

Participation by underrepresented groups in physical sciences and mathematics significantly decreases between undergraduate and graduate studies. Underlying causes of student attrition from undergraduate to graduate studies include cost, unequal access to research experiences, undefined merit assessment, and dearth of faculty professional development, especially in mentoring. Training a diverse, innovative, and globally competitive scientific workforce requires investment in evidence-based, inclusive institutional practices. The ecosystem of a graduate student includes mentoring and supervising. The advising relationship is seen as a space for growth to the benefit of recruitment and retention of underrepresented student populations. Scientific societies' role as a gathering place for graduate students and their research mentors uniquely positions societies as agents of change for the education of graduate students.

Scientific societies play an important role in higher education, but they've been largely underleveraged and understudied relative to their role as stewards for their field. This study examines the implementation and impact of an Alliance of nearly 30 societies, organizations, corporations, and national laboratories to create pathways and remove barriers in graduate education in the physical sciences and thereby ensure inclusion of minoritized students. Scaling-up previous successes from pilot scale studies, the Inclusive Graduate Education Network (IGEN) Alliance, an NSF INCLUDES Alliance, implemented the following: a free, common application to over 100 graduate departments, communities of practice as support structures for cohorts of faculty working towards adoption of inclusive practices, communication of existing and foundational education research translated to new audiences and extensive culturally-aware mentor training of national lab mentors to have a viable route to employment.

As part of its effort to increase the number of underrepresented students earning graduate degrees in the physical and mathematical sciences, IGEN-supported Bridge Programs helped 466 students gain acceptance into graduate programs over the life of the initiative. IGEN leaders aimed to close the gap between the number of bachelor's degrees and graduate degrees earned by these student populations, known as the degree gap. Based on average enrollment and retention data across the duration of the initiative, IGEN reduced this gap significantly: by 19 percent in chemistry, 54 percent in geoscience, and 69 percent in physics. Overall, IGEN-associated Bridge Programs at the American Chemical Society, the American Geophysical Union, and the American Physical Society retained 96 percent of students admitted in the first five years of the project. Evaluation data also suggests IGEN-affiliated Bridge Programs became an incubator for innovative thinking and inclusive practices that spread to other departments, and even universities.

IGEN catalyzed widespread adoption of evidence-based inclusive practices across the physical and mathematical sciences, especially in graduate education. Over seven years, 3,340 participants from 65 institutions attended inclusive practices workshops led by the IGEN Inclusive Practices Hub. Scientific societies sponsored eight of these events, helping to embed inclusive practices within the American Astronomical Society, American Chemical Society, American Geophysical Union, American Physical Society, and Materials Research Society. In addition, IGEN partner organizations collaborated to host a range of workshops, webinars, and informal coffee hours focused on inclusive mentoring and inclusive practices for students, faculty, and postdoctoral researchers at colleges, universities, and national laboratories.

To support institutional change and more inclusive graduate education, IGEN's Research Hub conducted and shared research to identify and scale effective practices. Since 2018, the Research Hub has served as a resource for partnering organizations, offering expert guidance, current research, and tools to help support Black, Indigenous, and Latinx students in their programs. A total of 19 research studies have been conducted or are currently underway: six funded by Research Accelerator Grants and thirteen supported directly by IGEN. For example, the "Facilitating Equity-Minded Mentoring Relationships in STEM Graduate Education" study, led by Dr. Annie Wofford, began in 2021. The Research Hub team also translated research findings into accessible formats to reach a wider audience, producing 37 documents such as infographics, research briefs, paper summaries, and resource guides. These materials, along with translational essays for disciplinary journals, a dedicated website, and professional development workshops, have helped disciplinary societies and academic leaders apply evidence-based practices in their own institutions.

IGEN has built and sustained a broad network of cross-sector partnerships to support the advancement of historically marginalized students from undergraduate education into professional careers in the physical and mathematical sciences. Since 2018, IGEN has collaborated with 192 partner organizations, including previously mentioned disciplinary societies, national laboratories (e.g., Argonne National Laboratory), universities (e.g., University of Southern California), and industry partners (e.g., Bristol Myers Squibb). In national laboratories, leaders are working with the Center for the Improvement of Mentored Experiences in Research (CIMER) to improve the quality of mentoring for postdoctoral scholars. CIMER has provided professional development for research mentors working across federal agencies, including DOE, NASA, and DOD, and created resources to help graduate students explore and prepare for careers in national labs.

Possible Categories = partnerships, retained students, evidence of adopted practices, published stuff

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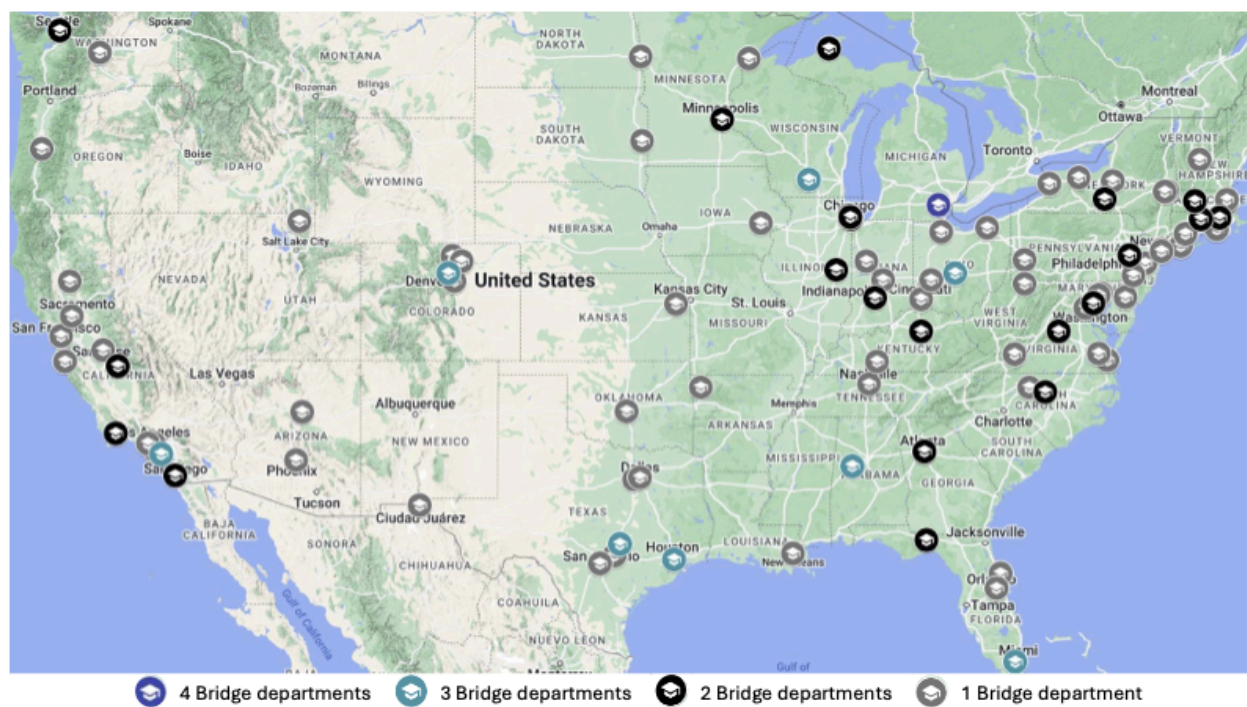
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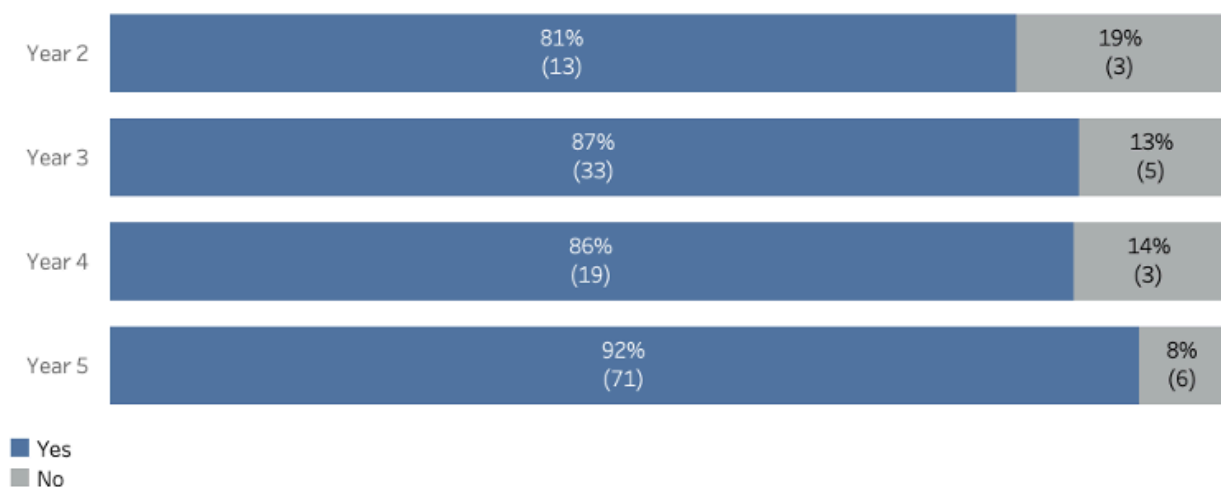
IGEN-affiliated Bridge Programs are located across the United States (see Figure A). Several universities have multiple partners that are hosting Bridge Programs. In year 6, 21 institutions had 2 departments hosting Bridge Programs, 8 institutions had 3 departments hosting Bridge Programs, and 1 institution had 4 departments hosting Bridge Programs. [Click here](#) for interactive map.

Figure A. Location of IGEN Bridge Programs



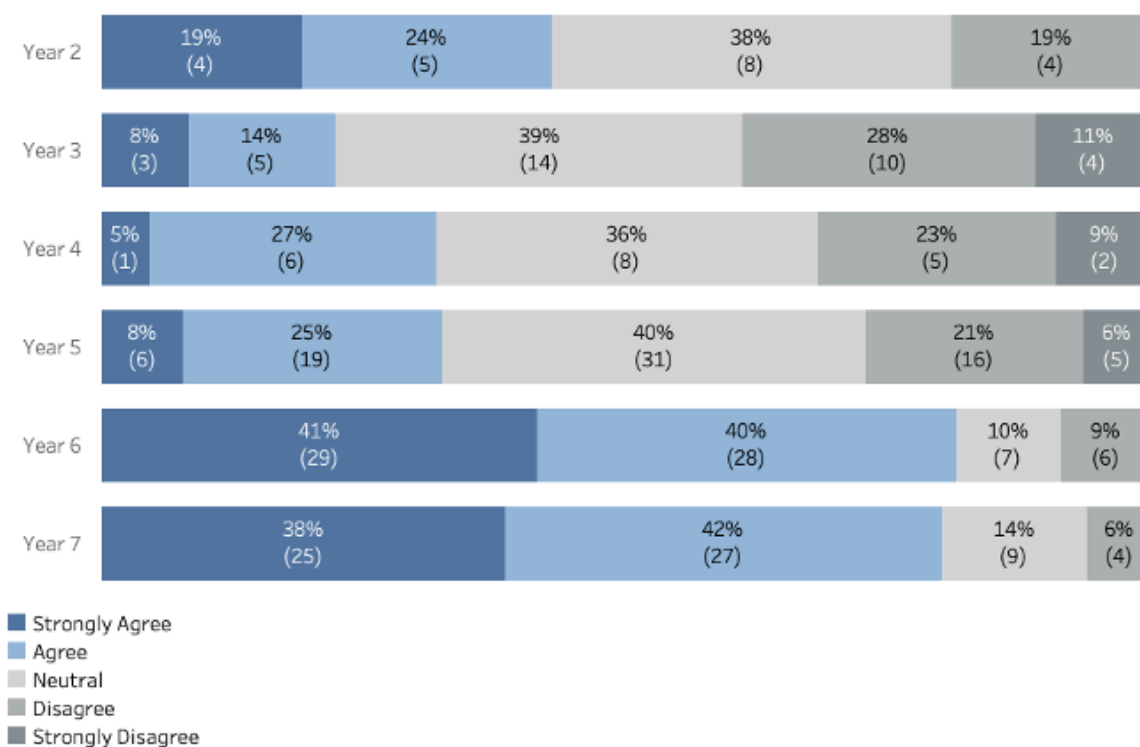
Faculty reported changes to their admissions practices since engaging with IGEN, either through workshops or as part of the process to become a Bridge Program (see Figure B). In year 2 of the project (2019-20), 81 percent of responding faculty members indicated they used holistic admissions practices in their department. In the fifth year of the IGEN Alliance (2022-23), 92 percent of faculty members reported using holistic admissions practices. Many survey respondents also indicated that they use a rubric for both the Bridge Program and regular department admissions.

Figure B. Use of holistic admissions practices



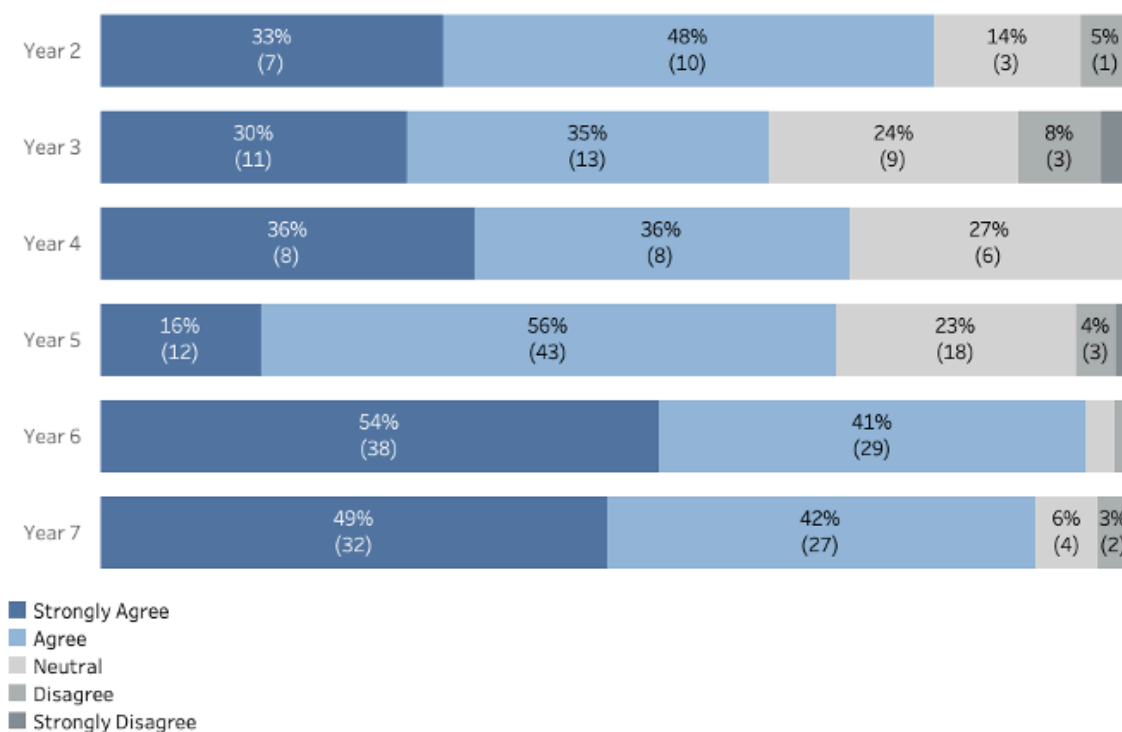
Survey responses indicate significant shifts in engagement with underrepresented students on research during the IGEN Alliance (see Figure C). In years 2-7, faculty members were asked if they regularly collaborate on research with Black, Indigenous, and Latinx students. In year 3, only 22 percent of faculty members reported collaborating with Black, Indigenous, and Latinx students. In the years 6-7, more than 80 percent of responding faculty members reported conducting research with these underrepresented student groups.

Figure C. Regular collaboration on research with Black, Indigenous, and Latinx students



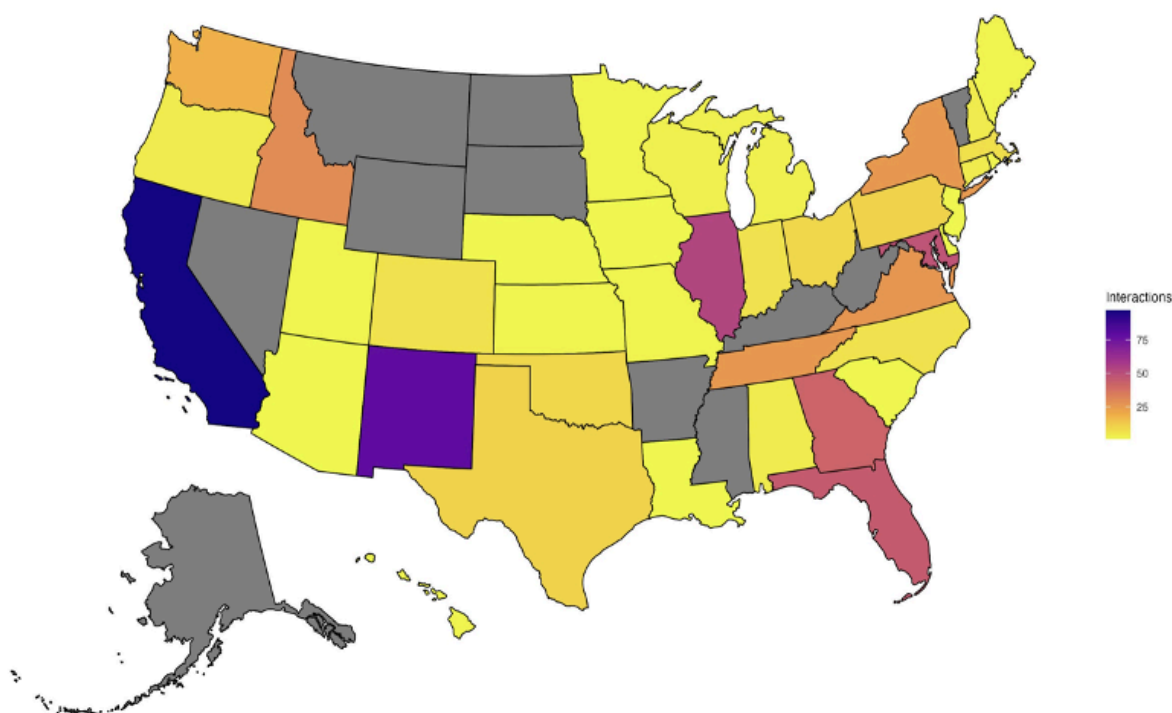
Survey responses also show an increase in the percentage of faculty members who indicated that mentoring underrepresented students in research was an important part of their work (see Figure D). In year 3 of IGEN, 65 percent of faculty members agreed that mentoring Black, Indigenous, and Latinx students was an important part of their work. That percentage grew to 95 percent in year 6 and 91 percent in year 7.

Figure D. Mentoring Black, Indigenous, and Latinx students in research is an important part of my work



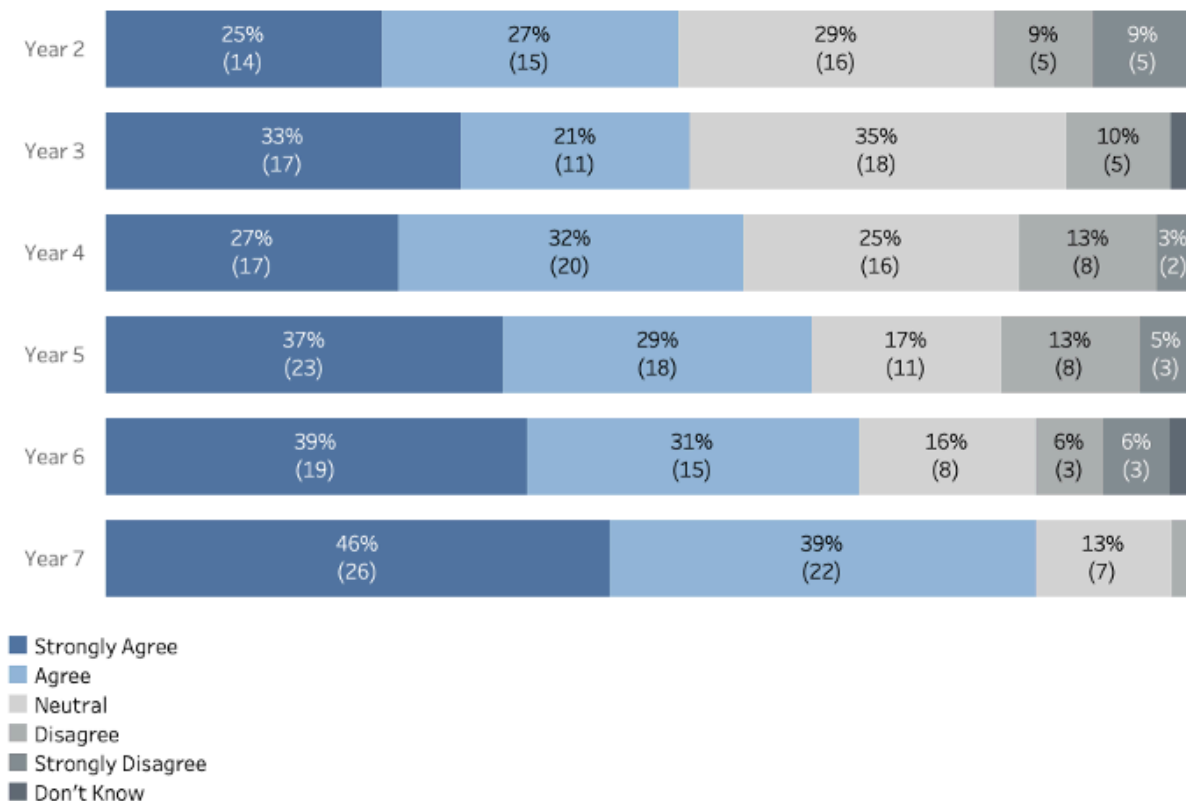
In year 6, CIMER (in collaboration with WestEd) created a national laboratory engagement dataset and developed heat maps and other visual tools to tell the IGEN story in the federally-funded research center sector. The engagement database (682 entries) has been instrumental in tracking participant engagement across the entire life of the grant. When analyzing CIMER engagements in all types of institutions (post-secondary institutions, national laboratories, other governmental organizations), the highest number of total interactions are in California and New Mexico (see Figure E). Overall, the majority of states reported 25 or fewer interactions, consistent with the number of interactions reported at national laboratories country wide. Several exceptions are Illinois, Florida, Georgia, and New York which reported approximately 50 interactions.

Figure E. Heatmap of total CIMER interactions



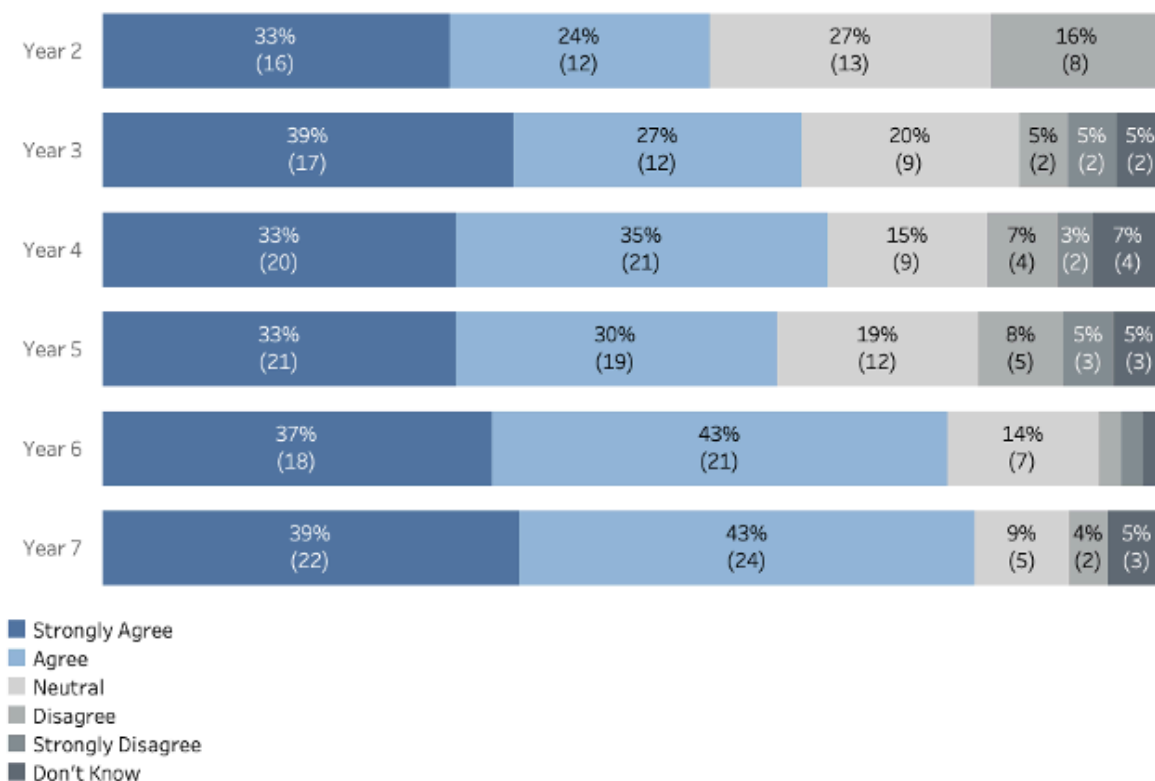
Throughout the initiative, students were generally satisfied with the support they received from faculty members and program staff who work in the departments that host their Bridge Programs. The percentage of students who indicated their department provided opportunities to connect with faculty members increased each year (see Figure F). In year 2, 52 percent of students in Bridge Programs reported having opportunities to connect with faculty members. In year 7, 85 percent of students indicated their departments provided opportunities to connect with faculty members.

Figure F. Regular opportunities to connect with faculty members



Students' survey responses also suggest the support they received from faculty mentors in their Bridge Program was overwhelmingly positive (see Figure G). In year 2, 57 percent of responding students agreed or strongly agreed their faculty mentor was able to accommodate different communication styles. In years 6-7, that percentage increased to 80 and 82, respectively.

Figure G. Faculty mentor(s) can accommodate different communication styles



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