Models to Address the Needs of Disadvantaged Students in STEM Fields

In this report, Hanover Research provides a review of the literature regarding recruiting and retaining underrepresented students in STEM majors. The report begins with an overview of trends and barriers for underrepresented students in STEM courses. It continues with a detailed summary of effective intervention methods for increasing retention. Finally, it closes by offering profiles of seven successful STEM intervention programs used by colleges and universities across the country. These profiles include program descriptions, associated components, funding capabilities, and suggested or documented impacts.
Executive Summary

In this report, Hanover Research addresses the under-preparedness of students entering higher education institutions expecting to succeed in science, technology, engineering and math (STEM) disciplines. To do this, we examine current trends, barriers, and strategies associated with the retention of underrepresented student populations in STEM fields. We then detail the characteristics of STEM programs that have been successful in increasing student retention and achievement. The report is divided into three main sections, as detailed below.

Section I: Literature Review: The opening section introduces the topic of underrepresented students in STEM majors through an overview of relevant research. It describes current trends, identifies several barriers to student success, and offers a theoretical framework.

Section II: Operational Models to Support Disadvantaged Students: The second section provides greater detail regarding strategies to assist disadvantaged students in STEM fields. It delves into specific models and approaches to help students succeed in STEM majors.

Section III: Institutional Profiles of STEM Programs: The third section provides profiles of STEM programs at institutions that have employed the models outlined in Section II. We examine seven programs and outline their corresponding strategies, components, funding, and impact. The following institutions are profiled in this section:

- Bowling Green State University
- Purdue University
- Rutgers University
- University of Maryland, Baltimore County
- University of California, Berkeley
- University of California, Davis
- University of California, Leadership Excellence through Advanced Degrees

Key Findings

- Recruiting and retaining underrepresented students majoring in STEM fields is a challenge for colleges and universities. Despite a modest increase over the last 15 years, minorities (African-Americans, Hispanics, and Native Americans), women and economically disadvantaged students are still classified as underrepresented in STEM disciplines.
In 1998, the national average of African-American, Hispanic and Native American students accounted for about 12 percent of the total STEM degrees awarded. In 2009, this number rose to approximately 15 percent. Thirty-one percent of those earning STEM degrees were women in the 2008-2009 academic year, a 5.9 percent increase from 2000-2001.

The first two years of college represent a critical transition point for STEM students, as many leave their intended STEM majors during this time. This trend is more prevalent among underrepresented minorities and female students.

There is conflicting research regarding the reasons why a disproportionate number of women and underrepresented minorities leave STEM majors. Research has suggested that students lose interest in STEM, perceive faculty as inadequate teachers, pursue STEM careers with insufficient information, and become overwhelmed by the curriculum’s pace and workload.

Attitudinal and institutional barriers that limit the retention of underrepresented populations in STEM in higher education include:
- Flawed rewards systems
- Antiquated governance structures
- Resource constraints and inequities
- Inadequate outreach services
- Social bias and a lack of support

Strategies to increase degree completions in STEM include:
- Reduced class sizes
- Regular monitoring of courses
- Implementation of a common first-year experience for all students
- Provision of experiential learning opportunities
- Increased student support and mentoring

Institutions have employed a variety of methods to assess the experiences of their students, including: establishing learning outcomes; informal feedback; locally-designed student surveys and interviews (measuring attitudes and perceptions); tracking student achievement over time; and the National Survey of Student Engagement.

Research has shown that summer bridge programs do not provide enough support for students throughout their academic careers. Effective intervention models for addressing the needs of disadvantaged students in STEM fields are likely to include one or more of the following components over multiple years:
- Financial aid
- Top-level administrative support
- Academic support
- Inclusivity, diversity awareness and/or multicultural sensitivity programs
Section I: Literature Review

It is in the interest of the United States to develop a group of STEM graduates that represents the diversity of the country. The role of higher education institutions is to produce a talented, highly skilled, and diverse technical workforce. As Charles Vest, the president of MIT, has stated, “If this nation is to thrive—economically, socially, politically—we must do all we can to ensure that all of our citizens are able to reach their full potential. Only then will we realize the full benefits to be found in a society peopled with different cultures, races and nationalities.”1 STEM graduates are needed to replace the aging workforce, meet demand in the growing technological business sectors, and to sustain the United States’ position as a global innovator. However, there have been long-term declines in students majoring in these high-demand disciplines, especially among minorities and women.

Recruiting and retaining underrepresented students majoring in STEM fields is a challenge for colleges and universities. Despite a modest increase over the last 15 years, minorities, women and economically disadvantaged students are still underrepresented in STEM disciplines. In 1998, African-American, Hispanic and Native American students accounted for about 12 percent of the total STEM degrees awarded. In 2009, this number rose to approximately 15 percent. Literature indicates that “approximately half of the African-American and Native American freshmen entering STEM majors drop out or switch majors and two-thirds of Hispanic students do not complete their degrees.”2 Table 1 and Figure 1 show detailed STEM degree conferral statistics collected by the U.S. Department of Education’s National Center for Education Statistics (NCES).

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Table 1: Number of Degrees Conferred in STEM Fields by Race/Ethnicity for Academic Year 2008-2009

<table>
<thead>
<tr>
<th>Race/Ethnicity</th>
<th>Total No.</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>248,595</td>
<td>57.3</td>
</tr>
<tr>
<td>Asian</td>
<td>41,317</td>
<td>9.5</td>
</tr>
<tr>
<td>African American</td>
<td>32,488</td>
<td>7.5</td>
</tr>
<tr>
<td>Hispanic</td>
<td>30,516</td>
<td>7.0</td>
</tr>
<tr>
<td>Unknown</td>
<td>26,228</td>
<td>6.0</td>
</tr>
<tr>
<td>Non-Resident Alien</td>
<td>51,308</td>
<td>9.5</td>
</tr>
<tr>
<td>Native American</td>
<td>2,795</td>
<td>0.6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>433,742</strong></td>
<td><strong>97.4</strong></td>
</tr>
<tr>
<td><em>Women (of all races and ethnicities)</em></td>
<td>134,634</td>
<td>31</td>
</tr>
</tbody>
</table>

Source: NCES

Figure 1: Number of Degrees Conferred in STEM Fields by Race/Ethnicity for Academic Year 2008-2009

As depicted above, African-Americans, Hispanics, Native Americans, and women are underrepresented in STEM majors. Note, however, that the percentage of women earning STEM degrees rose by 5.9 percent between the 2000-2001 and 2008-2009 academic years. Generally, Asians and non-resident aliens are not considered underrepresented.5

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3 Ibid.
The first two years of college are a critical point for STEM students, as many leave their intended STEM majors during this time. This trend is more prevalent among underrepresented minorities and female students, as depicted in Figure 2.

Figure 2: Lost Talent in Higher Education

There is conflicting research regarding the reasons why women and underrepresented minorities leave STEM majors disproportionately. Some scholars have suggested that students lose interest in STEM, perceive faculty instruction as inadequate, pursue STEM careers with “insufficient information,” or become overwhelmed by the curriculum’s pace or workload. Other literature has indicated that students’ “performance or attitude attributes” are more directly related to their likelihood of dropping out.6

Barriers for Disadvantaged Students in STEM Fields

In this subsection, we discuss attitudinal and institutional barriers that limit the retention of underrepresented populations in STEM in higher education. These barriers include:7

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6 Weaver, G. et al. “Attracting Students to STEM Careers: A White Paper Submitted to the 2007-2013 Purdue University Strategic Planning Steering Committee,” p. 3. Purdue University.  
http://www.purdue.edu/strategic_plan/whitepapers/STEM.pdf

- Flawed rewards systems
- Antiquated governance structures
- Resource constraints and inequities
- Inadequate outreach
- Social bias and the lack of support groups

The first four factors are primarily institutional barriers, while the last is attitudinal. “Flawed rewards systems” refers to tenure systems rooted in research rather than diversity. Researchers have noted that in many institutions, there are “limited opportunities for younger science and engineering professionals, particularly women and underrepresented minorities.”8 “Antiquated governance structures” relate to the lack of leadership or incentives for the inclusion of minorities and women. Additionally, institutions that educate the majority of minority populations tend to be “less well-endowed, with fewer state-of-the-art facilities and instrumentation.”9 Furthermore, negative attitudes may contribute to “the stereotyping of students and the use of pedagogies that fail to recognize variations in learning styles,” both factors which “remain … fundamental contributor[s] to the attrition of underrepresented groups.”10

The success of a student is largely dependent on his or her K-12 education. For example, insufficient academic preparation at the post-secondary level is often seen in students who did not develop appropriate study habits earlier in their education. Students may find STEM courses more difficult than coursework in other disciplines and, as a result of this difficulty, may lower their expectations regarding their ability and likelihood of success.11 Additionally, negative perceptions of themselves as STEM students can accompany negative attitudes regarding STEM disciplines in general. Research has found evidence of “discrimination and harassment in the classroom, especially against girls.”12 In fact, literature suggests that “by the age of twelve, children have already formed firm beliefs about the subjects at which they excel and those at which they fail.”13

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8 Ibid.
9 Ibid.
10 Ibid.
Underrepresented groups are likely to experience anxiety when entering STEM courses. In such instances, a lack of community may be a significant barrier to individuals who already feel that they do not belong. This lack of community can be more pronounced for students who are in the minority and without peers in a class, such as African-Americans, Hispanics, and women. For instance, research has shown that African-Americans at predominately white institutions perceived that “faculty, students, and staff did not view them as full human beings with distinctive talents, virtues, interests, and problems.”

This finding is supported throughout the literature. In a survey conducted by Feagin and colleagues, researchers similarly noted that “black students at mostly white universities found they were so concerned about intellectual survival that they were unable to devote as much attention to their personal, social, and cultural development as they should.”

Another barrier to the retention of disadvantaged students in STEM disciplines is financial. Research has indicated that students are less likely to persist in their studies when their financial needs are not met. Additionally, financial limitations and attrition rates have been shown to be associated. The Pathways to College Network, for instance, found that only 25 percent of low-income students who enroll in postsecondary institutions receive a bachelor's degree. More affordable programs and convenient financial aid opportunities can increase retention and academic attainment for disadvantaged students. In a comparison study of African-American, Hispanic and white students, researcher Deborah Faye Carter found that in the case of African-Americans and Hispanics, sufficient financial aid can help students overcome parental education and income barriers.

Academic factors may also contribute to reduced interest or aspirations in pursuing careers in STEM. The figure below describes these factors, as outlined in a report by the Oregon Pre-Engineering and Applied Sciences Initiative’s Diversity Committee.
Strategies to Increase Degree Completions

There are several key strategies for increasing the retention of underrepresented students in STEM and combating the barriers discussed above. Since a high percentage of STEM losses occur in the first two years, institutions must work to change the learning experience for students during this time period. Researchers at Purdue University have offered the following six strategies for making the first- and second-year STEM curriculum more appealing to underrepresented students:20

- Reduced class sizes:
  - Limit course enrollment to 25 students or less
  - Decrease use of labs taught by teaching assistants
  - Allows students more opportunity to engage in small group and community-building activities
  - Increases time for high quality teacher-student and student-student interactions

- Regular monitoring of courses:
  - Implement enhanced teacher evaluations
  - Restructure courses with DFW (students who receive a D or F, or withdraw) rates of 25 percent or higher

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❖ Institute a common first year experience for all students
  o Program may include cross-disciplinary courses highlighting the
    significance and connection between STEM and other subject matter
    (e.g., business, politics, culture)

❖ Provide experiential learning opportunities
  o Develop research-based and/or service-learning programs
  o Helps to recruit well-prepared students into STEM majors

❖ Increase student support and mentoring
  o Provide students with information on selecting STEM courses
  o Provide students with information on available STEM careers
  o Offer assistance for students with academic difficulties
  o Encourage close relationships between STEM faculty, students, and
    others in the same disciplines
  o Expand student support services
  o Increase the amount of academic advisors
  o Encourage senior students to mentor incoming STEM students
  o Implement learning communities
  o Promote student groups (e.g., Women in Science, the Minority
    Engineering Program)

Measuring Success

Assessing STEM programs requires measuring underrepresented students at both the
collective and individual level. Institutions have employed a variety of methods to
assess student experiences. A survey conducted by Project Kaleidoscope and the
Association of American Colleges and Universities examined common assessment
tools used by institutions in a STEM interdisciplinary learning project.21 Table 2,
below, provides an overview of the various assessment instruments identified by
institutions. Figure 4 shows the results of a survey on the most commonly used
assessment strategies among institutions seeking to improve their STEM programs.

Data presented in Figure 4, below, show that institutions commonly use the
following methods to assess the experiences of their students: establishing learning
outcomes; informal feedback; locally designed student surveys and interviews
(measuring attitudes and perceptions); tracking student achievement over time,
and the National Survey of Student Engagement.

Kaleidoscope, Association of American College and Universities.
http://www.aacu.org/meetings/STEM/documents/W1b.pdf
Table 2: STEM Assessment Instruments Identified by Institutions

<table>
<thead>
<tr>
<th>Assessment Instruments Referenced in Campus Reports</th>
</tr>
</thead>
<tbody>
<tr>
<td>✤ National Survey of Student Engagement (NSSE)</td>
</tr>
<tr>
<td>✤ Faculty of Student Engagement (FSSE)</td>
</tr>
<tr>
<td>✤ Collegiate Learning Assessment (CLA)</td>
</tr>
<tr>
<td>✤ Association of American Colleges &amp; Universities (AAC&amp;U) VALUE Rubrics</td>
</tr>
<tr>
<td>✤ Summer Undergraduate Research Experience (SURE)</td>
</tr>
<tr>
<td>✤ Classroom Undergraduate Research Experience (CURE)</td>
</tr>
<tr>
<td>✤ Research on Integrated Science Curriculum (RISC)</td>
</tr>
<tr>
<td>✤ Student Assessment Learning Gains (SALG)</td>
</tr>
<tr>
<td>✤ Filed-Tested Assessment Guide (FLAG)</td>
</tr>
<tr>
<td>✤ Views about Science Survey (VASS)</td>
</tr>
<tr>
<td>✤ Course evaluations/student evaluations of faculty</td>
</tr>
<tr>
<td>✤ Embedded exam questions</td>
</tr>
<tr>
<td>✤ Other institutional data (course/program retention, Higher Education Data Sharing)</td>
</tr>
<tr>
<td>✤ Biology Self-Efficacy Scale, Science Literacy Scale, Self-Determination Scale</td>
</tr>
</tbody>
</table>

Source: Project Kaleidoscope & Association of American College and Universities

Figure 4: Commonly Used Assessment Strategies among Institutions Seeking to Improve STEM Programs

Source: Project Kaleidoscope & Association of American College and Universities
Section II: Operational Models to Support Disadvantaged Students

In this section, Hanover identifies effective intervention models for addressing the needs of disadvantaged students in STEM fields. If a program is better suited for underrepresented students, not only are such students more likely to enroll, but they are also more likely to succeed.

In fall 2002, the Student Affairs staff of the Minnesota State Colleges and Universities system reviewed approximately 1,000 institutional websites to distill the recruitment and retention practices of underrepresented students. A framework of best practices was generated through this research initiative, consisting of the following components:22

- Financial Aid
- Top-level administrative support
- Academic support
- Inclusivity, diversity awareness or multicultural sensitivity programs

In the remainder of this section, we discuss these practices in detail, beginning with the adoption of financial aid opportunities to target minority students.23 Section III provides examples of specific institutions that have experienced success by implementing these strategies in STEM programs.

Financial Aid

Financial support refers to adequate aid opportunities, especially for the first three years of a student’s collegiate career. Providing access to financial aid is not sufficient in and of itself; information and support must be provided to students as well.24 Financial aid is closely related to a university or college’s admissions and recruitment efforts. Table 3, below, shows the results of a study which determined that finances are an important priority for both parents and students in the college search.

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24 Ibid.
Table 3: College Priorities for Students, Parents, and Guidance Counselors

<table>
<thead>
<tr>
<th>Rank</th>
<th>Search Priorities of Low-Income and First Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Students</td>
</tr>
<tr>
<td>1</td>
<td>Major/program of study</td>
</tr>
<tr>
<td>2</td>
<td>Location and cost/financial aid</td>
</tr>
<tr>
<td>3</td>
<td>Student demographics and diversity/campus setting</td>
</tr>
<tr>
<td>4</td>
<td>Size</td>
</tr>
</tbody>
</table>


Top-Level Administrative Support

Administrators have the ability to set policies that benefit underrepresented populations in STEM disciplines. A variety of practices may be adopted, such as the implementation of student support services; experimentation with strategies to improve student success; and the use of student data to improve programs and services. Top-level administrative support has two central dimensions:

- Expressed support for improvements in minority student recruitment and retention at the highest administrative levels; and
- Inclusion of recruitment and retention goals in strategic plans and annual work plans, along with accountability mechanisms for achievement of the goals.

To be effective, administrative policies and practices should align with the mission of STEM programs and maintain a focus on encouraging student success. In essence, administrators should focus on policies that provide underrepresented students with a sense of belonging. A 2006 review of best practices highlighted the following effective strategies in the development of top-level administrative support policies:

- Reviewing data for gaps in completions among minority students as compared to white students;
- Forming an administrative position or structure (e.g., a standing committee) responsible for overseeing minority student success; and

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26 Ibid., 4 (bullet points quoted directly from source).
Establishing special policies on minority recruiting and hiring, and offering professional development for minority faculty and staff.

**Academic Support**

A variety of academic support services have been proven effective in aiding underrepresented students. Table 4 provides a breakdown of three types of academic support services and associated delivery methods.

**Table 4: Types of Academic Support**

<table>
<thead>
<tr>
<th>Type of Academic Support</th>
<th>Delivery Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Academic Skills</strong></td>
<td>☐ Summer bridge and developmental education programs</td>
</tr>
<tr>
<td><strong>Academic Direction</strong></td>
<td>☐ Early identification/intervention</td>
</tr>
<tr>
<td></td>
<td>☐ Highly-structured freshman year programs (directive advising, seminars, linked classes, study groups, etc.)</td>
</tr>
<tr>
<td></td>
<td>☐ Intensive orientation</td>
</tr>
<tr>
<td></td>
<td>☐ Advising, counseling or mentoring</td>
</tr>
<tr>
<td><strong>Academic Instruction</strong></td>
<td>☐ Interest groups</td>
</tr>
<tr>
<td></td>
<td>☐ Cohort course clusters</td>
</tr>
<tr>
<td></td>
<td>☐ Learning communities</td>
</tr>
<tr>
<td></td>
<td>☐ Tutoring</td>
</tr>
<tr>
<td></td>
<td>☐ Group study</td>
</tr>
<tr>
<td></td>
<td>☐ Supplemental instruction</td>
</tr>
<tr>
<td></td>
<td>☐ Mastery classes</td>
</tr>
<tr>
<td></td>
<td>☐ In STEM, emphasis on concepts and scientific reasoning; abstraction demonstrated through hands-on experimentation</td>
</tr>
</tbody>
</table>


These types of academic support also correspond with key factors that STEM students have identified as central to success. In a survey of which program components students found most beneficial, 82 percent of responses identified research projects; 67 percent, summer bridge programs; 60 percent, mentoring; 48 percent, financial stipends; and 32 percent, tutoring.29

Additionally, the following curriculum recommendations have been identified as effective for making programs more appealing to minority and female STEM students:30

- Classroom environments that encourage questions
- Group projects that foster cooperative learning

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30 Ibid., 16-17.
 Demonstrations of how STEM knowledge is applied in industry  
 Communication of STEM’s usefulness in broader life and social issues  
 Projects that make applications clear and build upon previous knowledge and experience  
 Remedial classes  
 Extra help  
 Use of inclusive language and examples  
 Acknowledgement of teachers’ biased or stereotypical attitudes  
 Grading assignments blind to the identity of students  
 Use of information, such as web documents, to encourage students to take STEM courses  
 Use of varied teaching methods to appeal to different learning styles  
 Summer school courses to help talented pre-college students overcome deficiencies in their backgrounds and build confidence in STEM skills

**Diversity Awareness or Multicultural Sensitivity Programs**

In addition to academic support services, **institutions must also create supportive social networks**. Successful institutions have used a two-pronged approach:  

- Increasing retention by integrating students into the university successfully; and  
- Fostering disciplinary socialization by immersing students into STEM fields as a profession.

An inclusive and welcoming institutional environment helps to connect students to that environment, particularly through the following activities: academic and social integration; mentoring; ethnic social groups; summer pre-college programs; learning communities; and intergroup dialogue.  

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31 Ibid., 16.  
Section III: Institutional Profiles of STEM Programs

This section profiles institutions with programs that adhere to the theoretical frameworks discussed in the previous section. Note that the institutions highlighted in this section have generally implemented a combination of the components or strategies highlighted in Section II. Institutional profiles include program descriptions and their associated components, funding capabilities, and suggested or documented impacts on student retention and achievement levels.

Bowling Green State University

Bowling Green State University offers the Academic Investment in Math and Science (AIMS) program to “increase the number of women and students of color” who graduate with majors in STEM and “who proceed to get terminal degrees in their fields [and] ultimately perform cutting-edge research and/or teaching.” Table 10 shows the constituent components of the AIMS program.

Table 10: BGSU’s Program Components for STEM Students

<table>
<thead>
<tr>
<th>Program Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-week Summer Accelerated Program</td>
</tr>
<tr>
<td>AIMS Seminar I and II, with the primary purpose being to provide students with a better sense of belonging to BGSU and AIMS</td>
</tr>
<tr>
<td>Ongoing mentorship program</td>
</tr>
<tr>
<td>Regular individual one-on-one meetings with the AIMS Director</td>
</tr>
<tr>
<td>Students Teaching and Reaching Students (STARS) give students the forum to:</td>
</tr>
<tr>
<td>o Teach and learn from each other</td>
</tr>
<tr>
<td>o Receive expertise on math/science topics</td>
</tr>
<tr>
<td>o Receive frequent and continued positive reinforcement for course material</td>
</tr>
<tr>
<td>Research opportunities after the freshman year, including summer REU</td>
</tr>
<tr>
<td>Summer internships</td>
</tr>
<tr>
<td>Participation in campus research seminars, poster sessions and/or presentations</td>
</tr>
<tr>
<td>Off-site visits to conferences at which AIMS scholars may be presenters</td>
</tr>
<tr>
<td>Volunteerism and promotion of AIMS program</td>
</tr>
<tr>
<td>Peer mentoring of incoming AIMS scholars</td>
</tr>
<tr>
<td>Academic counseling and tutoring</td>
</tr>
<tr>
<td>GRE/MCAT exam preparation, starting the sophomore year</td>
</tr>
<tr>
<td>Exposure to ‘real world,’ accomplished mathematicians and scientists</td>
</tr>
<tr>
<td>Visits to graduate school programs</td>
</tr>
<tr>
<td>Assistance in securing admission to and financial assistance in graduate programs</td>
</tr>
</tbody>
</table>

Source: Bowling Green State University

The summer bridge program listed in the table is designed to help students acclimate to campus life and STEM academics. According to its website, the summer program includes:

34 Ibid.
Two mini-courses in math and computer science
Science exposures (lecture and lab) with stand-alone topics in biology, chemistry, physics, geology, and astronomy
Co-curricular excursions to science-related facilities such as Pfizer Pharmaceutical, Marathon Oil, the Toledo Zoo, and others
Extra-curricular/recreational activities

In addition to the summer support, assistance is provided at the freshman-sophomore and junior-senior levels. The first phase, designed to facilitate academic success and encourage continued study in STEM disciplines, includes:  

- Cluster courses
- AIMS Seminar I and II
- One-hour graded course
- STARS group study
- Mentoring programs
- Exposure to undergraduate research
- STEM exposure (engagement with STEM-based activities)
- One-on-one meetings with program director or surrogate
- Weekly AIMS member meetings

The junior-senior phase, ending in graduation, includes “Experience Critiques (presentations about their experience to younger students), post-baccalaureate test taking (i.e., GRE exam), and job/graduate school searches.”

Upon successful completion of the Summer Bridge Program, students receive a $1,000 stipend and can officially matriculate for the upcoming fall. Students in “good standing” are awarded a four-year academic scholarship of $1,500 that increases annually by $500 increments.

The AIMS program has positively impacted students’ academic achievement. Documented findings include:

- A positive correlation between the achievements of AIMS scholars in their summer math class and their first fall semester grade point average.

- 2002-2003 AIMS versus control cohorts:

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36 Ibid., p. 11.
37 Ibid.
38 Ibid.
39 Ibid.
o AIMS scholars received about 65 percent A’s or B’s in their first semester math courses
o No AIMS scholar received an F in their fall math class
o In terms of overall grade distribution, AIMS cohorts received 62 percent A’s or B’s, whereas the control group received only 38 percent

❖ Retention in the 2002-2005 cohorts:
  o AIMS Scholars have been retained at the University and in STEM fields at a rate of about 90 percent
  o Of the 2002 control group, only 72.2 percent are still at BGSU

Purdue University

Purdue offers two programs to boost retention for underrepresented students in STEM majors. First, the University utilizes Learning Communities, which involve:40

❖ Co-enrolling a cohort of 20-30 first-year students in two or more courses based on their STEM majors; and
❖ Placing a group of first-year students in the same residence hall based on their STEM majors.

When creating learning communities, particular emphasis should be placed on underrepresented minorities and women. For example, at Purdue, the percentage of minorities and women in learning communities was higher than the percentage of minorities and women in the entire 2007 entering class. When comparing these groups, researchers found, “learning community participants show higher retention and better performance, relative to comparable groups who are not in learning communities.”41

Purdue’s second program provides experiential learning opportunities to STEM undergraduates. Engineering Projects in Community Service (EPICS) was founded in fall 1995 at Purdue, and over 2,000 students have participated to date. EPICS provides undergraduates the opportunity to design, construct, and implement their STEM knowledge to solve engineering-based problems in the local community. Projects are focused on the following areas: human services, access and abilities, education and outreach, and the environment. Students work in teams, which are multi-disciplinary and vertically-integrated: for instance, a freshman

41 Ibid.
engineering student may work on a technology-based problem with senior accounting students.42

Through EPICS, undergraduates gain “knowledge of engineering, mathematics, and science, and experience in engineering problem-solving and system design,” skills which “call for students to be able to function on multidisciplinary teams and communicate effectively.”43 Research has documented the benefits of service-learning for STEM students.44

EPCIS is structured so that freshman and sophomore participating students gain one credit per semester. Juniors and seniors earn one to two credits per semester. The program consists of weekly two-hour meetings at the laboratory with teammates. Meeting time is allocated for administrative matters, project tracking and planning, and technical tasks. Additionally, all students are required to attend a weekly common lecture lasting an hour, many of which are taught by guest-speakers.45

As discussed, the projects cover a wide range of community needs. However, each project has five distinct phases: establishing project partnerships, assembling a project team, developing a project proposal, system design and development, and system deployment and support. Below is a list of EPICS projects and descriptions provided on the program’s website:46

- **Advanced Design (APPS):** “This team will be an advanced design team exploring the projects such as advanced data bases, mobile device apps, iPad apps for assistive technology (child and adult), and Google Android apps. This team will be geared for ECE students interested in a senior design project that would be used in real world applications.”

- **Database and Innovative Software for the Community (DISC):** “This team will be creating scalable data-centric applications meant to track and organize project partners’ information. There is a focus on remotely accessible tools that are full function and easy to use. A lot of the current projects use .net and databases, but there are also python, HTML, CSS, and other technologies.”

- **Electric Vehicle Event Infrastructure (EVEI):** “This course is a project-based design course to develop the core infrastructure required to establish the Purdue Electric Vehicle Kart event. This project will explore and

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42 Ibid., Appendix J. and “EPICS.” Purdue University. https://engineering.purdue.edu/EPICS
44 Ibid.
45 Ibid.
46 “Teams” Purdue University EPICS. https://engineering.purdue.edu/EPICS/Projects/Teams
recommend electric go-kart design specifications, track and safety requirements, and race scoring. This interdisciplinary team will be using the EPICS Human Center Design Process to achieve the project deliverables.”

The EPICs program is supported by the National Science Foundation; the Corporation for National and Community Service, Microsoft Research, Hewlett-Packard, and National Instruments.47

Quantitative and qualitative evaluation methods in EPICS focus on specific course and program objectives. For example, the program’s overall retention rate is over 77 percent. In a student evaluation survey, 70 percent of students reported that the program “positively impacted their resolve to continue in engineering.”48 Moreover, “among the 30 percent who did not respond positively, several indicated that they were already committed to engineering and remained for after their EPICS experience, such as graduating seniors.”49

Rutgers University

The Extended Physics program at Rutgers University provides a successful alternative to the traditional introductory courses for students at risk of failure. The program was created in 1987 to compensate for the fact that only 63 percent of incoming freshman engineering majors passed first year physics, with 17 percent receiving a grade of D. Unsuccessful students were disproportionately female, African-American or Latino. Table 5 shows methods identified by the University to address various student risk factors.50

<table>
<thead>
<tr>
<th>Risk Factors</th>
<th>Recommended Methods for Addressing Risk Factors</th>
</tr>
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<tbody>
<tr>
<td>Low confidence</td>
<td>Group work</td>
</tr>
<tr>
<td>Impostor syndrome</td>
<td>Continuous feedback</td>
</tr>
<tr>
<td>Lack of community</td>
<td>Ample availability of staff</td>
</tr>
<tr>
<td>Weak academic preparation</td>
<td>Emphasis on concepts and scientific reasoning</td>
</tr>
<tr>
<td></td>
<td>Abstraction proceeded by hands-on experimentation</td>
</tr>
</tbody>
</table>


47 “EPICS Overview.” Purdue University. https://engineering.purdue.edu/EPICS/About
49 Ibid.
To address student risk factors, Rutgers implemented an extended courses in Analytical Physics I and II for engineering majors, and an extended course in General Physics for pre-med, science, and computer science majors. The table below shows the components of extended courses.

<table>
<thead>
<tr>
<th>Course Component</th>
<th>Description</th>
</tr>
</thead>
</table>
| **Group Work**   |  Teams of 2-3  
|                  |  Evaluated on both group and individual understanding |
| **Course Coordinator** |  Integration of all aspects of learning cycle  
|                  |  Continuity and cohesion among teaching staff  
|                  |  Advising and emotional support to students |
| **Assessment**   |  Nontraditional exam format  
|                  |  Assessments conducted in each class meeting  
|                  |  Diverse Assessment  
|                  | o 30%: Arranging meetings with TAs, showing up to meetings prepared  
|                  | o 10%: Rating of performance in group by other group members  
|                  | o 60%: Quality of work and presentation  
|                  |  Group projects/oral presentations replace one midterm exam |
| **Spiral Learning Structure** |  Each lecture followed by a small group meeting with hands-on collaborative activities |
| **Increased Weekly Contact Hours** |  Extended courses meet twice as often as their regular counterpart |


In addition to creating more supportive courses, the Equal Opportunity Fund offers the following assistance to “those who might otherwise be unable to attend [higher education] institutions”:52

- Summer program
- Tutorial assistance
- Reduced course load
- Extensive counseling services
- Knowledge and caring regarding life circumstances of students

The following impacts have been documented among students in extended classes:53

- The retention rate has nearly doubled for female students, and has increased by more than a factor of seven for black students.
- The physics pass rate of African-American and Latino first year engineers more than doubled, increasing from 26 percent to nearly 60 percent.

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53 Ibid.
University of Maryland, Baltimore County

The University of Maryland, Baltimore County (UMBC) offers the Meyerhoff Scholars Program to improve retention rates among underrepresented students in STEM disciplines. According to its website, the National Science Foundation and *The New York Times* have recognized this initiative as the national model for such programs. The Blue Ribbon Panel reported that the most striking component of the program is “its institutional commitment from the administration and the faculty” and that this commitment “is consistent with evaluation findings indicating that successful interventions to improve the participation of URMs (underrepresented minorities) in STEM fields must be institutionalized.” High school administrators are responsible for nominating students for the program. Funding ranges from $5,000 to $22,000 per year for all four years.

The Meyerhoff Scholars Program is one of the few *evidence-based intervention programs*. The program is designed to build a strong sense of community, which facilitates “a high level of academic achievement and an environment conducive to intellectual exchange.” The program is comprised of 13 components, outlined in Table 7.

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54 “Meyerhoff Scholars Program.” University of Maryland Baltimore County. http://www.umbc.edu/meyerhoff/about_the_program.html
56 Ibid.
57 Ibid.
### Table 7: UMBC’s Program Components for STEM Students

<table>
<thead>
<tr>
<th>Program Component</th>
<th>Description</th>
</tr>
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</table>
| Recruitment                       | ▶ Enrolls approximately 50 new students each year *(of approximately 2,000 nominations)*  
|                                  | ▶ Formal and informal screening process                                                                                                       |
| Financial Aid                     | ▶ A comprehensive, four-year financial-aid package, including tuition, and room and board                                                   |
| Summer Bridge                     | ▶ Mandatory pre-freshman six-week Summer Bridge Program, during which students take courses in math, science, and the humanities                  |
| Program Values                    | ▶ The following values are emphasized:  
|                                  | o Achieving a research-based Ph.D.  
|                                  | o Striving for outstanding academic achievement  
|                                  | o Seeking help (tutoring, advising) from a variety of sources  
|                                  | o Supporting one’s peers  
|                                  | o Participating in community service projects.                                                                                               |
| Study Groups                      | ▶ Students rank study groups as one of the most positive, beneficial aspects of the program                                                |
| Program Community                 | ▶ Family-like, campus-based social and academic support system  
|                                  | ▶ Students live in the same residence hall during their first year and are required to live on campus during subsequent years  
|                                  | ▶ Staff regularly hold group meetings—called “family meetings”—with students                                                                 |
| Personal Advising and Counseling  | ▶ Full-time academic advisor, along with the program’s executive director, director, and assistant director, regularly monitor and advise students |
| Tutoring                          | ▶ Students should attend tutoring and serve as peer tutors                                                                                  |
| Summer Research Internships       | ▶ Summer science and engineering internships arranged through contacts with STEM professionals                                               |
| Mentors                           | ▶ Individual students are paired with a mentor, recruited from the Baltimore- and Washington-area, many work in research labs                  |
| Faculty Involvement               | ▶ Faculty are involved in all aspects of the program, including recruitment, teaching, mentoring research, and special events and activities    |
| Administrative Involvement and    | ▶ Support from all levels of the university  
| Public Support                    | ▶ Founding from community organizations, such as the National Science Foundation, NASA, IBM, AT&T, and the Sloan, Lilly, and Abel foundations. |
| Family Involvement                | ▶ Parents are kept informed of their child’s progress and are invited to special counseling sessions if problems emerge  
|                                  | ▶ Parents are included in various special events  
|                                  | ▶ Parents formed the Meyerhoff Parents Association, a fundraising and mutual support resource                                                 |

Source: UMBC Meyerhoff Scholars Program

By implementing these components, the program has had a positive impact on the number of minority students succeeding in STEM fields. The following outcomes have been documented:

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58 Ibid.  
59 “Program Results – Meyerhoff by the Numbers” (bullet points quoted directly from source). UMBC Meyerhoff Scholars Program. [http://www.umbc.edu/meyerhoff/program_results.html](http://www.umbc.edu/meyerhoff/program_results.html)
Students were 5.3 times more likely to have graduated from or be currently attending a STEM Ph.D. or M.D./Ph.D. program than those students who were invited to join the program but declined and attended another university.

Since 1993, the program has graduated over 700 students. Over 85 additional alumni have earned graduate degrees in engineering, and nearly 300 alumni are currently enrolled in graduate and professional degree programs.

A total of 230 students were enrolled in the program for the 2010–2011 academic year, of whom 51 percent were African American, 26 percent Caucasian, 18 percent Asian, 5 percent Hispanic, 1 percent Native American.

A review of the program has been conducted using a “connoisseurial evaluation.” This approach is defined as one that makes use of both objective and subjective measures, as well as qualitative and quantitative data. The goal of the connoisseurs (evaluators) is essentially to draw on empirical as well as experiential data to evaluate a programs’ impact.60 Broad categories of evaluation of the Meyerhoff Scholars program included:61

- **Effort** – The “assessment of implementation,” or the quality and quantity of activity, regardless of output.
- **Performance** – Measure of the program’s success relative to clearly defined goals and objectives.
- **Adequacy of Performance** – Measure of “the degree to which effective performance is adequate to the total amount of need.”
- **Efficiency** – Primarily related to cost-effectiveness, efficiency may be evaluated more broadly by examining general administrative or institutional processes.
- **Process** – Measure of efficacy on the micro-level, through analyses of specific institutional processes, aimed at determining areas of weakness or potential improvement.

Data collection for the evaluation consisted of secondary research into existing literature; ethnographic methods (e.g., documenting student and faculty experiences); comparative quantitative research of the achievement of Meyerhoff students as opposed to the general UMBC student population; and surveys to examine the academic development programs of “feeder schools” sending large numbers of minority students to selective colleges. Researchers also investigated various existent program evaluation approaches to inform their own work.62

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61 Gordon W. and Bridglall, 9-10.

62 Ibid., 10.
Ultimately, the analysis found that “the extraordinary commitment of UMBC’s leadership, faculty, and staff to minority students’ academic achievement encourages them to constantly seek ways to enhance their students’ academic performance.”

**University of California, Berkley**

The University of California, Berkeley founded its Professional Development Program (PDP) in 1974 “to promote academic excellence and diversity for underrepresented students in mathematics, engineering, and the sciences throughout the educational pipeline from middle school through graduate school.” The following table provides an overview of the academic assistance offered to students.

<table>
<thead>
<tr>
<th>Program Component</th>
<th>Description</th>
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| Intensive Discussion Sessions          | ❖ Sessions in addition to attending the same lecturers as “regular students”  
❖ Sessions are 50 minutes twice a week for up to 80 minutes each  
❖ Students receive an additional unit for attending these longer, intensive discussion sections and a ‘pass’ or ‘no-pass’ grade  
❖ In sessions, students discuss key issues taught in lectures, complete worksheets, work in small groups, and have mini-lectures and quizzes |
| Adjuncts to Discussion Sessions        | ❖ Adjunct group-study courses offered by the Student Learning Center  
❖ Designed to help students improve study strategies, critical thinking, and exam-taking skills  
❖ Students regularly meet three hours a week to work on practice exams or additional problems; learn about time management; and work with peers to solve math problems  
❖ Upper division undergraduate or graduate students lead adjunct sections  
❖ Students receive one ‘pass’/‘not pass’ unit for attending the adjunct course. |
| Math Workshop Discussion Sections      | ❖ Discussion sections in which classroom instruction is comprised of question and answer sessions, mini-lectures, and quizzes with the GSI in front of the class for most of the twice-weekly, 50-minute discussion sections. |

Source: Chin, S. et. al. (2006)

Academic outcomes are measured using matching and statistical techniques (ordinal and regression analysis), designed to compensate for a lack of a randomly assigned, controlled experimental design. Evaluations showed the program to be “clearly effective in improving the performance of minority and other students in basic calculus courses.” However, these programs are “not effective in keeping students...

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65 Ibid.  
66 Ibid., 20-21.
in mathematics, physics, and engineering; raising their grades in later years; or raising the probability of graduating within four years.”

University of California, Davis

The University of California, Davis offers a Biology Undergraduate Scholars Program to all incoming freshmen, but especially encourages underrepresented minorities to apply. In addition to BUSP, UC Davis offers the Special Transitional Enrichment Program (STEP), held the summer before students enter their first quarter.

BUSP was founded in 1988. From 1988 to 1994, the participants had the following demographic breakdown: two-thirds female, 56 percent Hispanic, 26 percent African American, 5 percent Native American, and 13 percent Asian American. BUSP receives its funding from the Howard Hughes Medical Institute, Initiative for Minority Student Development and the National Institute of General Medical Sciences.

The program includes academic enrichment and financial and support services throughout a student’s academic career. However, it is primarily a two-year program for students interested in pursuing biology degrees. The table below outlines the program’s components and provides a brief description of each.

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67 Ibid.
<table>
<thead>
<tr>
<th>Program Component</th>
<th>Description</th>
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</table>
| **Freshman Year**  | ❖ Special pre-chemistry preparation and tutorial classes to supplement regular math and chemistry courses  
❖ Small group work for problem-solving and study skills that carry over into later years  
❖ A special seminar courses that examine important topics in modern biology  |
| **Summer Session 1 Following Freshman Year** | ❖ Courses include a chemistry introductory series and laboratory skills course for research experience needed in sophomore year  
❖ BUSP pays registration and course fees and a $1,200 stipend to offset living expenses  |
| **Summer Session 2 Following the Freshman Year** | ❖ A special “Biology Boot Camp” workshop to enhance student performance in the Introductory Biology Series that they will take the following fall quarter  
❖ A $765 stipend is provided to offset living expenses  |
| **Sophomore Year** | ❖ Year-long seminar course for scientific skills and professional development which includes presentations by guest speakers from science-based professions and campus resource units  
❖ Throughout the year, students receive financial compensation for conducting faculty-sponsored laboratory research  
❖ Students enrolled in lower-division biology courses participate in small study groups providing course-related expertise and tutoring  |
| **Junior & Senior Years** | ❖ Monthly presentations by faculty and staff on a variety of issues such as research ethics, career opportunities and a wide array of science-related topics  |
| **Advising Component** | ❖ Regular meetings with a professional staff advisor in the biological sciences throughout their freshman and sophomore years  
❖ Academic advice on course planning, guidance regarding course-load, and graduation planning, and personal advising  |
| **Research Component** | ❖ Opportunities to work for a salary in a research laboratory during students’ sophomore year  |

Source: UC Davis

Research has documented the positive impacts of this program; notably, participation has increased the odds of attaining a biology degree by 50 percent. When comparing BUSP students to a qualified comparison group, researchers found that BUSP students were more likely to successfully complete the three quarter sequences in General Chemistry and Calculus and to have a higher GPA. Research on BUSP additionally found that “a program of academic enrichment and personal support in the early college years can partly compensate for poor high school preparation.”

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71 “Curriculum.” University of California Davis BUSP. http://www.busp.ucdavis.edu/Home/Curriculum  
University of California, Leadership Excellence through Advanced Degrees

The University of California Leadership Excellence through Advanced Degrees (UC Leads) is a program funded through the Koret Foundation that provides services to STEM students in the California public university system.\(^{73}\) UC Leads is designed to encourage and train undergraduates so that they may pursue graduate studies or become professionals committed to combating the educational and economic barriers contributing to the underrepresentation of minorities in STEM fields. The program targets students who have:\(^{74}\)

- Experienced educational barriers to their academic progress, or who express a commitment to address the barriers that prevent participation of students from underrepresented groups in graduate academic programs.

- Experienced situations or conditions that impacted their advancement or ability to advance in a STEM field.

- Leadership potential to address the issues of underrepresentation of domestic minorities in the STEM fields.

- The potential to gain the personal and multicultural competency skills necessary to address the needs of a diverse State and global community through science and technology.

Undergraduates must be currently enrolled in, or about to be enrolled in, a UC undergraduate degree program in a STEM discipline. The program provides students with the tools needed to alleviate California’s continuing scientific, economic, and social challenges. The table below outlines the program’s eight components.

\(^{73}\) “UC Leads.” University of California, Office of the President. http://www.ucop.edu/ucleads/program_overview.htm

\(^{74}\) Ibid. (bullet points quoted directly from source).
<table>
<thead>
<tr>
<th>Program Component</th>
<th>Description</th>
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</table>
| Undergraduate Mentorship Experience | - Students are matched with UC faculty advisors and mentors  
- With mentors/advisors, students develop an educational action plan that includes structured research, graduate school preparation and exploration, and participation in professional and/or scientific society meetings.  
- This action plan should:  
  o Clearly describe the expenses required to support the scholar's research activities that will be supported by the UC Leads program, and  
  o Be approved by the scholar, mentor, and campus coordinator. |
| Academic Year Research | - Organized research program during each academic year, under the direction of the faculty mentor |
| Campus Academic Enrichment and Leadership Development Opportunities | - Academic enrichment programs with special training in scientific writing, academic presentations, and research or research-related skills  
- Campus coordinators assist students with developing leadership skills through participation in supervised experiential learning opportunities (e.g. mentoring other scholars) or workshops (e.g. time management, communication)  
- Graduate application assistance |
| Annual University-Wide Symposium | - An event for students to present their research and receive feedback from the academic community  
- Networking and mentoring opportunities  
- Presentations by leaders in STEM professions |
| Summer Research Program Experience | - Full-time research project (40 hours/week) for a $3,000 stipend and housing/housing compensation at either the home campus or another UC campus |
| Involvement in Professional and Scientific Societies | - Support provided for the registration, travel, and accommodation costs of attending national or regional professional or scientific society meetings |
| Scientific Research and Presentations | - Requirement to present research at national or regional scientific meetings |
| Travel to Other UC Campuses for Training and Exposure | - Requirement to travel to at least one UC campus each year |

Source: UC Leads

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75 Ibid.
Project Evaluation Form

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