

Feature From the National Academies

Changing and Evolving Relationships between Two- and Four-Year Colleges and Universities: They're Not Your Parents' Community Colleges Anymore

Jay B. Labov

National Academy of Sciences and National Research Council, Washington, DC 20001

This paper describes a summit on Community Colleges in the Evolving STEM Education Landscape organized by a committee of the National Research Council (NRC) and the National Academy of Engineering (NAE) and held at the Carnegie Institution for Science on December 15, 2011. This summit followed a similar event organized by Dr. Jill Biden, spouse of the Vice President, and held at the White House in October 2010, which sought to bring national attention to the changing missions and purposes of community colleges in contemporary American society.¹ The NRC/NAE event built on the White House summit, while focusing on the changing roles of community colleges in science, technology, engineering, and mathematics (STEM) education. An in-depth summary of the summit was prepared by the NRC and NAE for publication in late Spring 2012 by the National Academies Press (NRC and National Academy of Engineering, 2012). This paper provides a synopsis of that report, which is available at www.nap.edu/catalog.php?record_id=13399, and emphasizes how we can use the report to improve STEM education for our students, but also how much progress still needs to be made to realize this ideal.

As participants at the summit emphasized, the traditional notion of a cadre of students moving smoothly through a pipeline from high school to a community college and then to a 4-yr college or university is providing an increasingly inadequate and incomplete picture of today's postsecondary students. The presentations from the summit, summarized here, collectively make a compelling case that it would be

a mistake for any 4-yr institution to ignore or dismiss the importance of community colleges, with their many roles in and contributions to improving STEM education. Leveraging these new realities will create new opportunities for improving STEM education for a much larger and more diverse population of college students through strategic and dynamic partnerships between 2- and 4-yr colleges and universities. These findings have broad utility both for readers of *CBE—Life Sciences Education* in our efforts to improve biology

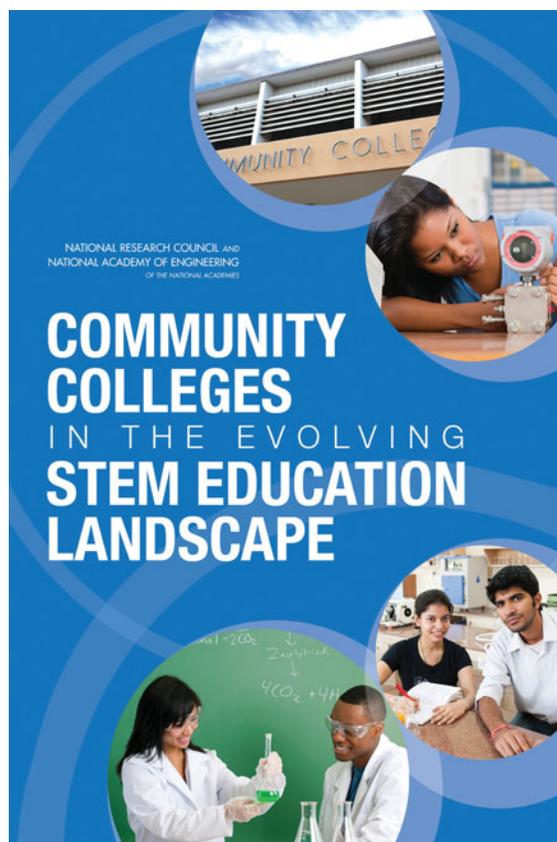
DOI: 10.1187/cbe.12-03-0031

Address correspondence to: Jay B. Labov (jlabov@nas.edu).

© 2012 J. B. Labov. *CBE—Life Sciences Education* © 2012 The American Society for Cell Biology. This article is distributed by The American Society for Cell Biology under license from the author(s). It is available to the public under an Attribution–Noncommercial–Share Alike 3.0 Unported Creative Commons License (<http://creativecommons.org/licenses/by-nc-sa/3.0>).

“ASCB®” and “The American Society for Cell Biology®” are registered trademarks of The American Society for Cell Biology.

¹Additional information about the White House summit is available at www.whitehouse.gov/communitycollege.



education in particular and STEM education more generally, and for the departments and institutions in which the strategies are employed.

BACKGROUND

Community colleges are becoming an increasingly important sector of the higher education community in the United States. With nearly 6.5 million students enrolled annually (46% of the nation's undergraduates), the nearly 1200 community colleges across the United States educate large numbers of students at a much lower cost than 4-yr institutions (e.g., Center for College Affordability and Productivity, 2010a). Students at a community college are typically far more diverse than their 4-yr counterparts in the same geographic location. Forty-seven percent of all African Americans, 47% of all Asian or Pacific Islanders, 55% of all Hispanics, and 57% of all Native Americans who are enrolled as undergraduates in the United States are currently studying in the nation's community colleges (compared with more than 3000 4-yr colleges and universities). Enrollments of these minority students are thus far higher in community colleges than in many non-minority-serving 4-yr institutions. Half of all baccalaureate degree recipients began their college careers at community colleges (National Commission on Community Colleges, 2008; Center for Community College Student Engagement, 2010).

Community colleges fulfill multiple missions. Some have established ongoing relationships with local community organizations, governments, and businesses, which allows them to respond quickly to changing community needs. They may retrain displaced workers in skills needed by local businesses and open gateways to individuals who would otherwise lack the preparation or financial resources needed to receive a college education (Boggs, 2010; Center for College Affordability and Productivity, 2010a, b). The College Board's National Commission on Community Colleges (2008, p. 5) argues that community colleges "are the nation's overlooked asset. As the United States confronts the challenges of globalization, 2-yr institutions are indispensable to the American future. They are the Ellis Island of American higher education, the crossroads at which K–12 education meets colleges and universities, and the institutions that give many students the tools to navigate the modern world."

Community colleges are also playing increasingly important roles in preparing grade K–12 teachers. The community college system has long been involved with preservice preparation of teachers, including teachers of mathematics and science (National Science Foundation [NSF], 1998; Recruiting New Teachers, Inc., 2002; Townsend and Ignash, 2003; Barnett and San Felice, 2005, 2006; National Association of Community College Teacher Education Programs [NACCTEP], 2008a,b; Patton, 2008; Fathe and Kasabian, 2009). Nearly half of elementary and middle school preservice teachers take some or all of their mathematics and science courses at 2-yr colleges (NSF, 1998, National Science Board, 2006). However, as is summarized in this article, multiple barriers remain, inhibiting successful transfer to 4-yr institutions for would-be teachers (see, e.g., Shkodriani, 2004).

Increasing numbers of community colleges also offer professional development for in-service teachers. According to

the NACCTEP (2008a,b), many community colleges offer focused courses, workshops, and institutes that boost teacher competency, especially in math, science, and technology. And many 2-yr collaborative preservice and professional development programs between K–12 school districts and higher education involve community colleges.

The roles of community colleges in the preparation of students for the STEM workforce are also becoming more visible and essential. Nearly half of U.S. students with bachelor's degrees in science and engineering attended community college at some point during their education (Tsapogas, 2004). Almost one-third of the recipients of science or engineering master's degrees began their postsecondary education at a community college. As noted above, nearly half of the nation's teachers, including teachers of science and mathematics, completed at least some of their mathematics or science courses at community colleges.

Some states now permit community colleges to offer baccalaureate degrees in certain fields (Floyd *et al.*, 2005; Lewin, 2009; Russell, 2010). Institutions that offer these degrees have established the Comprehensive College Baccalaureate Association to represent them. A few community colleges award graduate degrees. And, according to Dr. George Boggs, former president and CEO of the American Association of Community Colleges, increasing numbers of students who have earned baccalaureate or advanced degrees are returning to community colleges to complete some aspect of technical or skills training (Boggs, 2010).

A significant reason for the increasing enrollment in community colleges is their lower cost compared with 4-yr institutions. Although the absolute numbers are changing rapidly due to the current reductions of support for higher education in local budgets, community colleges charge far lower tuition than their 4-yr public or private counterparts, sometimes by an order of magnitude (~\$2,500 per year for community colleges vs. \$7,000 to \$18,500 per year for public universities [in-state and out-of-state students, respectively] and \$26,000 average per year for private universities).

This growth and transformation in the nation's community colleges is allowing them many more opportunities to be partners in STEM education with 4-yr colleges and universities. However, many educators and education policy makers at local, state, and national levels are largely unaware of these changes. Differences in governance, financial support, institutional cultures, and the roles of faculty at the nation's 2- and 4-yr postsecondary institutions have led to a series of challenging issues that can impede the successful recruitment of and completion of degree programs by students who opt (or are forced) to begin their college careers in community colleges. At the same time, resolution of these issues can significantly improve opportunities for STEM-oriented students. Some of these issues include:

- Interactions between 2- and 4-yr postsecondary institutions, including articulation agreements
- Interactions between community colleges and secondary education, including dual enrollments and crediting for high school students
- STEM education pathways and their effects on employment of community college graduates

- Mechanisms to aid community colleges in broadening participation for students, especially those from under-represented populations
- Standards for community college faculty, including credentialing and the use of adjuncts
- Nature and quality of STEM instruction at community colleges (although this is an important issue at many 4-yr institutions as well)
- Availability and quality of student advising
- Quantification of the economic impact resulting from community colleges' preparation of students for the workforce (at the community, state, national, and global levels)
- Quantification of the completion rate for students at community colleges, including whether the appropriate indicators for success are being measured
- Nature and levels of external funding for community colleges

Examining Important Issues Related to the Intersections and Increasing Interdependence of Community Colleges and 4-yr Colleges and Universities

Given the complexities of STEM higher education and the new roles that community colleges are playing, a coordinated set of targeted studies analyzing and synthesizing existing data, and efforts to communicate these findings broadly, would greatly benefit community colleges themselves, as well as the institutions and organizations with which they interact. This broader community consists of K–12 education; 4-yr colleges and universities; business and industry; and local, state, and federal governments and policy makers. With these perspectives in mind (coupled with earlier work from the NRC to address articulation pathways for students from traditionally underrepresented populations [National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2011] and for students in engineering programs [NAE and NRC, 2005]), the Academy approached the NSF to undertake one or more studies and related convening activities that would address the aforementioned issues as they relate to STEM education more broadly.

Following several discussions with program officers at NSF (Advanced Technological Education program and the Division on Undergraduate Education), the staff directors of the NRC's Teacher Advisory Council,² Board on Higher Education and Workforce,³ Board on Life Sciences,⁴ and the Education Program Office of the National Academy of Engineering⁵ worked together on this proposal. Our goal was to organize and convene a summit that would address the changing and evolving dynamics between 2- and 4-yr colleges and universities around STEM education and the opportunities that might be afforded to both sectors and their students and faculty through more strategic collaborations and articulation agreements.

That proposal was approved, and an organizing committee was assembled (see *Acknowledgments* for names and affiliations of committee members). The committee and staff chose

three scholars to draft commissioned papers on 1) outreach and partnerships between 2- and 4-yr institutions; 2) transfer and articulation issues; and 3) developmental (formerly called remedial) courses, in this case with an emphasis on mathematics. These papers were shared with summit participants prior to the event. Those draft papers, along with the summit agenda, biosketches of organizing committee members and presenters, and additional resources, such as PowerPoint presentations and videos from the webcast of the plenary sessions, are all available on the summit's website.⁶ Revised versions of the commissioned papers are included as appendices in the summary report of the summit.

Some 100 invitees from a broad spectrum of experts in K–12 and higher education and education research and policy; program officers from a number of departments and agencies of the federal and state governments; and representatives from private foundations, business and industry, and professional and disciplinary societies registered to attend the summit. At least 150 people were estimated to have participated via a live webcast of all plenary sessions.

A brief overview of the plenary presentations in the order in which they were delivered is provided below, along with observations from the oral presentations of break-out groups. (The Academy's more detailed and expansive summary report weaves these sessions and participant observations into a narrative based upon a series of themes that emerged during the summit.)

STEM Education and the World of Work. In her presentation, "Community College Opportunities and Challenges in STEM," Jane Oates, Assistant Secretary of the Employment Training Center of the U.S. Department of Labor, described the department's interest in community colleges. The Department of Labor focuses its attention and programs on students who do not complete high school and adults who return to school for retraining after losing their jobs. Under the Trade Adjustment Assistance Community College and Career Training Grant program, the Department of Labor is awarding a total of \$2 billion over 4 yr to help prepare students for successful careers in growing and emerging industries.⁷ The department has recently instituted rigorous evaluation of both grants and formula funds that are distributed to states. In the first round of these grants, consortia of institutions that formed around needs of particular sectors, such as advanced manufacturing, healthcare, and engineering, received about 60% of the \$500 million distributed. These consortia developed new curricula based on the needs of employers and developed new methods of delivering educational content, such as online learning. Community colleges are the point of entry for many people who could benefit from such programs.

The Department of Labor has supported the development of other web-based tools as well, such as My Skills My Future,⁸ which allows people to see jobs that are currently available. Similarly, My Next Move⁹ allows dislocated workers, especially military veterans, to search by zip code for jobs and to match jobs with additional skills that they have

²<http://nationalacademies.org/tac>.

³<http://nationalacademies.org/bhew>.

⁴<http://nationalacademies.org/bls>.

⁵www.nae.edu/programs.aspx.

⁶<http://nas-sites.org/communitycollegessummit>.

⁷www.doleta.gov/taaccct.

⁸www.myskillsmyfuture.org.

⁹www.mynextmove.org.

acquired through postsecondary training of some kind. In collaboration with the U.S. Department of Education, the Workforce Innovation Fund¹⁰ showcases innovations and partnerships between the workforce sector and community colleges. “The time is right for us to talk about the rigor and the wonder and the innovation that are going on in community colleges,” Oates said. “We have for too long seen them as a stepchild, and they can do amazing things.”

Challenges of STEM Education Pathways. Eric Bettinger, Associate Professor for Education and Economics at Stanford University, discussed “To Be or Not to Be: Major Choices in Budding Scientists.” His work involves analyses of students’ choices of majors and how those decisions change over the course of a 2-yr and a 4-yr education (Bettinger, 2010). His data from Ohio are for the 1998–1999 cohort of incoming students who took the ACT precollege examination and indicated their initial preference for a major in college. The data set has enabled him and his colleagues to follow choices that these students made in subsequent years. In a total sample of 18,000 students, 8.0% indicated an interest in the biological sciences and 11.7% in the physical sciences and engineering. These numbers are 5.5% and 9.4% for those who attend community colleges. The students at 2-yr institutions have somewhat lower average ACT scores than the average for all students, but their aspirations and academic characteristics are similar to those in 4-yr colleges and universities.

Among all students who declared an intention to pursue a STEM major, only 43% were still in a STEM field at the time of their last enrollment, with the rest moving to other majors. However, only 14% of the students at community colleges who intended to major in a STEM field were still in a STEM field at the time of their last enrollment. Almost half of all students who left STEM switched to business majors (48.7%). Other popular majors for switchers included the social sciences (21.2%) and education (11.1%). Among 2-yr switchers, about 30% switched to business majors, and slightly less than a quarter each went to social science and education majors. Only 5.5% of non-STEM majors for all institutions, and only 3.4% of non-STEM majors at 2-yr institutions, ultimately declared a major in a STEM field. These statistics have critical implications for the United States, given the increasing demand for workers with qualifications and training in STEM (President’s Council of Advisors for Science and Technology, 2012).

Bettinger listed five possible reasons for the relative lack of U.S. students pursuing STEM majors in 2- and 4-yr institutions:

1. Lack of preparation in grades K–12 to enter STEM fields
2. Low student interest in entering STEM fields
3. Difficulty of returning to a STEM major if students decide to leave early and then change their mind
4. Unhappiness with the culture of STEM fields in higher education
5. Insufficient rewards to justify the time and level of work required to complete a degree in STEM fields

He noted that students start switching away from STEM majors during their first semester in college. Regardless of

the type of institution, the students most likely to leave STEM majors take fewer STEM courses their first semester (<40% of their course load), rather than more. The relatively small cohort of students who convert to STEM majors also take relatively few STEM courses their first semester. The students who do leave STEM majors are just as likely to pass their initial STEM courses, so the difficulty of the courses or lack of preparation does not seem decisive. But the course demands for STEM majors are high and require commitment. However, as Bettinger observed, some of the majors to which students switch, such as education, also have extensive course requirements, albeit they are not as sequential as those for STEM majors.

Bettinger’s data also show that women are significantly less likely to stay in STEM fields, even among top students, which suggests, he said, that the culture of STEM may be a factor in their decisions. Since female students take STEM courses in high school and still express an interest in majoring in those subjects, the cultural problems would need to start or intensify in college for this explanation to hold. According to Bettinger’s research, African American students in 4-yr colleges are less likely to defect from STEM majors than other students, especially among the top African American students. However, that is not true at 2-yr colleges, where there are no statistical differences between African American students and other students.

One factor in students’ decisions about majors is the amount of money they potentially could earn after graduation. About three-quarters of all college students agree in surveys that an important objective of a college education is to be “well off financially” (Pryor *et al.*, 2011), and some colleges have increased their focus on vocational offerings. This is especially observed at 2-yr colleges, as in most cases it is part of their mission.

Three Primary Foci of the Summit. The three authors of the commissioned papers, Becky Wai-Ling Packard (Mount Holyoke College), Debra Bragg (University of Illinois, Urbana–Champaign), and Alicia Dowd (University of Southern California), each briefly summarized their papers before engaging in a panel discussion with the audience.

Factors Influencing Student Choices to Pursue STEM Degrees. Becky Packard described an “ecological model” that examines the many environmental factors and the relationships among them that affect students’ choices. Choices can be influenced by home, school, workplace, and other contexts, such as access to resources, transportation, financial aid, and child care. Many students, particularly first-generation and low-income students, do not know how to navigate the college and financial aid application process successfully. Financial considerations can be a significant barrier to college entrance and persistence. Further, students often lack information on transfer requirements and what they are likely to experience if they do transfer. When students gain mentoring in multiple contexts, they are more likely not only to persist in college but in a STEM major.

Packard highlighted several of the recommendations from her background paper. First, more students and families need to understand the differences between a technical degree from a career institute and the community college transfer pathway to a 4-yr STEM degree. They need to know much more about the broadening opportunities in STEM careers

¹⁰www.doleta.gov/workforce_innovation.

and should be exposed to STEM occupations; they will then be ready to learn what they need to do to qualify for those occupations. Excellent models already exist, and these are detailed in her paper.

Dual Enrollment. Any hands-on program designed to attract students into STEM needs to be paired with academic preparation, Packard said. She suggested an expansion in STEM-specific, dual-enrollment programs that pair community colleges or universities with high schools, in addition to more common outreach and recruitment strategies. Both honor students and struggling students can benefit from dual-enrollment courses, because taking college classes during high school can motivate students to continue their education. In addition, she contended that high school students should be able to use their college classes to fulfill a high school requirement, which would allow students greater flexibility.

Mentoring. Research on mentoring is robust, sophisticated, and rigorous, Packard noted. Most of the newer studies are comparative, longitudinal, or control for self-selection issues. However, more research is needed on how to create more effective mentoring programs and bring effective mentoring programs to scale. She noted that NSF has a mentoring requirement for grants that engage postdoctoral researchers, and suggested that there is no reason why this provision could not be extended to graduate and undergraduate students. Finally, informal mentoring and advising need to be infused by faculty into all courses, and especially at community colleges. Mentoring cannot be done through supplemental programs alone.

Packard noted that the American Institutes for Research has estimated that more than \$4 billion in grants and state allocations are lost when new, full-time community college students do not return for a second year of study (Schneider, 2011). As a consequence, Packard stated, "The only thing more expensive than fixing retention in community college is not fixing it."

The Challenges of Developmental Courses and Maintaining Student Success in Mathematics. In her overview, Debra Bragg said that many see mathematics as the backbone of the STEM pipeline. The typical mathematics sequence in U.S. education progresses from arithmetic to algebra to geometry to trigonometry to calculus. Many more students have recently embarked upon this progression in 2-yr institutions—from about one million students enrolled in 2-yr mathematics and statistics programs in the early 1980s to more than two million today.

Over the past three decades, about 47% of mathematics enrollments in higher education have been at the 2-yr level. However, 57% of the students enrolled in 2-yr college mathematics are enrolled at the precollege, noncredit level. Elementary algebra, which is usually one to two levels below college-level algebra, commands the largest enrollments, and most students do not move beyond that level. About 7% of enrollments are in calculus, and another 7% are in statistics courses, with most students never moving beyond the introductory courses in these subjects. Bragg noted that relatively few 2-yr colleges offer special mathematics programs providing support for minorities or women (11% and 6%, respectively). In contrast, 90% of the 2-yr college mathematics programs require diagnostic or placement testing. An increasing number

of researchers are raising questions about the use and value of these tests, said Bragg, and about their contributions to student defections from mathematics. However, about 14% of the mathematics programs offer undergraduate research opportunities, and 20% offer honors sections for their students. The American Mathematical Association of Two-Year Colleges has committed to reforming mathematics education to improve the overall situation.

Bragg made four suggestions for future action on the basis of her observations:

- Reform of the mathematics curriculum needs to encompass the entire educational system. Without a strategic, collaborative endeavor, it will be difficult for 2-yr colleges to implement and sustain reform, except in isolated ways.
- More research is needed on teaching and learning in 2-yr college mathematics, especially in college-level mathematics.
- The characteristics, experiences, and aspirations of students who enroll in 2-yr college mathematics need to be investigated further to understand how they develop the "habits of the mathematical mind" that are required to be successful in all STEM fields.
- Two-year faculty would benefit from opportunities to engage in research that encourages them to explore and assess new pedagogical strategies in the classroom and how these strategies affect student learning.

Challenges and Opportunities for Student Transfer from Community Colleges to 4-yr Institutions. In her analysis of transfer from community colleges to 4-yr institutions, Alicia Dowd cited a recent report from the National Science Board (2010) that called for 1) providing quality science and mathematics teaching to all students, 2) improving identification of STEM talent, and 3) creating supportive "ecosystems" through professional development for STEM educators. All three steps are needed to enhance the flow of students from community colleges to 4-yr institutions, she said. Unfortunately, current statistics are far from good news: The transfer rate for the most competitive private institutions has dropped from around 10% of student enrollments in 1990 to a little more than 5% in the most recently available data. Other institutions enroll a higher percentage of transfer students, but the percentages at these institutions have also been declining.

Using survey data collected by NSF from recent college graduates, Dowd and her colleagues have examined degree choice among Latino and Latina students who earn an associate's degree prior to transferring to a baccalaureate program. They found that the majority of students who transfer from a 2-yr college to a Hispanic-serving institution and earn a STEM degree do so in the social and behavioral sciences, rather than in engineering or the natural, agricultural, or environmental sciences. She reported that the culture, values, and beliefs of faculty are critical factors contributing to the lack of transfer students in the natural sciences and engineering. Faculty members from both 2- and 4-yr schools need to be partners in redesigning transfer systems, and they need robust evidence about what is effective and what is not. Transfer scholarships focused specifically on STEM fields could be powerful inducements both for students to pursue STEM degrees and for institutions to change their environments in

ways that would attract and retain these students. She also suggested that individual development accounts—savings accounts that are matched by public and private sources—could help increase the diversity of students in STEM fields.

Dowd also suggested the creation of evidence-based innovation consortia that would facilitate transformational educational innovations, thereby enabling *all* students to thrive. Consortia or networks composed of community colleges, universities, and open-education resource practitioners could support the adoption and adaptation of evidence-based innovations. These networks would include agencies, organizations, industry, foundations, and others interested in specific topics, such as the reinvention of the mathematics curriculum. They would support the development of effective tools for systemic interventions and could conduct and support research to gather and analyze evidence of innovations' effects.

Developing Programs That Allow Underrepresented Minority Students to Thrive in STEM

As keynote speaker, Freeman Hrabowski, President of the University of Maryland, Baltimore County, began his remarks by noting that the demographics of the U.S. population are undergoing a dramatic shift. Ethnic groups currently underrepresented in the sciences soon will make up the majority of school-age children in this country. Drawing from the recent report of a committee that he chaired (National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2011), Hrabowski pointed out that the proportion of currently underrepresented minorities in science and engineering will need to triple to match their representation in the overall U.S. population. To maintain the strength and vitality of U.S. science and technology, many more of these minority children must not only decide to become scientists and engineers, but must be provided with opportunities and educational pathways that will allow them to succeed. Given the high representation of minority students in community colleges, these institutions will be critical in achieving this goal.

This underrepresentation of minorities in the science and engineering workforce stems from their low participation in science and engineering at every level of the pathways from elementary school to higher education and the workplace. Though underrepresented minorities now account for almost 40% of K–12 students in the United States, they earn only 27% of the associate's degrees from community colleges, only 17% of the bachelor's degrees, and only 6.6% of the doctorates in STEM fields.

In 2000, the United States ranked 20th in the world in the percentage of 24-yr-olds who had earned their first college degree in the STEM fields, Hrabowski noted. The report *Rising Above the Gathering Storm* (National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2007) called on the United States to raise the percentage of 24-yr-olds with a first degree in STEM from 6% to 10%. This would require a tripling, quadrupling, or quintupling of the percentages for underrepresented minorities, which are 2.7% for African Americans, 3.3% for Native Americans, and 2.2% for Latinos.

Since the 1980s, underrepresented minorities have aspired to major in science and engineering at about the same pro-

portions as their white and Asian American peers, Hrabowski observed. Yet they complete STEM degrees in lower proportions than whites and Asian Americans. Five years after matriculating, only about 20% of underrepresented minorities who intended to earn a STEM degree have done so, compared with about 33% of whites and slightly more than 40% of Asian Americans. Hrabowski ascribed part of this attrition to the culture of science and engineering in college. A large part of the problem is the “weed-out” mentality still held by many college faculty in these subjects, he said.

The problem is urgent, Hrabowski said. A national effort to address underrepresented minority participation and success in STEM fields needs to be initiated and sustained. This effort must focus on all segments of the pathways, all stakeholders, and the potential of all programs, whether targeted at underrepresented minorities or at all students. Students who have had less exposure to STEM and to postsecondary education than others require more intensive efforts at each level to provide adequate preparation, financial support, mentoring, social integration, and professional development. Evaluations of STEM programs, along with increased research on the many dimensions of underrepresented minorities' experiences, are needed to ensure that programs are well informed, well designed, and successful.

Colleges and universities need to increase the inclusiveness of their programs and the success of underrepresented students in STEM fields. College personnel have a tendency to say that the problem is at the K–12 level, but Hrabowski disagreed. K–12 education does need to be improved, but he contended that more students are better prepared to go to college than postsecondary faculty and administrators think. According to a recent study that he cited by Hurtado *et al.* (2010), the larger the number of Advanced Placement credits a student has taken, the higher her/his SAT score, and the more selective the university, the greater the probability that a student will leave science as an undergraduate. “It is not just a matter of preparation.”

Hrabowski cited several challenges that are particularly acute for community colleges:

- Inadequate levels of mathematical preparation. This is a problem for almost all colleges and universities, but it is an especially difficult problem at community colleges.
- Balancing the preparation of students for further study at 4-yr colleges and graduate schools, while also offering what for many students will be terminal 2-yr degrees and certificates for the technical workforce.

Several federal programs facilitate the transfer of underrepresented minorities from community colleges to 4-yr institutions, Hrabowski noted. These include programs such as the Bridges to the Baccalaureate¹¹ and the Community College Summer Enrichment Program at NIH.¹² Increasing numbers of community colleges have mounted promising initiatives, he noted, such as Miami Dade College's Windows of Opportunity program, which helps academically promising, low-income students obtain associate's degrees in the arts or in STEM disciplines; several programs at his own university encourage and facilitate student transfer from community

¹¹www.nigms.nih.gov/Research/Mechanisms/Bridges/Baccalaureate.htm.

¹²www.training.nih.gov/ccsep_home_page.

colleges. Strategies that promote transfer include grants that allow community college students to work less outside of their academic programs, enabling them to complete their associate's degrees in 3 yr and then successfully transfer to complete their 4-yr degrees.

Hrabowski also emphasized the potential for internships to motivate students and prepare them for careers. Internships make students more serious about their work. The needs of industry can be infused into the curriculum, especially when people from business are involved in teaching the courses. Students learn how to work in teams, express themselves clearly, and gain other critical skills that they can use in the workplace (e.g., NRC, 2010).

CONCLUDING THOUGHTS

New realities in the postsecondary education landscape include the nation's changing workforce needs and shifting economy and the increasingly pervasive roles that science and technology are playing in virtually all aspects of our society. These changes have created unprecedented challenges, but also unrealized opportunities to improve education and work opportunities for many more students, especially for those students who will pursue higher education at least partially through community colleges.

As noted in this paper, numerous obstacles are also limiting the realization of what is possible through enhanced cooperation between community colleges and 4-yr institutions. These barriers result in major disincentives for many students who are the nation's untapped potential for the STEM workforce. In a presummit survey, several issues were articulated by registrants as requiring immediate attention, including a greater focus on inquiry-based learning in the classroom and lab; teaching STEM content in the context of employable skills; better articulation pathways between 2- and 4-yr institutions; providing better support systems for students and access to the scientific "culture"; making STEM education more visible to community college students and the potential of these students more visible to 4-yr institutions; and building professional communities across institutions to work on these challenges.

Although not always directed exclusively at STEM education, numerous projects and initiatives, supported by federal and state governments and private sources, are now addressing these issues. Through its Educate to Innovate initiative,¹³ the Obama administration has called for greatly increased funding of community colleges to produce more STEM graduates who can enter the workforce or pursue higher degrees in baccalaureate-granting schools. All but six states have now developed some level of articulation agreements that make it easier for graduates of community colleges to transfer their credits to 4-yr institutions (e.g., Center for American Progress, 2011). The Bill and Melinda Gates Foundation has invested millions of dollars over the past several years in major projects to transform developmental/remedial courses,¹⁴ increase graduation rates in community colleges,¹⁵ and en-

courage direct partnerships between community colleges and 4-yr institutions.¹⁶

The new realities also suggest that the old pipelines through higher education are being supplanted and superseded by a variety of pathways. With so many more students who hold bachelor's degrees returning to community colleges to acquire specific workplace skills, and with some community colleges now offering applied baccalaureate and advanced degrees, higher education needs to focus more of its attention on student success and growth as the primary metric and unit of analysis. The good news is that with creative and imaginative thinking and the will to focus on student success, these pathways also offer institutions of higher education new opportunities to share resources and create new efficiencies in this era of shrinking budgets. Together, faculty and administrators from 2- and 4-yr institutions who are truly concerned about and dedicated to the improvement of student learning and academic achievement in the STEM disciplines will view one another as partners, collaborators, and colleagues.

This summit laid the groundwork for the further exploration of critical issues in this changing STEM education landscape. Although not included in the report, a postsummit survey of participants asking them to envision the next critical steps is posted on the summit's website (<http://nas-sites.org/communitycollegessummit>). Hopefully, the combination of the summit report and the ideas that emerged from the survey will offer readers of *CBE-LSE* and their colleagues new avenues for discussion about these issues, which are of critical importance to postsecondary education today and in the future.

ACKNOWLEDGMENTS

The project on which this paper is based was supported by NSF grant EHR 1112988. I thank the members of the organizing committee for their continual support, ideas, and perspectives in organizing this event: George Boggs (Chair), American Association of Community Colleges (Ret.); Thomas R. Bailey, Columbia University; Linnea Fletcher, Austin Community College; Bridget Terry Long, Harvard University; Judy C. Miner, Foothill Community College; and Karl S. Pister, University of California.

I am grateful to my co-principal investigators for their ongoing support and hard work in organizing this event: Catherine Didion (National Academy of Engineering), Peter Henderson (NRC Board on Higher Education and Workforce), and Martin Storksdieck (NRC Board on Life Sciences). Margaret Hilton worked closely with me as the senior program officer and manager of the project. Cynthia Wei and Rebecca Fischler produced and managed the summit's website. Orin Luke and Mary Ann Kasper served to organize the logistics for the summit.

I thank the presenters at the summit for their insights, which made this paper possible. I also thank Steve Olson for writing the first draft of the report from the summit. Some of the text in this paper is excerpted and modified from that report.

REFERENCES

Barnett L, San Felice F (eds.) (2006). *Teaching by Choice: Cultivating Exemplary Community College STEM Faculty*, Washington, DC: Community College Press. www.aacc.nche.edu/Resources/aaccprograms/Documents/stemfaculty.pdf.

¹⁶www.aacu.org/pkal/rampingupstem/actionlabtwo.cfm.

¹³www.whitehouse.gov/issues/education/educate-innovate.

¹⁴www.gatesfoundation.org/press-releases/Pages/new-ideas-for-remedial-education-in-community-college-100420.aspx.

¹⁵www.gatesfoundation.org/press-releases/Pages/increasing-community-college-graduation-rates-101004.aspx.

- Barnett L, San Felice FS (2005). Teaching by Choice: Community College Science and Mathematics Preparation of K–12 Teachers, Washington, DC: Community College Press. www.aacc.nche.edu/Resources/aaccprograms/Documents/sci_math_prep.pdf.
- Bettinger E (2010). To be or not to be: major choices of budding scientists. In: American Universities in a Global Market, ed. C. T. Clotfelter, Chicago: University of Chicago Press.
- Boggs GR (2010). Growing role for science education in community colleges. *Science* 329, 1151–1152.
- Center for American Progress (2011). Articulation Agreements and Prior Learning Assessments: Tools to Help 21st Century Students Achieve Their Postsecondary Education Goals and Keep America Competitive, www.americanprogress.org/issues/2011/06/pdf/colleage_credits.pdf.
- Center for College Affordability and Productivity (2010a). 25 Ways to Reduce the Cost of College—#1: Encourage More Students to Attend Community Colleges, Washington, DC. www.centerforcollegeaffordability.org/uploads/25_Ways_Ch01.pdf.
- Center for College Affordability and Productivity (2010b). 25 Ways to Reduce the Cost of College—#2: Promote Dual Enrollment Programs, Washington, DC. www.centerforcollegeaffordability.org/uploads/25_Ways_Ch02.pdf.
- Center for Community College Student Engagement (2010). The Heart of Student Success: Teaching, Learning, and College Completion (2010 CCCSE Findings), Austin, TX: University of Texas at Austin, Community College Leadership Program. www.ccsse.org/publications/national_report_2010/36379tw/CCCSE_2010_national_report.pdf.
- Fathe LA, Kasabian J (2009). The State of Affairs: Impact and Implications of STEM Teacher Education at Two-Year Colleges, Torrance, CA: El Camino Community College District.
- Floyd DL, Skolnik ML, Walker KP (eds.) (2005). The Community College Baccalaureate: Emerging Trends and Policy Issues, Sterling, VA: Stylus.
- Hurtado S, Pryor J, Tran S, Blake LP, DeAngelo L, Aragon M (2010). Degrees of Success: Bachelor’s Degree Completion Rates among Initial STEM Majors, Los Angeles, CA: Higher Education Research Institute, University of California, Los Angeles.
- Lewin T (2009). Community colleges challenge hierarchy with 4-year degrees. *New York Times*. May 2, 2009. www.nytimes.com/2009/05/03/education/03community.html.
- National Academy of Engineering and National Research Council (NRC) (2005). Enhancing the Community College Pathway to Engineering Careers, Washington, DC: National Academies Press. www.nap.edu/catalog.php?record_id=11438.
- National Academy of Sciences, National Academy of Engineering, and Institute of Medicine (2007). Rising above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future, Washington, DC: National Academies Press. www.nap.edu/catalog.php?record_id=11463.
- National Academy of Sciences, National Academy of Engineering, and Institute of Medicine (2011). Expanding Underrepresented Minority Participation: America’s Science and Technology Talent at the Crossroads, Washington, DC: National Academies Press. www.nap.edu/catalog.php?record_id=12984.
- National Association of Community College Teacher Education Programs (NACCTEP) (2008a). Ten Myths and Realities about Community College Teacher Education Programs, Tempe, AZ. www.nacctep.com/Drupal/PDF/Myths.pdf.
- NACCTEP (2008b). Blueprint for Excellence: National Association of Community College Teacher Education Programs’ Guiding Principles, Tempe, AZ. www.nacctep.com/Drupal/PDF/Blueprint.pdf.
- National Commission on Community Colleges (2008). Winning the Skills Race and Strengthening America’s Middle Class: An Agenda for Community Colleges, New York: College Board. www.collegeboard.com/prod_downloads/prof/community/winning_the_skills_race.pdf.
- NRC (2010). Exploring the Intersection of Science Education and 21st Century Skills: A Workshop Summary, Washington, DC: National Academies Press. www.nap.edu/catalog.php?record_id=12771.
- NRC and National Academy of Engineering (2012). Community Colleges in the Evolving STEM Education Landscape, Washington, DC: National Academies Press. <http://nas-sites.org/communitycollegessummit>.
- National Science Board (2006). Higher education in science and engineering. In: Science and Engineering Indicators 2006, Arlington, VA: National Science Foundation. www.nsf.gov/statistics/seind06/c2/c2s1.htm.
- National Science Board (2010). Preparing the Next Generation of STEM Innovators: Identifying and Developing Our Nation’s Human Capital, Arlington, VA: National Science Foundation. www.nsf.gov/nsb/stem/innovators.jsp.
- National Science Foundation (1998). The Integral Role of Two-Year Colleges in the Science and Mathematics Preparation of Prospective Teachers: Report from a National Science Foundation Workshop, NSF 99-49, Arlington, VA. www.nsf.gov/pubs/1999/nsf9949/nsf9949.pdf.
- Patton M (2008). Community colleges impact K–12 STEM teaching. In: Community Colleges Impact K–12 STEM Teaching, ed. L. Barnett, Washington, DC: American Association of Community Colleges. www.aacc.nche.edu/Resources/aaccprograms/Documents/impactk12_2008.pdf.
- President’s Council of Advisors for Science and Technology (2012). Report to the President: Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics, Washington, DC. www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-executive-report-final_2-13-12.pdf.
- Pryor JH, DeAngelo L, Palucki Blake L, Hurtado S, Tran S (2011). The American Freshman: National Norms Fall 2011, Los Angeles, CA: Higher Education Research Institute, University of California, Los Angeles. <http://heri.ucla.edu/PDFs/pubs/TFS/Norms/Monographs/TheAmericanFreshman2011.pdf>.
- Recruiting New Teachers, Inc. (2002). Tapping Potential: Community College Students and America’s Teacher Recruitment Challenge, Belmont, MA.
- Russell A (2010). Update on the Community College Baccalaureate: Evolving Trends and Issues, Washington, DC: Association of American Colleges and Universities. [www.aascu.org/uploadedFiles/AASCU/Content/Root/PolicyAndAdvocacy/PolicyPublications/AASCU_Update_Community_College_Baccalaureate\(1\).pdf](http://www.aascu.org/uploadedFiles/AASCU/Content/Root/PolicyAndAdvocacy/PolicyPublications/AASCU_Update_Community_College_Baccalaureate(1).pdf).
- Schneider MS (2011). The Hidden Costs of Community College, Washington, DC: American Institutes for Research. www.air.org/files/AIR_Hidden_Costs_of_Community_Colleges_Oct2011.pdf.
- Shkodriani G (2004). Seamless Pipeline from Two-year to Four-year Institutions for Teacher Training, PT3 Policy Brief, Denver, CO: Education Commission of the States. www.ecs.org/clearinghouse/49/57/4957.pdf.
- Townsend B, Ignash J (eds.) (2003). The Role of the Community College in Teacher Education: New Directions for Community Colleges, New York: Jossey-Bass.
- Tsapogas J (2004). The Role of Community Colleges in the Education of Recent Science and Engineering Graduates, Info-Brief 04–315, Arlington, VA: Division of Science Resources Statistics, National Science Foundation. www.nsf.gov/statistics/infbrief/nsf04315.