Curriculum

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A Career Preparation Course for Biomedical Science Majors Focused on Skills for Diverse Career Paths

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Training in career preparation is vital for biomedical science, microbiology, and related life science undergraduates to know the types of careers available in the field, to obtain employment after graduation, and to be successful in these careers. This is especially critical for historically marginalized students who have lower science, technology, engineering, and math (STEM) retention and lower STEM employment rates. Thus, we developed a career preparation course aimed for second- and third-year students in biomedical science, microbiology, biology, and related majors. This course introduced students to diverse careers via guest speakers and provided training and practice in key career skills, like writing CVs and cover letters. In this curriculum article, we present our course curriculum and resources, evidence of student achievement of learning objectives, and evidence that this course supported growth in constructs like science networking and confidence in future self, which are known to support student STEM retention and success.

KEYWORDS broadening participation, career preparation, mentorship, networking, professional development

INTRODUCTION

It is critical to support science, technology, engineering, and math (STEM) students' preparation for future careers after graduation, as well as to broaden participation in STEM careers. Career development activities promote STEM retention (1), and career engagement while at a university predicts higher job and career satisfaction once in a job (2). Many interventions can support students' career preparation, including mentoring programs, internships, courses, and more (3, 4). Students from historically excluded groups in STEM, such as students of color, have lower STEM retention (5) and STEM career intentions (6) and are underrepresented in STEM careers (7). Providing explicit professional development training is a way to close these opportunity gaps for marginalized students (8).

We developed and evaluated the efficacy of a career development course specific for biomedical science majors. Specifically, we evaluated the efficacy of the course in terms of student confidence in skills to find, apply for, and receive a job in their desired career. Much of the prior research on promoting career development for life science majors includes preparation for students pursuing research careers or professional programs like medicine (9, 10). However, we wanted to provide more diverse options of career development to increase students' awareness of other career options using their biomedical science major (11). Thus, we especially focused on highlighting jobs that students can pursue with or without a graduate degree. We also highlighted science-adjacent careers like sales and science illustration in order to promote students' realization that they can apply diverse scientific skills to any type of career. Guest speakers in STEM professional development courses help students be aware of diverse career paths (12). Additionally, the identity of who teaches STEM concepts to a student matters; for instance, similar representation in STEM has been shown to help minority students feel more included (13). Thus, we invited guest speakers from diverse backgrounds to describe their backgrounds and their career journeys in sciences. We also provided training and practice in professional skills, such as communicating clearly, preparing a job application, identifying opportunities for internships and networking, and creating an individualized development plan.

Overall, the three goals of this career development course were the following:

1. Introduce students to diverse career options, including those that do not require an M.D., D.V.M., or Ph.D. degree;
2. Provide diverse representation of careers and people pursuing those careers;
3. Provide training and practice in professional skills that are critical for career development in the life sciences, such as science communication, developing an individualized development plan (IDP), creating job application materials, and preparing for an interview.

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In this curriculum article, we will describe the course learning objectives and how we assessed student mastery of these learning objectives via course assignments. We will provide details on how we implemented the course. Additionally, we hypothesized that this course would increase student science networking and communication (14), science self-efficacy (15), science identity (15), career strengths (16), and confidence in future self (16). These are factors that have been shown to promote STEM retention and success. We measured these factors using previously published and validated survey scales (14–17) in a pre- and postcourse survey. This survey also gave students the opportunity to provide qualitative feedback regarding the course. We present quantitative and qualitative findings from these surveys.

Intended audience

This course was developed in a microbiology department for undergraduate majors in the broader biomedical sciences major, with an intended audience of sophomore and junior students. These students have progressed enough through their degree program to have an idea of what careers they might be considering, but they still have time before graduation to improve their CVs, including pursuing internships, working in a laboratory, or enrolling in a course-based undergraduate research experience (CURE) or other courses relevant to an identified career. However, we have enrolled students who were not biomedical science majors (including biology and other similar majors), and we have enrolled seniors who still benefitted from the course.

Learning time

This was a 1-credit course that met for 1 h per week for 16 weeks.

Prerequisite student knowledge

There were no specific prerequisites listed for the course. However, students should have a general biology background, such as the normal biology sequence taken by first-year students, so that students can appreciate both the scientific skills they have developed so far as well as the careers (such as medical lab scientist, genetics counselor, etc.) presented by the guest speakers.

Learning objectives

Students successfully completing this course will:

1. Develop a plan to receive mentorship;
2. Write a resume and/or CV and a cover letter;
3. Engage with the weekly speaker with questions related to their careers (in the fourth iteration of this course, this was changed to "find job postings in diverse careers");
4. Identify potential career options;
5. Write their own letter of recommendation, identifying the transferrable skills from their previous or planned experiences that are beneficial for future employment;
6. Define what skills or courses are needed for potential careers of interest to them; and
7. Develop an IDP to attain the career of interest.

PROCEDURE

Materials

No specific materials are required for this course, beyond assignments, rubrics, etc. These are described in the "Student instructions" and "Faculty instructions" sections.

Student instructions

At the beginning and end of the semester, students took a survey (see survey scales in Appendix S1 in the supplemental material). This enabled us to assess the efficacy of the career development course in supporting students in growing in their confidence, self-efficacy, and other factors. In addition, we analyzed the survey to determine if students of historically marginalized groups (Black, Indigenous and People of Color [BIPOC], low income, and first-generation college students) particularly benefited from this course. Results are described in the Discussion section.

Students also received the syllabus, assignment guidelines, and rubrics via the course learning management system. While the syllabus and exact points for each assignment varied semester to semester, a representative example is shown in Appendix S2. This also highlights how the various learning objectives were assessed.

Faculty instructions

The course is set up so that during most class sessions, there is a guest speaker for ~30 min and then a topic of the day for ~30 min. Faculty were responsible for recruiting guest speakers by using their scientific network. Sources of guest speakers included current employees at the institution (e.g., Biosafety), former members of the laboratory (e.g., Forensics), friends (e.g., Public Health), and former students (e.g., Medical Laboratory Scientist). The vast majority of people approached to be guest speakers accepted the request. Studies have shown that students prefer guest speakers who are diverse in background and experiences and are relatable, such as alumni and recent graduates (18). Thus, we connected to previous students and colleagues from our department and similar programs in our networks. We received departmental support to provide an honorarium to each speaker in order to avoid exploiting the labor of our speakers, many of whom were women and/or people of color. The guest speakers joined remotely or in person if local. Over the four semesters, we highlighted a variety of

TABLE 1
Student grades for select assignments showing evidence of student achievement of learning objectives[a]

Assignment	Learning objectives assessed	Student grade descriptive statistics (n = 46)
Resume or CV and cover letter	2. Write a resume and/or CV and a cover letter 4. Identify potential career options	Of 20 possible points: 18.71 ± 1.58 (avg ± SD) Range, 14–20
Letter of recommendation and IDP	4. Identify potential career options 5. Write their own letter of recommendation, identifying the transferrable skills from their previous or planned experiences that are beneficial for future employment 6. Define what skills or courses are needed for potential careers of interest to them 7. Develop an IDP to attain career of interest	Of 30 possible points[b]: 28.97 ± 2.49 Range, 15–30

[a]Data were combined from 46 students from four semesters. There was no statistically significant difference in grades between the cohorts.
[b]One student did not complete the assignment and received a 0 as per course policy (those who received a 0 for not completing the assignment were removed from the analysis).

careers, including medical laboratory scientist, genetic counselor, forensic scientist, science illustrator, biosafety officer, food safety technician, lab research technician, brewer, patent licenser, biosafety officer, and STEM educator. We have had a variety of ages and career stages of guest speakers; some were very recently out of undergraduate programs, so that our students could relate to them, and others were a bit farther in their career and could highlight their changes in career choices over time. Many guest speakers commented that this experience was useful for them to analyze their own career path and communicate the value of their work to students. Example of comments from guest speakers included the following:

> "[Being a guest speaker] helped me look a little deeper into my own career and how I have developed throughout, and giving me a new appreciation for what I do. Also being a guest speaker helped me realize that I really enjoyed this type of outreach to students and sharing my profession and that I want to do more things like this in the future."
>
> "It's always beneficial to reflect on experiences and the journey through life. Since I've graduated and joined the workforce, I hadn't really taken the time to look back and see my undergraduate experience and career development from more of a distance. It also gave me perspective about where I am in life now; I felt lost in undergrad, but now it feels like everything fell together just the way that it should have. I still feel a little lost now, but it helped me feel like things are still just gradually falling together and that one day I'll be able to see my experiences now as informative and maybe even transformative, just like I get to do now with my time in college. I hope that some pieces of this story were helpful to at least some of the students in this class—if it spoke to at least one person a little bit, I'd feel like I accomplished something."

During the first three semesters, students were required to post a question for each speaker before their visit in order to increase engagement with the guest speaker (19). In the fourth semester, students had to search for a job opening in the guest speakers' field and then identify what skills and experience were needed. This gave students the opportunity to gain practical skills when searching for jobs and identify additional skills and experiences to those highlighted by the guest speaker.

For the topic of the day, the instructors provided teaching and discussion to students regarding various key aspects of career development. Many of these aspects map to the National Association of Colleges and Employers career competencies (20). This prepared students for the assignments and opened an opportunity for students to ask questions. The topics included a description of resumes, CVs, cover letters, and recommendation letters; transferrable skills; career searching tools; description of the IDP; mentorship; science communication theory and practice; overcoming impostor syndrome; envisioning your future possible self; interview skills; and career adaptability. Resources for these various topics are provided in Appendix S3.

Suggestions for determining student learning

We utilized rubrics and guidelines for each assignment in order to provide constructive feedback to students on the assignments, which were linked to learning objectives (see Appendix S2). Students had an opportunity to do a draft assignment, receive peer and faculty feedback, and then submit their final assignment for final grading. Additionally, quantitative and qualitative survey data were used to assess the impact of this career development course on all students as well as students of historically marginalized groups.

Sample data

Examples of student assignments are shown in Appendix S4. Student grades for all four semesters, with 18 students the first semester, 7 students in the second semester, 8 students in the third semester, and 11 students in the fourth semester, are shown in Table 1. For most assignments, we had students submit a draft, and we provided input on the drafts before students

TABLE 2
Precourse vs postcourse survey scores for validated constructs[a]

Construct	Score (mean ± SEM)		*P* value[b]
	Precourse	Postcourse	
Science networking	3.644 ± 0.118	3.833 ± 0.120	0.027
Science self-efficacy	4.139 ± 0.129	3.993 ± 0.148	0.189
Science identity	3.819 ± 0.152	3.889 ± 0.148	0.645
Career strengths	3.992 ± 0.102	4.048 ± 0.110	0.238
Confidence in future self	3.652 ± 0.106	3.849 ± 0.101	0.029

[a]Data were pooled from four semesters, $n = 24$ students in total.
[b]Determined with paired *t* test between pre- and postcourse scores.

submitted the final version. Also of note, some of the points for assignments were adjusted between semesters; these scores were normalized for pooling. There was no significant difference between semesters and student scores.

In Table 1, we also indicate which learning objectives were assessed in the assignments. Learning objectives 1 (regarding a mentorship plan) and 3 (preparing for the weekly speaker) were graded based on completion.

Ethics statement

This research was approved by the CSU IRB (protocol numbers 2123 and 2753).

Safety issues

This study did not entail any safety issues.

DISCUSSION

Field testing

This course has been run for four semesters. Each semester, there are two instructors teaching in a team. One instructor (G.I.B.) taught all four semesters, and the other instructors taught for 1 (N.C.K.) and 3 (C.M.) semesters. There were 18 students in the first semester, 7 students in the second semester, 8 students in the third semester, and 12 students in the fourth semester. The first semester was run entirely remotely during the 2019 coronavirus disease (COVID-19) pandemic; the return to in-person learning may have had an impact on student registration. We recruited students for this course via academic advisors in the department.

Evidence of student learning

As indicated above, in addition to providing student grades on assignments related to the learning objectives (see "Sample data" section), we implemented previously validated surveys to analyze how the course influenced students' growth in science networking and communication (14), science self-efficacy (5), science identity (5), career strengths (16), and confidence in future self (17).

We analyzed changes in these factors in our students, including those students from historically marginalized groups. These historically marginalized students included first-generation college students, students of low socioeconomic status, and students who identified as BIPOC. These students have lower STEM retention in many programs, including our college (CSU Institutional Research). While career success postgraduate in STEM is not currently tracked in our department, nationally there is inequity in individuals from underrepresented groups in STEM careers (7). Additionally, many of these student affective measures, which are correlated with STEM retention and career success, have been shown to be lower in historically marginalized students (5, 15).

We only utilized the data for which a student had completed both the pre- and postcourse surveys ($n = 15$ marginalized students and $n = 9$ nonmarginalized students pooled from the four semesters). We utilized paired *t* tests to compare pre- versus postcourse scores in the same students. For the five scales we analyzed—science networking and communication, science self-efficacy, science identity, career strengths, and confidence in future self—the scales which had a significant increase from pre- to postcourse survey for all students combined were the science networking and communication scale and the confidence in future self scale (Table 2). Of note, for these scales the increase between pre- and postcourse survey was most pronounced in historically marginalized students, with significant increases for marginalized students but not nonmarginalized students (Table 3). The increase in science networking and confidence in future self makes sense, as the focus of the course was particularly on networking skills for careers and building skills for the future. The science networking scale (14) has been included in a larger construct to measure college student persistence in the sciences (21). Science self-efficacy and science identity are often increased in courses like CUREs where students are performing science skills (21), so it makes sense that these may not have increased for students in our course. In the future, as we turn the course into a 2-credit course, we hope that the

TABLE 3
Precourse vs postcourse survey scores by student group

Construct	Student group[a]	Mean score		*P* value[b]
		Precourse	Postcourse	
Science networking	Marginalized students	3.614815	3.814815	0.05595
	Nonmarginalized students	3.691358	3.864198	0.15646
Confidence in future self	Marginalized students	3.636364	3.854545	0.01639
	Nonmarginalized students	3.676768	3.838384	0.24568

[a]*N* = 15 marginalized students and *N* = 9 nonmarginalized students.
[b]Determined with paired *t* test between pre- and postcourse scores.

career strengths scale will show increases for students. The small sample sizes of data are a notable limitation in the statistical analysis of these surveys.

Students indicated in free-response sections of the postclass survey that they liked the approach to a career preparation course that includes both guest speakers and training on key skills: "The format of having different people talk about their career path, and then having a small lecture on an aspect of career acquisition preparation, works really well." In particular, the students found the guest speaker experiences to be helpful, with comments such as "I found the guest speakers the most useful; a lot of them didn't have unilateral paths to get to the career they are in now, and it was inspiring to hear how they found their way." Students made personal networking connections with some guest speakers that led to volunteer and job opportunities; in particular, students were interested in medical laboratory scientist (MLS) and forensics guest speakers. Overall, many students commented about how the course eased their anxiety about graduating and seeking a job, with comments such as "I feel better prepared to handle my career development after taking this class."

Some students reflected on their experience in the course months after taking it, as they neared or passed graduation.

> "The course deadlines kept me on track to finish my resume on time for graduation, it helped me craft a better resume than what I had before, it helped me realize that it's ok if you don't end up working in the field you set out to work in, and it helped me figure out what fields I did or did not want to work in."
>
> "I found that having guest speakers come into class to talk about their work was the most important thing I learned over all my other microbiology classes. It is so important to find connections in college to help you land a job right after you graduate, and having these guest speakers LITERALLY handed you connections (I wish I would have made better use of this as a resource). But if you are like me, and were still applying for jobs through online resources it was so nice for me to go back into my notes and look at those starting salary's that the guest speakers had talked about (so that way I knew what salary range to shoot for and not sell myself short)."
>
> "My career goals were not set in stone at the time of the course but I was very anxious that they were not well defined yet in my junior year. The course made me feel better about feeling lost navigating different career options. I had thought maybe research would be something I would like but was considering doing more school and unsure what option to take. After taking the course I'm more open to taking opportunities that feel right and more open to exploring different careers until I find one that fits."

Possible modifications

We modified this course over time in response to student and faculty feedback as well as the evolving COVID-19 public health crisis. The first semester was run entirely virtually due to COVID-19. The next three semesters were run in-person, although guest speakers who were not local still joined the class remotely. We also adjusted some assignments over time: the career video assignment was converted to an in-person career presentation, the points for some assignments were adjusted, and mock interview and personal statement assignments were added. Additionally, in our department this course will be changed from a 1-credit course to a 2-credit course in the future. In our experience, guest speakers do not always limit their presentations to 30 min, thus limiting the time that instructors have to cover the topic of the week. Student's feedback also indicated that increasing the time allotted to the topic of the week would be beneficial. The switch from a 1-credit to a 2-credit course will allow the instructors to use active learning, including cooperative learning, to allow students to have a deeper understanding and practice of the topics. Students in the first two semesters had mentioned that they enjoyed speakers that utilized slides during their career journey talks. These guest speaker talks tended to be better structured than those given by speakers who did not use slides. In the third and fourth semesters of this course, we provided speakers with slides containing prompt questions (Appendix S5).

Elements of this course, including diverse guest speakers or the career skills topics and assignments, could be integrated into other courses, including disciplinary STEM courses, rather than this stand-alone career development course. Additionally, this course could be adjusted for other STEM majors rather than biomedical science majors. The career paths highlighted and guest speakers invited would simply need to be adjusted to be relevant to the field.

In our experience, many students enter the course unsure of what career they want to pursue and are not even aware of the options. Based on student comments, this course was instrumental in helping students identify careers and develop the skills necessary to begin pursuing those careers. Based on this success, our department is considering making this course required instead of optional for students.

SUPPLEMENTAL MATERIAL

Supplemental material is available online only.

SUPPLEMENTAL FILE 1, PDF file, 1.8 MB.

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