There is broad interest among Collaboratory campuses in doing so. There is also a general recognition that while the most effective strategies are certainly helpful to the students who use them, their effect sizes are small, and the students who need the strategies most are not always the ones who receive them. This sense of limited effectiveness is borne out by a series of studies by MDRC (Scrivener et al., 2008; Scrivener & Weiss, 2009; Visher, Butcher, & Cerna, 2010; Zachry, 2010).

Intensification of Students' Connections to Peers, Instructors, and College Resources

As for the second force shaping our college success work, insights gained from Treisman's earlier efforts to create effective pathways to STEM majors, especially for first-generation college students and other groups historically underrepresented in mathematics-intensive professions (Asera, 2001; Treisman, 1992), have been key. One aspect of this work that we expect to be relevant to the Statway is the importance of deepening and intensifying the complexity of students' connections to their peers and instructors, and, more broadly, to campus resources. In addition to the acculturative value of properly constructed academic and social connections, such connections provide students with an explicit mechanism for normalizing their expectations of what their instructors, advisors, and institution expect from them. This knowledge enables students to better organize their academic lives and to make better use of campus resources when needed.

Treisman's experience crystallized the importance of helping students learn to navigate the boundaries of the academic and social worlds of higher education. In particular, helping students to develop and "try on" identities as mathematicians, as academics, and as professionals increased their productive persistence in their studies and, he conjectured, shaped the way they made sense of the academic content they were studying.

Enrollment in Fewer Courses Overall and Developmental Education Courses First

Treisman also found that students new to higher education can benefit by initially enrolling in fewer courses than is typical but engaging in them more intensively, under the coordinated direction of a small number of faculty and professional staff who know them and serve as their advocates. Adjusting to the intensity of college coursework may be one of the greatest challenges for new college matriculants (Conley, 2007; CCCSE, 2009a), and a smaller but more intense course load may help students by encouraging them to set priorities early and force out distractions. Furthermore, supporting students in their first two to four weeks of college may be especially critical (CCCSE, 2009a).

Specifically Treisman observed that although a majority of the faculty members he surveyed perceived struggling students to be insufficiently motivated to succeed, many of them entered college with extremely high confidence that they would succeed. However, these students almost immediately had their confidence shaken by a hard homework assignment or challenging lecture (Treisman, 1992). As the students lowered their estimates of success, they hedged their bets and adjusted their commitment to school downward, often adding hours of paid employment and missing classes. This led to a systematic cycle of disinvestment that ultimately led to failure despite students' understanding of the importance of their success. In picoeconomic terms, they increasingly over-discounted the future value of academic success (Ainslie, 1992; Laibson, 1997).

We recognize, of course, that community colleges serve a more diverse population of students than Treisman studied at Berkeley. Many community college students face complex life challenges that might make pursuit of an accelerated pathway challenging. A recent study from the Center for Community College Student Engagement (CCCSE, 2009b) found that 54 percent of community college students work more than 20 hours a week and that many cite lack of money (46 percent) and caring for dependents (28 percent) as reasons that they would be very likely to withdraw from their studies. Nonetheless, we believe that research supports a policy that encourages, if not requires, most students to complete their developmental coursework as early in their academic careers as possible (Achieving the Dream, 2006a, 2008).

A Support Framework Based on Students' Assets and Confidence in their Abilities

Finally, and perhaps most important, Treisman rejected what he saw as debilitating, deficit-based frameworks that dominated the organization of student support services. He noted in his original studies that the very lexicon of student services was organized around the putative weaknesses of the students that they were designed to help and that one result was the focus on helping students pass courses rather than excel in them. He thus organized his Emerging Scholars Program around what he believed were important assets and attributes students brought to college, which he believed could be developed and nurtured to increase the likelihood of success. The program took seriously students' high motivation at entry and endeavored to prevent the disinvestment cycle described above.

The third force shaping our work is, therefore, a growing corpus of psychological research that describes the subtleties of motivation, persistence, self-efficacy, self-regulation, goal setting, sense of belonging, and other malleable characteristics, capacities, and beliefs that are known to shape human performance. Zimmerman (2002) and his colleagues at the City University of New York have shown that students can be taught to more accurately judge their effectiveness on certain academic tasks and that better calibration skills improve their academic performance. Lerner and his colleagues, as well as Weinstein, have documented the ways that skill in goal selection, optimization, and compensation can be taught, and the significant positive effects such learning can have on academic performance and persistence (Lerner, Easterbrooks, Mistry, & Weiner, 2003; Weinstein, Schulte, & Palmer, 1987).

Inzlicht and Good (2006) have documented the significant effects that a sense of belonging to an intellectual community can have on academic persistence and success and the ways that such a sense of belonging can moderate the effects of stereotype threat and other social–psychological phenomena that can lower academic performance (Aronson & Steele, 2005; Steele & Aronson, 1995). Her work on belonging and identity may clarify the ways in which interventions that deepen students' connections to each other and to campus services contribute to students' success (Aronson, Fried, & Good, 2002; Light, 2001; Tinto, 1997). Dweck (2002) and her colleagues have shown that students' beliefs about the nature of their intelligence profoundly affects the kinds of goals they pursue and that these goal choices can promote or derail learning.

The challenge for the Networked Improvement Community is to determine how to mine this powerful research knowledge to design new support structures for students. An initial effort at organizing relevant social psychological literature by Fong and Asera (2010) appears on the Carnegie website, along with a preliminary scan of college success courses and their content by Hope (2010).

At the 2010 Summer Institute, Collaboratory participants developed an initial list of 14 attributes that they believe can be developed and nurtured to increase students' success. These attributes include, for example: (1) a belief that, with effort, one can be successful in mathematics; (2) the ability and decision to persist in the face of confusion and even failure; and (3) the ability to form productive relationships to support success. Participants at the meeting agreed that developing these and other success-linked attributes is a proper goal of a new, common, college success strategy.

An Improvement-Focused Approach to Research and Development

At the heart of the Statway Initiative is a novel approach to improvement-focused organizational learning and development that is designed to create promising solutions to critical, high-leverage problems of teaching and learning. The approach, called Design Educational Engineering Development (DEED), has been conceptualized in papers by Carnegie's president, Anthony S. Bryk, and University of Pittsburgh professor and Carnegie senior partner Louis Gomez (Bryk, 2009; Bryk & Gomez, 2008), with significant contributions from Alicia Grunow, Carnegie associate partner. What follows is a brief description of the DEED approach and its influence on the development of the Statway.

In a 2010 interview, Gomez delineated six core DEED principles that are primary forces shaping the Statway project and its work with Collaboratory campuses:

- Anchor R&D efforts in important, specific, and measurable improvement problems.
- Recognize that improvements at scale on complex educational problems entail sustained, coordinated efforts across diverse sources of expertise.
- Affirm the power of practical design, educational engineering, and development activity (DEED) for advancing continuous improvements over time.
- Acknowledge that the formation of such an intentionally designed network of expertise entails not only new ways of working but also new norms for practice.

- Embrace a performance-improvement ethic through which change efforts are guided by a common analytic framework that is constantly tested and revised against emerging evidence about what is and is not working, for whom, and under what set of circumstances.

- Exploit the capacities of open resources to accelerate both innovation and the rapid diffusion of demonstrated effective practices.

In operationalizing these principles, the challenge for the Networked Improvement Community will be to create reliable, robust, and efficient protocols that lead to fundamental program and service innovations, as well as to introduce what can become normative, Collaboratory-wide supports for continuous process improvement. In this regard, the new pathways initiative owes a great debt to the Institute for Healthcare Improvement (www.IHI.org) and its improvement strategies. IHI has developed and tested a set of protocols for choosing a potential improvement, testing its effects, implementing change when merited, and disseminating the enacted, refined improvement and the evidence for its efficacy (Langley et al., 2009). At the macro level, these IHI processes are organized around powerful but pragmatic questions like those we are trying to address: "How will we know that a change is an improvement?" and "What changes can we make that will result in improvement?" At the next level down, the improvement process is driven by rapid prototyping consisting of consecutive "plan, do, study, act" cycles.

One example of the Statway initiative's approach to improvement is the planned use of the simplified version of Japanese lesson study, referred to above, to systematically and iteratively improve and refine an initial set of Statway lessons being developed by the Dana Center. The Statway's seven-step lesson study protocol closely mirrors the IHI strategy and has deep roots in the mathematics education community. Another example is the process for improving the Statway course outcomes. We are developing a validation framework for the outcomes in which a warrant is attached to each core curricular element. These warrants might assert a claim that a topic is critical for subsequent coursework, or for a subsequent topic, or perhaps is intellectually central to the discipline. The plan is to collect evidence about the warrants so that when the outcomes are revised, which we expect will happen every three to five years, the revision will be driven not only by professional judgment but also by evidence.

We also envision validating a core set of Statway instructional tasks by collecting data on their effectiveness in supporting later learning. Specifically, if students master Task A, with what probability will they master Task B? This practice of instructional task validation is increasingly common in modern, technology-mediated instructional support systems.[3] The Carnegie Foundation is building a common Statway data system that can support such analyses, and Collaboratory campuses have agreed in formal memoranda of understanding to collect and report data on a common set of core Statway assessments. The goal is to raise the standard of efficacy evidence for the instructional tasks faculty use to help students learn important concepts and skills.

[3] See, for example, Wireless Generation (www.wirelessgeneration.com) and the Dana Center's collaboration with Agile Mind (www.agilemind.com).

3. Conclusion: The Joyful Conspiracy

Scaling the Statway so that it serves large numbers of students now placed in developmental mathematics courses will be a daunting challenge with manifold opportunities for failure. Faculty members have almost unfettered autonomy in deciding how to use their time. Further, incentive and authority structures are highly decentralized, with departments, colleges, and professional societies each playing key roles in shaping faculty conceptions of responsible and normative practice. The mix of faculty autonomy and highly dispersed incentive and authority structures constitutes an almost perfect immunological system that enables higher education to reject efforts, political or educational, to change its core practices. Higher education is effectively organized to protect academic freedom, but, as Ewell (2002) has observed, its organizational features also "act to subvert change of *any* kind."

While the organization of higher education presents barriers for any systemic change initiative, the particular innovations we hope to spread are likely to engender special challenges. Among them is the fact that in most community colleges the majority of developmental courses are taught by part-time, adjunct faculty members. These educators, while typically selected for their content knowledge and pedagogical skills, are rarely provided the time to learn new skills or to participate in institutional program improvement activities. Indeed, some community colleges have begun to hire developmental education instructors through temporary employment agencies (Jaschik, 2010).

Even for senior mathematics faculty members, those who teach the Statway will have to learn demanding new pedagogical and assessment routines, which will take time and effort. Scaling activities that require increased energy output are quick to lose steam as they move from an initial group of developers and advocates to a broader population of faculty members who have not been involved in the pathway's creation. To compensate for the special demands of teaching the Statway, it will be necessary to provide faculty members with productivity tools that make at least some parts of their teaching more efficient—this is a design priority.

Another challenge to scaling the Statway is that it is designed to address the "instructional triangle"—that is, the ways in which faculty members and students interact with one another and with mathematical and statistical content in the classroom (Cohen & Ball, 1999). Scaling such instructional innovations is especially challenging (Elmore, 1996; McLauglin & Mitra, 2001) and requires detailed attention to the spread of supportive norms, principles, and beliefs that can support the new instructional practices (Coburn, 2003).

Added to the mix of challenges, expenditures on instruction and student services have been dropping as a proportion of total institutional spending (Desroacherset et al., 2010). As community colleges continue to face fiscal challenges, it is imperative that the Statway be economically efficient.

In her insightful history of the Emerging Scholars Program, Asera (2001) recounts the lessons learned in scaling that initiative. She points to the formidable challenges of moving from pilot to established offering and from soft funding to hard. She emphasizes the need for vigilance, lest there be a recrudescence of the practices the innovation was designed to address. Further, Kezar (2008) notes that successful higher education change initiatives require coordinated action at many levels—faculty, campus administrative, institutional governance, private foundations, and disciplinary societies and associations, and so on. And work at each of these different levels is typically driven by a different operating theory of change, which makes planning for coordination essential.

Despite these challenges, we note that higher education has not been static and indeed has always shown the capacity to respond to national needs. We have been encouraged by, and draw inspiration from, the rapid spread and now broad adoption throughout higher education of service learning, LEED certification, the use of technology-mediated learning systems, and increasingly, of open education instructional resources.

As D'Orazio (2009) observes, these positive examples of scaling suggest the power of intermediary organizations to bring about and sustain change in higher education. These intermediaries (such as Campus Compact in the case of service learning), each dedicated to their particular causes, can facilitate effective collaboration across campuses, permit campus and external partners to share mutual expectations for transformative work, provide spaces to develop substantive products, and efficiently disseminate the benefits of successful change (see also Ewell, 2002).

Because of its longstanding role as an influential and trusted convenor, The Carnegie Foundation for the Advancement of Teaching is well situated to play such a coordinating, intermediary role in transforming developmental mathematics education. It has created a set of overlapping advisory and working groups comprising influential senior leaders from the many levels at which action will be necessary. These groups offer direct connection to key policy-makers and foundation heads, system governance and professional society leaders, administrative leaders, and influential faculty members. At Carnegie and Dana, this strategy is known as the "joyful conspiracy," designed to help community colleges realize what we see as their most important mission: providing a reliable pathway to upward social and economic mobility for all who seek to improve their lives through education.

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Appendix A: Statway Collaboratory Colleges

State	College	City
California	American River College	Sacramento
	Foothill College	Los Altos Hills
	Mount San Antonio College	Walnut
	Pierce College	Woodland Hills
	San Diego City College	San Diego
Connecticut	Capital Community College	Hartford
	Gateway Community College	North Haven
	Housatonic Community College	Bridgeport
	Naugatuck Valley Community College	Waterbury
Florida	Miami Dade College	Miami
	Tallahassee Community College	Tallahassee
	Valencia Community College	Orlando
Texas	Austin Community College	Austin
	El Paso Community College	El Paso
	Houston Community College	Houston
	Northwest Vista College	San Antonio
	Richland Community College	Dallas
Washington	Seattle Central Community College	Seattle
	Tacoma Community College	Tacoma

Appendix B: Mathway Collaboratory Colleges

State	College	City
Georgia	South Georgia College	Douglas
New York	Westchester Community College	Valhalla
	Onondaga Community College	Syracuse
	Borough of Manhattan Community College	New York
Ohio	Cuyahoga Community College	Cleveland
	Sinclair Community College	Dayton

Appendix C: Members of the Carnegie Committee for Statistics Learning Outcomes (CCSLO)

Committee Member	Professional Affiliation
Kris Bishop	Charles A. Dana Center at the University of Texas at Austin
Richelle (Rikki) Blair	American Mathematical Association of Two-Year Colleges (AMATYC); Lakeland Community College, OH
David Bressoud	Mathematical Association of America (MAA); Macalester College, MN
Bernadine Chuck Fong	The Carnegie Foundation for the Advancement of Teaching
John Climent	American Mathematical Association of Two-Year Colleges (AMATYC); Cecil College, MD
Peg Crider	Lone Star College, Tomball, TX
Bob del Mas	Consortium for the Advancement of Undergraduate Statistics Education (CAUSE); University of Minnesota
Karen Givvin	University of California, Los Angeles
Larry Gray	American Mathematical Society (AMS); University of Minnesota
Susan Hull	Charles A. Dana Center at the University of Texas at Austin
Rob Kimball	American Mathematical Association of Two-Year Colleges (AMATYC); Wake Technical Community College, NC
Dennis Pearl	Consortium for the Advancement of Undergraduate Statistics Education (CAUSE); The Ohio State University
Roxy Peck	American Statistical Association (ASA); Consortium for the Advancement of Undergraduate Statistics Education (CAUSE); California Polytechnic State University
Myra Snell	American Mathematical Association of Two-Year Colleges (AMATYC); Los Medanos College, CA
Jim Stigler	The Carnegie Foundation for the Advancement of Teaching; University of California, Los Angeles
Daniel Teague	Mathematical Association of America (MAA); North Carolina School of Science and Mathematics
Uri Treisman	The Carnegie Foundation for the Advancement of Teaching; Charles A. Dana Center at the University of Texas at Austin