

Impact of a Sophomore Seminar on the Desire of STEM Majors to Pursue a Science Career

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Background

Since the late 1980s, national reports have called for reform in undergraduate science, mathematics, and technology education (AAAS, 1990; NRC, 1997, 1999; NSF, 1996; Project Kaleidoscope, 1991). These calls for reform have captured the attention of many university faculty who recognize the need to rethink the student experience, especially in the early years, to attempt to keep student interest in the sciences (Ebert-May, 1997). One of the reasons behind the need for change comes from the loss of students. Seymour and Hewett (1997) reported that 40–60% of undergraduates from a representative sample of universities leave the fields of science and engineering. This loss of talent and creativity not only occurred among the most highly qualified college entrants (Bhattacharjee, 2009) but also was disproportionately high among women and students of color.

In order for students to pursue science careers, they must connect with their intended field. Astin reports a wide range of ways students connect to a college or university (Astin, 1984, 1993), and many of the same ideas could be expected to be true for why students complete certain majors. Specifically within the sciences, research has suggested that connecting undergraduates with authentic research experiences helps maintain interest in the pursuit of a science major (Russell, Hancock, & McCullough, 2007; Seymour, Hunter, Laursen, & Deantoni, 2004). Providing all introductory students with real undergraduate research experiences early in their careers has been a challenge, but there are examples of success at large institutions for larger enrollment classes (Full, 2010; Luckie, Krha, Loznak, & Maleszewski, 2004; Weaver et al., 2006). However, there are other potential mechanisms for helping students find the connection to the sciences that will inspire them to pursue a career in the sciences. Many educators have viewed seminar courses as a possible solution in order to deeply connect students with and within the sciences (AAUW, 1994; Gilmer, 2007; Jesse,

2006; Kulis, Sicotte, & Collins, 2002; Pell, 1996; Preston, 2004; Xu, 2008). These projects often focused on success variables, including retention in the sciences, grades, and degree completion, rather than the underlying student experience. The smaller nature of seminar courses typically lead to increased opportunities for out-of-class student-faculty interaction, something that has been found to greatly impact undergraduate students (Strong, 2009), or to help students better understand the connections between science and society (Goldey, 2008; King, 2008).

Even for students entering college with a plan to pursue a non-medical science career, there is still another major challenge: the dominance of interest in health careers. Within Lyman Briggs College (a science-oriented residential college at Michigan State University), of the 398 students enrolled in general chemistry their first semester, 79 (19.8%) indicate an intention to pursue a physical science or non-medical life science career, with 55 (13.8%) being undecided (*Internal Lyman Briggs Statistics*). 218 (55%) of the students expect to pursue medical or veterinary doctoral degrees while 46 (11.6%) indicated an “other” career plan (typically with a nursing or dental focus). With over a dozen science-based pre-professional organizations on MSU’s campus, students can easily find others with similar career paths. Anecdotal evidence suggests that many of the students planning to pursue non-medical STEM careers feel neglected or slighted in terms of resources and support compared to their pre-professional classmates. These students even have challenges finding others with similar long-term career goals, thus increasing feelings of isolation.

In recognition of many of these challenges and of the fact that financial need is a key factor in the departure of students from the sciences (Fenske, Porter, & DuBrock, 2000; Gupta, Hensel, Savakis, Tymann, & Narayan, 2006), Congress directed the National Science Foundation to create a scholarship program to increase the number of undergraduates seeking to pursue a science career (*American Com-*

Abstract

This study focuses on the impact of a sophomore seminar on STEM majors’ desire to pursue a science career. This seminar was a component in a broader scholarship program and focused on helping students gain a more in-depth understanding of the process of science, exposing students to a range of career options, and providing opportunities for outside of class student-faculty/scientist interactions. Interviews and reflection papers by the fifteen students who completed the seminar suggest that the most common benefits from the course involved development and refinement of career decisions, fomenting of self confidence and empowerment, and awareness of available resources to assist in the pursuit of a STEM career. The students very clearly indicated the importance and impact of a wide range of informal interactions between themselves and/or faculty or other scientists, helping the students put a personal face on those who have previously pursued a science career. Additionally, the exposure to these scientists and their stories, along with a more complete discussion about the process of science (including funding, dissemination and ethics), spurred three of fifteen students to favorably reconsider the possibility of research as a career option.

petitiveness and Workforce Improvement Act of 1998, 1998). Yet the program is designed to not only support students financially through scholarships, but also to foster a sense of community and support for and between the scholars. The desire to develop these interpersonal connections is in part a recognition of the importance that such connections play in helping students reach graduation (Astin, 1993). However, there has been little evaluation of the impact of this support from the student point of view within these programs.

Lyman Briggs College

The *Briggs Scholars* Program exists within Michigan State University's Lyman Briggs College (LBC), a residential college for the study of science and the impact of science on society. Annually, 625 first-time, first-year students enter the college to study one of 38 coordinate majors in the life, physical, and computational sciences, or a major in the history, philosophy, and sociology (HPS) of science as part of their bachelor of science degree program. LBC has nearly 1900 total students in our program, and all first-year students are required to live in the residence hall where LBC classrooms, laboratory, faculty, staff, and administrative offices are also located. The core curriculum is composed of calculus, general chemistry, physics, biology (all with instructional laboratory components), a three-course sequence in HPS, and a senior seminar capstone course. University courses in general education and the student's selected coordinate major round out the students' curriculum. Students self-select into the college through their application for undergraduate admissions. There are no special requirements or costs associated with the program; it is open to all entering students on a first-application priority basis.

The Briggs Scholars Program

The *Briggs Scholars* Program was developed with a grant from the NSF S-STEM (DUE Award #0849911) program with the specific goals of *supporting* undergraduate students in attaining their science degrees as a step

toward STEM careers and of *exposing* them to a variety to opportunities within science. These two main pillars of the program were the foundation on which all of the activities are built (Figure 1). The *Briggs Scholars* provided a longitudinal experience in support of these goals to 29 students in two cohorts. Scholars fully participating in the program applied for scholarships in their freshman year that would apply during the subsequent three-year period which stretched across their sophomore, junior, and senior years of college (Table 1). Students were supported through a generous scholarship, academic advising, and mentoring, as well as by their other cohort members. Students were exposed to science opportunities through research support, field exposure, engagement in the process of science, and interaction with faculty and scientists.

Pillar of Support:

Scholarship

Financial need is a key factor in student departure from the sciences (Fenske, et al., 2000; Gupta, et al., 2006). To address this, through an NSF S-STEM grant, each student may receive up to \$18,000 in scholarship monies that are distributed on a graduated scale—\$1,500 for each of the two semesters in their sophomore year, \$3,000 for each of the next two semesters in their junior year, and \$4,500 for each of the final two semesters in their senior year. Students are reviewed for satisfactory academic progress, major declaration, and financial eligibility (based on the FAFSA) every semester to assess continuing program eligibility and scholarship funding.

Advising

Each student participated in a mandatory individual academic advising session at least once per semester (Hendel, 2007; Hrabowski III & Maton, 2009). (Normally, academic advising on this campus is optional at the request of the student.) The academic advisor works with students on academic, professional, career, and developmental goals and assessment through

Year	Key Academic Component	Financial support
Freshman	Application to program	NA
Sophomore	Program Begins One-credit seminar (focus of assessment)	Up to \$3000/year
Junior	One-credit seminar	Up to \$6000/year
Senior	Four-credit capstone seminar	Up to \$9000/year

Table 1: Briggs Scholars Program Outline

resource development, skill development, self-authorship, and personal reflection with respect to espoused goals.

Mentoring

Three primary faculty and academic staff support the program, the academic advising, and the classes. Additional faculty and academic staff are introduced through the seminar class, research opportunities, field experiences, and class assignments. The goal was to connect students with faculty as a means to further investigate and prepare for a career in the sciences. These forms of out-of-class student-faculty interaction have been shown to have tremendous positive impacts on many areas of student development, including retention, persistence to degree, career identification, and overall student satisfaction (Lampert, 1993; Strong, 2009).

Career development

Throughout the program activities and resources relevant to the students' current needs are presented as a means to reduce barriers to STEM career choices (Lent et al., 2002). Early in the program this involved sessions for things such as résumé creation and applying for research opportunities or internships. Later in the program sessions on topics such as graduate school applications or interviewing for jobs were included.

Cohort

Students were immediately immersed in a cohort of 15 within the program. The cohort was designed to provide peer support and opportunities for collaboration in projects, events, and personal reflections. It also aimed to express the wide variety of majors and career options within the STEM environment (Beaudin, Roth, Greenwood Jr., & Boudreau, 2002; Hrabowski III & Maton, 2009; McKinney & Denton, 2006). The cohort will thus act as a foundation for the student experience by providing the opportunity for students to directly support each other and simultaneously highlighting the commonality across the science disciplines.

Pillar of Exposure:

Research

Research experiences are important in fostering continued student interest in the sciences (Cox & Androit, 2009; Seymour & Hewitt, 1997). Therefore, in the first year of the program, students were exposed to a wide variety of re-

search programs throughout the institution and through other undergraduate student research forums. The program will support up to \$1,000 per student for materials, equipment, and stipends in support of the endeavor if students are interested in pursuing any aspect of faculty supervised research.

Site Visits

All students were encouraged to participate in program events developed to provide exposure to careers in science as a means of enhancing the likelihood of continued pursuit of a science career (Tai, Qi Liu, Maltese, & Fan, 2006). These field trips were weekend events offered once a semester at no cost to the students and another means by which to develop a strong cohort.

Scientists

Throughout the program, we have provided formal and informal opportunities for *Briggs Scholars* to interact with scientists—professionals working in a range of science careers. These scientists often shared their pathway/journey into their profession and addressed

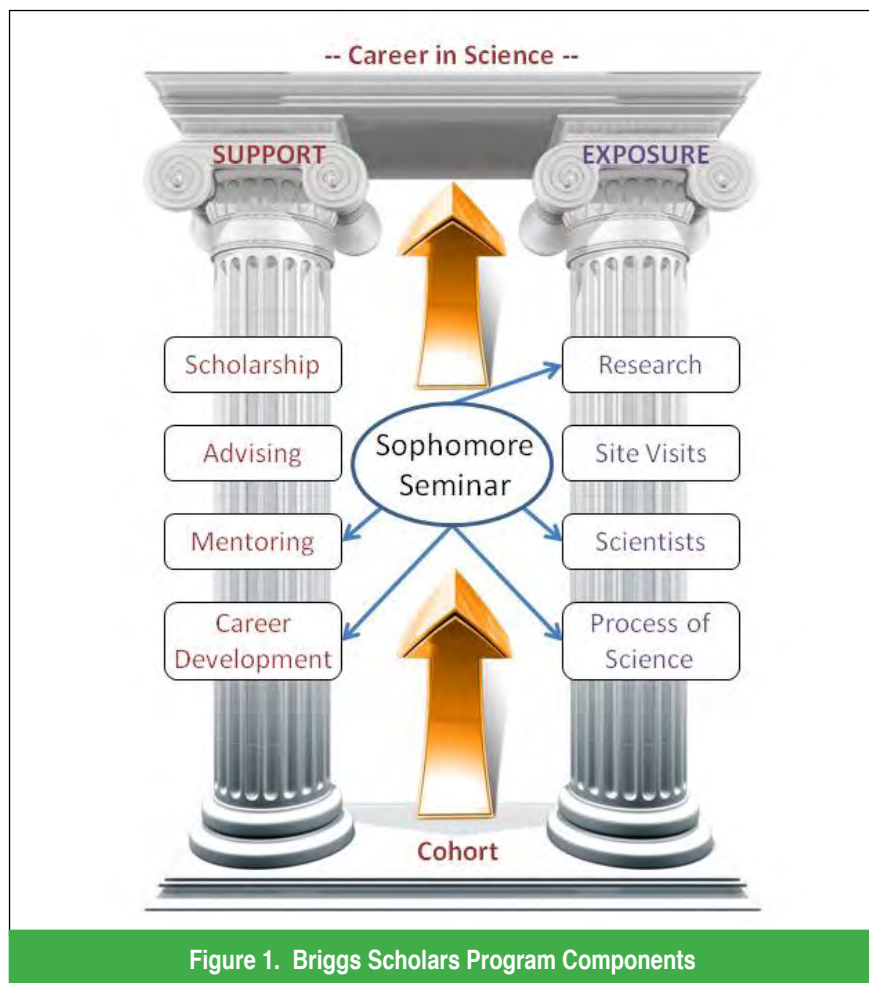


Figure 1. Briggs Scholars Program Components

many of the potential roadblocks or pitfalls to entering their selected career. In essence, we provided strong and realistic models for some careers in science (Smith & Erb, 1986).

Process of Science

Throughout the program students had the opportunity to discuss and learn about aspects of science that are often overlooked in standard classes. These include topics such as the dissemination of science (both formally and informally), validity and peer review, funding of science, industry versus academia, and ethics in science. Although many of these concepts are addressed informally in research laboratories, we believe that an intentional and early introduction to these topics will help students understand the overall process of science as an endeavor which inherently involves the active role of a wide range of scientists. We believe that through exposure to these different aspects students will see a greater scope of potential science careers that extend beyond simply being a laboratory researcher or professor.

The seminar

Central to the program were one-credit seminars during each the sophomore and junior year, followed by a four-credit capstone course

in the senior year designed to help students connect to the core ideas of the program. This paper focuses on the impact of the first of these seminars (during the sophomore year) on the students' connection with and desire to pursue a career in the sciences. The course involved a number of activities designed to fulfill the major goals of the program through specific activities (Table 2). The paper will describe the students' responses to a variety of different experiences and highlight the advances that these students made toward a career in the sciences. This information can help provide informed rationale behind the incorporation of activities in the student curriculum designed to help fix the leaky scientific pipeline.

The study

As stated earlier, the Sophomore Seminar class was an essential component of the Briggs Scholars Program. The seminar class was designed to help students 1) understand the process of science, 2) gain knowledge about how to pursue a science career, 3) discover other possible science career options, and 4) experience positive and meaningful student-scientist interactions. Our study is designed to evaluate the overall impact of the Briggs Scholars Program and its impacts on the advancement and

GOAL	ACTIVITY	REFLECTION
Process of Science (Dissemination)	In class presentation – scientific process	Discussion
	Attend two campus seminars/lectures	Paper
	Attend two campus research symposiums	Paper
Career development	In class presentation – resume format	Create resume
	In class peer review workshop – resume	Revise resume
	Interview two science faculty member	Paper
	In class presentation – professionalism	
	In class presentation – graduate school process	Discussion
Exposure to Research	In class presentation – undergraduate research	Discussion
	In class presentation – ethics	Discussion
	Attend two campus seminars/lectures	Paper
	Attend two campus research symposiums	Paper
Exposure to Scientists (potential mentors)	Interview scientists/faculty	Paper
	Faculty panel	
	Discussions led by scientists	

Table 2: Components of Sophomore Seminar Course

Pseudonym	Sex	Career idea	Level of certainty	#1 Outcome	#2 Outcome	Key activity
Allison	F	High School Science Teacher	High	Expanded resources	Career decision/ Confidence	Guest Speakers
Andrea	F	Genetic Counselor	High	Confidence	Broadened Career Considerations	External Site Visit
Anna	F	Genetic Counselor	High	Career Decision		Faculty Interviews
Jason	M	Professor Neuroscience	High	Career Decision		Ethics/dissemination of Science
Mary	F	Experimental Scientist	High	Resources		Faculty interactions (not class initiated)
Sam	F	Veterinarian/ Research	High	Career Decision		Cohort; discussions
Amy	F	Work with Animals	Moderate	Reassurance of major choice		Attending Seminars
Megan	F	Laboratory Researcher	Moderate	Graduate School	Resources	Informal dinner with speakers
Abby	F	Undecided Research	Low	Career	resources	Resume Activity
Brad	M	Undecided medical	Low	Clarification of goals/ career ops	Increased Confidence	Service-learning
Courtney	F	Undecided	Low	Major decision		Grad School discussion / Faculty interview
Joanne	F	Undecided Medical	Low	Confidence		Course Faculty
Sarah	F	Undecided	Low	Empowerment		No one specific activity
Taylor	F	Undecided	Low	Career Decision		All impactful; faculty interview
Walter	M	Medicine	Low	Empowerment		Faculty interactions

Table 3: Summary of student outcomes

retention of the students involved. The students involved in the program had a range of science majors including Microbiology and Molecular Genetics, Biochemistry, Physics, and Chemistry. The focus of this paper is on the student response to the seminar course and the identification of aspects of the course that helped the students envision themselves as scientists.

Methodology/methods

Using document-review and analysis (written narratives) (Caracelli & Greene, 1993) administered through the sophomore seminar course along with an individual responsive interview protocol (H.J. Rubin & I.S. Rubin, 2005) administered at the end of the year, students reflected upon their experience at certain points along the past year on a variety of subjects within the *Briggs Scholars* program.

At the end of the first year of the program, the fifteen participants (Table 3) were split into two groups. Each investigator was assigned a group and met individually with each participant

of his or her group to conduct an individual responsive interview (H. J. Rubin & I. S. Rubin, 2005) to provide a more comprehensive phenomenological picture (Marton, 1981). The interviewers took field notes and recorded each interview on a digital audio recorder and then transcribed the interviews into manuscript format. The responsive interview protocol is essential in allowing the researcher to participate in a structured conversation with each participant. This method provides the researcher the ability to better manage continuity, clarification of meaning, and understanding, and allows for the incorporation of narrative responses within the interview (H. J. Rubin & I. S. Rubin, 2005).

Results and Discussion

Upon analysis and review of the data streams, three primary themes emerged from the student responses:

- Discovering or reaffirming their major/career decision

- Learning about available resources
- Gaining confidence or feeling empowered

The student experience varied significantly with regard to the level of certainty of career direction with which the student entered the seminar. Certainty was determined and categorized based upon the students' reflections upon their level of confidence and comfort associated with their career decision (Table 3). Data to determine the categorization came from the application materials where students listed their intended career and current major. Students also submitted an essay expounding on their career interest, motivation, and pathway. Students were evaluated on relative level of certainty of career choice as espoused in their essays. The "high" category students (N = 6) expressed a singular or narrow career pathway with specificity. The "low" category students (N = 7) were unable to identify a single career field or were very broad in their options. The "moderate" category students (N = 2) provided a range of career fields, but had no direct pathway (e.g. "I am interested in working with animals.")

Of the fifteen scholars, six (40%) entered the cohort with a high level of certainty about their proposed career pathways (Table 3). Of those six students, four indicated that over the course of the year, including the seminar course, they had confirmed and further supported their initial career decisions. Three of the six students identified that they have expanded their resources within the university to help them attain their careers of choice.

The two scholars (13%) with moderate levels of career certainty were mixed with their responses as to their greatest outcome from the first year of the program. One identified a strong reassurance of her major choice while identifying a wider variety of career options stemming from the major; the other identified graduate school as the next major step in her preparation for a still ambiguous career pathway. These scholars tended to focus more on their major and educational pathways than the scholars with very high or very low levels of career pathway certainty.

Seven (47%) of the fifteen scholars entered the program with a low level of certainty pertaining to their proposed career pathways. This group had a wider range of espoused primary outcomes from their first year in the program. Two identified that they felt more empowered about their own lives and the process for selecting a career. Another two scholars, both with incoming undecided majors and careers, actually selected an initial career pathway. One scholar

identified greater confidence, and another identified the career identification and selection process as becoming clearer for her.

Four of the students expressed that the greatest benefit of the course involved an increase in self-confidence or feeling more empowered in their ability to pursue their career. A fifth scholar also cited increased confidence in the interview, but not in the reflective essays. The source of this confidence seemed to come predominantly from the interactions with faculty. Joanne specifically cited that her interactions with faculty members (including those leading this program, invited guest speakers, and those she reached out to through the seminar attendance and faculty interview assignments) as having a significant impact. She said, "I feel confident in my ability to complete my undergraduate degree, but I desire to establish solid relationships with faculty to gain experience and networking for further education." Thus this course provided her with the structure and impetus to find and interact with a wide variety of faculty. Andrea also identified that she has a much greater level of confidence and that she feels at ease about the processes of continuing her education and/or career preparation. For her, the seminar course served as more of a spark-plug in moving her forward toward her pursuit of her degree. Sarah and Walter each took their new confidence to the next level and were empowered to take additional steps toward their career goals. As Sarah stated, "I feel like this class and all of our experiences has definitely made me like ten times more confident in myself as far as going to find research..."

How students responded to class activities

Additionally, the students had very positive responses to many of the individual course activities. What is perhaps most astounding in Table 3 is the wide range of activities that students identified as the most impactful or as the "key activity" within the program. Each of the activities in the class (with the exception of attending on-campus research symposia) was explicitly mentioned by at least one of the students as being a key activity for them. This highlights the significance of having a wide range of experiences for the students, since each is at a unique point in his or her pursuit of a career and different activities will resonate with different students. Many of the students also cited that the class helped them get a much better understanding of how science is practiced. Andrea perhaps stated it best when

she said, “[The seminars] all came together and they were all like pieces of a puzzle, you know? They all came together and once you listened to all of them, you kind of saw the big picture and how they all fit.” The students were seeing the full arc of science, not just the laboratory practice of science, but also the funding, dissemination, and ethical considerations, as well as a pathway to join the enterprise of science.

Overall, the most consistently cited activities involved interactions with faculty. This may not be surprising given that many of the course aspects were designed to encourage interaction with faculty. Each of the activities (the interviews, informal dinners, course faculty, and simply “faculty interactions”) was cited as being a key activity. Given the importance of outside-the-classroom student-faculty interactions (Strong, 2009), it is not surprising how frequently these experiences were cited as being meaningful. Courtney said, “I really like the dinner with faculty. I thought that was a really great idea. In my classes I never really got close with faculty so this was kind of like having an opportunity to talk to them outside of class. That was really helpful.” Sarah also indicated the importance by stating, “this class forced me to leave my comfort zone and talk to faculty...” As she expounded on the process and the information she gleaned from the interactions, she concluded, “I became more comfortable talking to faculty and hope that I can do it more often next year.” With the exception of Mary, each of the students who mentioned the faculty interactions cited specific key activities. Mary instead credited faculty interactions through the Honors College and her research project as being most influential on her development. External activities provided Mary with additional opportunities to interact with faculty; Courtney and Sarah suggested that the other students may not have had, or did not readily take advantage of, such additional experiences.

In our interviews with the students after the completion of the course, we asked the students if they had recommendations about activities that were in the class that should be adjusted, removed, or added for the cohort following them. The students typically had no suggestions for what to remove because they saw how everything fit together to give them a better understanding of how to become a scientist and what it would entail. Taylor said, “...every tiny, little thing we did in this class connected perfectly for me. I’m amazed because, like, the service projects all connected with a professor, with an interview, with my career options, with

my understanding of scientists and science, and how going to those symposiums made me realize, ‘Oh, my God, there’ so much out there. I can do so much.’ It doesn’t have to just be this one type of science. All of it connected.” The students often had some recommendations for how to change some of the sessions to make them more engaging. In terms of recommended additions, the main component that the students wanted to see was something that helped them understand careers in industry and how they would be different from academic careers.

Impact of exposure to research

Interestingly, five students who had initially decided that research was not a career path in which they were interested have started to reevaluate that decision. Allison, Amy, Andrea, Joanne and Walter each felt that the class opened up their understanding of what research in science really entails. Allison stated it well when she said, “I think I have a more positive outlook about research careers, ‘cause I’ve always thought that that’s not what I want to do, but I’m looking at it more now—now that we’ve talked to people who are in those positions. We talked with professors who do research and I’ve kinda gotten to hear about their daily lives and that—I mean that really helps for me, just knowing that they’re not always just shut up in a lab.” These students seem to typify the habit of extrapolating the experiences in classroom labs into what a career in the sciences entails. It suggests the importance of ensuring that authentic science (with unknown answers/results) be included in science labs and not simply having the students complete verification laboratories. Once these students had a real view of what research science entails they were willing to reconsider research as a potential career option.

Conclusions

This sophomore seminar course appeared to have a very significant impact on the students’ development as budding scientists. Although each student responded uniquely to the experience, there were a number of common themes that emerged. Most frequently the students determined/reinforced their career or major choice, gained self confidence, and developed relationships with faculty. Although students may be expected to make strides in many of these areas during college, the direct links that students were making between the course activities and their advancement in these areas suggest that for most students the

strides made were either larger than they would have been without the class, or occurred earlier in their college career. Either way the students are reassured in their decision and capability to successfully pursue a career in the sciences.

Additionally, a third of the students were re-evaluating their desire to consider research based careers due to having a greater understanding of the many different faces that research can take. This has great implications for the “leaky pipeline” as it suggests that some students may be leaving science (or not considering research) due to a false understanding of what it entails. Providing the students with opportunities to interact with real scientists and helping the students see the realities of science careers appears to have a very positive impact on students considering the field. Although this course occurred during the students’ second year, it seems that many of the lessons could also be extrapolated to 1st year students. This could be particularly important given the large number of students who leave the sciences within their first year of college (Seymour & Hewitt, 1997); however, offering smaller seminar courses (such as the one discussed here) may not be suitable for reaching such large numbers of students.

The experiences of the students with regard to the faculty interactions also provide a reminder of the very important role that faculty and other scientists play in mentoring and inspiring our students. Most scientists can likely point to one or more individuals who were inspirational to them on their career pathways. This should remind all scientists of the importance of intentionally supporting those who are considering entering their field and providing both support and encouragement. As was clear from the students’ comments, the interaction need not be extensive to be deeply impactful, but often it can simply be the telling of our past stories and our own struggles that help students to envision themselves in the role of scientist. In doing so, we can allay the students’ fears about their own difficulties and help students realize that they are not the first to struggle in a class or to be unsure of their future career paths. We can help students change their view of scientists from individuals for whom everything came easily and perfectly to people who have had to struggle and work hard to get to their current position. As Anna said, “I’m just realizing that you can talk to [scientists], they’re people too, they’re not some other class that doesn’t like to converse with anyone.”

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