Early Exploration of Opportunities in Science and Careers Encourages Students to Pursue Science Majors

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Four science programs at our public urban liberal arts college have struggled to attract and retain majors: physics, environmental studies, geology, and teaching science. The Brooklyn Opportunities in Science and Careers (BOSC) program aims to increase student participation in these majors using a new career-focused strategy to recruit students. Our hypothesis is that by providing capable students with information about employment prospects in diverse science-related careers during the summer before their freshman year, we could increase the total number of majors and graduates in these science departments. Field trips to explore science careers in unanticipated settings and a Career Investigation Project are the core innovations of the BOSC program. Students work in collaborative groups to investigate potential careers, gaining skills important in almost all careers such as teamwork and preparing and delivering presentations. Institutional and program evaluation data indicate that the BOSC program has had a significant positive impact on both the program participants and on the cultures and enrollments in the target departments.

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Students panning for fossils on a field trip.

The Brooklyn Opportunities in Science and Careers (BOSC) program, funded by the National Science Foundation's Science Talent Enhancement program, uses a new career-focused strategy to recruit students to major in science. We target incoming freshmen with better-than-average achievement in science and mathematics who are undecided about their majors on admission. Our hypothesis is that by providing capable students with information about employment prospects in diverse science-related careers, we can increase the number of majors and graduates in science departments. At our large (12,000 undergraduate), public, urban, nonresidential college with a strong liberal arts and sciences core curriculum, four science programs have struggled to attract and retain majors: physics, environmental studies, geology, and science teaching. The initiative focused on these programs.

The BOSC administrative team includes the chairs of the Geology and Physics Departments, the program coordinators of the Environmental Studies and Science Education Departments, and the dean of Graduate Studies and Research. The BOSC coordinator/student advisor is a recent graduate of our institution who drew on her experiences as an undergraduate for insight into student needs.

We innovated a Career Investigation Project to encourage uncommitted

students to consider pursuing majors in the physical sciences and applied lessons learned from other successful Science, Technology, Engineering, and Mathematics (STEM) programs to support retention of these students. Institutional and program evaluation data, including analysis of the progress of BOSC participants compared with similar students not in the program, indicate that these innovations at our institution have had a substantial positive impact on both the program participants and on the cultures and enrollments in the target departments.

Why the career emphasis?

Analysis of our institutional data has shown a marked preference for majors with clear career paths. The top five majors pursued by our undergraduates are business, management and finance, accounting, psychology, and childhood and early childhood education. When the project began, majors in physics, geology, and environmental studies were in the single digits, compared with over a thousand accounting majors. Computer and information sciences, a major with a clear career path, was our largest science major, but has declined as jobs in this sector have become less plentiful. Health and nutrition sciences, a professional-track science program, was also well enrolled. Relatively higher enrollments in biology and chemistry programs (see Table 1), compared with physics and geology, reflect interest in programs that prepare students for medically related careers.

To analyze trends in our students' choice of majors, we examined the college transcripts of 800 students who entered with strong high school science and mathematics backgrounds. We found that fewer than one in four declared majors in science or mathematics. Approximately 500 of these students took no science courses at all beyond those fulfilling general education requirements. Half chose majors in either business or accounting. Most of the remaining well-prepared students chose majors in psychology, education (excluding science teaching), or speech and hearing science. These data indicated that there are a substantial number of capable incoming students at our institution who might be directed to science majors.

This baseline analysis suggested that our incoming students may not realize the value of physical science majors as preparation for rewarding and remunerative careers. Others have shown that students who persevere in science majors want careers that are both financially rewarding and personally fulfilling (Seymour and Hewitt 1997). BOSC leads students to ask: What sorts of careers are open to graduates with a strong background in science? What careers might follow from a particular science major? With 20% to 50% of college students nationwide undecided about their vocational futures (Lewallen 1995), these answers may be of broad interest to entering freshmen.

Building on lessons from successful STEM programs

The BOSC program aims to direct students to science majors and to retain students through successful completion of these majors. We applied insights from successful STEM programs to structure the program to maximize retention of BOSC students in science majors. Astin (1997) and Noel-Levitz (2003) found that students stay in college in direct relation to the connection they feel to other students and faculty, suggesting that community-building strategies would be important for student success at our 100% commuter campus. The BOSC lounge in the science building provides an informal meeting place for study and socializing, encouraging students to spend time on campus. The program begins with a Summer Bridge program with opportunities for informal student–faculty interaction to build community and college-readiness (Ackerman 1991). Program advisors mentor students individually, as Hilborn, Howes, and Krane (2003) noted is characteristic of robust undergraduate physics programs. Because freshman learning communities have been documented to increase student engagement and overall satisfaction with college (Gabelnick et al. 1990; Zhao and Kuh 2004), the program incorporates block programming for freshman calculus and science courses. We also block-program English composition to build science-writing skills. Martin, Bland, and DeBuhr (1983) have shown that peer-assisted workshops help both workshop participants and leaders to succeed academically, so the program provides peer-assisted workshops for all math and science courses. We encourage all instructors to use active learning techniques and collaborative work, as recommended by the National Research Council (1999). We help all continuing students to secure paid summer internships because such experiences enhance career/graduate school preparation, and clarify/confirm career plans (Seymour et al. 2004).

Summer Bridge program

The Summer Bridge program begins the introduction to both science majors and science careers. To introduce students to the rigors of college-level work, it includes a credit-bearing course in mathematics or computer science. There is also an informal program of lectures, seminars, workshops, and field trips focused on the three BOSC target departments. The program also spends time on study skills development and introduction to general college services.

Each target department introduces participants to learning experiences that emphasize quantitative reasoning and investigative skills and exposes participants to career role models, with an emphasis on showcasing successful science careers in unanticipated settings. The physics workshop develops quantitative reasoning skills by having students work cooperatively in

TABLE 1

Change in enrollments in science majors during the BOSC program between 2005 and 2009.

	Enrollments		% Change
Majors	**2005 1st program year**	**2009 5th program year**	**1st vs. 5th program years**
Computer information science	326	275	−15.6%
Biology	263	319	21.3%
Health and nutrition science	238	334	50.0%
Chemistry	69	136	97.1%
Geology*	11	29	145.5%
Environmental studies*	6	16	166.7%
Physics*	7	11	228.6%
Science teaching*	6	34	466.7%
College undergraduate	11,068	12,021	8.6%

Note: Shown in *ascending* order of percentage change in majors; majors in the BOSC program are marked with asterisk. BOSC = Brooklyn Opportunities in Science and Careers.

small groups to freely investigate the phenomenon of friction. A field trip to Brookhaven National Laboratory explores cutting-edge applications of physics in a wide variety of disciplines. During the geology workshop, participants collect, identify, and analyze local fossils at a field site and tour the Hall of Planet Earth at the American Museum of Natural History, led by one of the hall's original curators. In some summers, students visit the Objects Conservation Department labs at the Metropolitan Museum of Art to see "behind-the-scenes" examples of alternative careers in science. The environmental studies workshop introduces the students to environmental issues and investigative methodologies and prepares students for introductory chemistry in the process. Students have visited the Fresh Kills landfill in its transformation into a city park. They analyze water samples from a historic but polluted local canal. This workshop also introduces career opportunities in sustainable development. One student commented, "With all the people I've met in BOSC, I can already see prospective job opportunities in the scientific field."

The field trips are popular and eye-opening. After one of the field trips, one student observed, "This trip showed me that science can be hands-on, interesting and fun." Another commented, "It helped me realize science is affecting us in more ways than I thought, and how much more potentially useful it is." Regardless of location, every college has access to unique and engaging local community resources and alternative science careers.

Career Investigation Project

The Career Investigation Project is the core innovation of the BOSC program. Students work in collaborative groups to gather information, interview professionals, and present their findings on potential careers involving STEM-associated skill sets. In the process, the participants extend their knowledge about how science is used in careers and the variety of paths that careers can take. In addition, the students gain experience in teamwork, as well as in preparing and delivering presentations. A Professional Conduct Workshop explores what is meant by professionalism in different contexts and at different stages in one's education and career. This workshop prepares students to conduct their career mentor interviews, and it more broadly develops skills that help students communicate effectively with professors and other adults in positions of authority. A Team Building Workshop explores the significance of working in groups (e.g., study groups, research teams, teaching teams) and introduces problem-solving techniques that foster successful teamwork.

On the basis of their initial career preferences, groups of students are assigned to a career mentor in fields such as biomedical research, science education, museum conservation, urban planning, "green" printing, and carbon trading. Prior to meeting their mentors, students research basic information about the careers, such as educational requirements, professional societies, and salary ranges. They explore how to conduct a proper interview and brainstorm a list of relevant questions to ask their mentors. Each mentor is interviewed at the workplace, providing a first-hand account of the career path and employment options, and a chance to speak with others in the workplace. Each group creates a PowerPoint presentation of their findings on the value of a strong background in science and quantitative reasoning as preparation

for the career that they investigated. They then present their findings to their peers, invited faculty, program directors, coordinators, and parents.

Peer-assisted learning

BOSC requires participation in peer-led workshops for mathematics and science coursework. The recruitment of peer leaders from among the small number of preexisting physics and geology majors created an enhanced sense of community that may have contributed to the immediate increase in retention in these departments. As the program has matured, we have been able to recruit workshop leaders from BOSC participants. These near-peer leaders have experiences in common with the students in their workshops. They serve as general mentors, not just academic subject mentors. In the Geology Department it was noted that the BOSC emphasis on teamwork and peer mentoring transferred to the broader community of geoscience majors with the spontaneous creation of both inclusive study groups and self-appointed peer mentors. Peer-led workshops for all gateway science courses are now offered by the college as part of a new university-wide commitment to improving student success. This investment is seen by the administration as facilitating increased four-year graduation rates and maximizing use of limited college resources by reducing the failure rate in gateway science courses.

Challenges and responses

In our first year, our greatest challenge was recruiting participants. We could recruit only from already admitted freshmen. In addition, the reputation of the college among local high school guidance counselors was that the science majors were difficult, with high attrition. The first cohort of BOSC participants helped to address this challenge by informally recruiting from among their peers, younger siblings, and friends still in high school.

Because of a lack of clarity in how we described the program, retention of students in BOSC was a challenge in the first year. At the end of the first summer program, only 7 of the 16 participating students opted to continue with the program in the fall semester because we had not required a full year's commitment. Revising our program literature to require a full-year commitment on admission led to near 100% retention for later cohorts. Still, four of the nine first-cohort students who left BOSC after the Summer Bridge program ultimately completed STEM majors, indicating that the Summer Bridge program alone may have provided a substantial boost to electing and completing a science major.

Students initially resisted attending peer-assisted learning workshops, so attendance had to be enforced in the first semester. However, participants came to understand the value of peer study groups, with over 60% reporting that they now self-initiate study groups in other courses. Students also disliked perceived pressure to choose majors in physics or geology, and so we revised programming for freshmen to require a set of course requirements applicable in any science major (i.e., chemistry, calculus).

Block programming, program oversight, and ongoing formative assessment allowed for early interventions to improve student performance. For example, when one midterm assessment signaled that substantial numbers of students were at risk of failing chemistry, the BOSC leadership intervened and suggested that the instructor increase quiz difficulty to allow students to better assess their depth of comprehension before taking high-stakes exams. This simple midcourse correction led to immediate improvement and ultimately success in the course. The episode underscores the value of close administrative attention to student progress.

Revising the career component

In our first year, we offered career seminars in which invited speakers discussed the advantages of majoring in science as a pathway into careers in law, medicine, business, finance, journalism, education, and research. Speakers described their own experiences and career trajectories. However, program evaluation indicated that students did not much like being talked at and found the seminars to be long, repetitive, and boring, even though they were informative. The solution was not finding better, more engaging speakers, but rather engaging our students actively in the process of gaining career awareness. The revised Career Investigation Project succeeded in this and created an ongoing attitude of openness to alternative career paths that has remained with the students throughout their college years.

In evaluating the first Career Investigation Project presentations, we observed that students did not consistently apply the critical quantitative reasoning skills that they were developing in the other components of the Summer Bridge program. We subsequently provided additional scaffolds to using these skills in the career research project. For example, to create a community of critical peers to assess the validity of their quantitative statements, students presented to and were critiqued by their peers before their formal presentations.

Evaluation of impact on participants and target departments

Over 90% of our students surveyed agreed that participation in the program increased their awareness of career opportunities and provided positive faculty role models. Over 90% also agreed that the program aided them in successfully adjusting to the college environment, in

establishing positive and productive interactions with peers, and in establishing a sense of community.

For program evaluation, a matched control group was created for each BOSC cohort using data in our student information system. Matched controls were nonparticipants matched on overall high school GPA, math and science GPA, standardized test scores in math and science, type of high school, gender, ethnicity and SAT scores, as well as registration in at least three science and math courses in their first freshman semester. Analyses indicated that BOSC participants significantly outperformed their matches in college GPA (mean = 3.26 vs. 3.04, paired $t[87] = 2.296$, $p < .024$). More BOSC participants declared science or mathematics majors than the matched controls (82.6% vs. 57.6%) and took more science classes (paired $t[86] = 10.251$, $p < .000$), indicating that BOSC helped "undecided" students commit to and do better in science majors than similar students who also started out studying science.

BOSC has been associated with a revitalization of the target departments, including a steady rise in the number of majors. Although the numbers of all science majors (except for computer science) have increased more than overall enrollment for the past five years, the target departments have all seen higher percentage increases than the other science departments, with increases ranging from 145% to 466% (see Table 1).

Although BOSC participants make up only a fraction of this total increase (14%–19%), they have had a noticeable impact on their chosen major departments. They have contributed to the development of a sense of community, which has helped to increase retention of students in these majors. For instance, the BOSC student-initiated peer-study groups in courses not supported by BOSC have contributed to student success in science courses in general. The supportive, team-based approach of BOSC is helping to transform our science classrooms from a culture of competition to a culture of collaboration. Also of note, recruitment materials for BOSC detailing its aims, methods, and assumptions were sent via mail and e-mail blast to all eligible incoming freshmen for the past five years. These mailings constitute an intervention in and of themselves. Thus the core message of BOSC, "the study of science can lead to a wide array of careers," may have contributed to the collegewide increase in science majors.

Sustaining the BOSC interventions

The final challenge is the institutional sustainability of the BOSC program. We have piloted a scaled-down, two-week Summer Bridge program that focuses on meeting science faculty and exploring their research in brief quantitative reasoning workshops, an introduction to possible science majors, and field trips to broaden awareness of alternative science careers, some led by senior BOSC students and graduates. Of the 15 students who responded (response rate 94%), 93.3% agreed that the briefer summer program "increased my awareness of career opportunities," and 73.3% agreed that it "helped [them] to see how studying science supports [their] long term goals." One participant commented, "Through the BOSC program I gained new insights into fields like geology and physics. I learned the types of thinking skills needed for these sciences and the vast career diversity in the fields of geology and physics." The Career Investigation Project and study skills development was incorporated into a two-credit, tuition-supported freshman seminar course that is part of the college's ongoing freshman learning community program. The dean of Undergraduate Studies is using BOSC results to inform revision of the college's internally funded summer Science Bridge program for entering freshmen, and there is consideration of creating a science advisor position in our academic advisement office in addition to the health science advisor.

Furthermore, many of the beneficial elements of BOSC are being incorporated in individual departments and other college programs. For example, the Geology and Sociology Departments have piloted a thematic, block-programmed environmental learning community for incoming freshmen that stresses practical skills, quantitative reasoning, and teamwork and includes a concurrent career exploration seminar. Introductory courses for geology majors have been redesigned to stress career-valued skills and practical career-related research projects. The Physics Department is experimenting with a studio approach to introductory physics.

Final thoughts

Proven strategies to retain STEM majors can only be effective if students enter the STEM pipeline. We have shown that capable students uncommitted to a major in science can be encouraged to choose physical science majors when made aware of interesting career opportunities and role models early in their college experience. BOSC has developed and tested career-focused strategies for recruiting and retaining students in science majors that should be transferable to many liberal arts colleges. Opportunities to develop career awareness and participation in a community of interdisciplinary science majors can help "undecided" students realize the potential of a science major to lead to a wide variety of rewarding careers. ■

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