Effective Outreach, Recruitment, and Mentoring into STEM Pathways:

Strengthening Partnerships with Community Colleges

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Executive Summary

The community college is the modal entry point for higher education across the nation, and is even more typical for first-generation, low-income, racial-ethnic minority, and nontraditional-aged college students. Complex barriers decrease the feasibility of four-year science, technology, engineering, and math (STEM) pathways via community colleges. Fortunately, several outreach, recruitment, and mentoring strategies can mitigate barriers and improve retention. Outreach and recruitment efforts, however, need to be paired with accessible, sustained mentoring so students can navigate pathways efficiently and effectively. Specifically:

1) *Outreach* efforts need to target students and their families so they can learn about the many pathways and career options within STEM fields as well as the tri-level partnerships that exist among high schools, community colleges, and four-year institutions. Federal agencies and state departments of education should prioritize funding initiatives that exemplify tri-level partnerships and emphasize sustainable, coordinated approaches to outreach. The National Science Foundation's Advancing Technology Education (ATE) program provides many effective models for replication and expansion.

2) *Recruitment* is more effective when students can see the feasibility of completing a four-year STEM degree. Completing a college-level math course while in high school, or in the first year of college, improves feasibility and is linked to persistence in college and in STEM. States should expand dual enrollment programs that emphasize both math and curricular collaboration between high school and college faculty. Local policies should lift restrictions so that college classes count for both college and high school requirements. Gaining career-relevant experience is also an important recruitment mechanism; governmental incentives should be directed toward industry partners who provide STEM-specific internships targeting high school and college students.

3) *Several mentoring practices* including developmental bridge programs, science scholar programs, peer-led supplemental instruction, and undergraduate research experiences have been documented as improving student retention. Further research is needed into the design principles that make these mentoring practices more effective and scalable. The National Science Foundation and other agencies should require student mentoring plans in all relevant grant proposals, akin to NSF's requirements for postdoctoral researchers. Grant programs should support innovations including part-time summer research experiences targeting nontraditional students or graduate students who want to become community college faculty. State higher education offices should include mentoring and retention plans as criteria for approving academic programs. Beyond formal programs, institutions need to expand the use of informal mentoring strategies by faculty and staff.

In sum, collaborative, coordinated, well-designed, and sustained mentoring efforts are important investments in our nation's workforce. Changes in educational policies and grant requirements can help to strengthen their impact. We also need to help institutional leaders in four-year institutions to recognize the benefits of collaborating with and learning from community colleges. Ultimately, the recruitment and retention of diverse community college students in STEM fields needs to be prioritized and shared by all.

Introduction

This paper focuses on effective outreach, recruitment, and mentoring strategies that can increase the number and diversity of students who use community college pathways to earn four-year degrees[1] in science, technology, engineering, and math (STEM). Many occupations in STEM fields now require a four-year degree; individuals who earn a bachelor's degree on average earn hundreds of thousands of dollars more during their careers and have broader ranging career choices than high school diploma recipients do [1]. Increasing STEM degree completion in the U.S. has been identified as an issue of national priority to boost global competitiveness [2]. The U.S. does not sufficiently tap the talents of the nation's students as evidenced by the underrepresentation of women, racial-ethnic minority, low-income, first-generation, and nontraditional-aged college students in many four-year STEM degree programs [3-5], and the high percentage of foreign nationals in U.S. graduate STEM programs [6].

Yet, this is where challenge and opportunity meet. Community colleges attract students from all backgrounds, especially those underrepresented in STEM, by the hundreds of thousands. *Indeed the community college is the most typical entry point into higher education today, representing about 50% of college students* [5, 7, 8]. However, community college pathways to four-year degrees are not as effective as they could be. Each year, *over four billion dollars* in grants and state allocations are lost when new, full-time community college students do not return for a second year of study [9]. Transfer rates from community college to four-year institutions are low overall, especially for low-income students of color [5, 7, 10, 11]. In addition, the use of the STEM transfer pathway is rare, particularly by women [10, 11].

[1] The importance of STEM associates and certificate programs is recognized; however, these programs are not the focus of this paper.

In order to strengthen pathways to a four-year degree for students from diverse backgrounds, it is critical to identify effective outreach, recruitment and mentoring strategies that can mitigate barriers and improve retention. Further, we need to identify levers of change to expand these practices across the nation. This paper describes barriers facing students, best practice for outreach, recruitment and mentoring strategies, and makes recommendations to strengthen their impact and reach across the nation.

Conceptual Framework: The Ecology of STEM Pursuit

Students develop their college and career plans within a complex social ecology. Bronbrenbrenner's ecological model helps us understand the influence of interconnected contexts on students' learning and career trajectories [12]. Students develop within many spaces including the home, school, and workplace. The relationships between contexts also influence students such as how strongly parents and teachers communicate. Indirect influencers such as access to transportation or availability of jobs also influence students as do the broader political or economic contexts within which we all live such as being in an economic downturn.

Applied to STEM pursuit, it is typical for students to turn to a family member or a family friend for guidance on careers or school [13]. First-generation college students and low-income students also turn to family [14]; however, when they do, they are not as apt to gain access to knowledge about college navigation, leads on internships, or a financial cushion if complications arise [15, 16]. For example, many parents without college experience do not know that job training certificates rarely contribute toward an associate's degree, or that certain prerequisites are necessary to transfer from a community college into a four-year STEM program.

In the school realm, low-income parents may feel intimidated to approach high school math and science teachers, missing out on school-based support [17]. High school preparation is an issue. In a study of 5000 Latino community college students in Los Angeles, researchers found after three years of study, less than 9% of students were in a position to transfer to a four-year school, mostly due to the need for developmental courses [24]. Thousands of students each year enroll in developmental math, but only a few continue on to the transfer-based math courses and into a STEM program [31]. On the positive side, community college students generally report having positive experiences in STEM education with dedicated teachers and smaller class sizes which can encourage them to consider continuing their education [26].

Financial background is a major predictor of college entrance and persistence. Students from lower-income backgrounds are most likely to delay going to college, to work many hours while attending college, to attend school part-time, and limit their time on-campus—all factors that predict degree non-completion [18, 19]. Low-income, first-generation college students are four times more likely to leave college during their first year than their peers, and more than three times less likely to transfer to a four-year school in a six year time frame [7]. Simply put, transfer delays discourage students; they may elect shorter-term educational programs such as drafting instead of a longer-term career choice such as engineering or leave STEM completely [20]. To emphasize this point, about 50% of students are employed at least part-time, and many are working full-time, while going to school [22]. Although access to a relevant job can positively contribute to STEM persistence [23], when students work many hours, they may not be able to avail themselves to academic resources. For example, office hours or study group sessions may cater to traditional-aged students' schedules [18, 19], thereby decreasing access to these effective opportunities to grow students' academic capacities and sense of capability [21].

Finally, the pressure on community colleges to provide an effective and efficient mechanism for transfer has intensified in recent years despite serious resource constraints [27]. A study of 400 students from nine community colleges in Los Angeles found that ineffective advising, influenced in part by extremely high student-to-counselor ratios, led to a lack of student information about transfer requirements [28]. In many states, community colleges are not aligned with each other [29]. For example, Biology 101 is not necessarily the same course at one community college as it is at another community college, leading students even in the same state to lose credits and time [30]. Going further, articulation agreements between community colleges and four-year schools still require attention at the disciplinary level; it is still often the case that students will take a STEM prerequisite at a community college and later earn only general credits, rather than major requirements, upon transfer to a four-year institution [10, 11, 29]. In addition, women earn the majority of associate's degrees within community colleges, but only 5% of them are in are in STEM fields [32], with male students outnumbering their female peers in STEM majors within community colleges at a ratio of three to one [4]. Negative stereotypes about STEM careers are still prominent and can deter students from these fields; students from racial-ethnic minority backgrounds may especially question their fit or feel alienated from STEM fields [33-34]. Current programs designed to improve outreach, recruitment, and mentoring are not yet sustainable on a larger scale; not enough students are experiencing best practice in these domains. More can be done to coordinate these efforts and strengthen their impact.

To summarize, students may not have ready access to information about college pathways, while others question their fit within the STEM profession. A lack of academic preparation, particular in math, may thwart the pursuit of STEM fields while others may find STEM degrees less feasible to pursue due to time and financial barriers. Additional delays are often experienced during the transfer to a four-year institution due to curricular misalignment or ineffective advising, leading some students to let go of their STEM majors. In the next sections, I discuss effective ways to improve outreach into STEM, highlighting the effective leadership that community colleges have taken in this domain. Second, I address effective recruitment into STEM by focusing on STEM-specific dual enrollment and the importance of completing a college-level math course. Third, I review highly effective mentoring practices that promote retention in STEM within community college pathways to a four-year degree.

BARRIERS FOR COMMUNITY COLLEGE STEM STUDENTS:

* Limited knowledge about college navigation
* Financial - both time and cost
* Academic preparation in math and science; need for developmental courses
* Misalignment of core courses across community colleges and four-year schools
* Delayed, inconsistent advising, orientation, and mentoring
* Constraints affecting the academic and social integration of working students
* Self-doubt regarding capabilities
* Cultural fit with professional identity or four-year institution
* Limited sustainability of programs designed to improve retention

Outreach: Building Relationships and Cultivating Interest

Students and their families need greater access to information about college-going, to feel invited into the college environment, and to see options in STEM fields. Outreach in this paper refers to an initiative designed to inform or invite students into STEM pathways. Outreach techniques include information campaigns, career days, and job shadowing [35]. For outreach, role model selection influences effectiveness. Interactions with role models with whom students can relate, such as alumni from their own communities who discuss challenges they overcame, or students just a step ahead of them in their education, can be most effective at motivating students and cultivating their interests [36].

Outreach is a limited strategy, however, as its primary aim is to inform or spark interest, not necessarily to provide a pathway where an aspiration is transformed into a reality. Any one-time initiative that simply exposes a student to a range of interesting career options on a single day is not likely to have a long-term effect on enrollment or persistence. However, even short-term programs that integrate scientists into classrooms where students engage in hands-on, authentic activities do contribute to student knowledge and interest in science careers, which are both desired, realistic outcomes for outreach initiatives [37]. More time-intensive programs such as pre-college summer programs where students are exposed to college campuses and laboratory experiences over the course of several weeks have been found to contribute to increased student interest in learning college science or pursuing a science career [38]. Without on-going support and continued experiences, however, students may gain interest but not have these interests sustained [39]. Thus, outreach efforts that are more time-intensive or sustained over a period time are more likely to contribute to lasting interest and subsequent enrollment behaviors.

Consortia. Statewide and nationwide consortia, where clusters of programs are coordinated, organized or offered in collaboration across a region, state, or nationwide, or across age and grade levels, can have more compelling effects than single programs operating in isolation. When programs are linked, students can more easily move forward through STEM pathways and continue to experience encouragement and engagement in a progressive manner, and resources can also be better allocated and utilized.

Two projects funded by the National Science Foundation's Building Capacity in Computing program demonstrate effective statewide initiatives: Georgia Computes! (http://gacomputes.cc.gatech.edu/) and Massachusetts's Commonwealth Alliance in Information Technology Education or CAITE (http://www.caite.info/). In each project, efforts are coordinated statewide and across levels of education. In Georgia, they have coordinated access to middle and high school summer camps, linked high schools with colleges, and college students with graduate students using collaborative on-line tools. In addition, they work with high school teachers through the Georgia Department of Education to offer workshops to computing faculty on new approaches to stimulate interest in computing education. While the exact focus of the activities differs in Massachusetts, the CAITE program's efforts to coordinate across regions and the state are also an exemplary model. Further, a number of national-level organizations were recognized by the White House for working across the nation to promote effective outreach in STEM. For example, the National Girls Collaborative (http://www.ngcproject.org/) maintains a database of organizations that support outreach to girls in science. Thus, for more effective outreach, one specific recommendation is for grants to prioritize collaborative projects that coordinate outreach efforts across a state or across levels of education.

Embedding a message within communities. Colleges can work to embed themselves within their local communities and high schools so that people in those communities see an open door to higher education. The more relationship-building there is between community colleges and four-year colleges and universities, the more successful we will be at helping students and families to want to navigate these four-year college pathways. Many community colleges already provide leadership on this front. For example, Austin Community College (ACC) has successfully embedded itself in the community by using multiple methods to increase the number of students who enter its doorways. Of particular interest is the College Connection program, which won the Texas Higher Education Coordinating Board 2006 Star Award. Through this partnership, ACC works with high school seniors in 15 school districts to provide admission and enrollment services on their high school campuses. A stunning 6,400 high school seniors in Central Texas received an admissions acceptance letter to ACC with their high school diplomas. From 2003 to 2005, enrollments increased nearly 38%; the program also encouraged students to enroll in other colleges and universities [40]. One recommendation is that all high schools should have community college and four-year partners and should be supported by state-level funding.

In addition, college information should be disseminated to families more effectively. For example, efforts might target parents through doctors' offices or the parents' workplaces to ensure greater access to families. Ultimately, students need to get the message repeatedly that applying to the community college goes hand in hand with the pursuit of a four-year college and university. The focus of this paper is the pursuit of STEM; thus, it is important that messages about college access include a disciplinary message (for instance, start your science career or science degree at this community college). Having a scientist or college science students in the classroom, from both community colleges and four-year institutions, can communicate a powerful message on this front. Many including the Boston Area Technological Education Connections (BATEC) have provided leadership in developing effective outreach protocols for dissemination [41].

Finally, math and science teachers in high schools are critical partners to community college and four-year schools. Building a network of educators is critical in the recruitment and retention of STEM educators because improving science education can contribute to the number of students interested in studying science. Community college science and math teachers are taking leadership in recruiting and preparing new K-12 teachers as they exemplify the concept of "teaching by choice" and being invested in their practice [42]. A premier program that joins K-12 teachers and postsecondary educators at the four-year level is the Teachers Occidental Partnership in Science (TOPS) program at Occidental College. Under this progressive program, high school educators have access to a number of resources including cutting-edge instrumentation in the natural science fields, access to technology-based web programs that can be integrated into the K-12 curriculum, and support in professional development. Additionally, TOPS is also successful due to its alignment with statewide policies from the California Department of Education [43].

The National Science Foundation's Advanced Technological Education (ATE) division has many exemplary programs for outreach efforts, and more specifically, the development of education modules to disseminate math and science instruction across the country. This program is the largest within NSF to focus on community colleges; the numbers of students, families, and institutions positively affected are numerous [44]. One program, coordinated by the Museum of Science in Boston, is focused on improving educators' understanding of engineering, science, and technology by infusing engineering and technology concepts and skills into core introductory science and education courses in community colleges and four-year institutions. Many other STEM education program elements in the ATE portfolio are also worthy of replication and expansion. Thus, I recommend the importance of sustaining this program and disseminating its models more broadly.

Summary of Outreach Recommendations

- Select compelling role models who are step-ahead peers or alumni.
- Coordinate outreach efforts across states and through national-level consortia.
- Provide funding for outreach when efforts are organized across states, stakeholders, and levels of education.
- Embed community colleges and four-year institutions into communities by working closely with high schools and sending united messages about access.
- Disseminate college information through doctor offices and parents' workplaces to reach more families.
- Invest in STEM teacher education as a form of outreach for teachers and students.

Recruitment: Creating STEM Pathways from High School into College

Recruitment is typically viewed as going one step further than outreach; beyond sparking an interest or expanding career knowledge, the goal is to get students enrolled in their first course or enrolled in a STEM major. In this section, I focus on creating feasible pathways for students to pursue STEM college degrees while they are still in high school. We need to place attention on making the entire STEM pathway realistic from the outset. As mentioned, too many students are arriving at community college without the requisite math or science courses, leaving them with the choice of undergoing a series of developmental math courses or choosing a different field of study that can be completed more efficiently. Initiatives that increase the number of students arriving at college with college-level math in place will likely increase the possibility of completing a STEM transfer pathway. Indeed, an improved sense of feasibility can positively influence interest and persistence in STEM among low-income and first-generation college students [10, 20]. In this section, I will focus my review on dual-enrollment programs and STEM-specific early college high schools.[2]

Dual enrollment, also called concurrent enrollment, refers to a practice in which high schools students take college level classes, often on a college campus, while still working toward their high school diploma. Dual enrollment programs provide exposure to college and the opportunity to earn college credit-- dual credit, meaning credits that are applicable toward high school and college [45]. During the 2002-2003 school year, almost a decade ago, only 5 percent of all high school students across the nation took college credit courses. Of these 813,000 students, 77 percent did so through dual enrollment partnerships between their high school and local community college [46]. That number has dramatically increased. The National Alliance of Concurrent Enrollment Partnerships (NACEP) is an organization that accredits concurrent enrollment programs, for seven years at a time, assuring that the courses high school students take throughout the nation are college quality and optimal for college readiness. There are currently only 66 NACEP-accredited programs; most are two year college partnerships while 24 are four-year institution partnerships.

A dual enrollment experience is more successful in predicting future college-going when students have had a more authentic college experience. Authenticity is enhanced by having class at the college campus and having classes in mixed groups of high school and college students [47]. Across the country, state-level policies exist that aim to support success in dual enrollment [48]. For example, 18 states have a mandatory state policy on dual enrollment in which high schools must inform students of program opportunities and accept credit.

[2] Thus, although scholar cohort programs and developmental bridge programs are also effective recruiting mechanisms, I choose to highlight these approaches in the mentoring section of this paper in order to describe a comprehensive range of effective mentoring initiatives together.

In addition, the typically targeted populations for dual enrollment have been advanced students, students with high grade point averages or career and technical education students [49, 50]. However, based on research within Florida and New York, expanding the eligibility requirements to students with even lower grade point averages--- students even more motivated to persist in college as a result of gaining college credit while in high school-- could help to strengthen the impact of dual enrollment [50, 51]. This important work also suggested designing dual enrollment sequences, because students who took more than one dual enrollment course observed greater benefits and to offer dual enrollment courses tuition free to aid those economically disadvantaged. Based on this research, I would advise identifying a sequence of math and science courses to recommend to dual enrollment programs. This will help students to avoid lengthy developmental course sequences and complete a college level math course. Completing a college-level math course not only opens doors to STEM degrees but also predicts college persistence in general [52].

In a related movement to dual enrollment programs, we find early college high schools, which have offered merged high school and college experiences on a compressed timetable. Recent external research based on five years of this practice in which high schools are housed on a college campus cautiously suggested positive outcomes and the need to continue longitudinal work in this domain [53]. In 2009, there were over 200 early college high schools in 28 states, accounting for 50,000 students, with students from a low-income background (70 percent) and ethnic minorities (59 percent) accounting for the majority of participants [54-55]. Almost all early college high school graduates earn college credits across many fields of study. For example, a striking 95 percent of students at the Hidalgo Independent School District in Texas, a rural high-poverty district serving mostly Hispanic students, earned college credits while enrolled in an early college high school [56].

What is especially relevant about the *Early College High School Initiative* is that about one in three is STEM-specific [57]. In 2009 and 2010, close to 1500 students graduated from over 30 STEM-themed early college high schools. Of these graduates, 25% earned an associate's degree while in high school, and two-thirds went on to a four-year college. One STEM-specific early college high school is Metro in Ohio, which has a partnership with Ohio State University and Battelle**,** a corporation in Columbus Ohio. Technically, Metro is a program that draws students from 16 neighboring district schools. These students come from a wide range of backgrounds with varying levels of STEM experience. To date, Metro has successfully graduated 168 students, 75 were in the class of 2010 and 93 graduated in 2011. In Metro's first graduating class, a mean of 40 college credit hours was earned per student. The positive outcomes from Metro's curriculum are further evident, as all students were accepted to college, many students received college scholarships, and all were STEM-ready.

In sum, policymakers can find ways to make these programs more accessible and help credits transfer. For one, it needs to be a more common practice where college credit hours can fulfill state requirements for days and minutes needed for students' high school graduation [58]. State and local district policies need to lift restrictions so that college courses can count toward high school requirements as well as college credit. The practice of dual or concurrent enrollment can also be facilitated by making use of technology such as on-line or blended course modules where more students can gain access to a college-level math course [59].

Summary of Recruitment Recommendations

- Compress timetables for college completion, thereby increasing feasibility of STEM college pathways
- Invest in dual enrollment programs and STEM-specific early college high schools that prioritize completion of a college-level math course
- Expand eligibility for dual-enrollment programs to a wider range of students including students with lower grade point averages
- Lift restrictions so that college courses can count toward high school requirements and college credits

Mentoring: Comprehensive Networks at Transition Points

Typically, mentoring is described as a term depicting a close one-to-one relationship, often formalized and intensive, where an older, more experienced mentor helps to guide and encourage a younger less experienced mentee [60]. However, models of mentoring have transformed in the past two decades such that it is now more widely accepted that mentoring can be obtained through various sources, including professional organizations, on-line systems, and even shorter-term relationships [61, 62]. What we know from examining research and best practice is that many different kinds of mentoring relationships contribute to persistence in college and within STEM specifically. Students are more likely to persist in STEM when they experience a combination of 1) socio-emotional mentoring functions, such as encouragement or role modeling, and 2) instrumental mentoring functions, including academic support, college navigation, and career coaching [63]. When students have multiple mentors from a variety of contexts across home, school, and the community, they are more likely to obtain a wider range of mentoring functions [64]. This constellation approach to mentoring, referring to a set of strategically assembled mentoring relationships from different sources that provide a range of mentoring functions along one's pathway, is recommended to promote persistence. In the literature, this is considered a functional approach to mentoring, rather than a role-based approach to mentoring, simply meaning that one focuses on the functions that a student needs. A functional approach is helpful when considering the experiences of underrepresented groups as it is unlikely one can find a singular mentoring source to provide all functions needed [61]. In addition, a functional approach assumes a broad conception of mentoring due to its focus on functions. Peer sources of mentoring can sometimes be overlooked when using traditional conceptions of mentoring; however, they are very effective at promoting a student's sense of belongingness and academic capability [10, 88].

A broader economic context also provides insights into additional support needed to access available mentoring. For example, if a student does not have access to transportation or cannot afford to give up the remaining four summer weeks of pay in order to participate in a summer mentoring program, then a particular mentoring initiative may neither draw the target students or may not achieve in its goals. Furthermore, students need to be able to re-assemble their networks at transition points. Indeed, the mentoring that helps students to enter community college and select a STEM major may be different from the mentoring that helps students persist in a STEM major after transferring to a four-year school.

Several mentoring practices have been highlighted in the literature as facilitating student retention. These include:

- Transition mentoring programs such as developmental bridge programs, college success courses, learning communities, and scholar cohort programs

- Academic mentoring programs including peer-led supplemental instruction
- Career-relevant mentoring programs including undergraduate research experiences and on-line career mentors (MentorNet)

These can each have a strong impact on diverse students pursuing community college STEM pathways to four-year degrees. Next, I will briefly describe some promising design principles for each of these approaches.

Transition Mentoring Programs. The first semester of college, the student is more likely to stay enrolled. Transition mentoring programs leverage same-stage peer mentoring by establishing smaller cohorts of students. They often feature regular academic and counseling support for students, easing their transition. However, important research has been conducted that examine different instantiations of these programs, highlighting important design principles. In the next paragraphs, I discuss Developmental Bridge Programs, College Success Courses, Learning Communities and Scholar Cohorts in further detail.

The idea behind a developmental bridge program is that enrolling in the bridge program will help students to accrue necessary academic and social skills before officially entering college so that they will be more apt to succeed. In a rigorously-designed study of eight different developmental bridge programs in Texas, program students gained several benefits compared to control students, such as greater academic success in math and writing courses, as well as a greater likelihood to enroll in future writing and math courses [66]. It was clear that a combination of regular academic instruction (in math and writing), college success advising, and academic plus social support from upper-level students contributed positively. However, the authors suggested that some institutions do not find developmental bridge programs to be economically viable, so these elements are sometimes integrated into existing developmental courses or learning community approaches already used by the institution. Related research has discussed the impact of college success courses or extended orientation programs; researchers have been surprised at the positive impact on persistence above students who do not participate in such programs [52, 89].

An alternative to developmental bridge programs that is more applicable to all students is to invest in first year seminars or learning communities. Research focused on the first year seminars [67] and learning communities [68] shows that these approaches have also been associated with positive outcomes. However, further study will give us a better sense of the important elements. A recent, rigorously-conducted research study suggested that a “basic” model of having students co-enroll in two or more classes together is not sufficient and instead, a more elaborated model involving interdisciplinary course planning by the professors of the two classes and special advising of the students was more effective [68]. Specifically, Kingsborough community college organized co-enrollment of racially diverse cohorts in three classes: developmental English, an academic subject, and one credit of college orientation. Students also obtained counseling and a book voucher, while faculty received special professional development. In comparison to the control group, students felt more integrated and engaged, they passed more courses and earned more credits in their first semester, and slightly more program group members were still in college and two years later. At Hillsborough Community College, a more basic approach was used in at least the first two semesters where students co-enrolled in a developmental reading course and a college success course. At the third semester, the faculty increased their collaboration and linked the co-enrolled courses more closely together. Positive impacts of the learning community students in contrast to the control students were only observed in the third semester, suggesting that simply co-enrolling students does not make a learning community.

Yet a third instantiation that also leverages same-stage peer mentoring, but focuses on recruiting the most talented students, is found in scholar cohort programs. A scholar cohort is a group of students selected to be part of a distinguished cohort, such as a team of science scholars, because of academic qualities or leadership. Typically a scholar cohort will stay together for at least the first year of college. Science scholar cohorts have been studied, and are shown to promote persistence particularly among first-generation college students and low-income students [69], as well as promote graduate school attendance in STEM fields [70]. A very effective university-housed program is the Meyerhoff Scholars program at the University of Maryland at Baltimore County. According to research on this program using a number of comparative samples, the Meyerhoff Scholars were more apt to persist in a STEM major, to go to graduate school in STEM, and to earn better grades. In addition to the rigorous selection process and strong financial support of students, the use of study groups, a required summer bridge program, a shared residential location on campus, and professional mentoring are credited as important factors in the success of this program [71, 72].

Another incredibly powerful example is the Posse Scholar model (see possefoundation.org). Most posse scholars are students of color and first-generation college students. The quotation from the Posse website is compelling, “I would have made it in college if I had had my posse with me.” Thus, by creating a posse and sending the posse to college together, the students are more likely to persist than any one member would have alone. The results have been remarkable, with 90% of posse scholars graduating from college, and most going on to graduate school. Selection is highly competitive, and the program prepares the scholars months in advance, through workshops provided by a special trainer. The selective four-year college provides full merit scholarships, and an on-site mentor with whom they meet every other week, among other resources. Of particular interest is Brandeis, the first university with a Science Posse, funded by Posse and Howard Hughes Medical Institute. Their selection process, too, is highly competitive (10 chosen from 1600 applications in New York City). Science posse students attend an intensive two-week science bootcamp, enroll in a math and science course in their first year, and are placed in a research laboratory in their first semester. According to the Brandeis coordinators, the program has been highly successful. When a science posse student thinks about leaving STEM, they think twice because of what that means for their peers.

Academic Peer Mentoring. Academic mentoring is critical for student success. Many colleges and universities have tutoring programs, but they are often critiqued as providing only a remediation model. In contrast to tutoring, academic peer mentoring programs such as supplemental instruction (SI) or facilitated study groups (FSG) can encourage a culture of excellence in STEM through peer academic support for all. SI sessions are fundamentally very different from tutoring because peer instructors lead a reprise of the lecture, with prepared interactive materials designed to target misconceptions and trouble spots. The underlying premise of a facilitated study group (FSG) is similar to SI, but the overall climate of an FSG can feel more like a collaborative study session with the leader facilitating problem-solving exercises. Developed by Uri Treisman, the FSG approach helps to de-stigmatize help-seeking and instills habits of mind that are predictive of excellence [78]. In these models, students have leadership positions to grow into as they advance in the major, providing even more incentive, due to improved mastery and commitment to their majors [73]. The programs are cost-effective and help to alleviate burden on faculty in office hours.

Supplemental instruction is an approach with a strong research foundation [74-77]. University of Missouri-Kansas City's National Center for Supplemental Instruction recommends a method in which gateway courses, or ones that appear to hold people back from progressing in the major, are identified by analyzing course grades and withdrawals, as well as by using faculty nomination and student nomination. Students who attend SI or FSG sessions tend to do better in the gateway class, with positive results documented in introductory and upper-level courses, across science disciplines, with even greater benefits to racial-ethnic minority students [76]. In summary, colleges should ensure that students in gateway courses not only have tutoring services, but also have SI or FSG sessions attached to them, as these provide insurance for retention and excellence for all students.

Undergraduate Research Experiences. Numerous studies have documented the positive influence of undergraduate research experiences [62, 79, 80]. Students gain a better sense of the field, grow their skills, and increase their commitment to STEM fields. Students can benefit from either summer research opportunities or academic year research experience. One recommendation is to fund more flexible research experiences for undergraduates, such as part-time summer research programs, so that nontraditional-aged students, students who need to continue working in another job, or students with families would be more apt to participate. In addition, on-line career mentoring systems such as MentorNet have been effective at sustaining career interests [62]. To expand these types of program, businesses can be incentivized for providing STEM internships or participating in STEM mentoring program initiatives. A program could be developed to support graduate students who want to learn more becoming a faculty member at a community college. This initiative would help to build a pipeline of faculty committed to science education. Training for mentors needs to be expanded to improve the efficacy of programs [81]. Institutions also need to expand their institutional research capacities so that mentoring initiatives can be studied and linked to retention outcomes.

Summary of Mentoring Recommendations

- National Science Foundation and other organizations should require student mentoring plans akin to NSF's postdoctoral research plans.
- State-level higher education offices should require mentoring and retention plans for new programs.
- Institutions should invest in their institutional research offices in order to study the effectiveness of bridge programs, college success, and supplemental instruction on retention within disciplinary majors.

Overall Conclusions and Next Steps

We know that students and their families need access to information about STEM programs and opportunities in college. By forming partnerships across high schools, community colleges, and four-year institutions, and coordinating outreach efforts, we can reach more students, grow knowledge, and spark interest. Beyond this, students need to find STEM pathways feasible to pursue. By expanding dual enrollment programs, we will recruit more students into STEM pathways when more students earn college-level math courses. Beyond outreach and recruitment, we need to build in sustained support. Several mentoring program types have been documented to show positive outcomes. Some programs target the initial transition into college, while others support academic progress in gateway STEM courses, and still others provide hands-on research experience under the supervision of a faculty member or seasoned students. Multiple research studies document which programs tend to work and the beginnings of why some work better than others; additional research is needed to continue to identify the core elements that improve effectiveness and can help to scale these programs. State-level higher education offices that approve new academic programs should require mentoring and retention plans [82]. Grants should require a mentoring plan for students much like the National Science Foundation requires a postdoctoral mentoring plan. Mentoring initiatives will become more widespread, documented, and assessed.

A final caution: all of the formal programs and initiatives outlined will not have the impact we need. Ultimately, we need to infuse informal mentoring strategies into the daily activities of faculty and staff across campuses. Indeed, one of the strongest predictors of student engagement and persistence in STEM fields is the quality and type of interactions with faculty [83-87]. Institutional leaders need to understand the value of recruiting and retaining diverse students in STEM from community colleges to four-year institutions so that all students, especially our most underrepresented, see STEM fields as fields they want to pursue and places in which they will thrive. Collectively, by engaging in outreach, recruitment and mentoring together, we can improve the experiences students have in multiple STEM pathways as well as our nation’s workforce.

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