Supports and Barriers that Impact Persistence of Undergraduates in STEM Career Pathways

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ABSTRACT

There is a shortage of diversity, and issues with persistence, in professional Science Technology, Engineering, and Math (STEM) careers in the United States. Undergraduate biology students’ differential access to STEM experiences, may be contributing to this problem. In order to persist in a STEM career pathway, undergraduate biology students need critical experiences, such as lab research, career shadowing, and volunteer hours for admission to an advanced degree program. My aim was to identify supports and barriers encountered by undergraduate biology students while trying to gain access to critical experiences and admission into an advanced degree program. Six transcribed interviews from biology students who had been accepted into a graduate or medical school were analyzed using a qualitative coding technique to identify trends. Here, I inductively identified supports and barriers that fell into five broad categories, including academic, financial, personal, institutional, and professional social networks. It is my hope that my findings will inform design and deployment of educational interventions that strengthen supports and eliminate barriers to help undergraduates gain admission into an advanced degree program for the opportunity to persist in a STEM career pathway.
INTRODUCTION

Despite coming from highly diverse undergraduate populations, professionals in fields like medicine and research continue to be predominantly white (Byars-Winston et al., 2015) and from affluent backgrounds (Lee et al., 2016). Although efforts to diversify biology professionals are made at graduate and other career stages, factors acting at the undergraduate level may be limiting who makes it into the applicant pool for advanced positions. To be competitive for advanced degrees or careers, undergraduate students must achieve more than a high GPA; they must also acquire various critical experiences (CEs) as ascertained by surveys by the Association of American Medical Colleges (AAMC, n.d.). Critical experiences can be defined as activities or events students can engage in during undergraduate years that have been correlated with increased competitiveness for medical school, graduate school, or biology careers. Some examples of CEs are research in a lab or clinic, volunteer hours, and studying abroad.

Some students may be more aware of, or able to access, the critical experiences required for persistence in a biology career than others. This discrepancy among students may lead to inequities among students who apply and are accepted to an advanced biology-related degree program. It is important to understand the positive and negative factors mentioned by undergraduate students trying to access CEs, however, to first lay the groundwork for identifying these factors and to build the most comprehensive list possible, I sought to identify all positive and negative factors that undergraduate biology students face, even if they were not connected to a specific CE. It is my hope that, by addressing all the factors, I can begin to identify ways to reduce inequities in advanced degree paths, and ultimately close the diversity gaps pervasive to biology careers.

The factors that contribute to a student’s ability to persist in a biology career path can be viewed using Social Cognitive Career Theory (SCCT) as a lens (Lent et al., 2000). This theoretical framework seeks to explain the variables that enable people to influence their own career development. At its core, SCCT states that an individual’s experiences and expectations affect their interests, goals, and actions (Fig. 1). SCCT also explains how contextual influences, both distal and proximal (see below), affect the core of the theory. Distal contextual influences are those that help shape a person’s interests and the way they perceive themselves such as,
“differential opportunities for task and role model exposure, emotional and financial support for engaging in particular activities, and cultural and gender role socialization” (Lent et al., 1994). Proximal contextual influences are those that come into play at critical choice junctures and include “personal career network contacts and structural barriers like discriminatory hiring practices” (Lent et al., 1994).

Figure 1. Model of how SCCT influences engagement in critical experiences and persistence. Supports and Barriers are found under both distal and proximal influences. Solid arrows represent direct effects and dotted lines indicate moderator effects. In this context, actions are critical experiences and persistence is acceptance in a graduate or medical school. Adapted from Lent and colleagues, 1994.

For my study, I focused on similar contextual variables by inductively identifying supports and barriers reported by undergraduate students who persist in a biology career path. I consider supports to be features that promote or advance success in educational and occupational pursuits, whereas barriers interfere with this success. In an undergraduate biology-degree context, supports and barriers might include environmental conditions and/or resources. Environmental conditions could include supportive/unsupportive family members, the amount of social professional influence, or the size of a friend group sharing the same major. In contrast, resources could include funding for tuition and access to a clean-living space near campus or to affordable textbooks.

To address supports and barriers pertaining to persistence in a biology career path, a critical first step is to characterize supports and barriers students encounter during their undergraduate trajectory. Specifically, my thesis addressed the following research questions:

I. What supports do undergraduate biology students possess that promote attainment of, engagement with, and/or participation in STEM?
II. What barriers do undergraduate biology students encounter that discourage the attainment of, engagement with, and/or participation in STEM?

The results from this analysis contributes to the field in several ways. First, this work moves the traditional bar for persistence from matriculation, as seen in most literature, to acceptance to an advanced degree program. My research also addresses calls to increase the number of STEM professionals that the United States is desperately lacking (Dall et al., 2015). In fact, the American Association of Medical Colleges is calling for 61,000 to 94,000 additional physicians by 2025 (Dall et al., 2015). One of the reasons for the lack of STEM professionals in the United States is a problem with persistence in STEM at the undergraduate level (Graham et al., 2013). Recent studies show that “Less than half of the three million students who enter U.S. colleges yearly intending to major in a STEM field persist in STEM until graduation” (Olson et al., 2012). By studying the supports and barriers that undergraduate students encounter as they aim to acquire the credentials required to progress to an advanced degree, I hope to identify potential targets for educational interventions that improve supports and reduce barriers towards increasing persistence in STEM careers.

Another contribution to the literature will be my research on supports. Supportive conditions and resources have long been researched in the career-development literature, but are understudied in comparison to barriers within the education literature (Lent et al., 2000). I aim to contribute more research to this literature by characterizing the supports impacting a student’s ability to persist in a biology career path.

Barriers, on the other hand, have been widely researched in recent years, and are sometimes thought to result from specific decisions made by individuals (Lent et al., 2000). For example, a student who decides to major in biology, but faces a forty-five-minute commute to the closest university that offers this major, encounters a barrier to success. Even if the student persists in this biology degree path despite the distance, the barrier is still present. Despite the breadth of knowledge on barriers, they may not have been studied using an appropriate framework (Lent et al., 2000). Barriers have also not been researched in the specific context of undergraduate biology students. Here, I use SCCT to characterize barriers experienced by undergraduate biology students while trying to persist in a biology-career pathway.
Supports and barriers are factors that actively promote or discourage success in persistence (Betz, 1989). A barrier is thus not the absence of a support, and a support is not the absence of a barrier. They are, instead, individual, active factors that can either work together or independently. How these two interact is currently not well understood (Lent et al., 2000). In my study, I sought to understand whether supports and barriers work together or independently, and what effect this may have on an undergraduate biology student.

Based on SCCT, I hypothesized that a combination of supports and barriers influence a student’s pursuit of critical STEM experiences and thus persistence in STEM career pathways. I hope that results from this study will inform the design and deployment of educational interventions that help undergraduates access more supports and eliminate barriers that affect students’ persistence in STEM career pathways.

**METHODS**

To address the research questions, my study took a phenomenological approach, which is a qualitative research methodology that studies participants’ lived experiences and common experiences among a group of people (Creswell, 2014). This was achieved by conducting in-depth, semi-structured interviews with students who had majored in biology, recently graduated, and intended to persist in a STEM career path. The mark for persistence in a STEM career path was taking the "next-step" beyond earning an undergraduate degree and transitioning to an advanced degree to one of two major biology career paths: admission to graduate school or medical school. We interviewed students choosing to transition to medical or graduate school because these programs represent applied and basic career paths many students intend to pursue. These schools also have clear, defined metrics for admission, many of the same application requirements and recommendations, and the standards for admission are made publicly available. Below, the participant recruitment process for this study and participant demographics, interview protocol, qualitative data processing, analysis of themes found through the research, and my positionality surrounding this study are described.
**Participant Recruitment and Demographics**

To identify students who have been accepted into either a graduate school or a medical school, graduate and medical school recommenders, such as academic advisors, mentors, and instructors, were asked for contact information for possible student participants. Recommended students were then invited to fill out an initial survey with a variety of demographic and academic questions. These survey responses were then analyzed to determine eligibility for an interview, including making sure applicants had majored in biology, were accepted into a graduate or medical school, and could potentially contribute broad perspectives based on their demographics.

This study was conducted using participants from both the University of Colorado, Boulder and Florida International University. These universities differ in several ways, including size, flagship status, prevalence of residential versus commuter students, racial/ethnic composition (majority White vs. Hispanic students), which allowed for collection of broad perspectives. My analysis was performed on a subset of interviews from six participants (Table 1). For this study, to be considered a first-generation college student, a participant’s parents or guardians had to not have received a four-year college degree. To understand a participant’s financial standing, we asked about their eligibility for a Pell grant, a needs-based grant for undergraduate college students funded by the United States Federal Government (Federal Student Aid, n.d.). Eligibility for this grant is determined by the participant’s personal or family financial situation using tax filings and income information (Federal Student Aid, n.d.).

<table>
<thead>
<tr>
<th>Participant</th>
<th>Adv. Degree</th>
<th>Gender</th>
<th>Race/Ethnicity</th>
<th>First Gen.</th>
<th>Pell Grant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elena</td>
<td>Grad School</td>
<td>Female</td>
<td>White/Hispanic</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Maria</td>
<td>Grad School</td>
<td>Female</td>
<td>White/Hispanic</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Emma</td>
<td>Grad School</td>
<td>Female</td>
<td>White</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Megan</td>
<td>Med School</td>
<td>Female</td>
<td>White/American Indian</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Matthew</td>
<td>Med School</td>
<td>Male</td>
<td>White</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Miguel</td>
<td>Med School</td>
<td>Male</td>
<td>White/Hispanic</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 1. Participant Demographics. Participant name (column 1) are pseudonyms to protect participants’ identity. Column 2 represents the advanced degree being pursued by participant. Columns 3 and 4 represents Gender and Race/Ethnicity of participant. Columns 5 and 6 represent presence or absence of First generation college student status and Pell grant eligibility. 1s indicate the presence of a characteristic while 0s indicate the absence of that characteristic. An * represents a participant that was denied access to the advanced degree.

Interview Protocol

Eligible students were invited to participate in an hour-and-a-half-long interview conducted over video-call or in-person. Twenty dollars was offered as an incentive for any applicant who completed the survey and interview. Interviews were semi-structured with two guiding resources, a LifeGrid and a set of questions that followed a set protocol. A LifeGrid is a visual interview tool that represents a participant’s life experiences over a specific period of time (Rowland et al., 2019). The column headings on a life grid describe specific experiences, such as lab work, financial support, and family events. The row headings on the life grid describe the timing of these experiences, such as Pre-Undergraduate years, Year 1 Fall, and Post-Undergraduate years. The majority of the grid spaces are left blank to be filled out collaboratively by the interviewer and participant. During the interview, the LifeGrid is available for both the interviewer and the participant to view, which benefits the interview in several ways, including building rapport, directing conversation to relevant topics, allowing the participant to have ownership of their narrative, constructing a more accurate timeline by correcting and cross-referencing, and developing rich narratives when using select protocol questions. Table 2 depicts an abbreviated version of the LifeGrid used.

<table>
<thead>
<tr>
<th></th>
<th>Residence</th>
<th>Family events and Relationships</th>
<th>Interests and Career Goals</th>
<th>Activities (research, volunteering, clubs, etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1 Fall</td>
<td>Lived in dorms</td>
<td>Ended relationship from high school.</td>
<td>Declared a biology major. Wanted to be a doctor.</td>
<td></td>
</tr>
<tr>
<td>Year 1 Spring</td>
<td>Lived in dorms with new roommate</td>
<td>Grandmother passed away.</td>
<td>Took immunology and loved it.</td>
<td>Joined the Pre-Health club. Volunteered for the Health Fair.</td>
</tr>
</tbody>
</table>

Table 2. Abbreviated BER Grid. Column 1 shows times that are relevant to the study. Columns 1 and 2 (gray) represent indirect indicators. Columns 3 and 4 represent direct indicators. Fictitious representative responses shown in italics. Blank spaces exist and are expected in the BER LG application.
Filling out the LifeGrid is a collaboration between the interviewer and the participant. When an event is mentioned by a participant, the interviewer asks the following questions:

1. Did you develop any career goals during that (activity)?
2. What led to your participation in (activity)?
3. What did you gain from participating in the activity? Was it worth your time?
4. Was there anything or anyone who helped gain access to this (activity)?
5. Were there any CEs you wanted to participate in, but couldn’t; what prevented your participation?

Without these questions, our LifeGrid would comprise only a chronological sequence of events and lack details about how and why things happened. The added questions further the conversation of differential access and outcomes of critical experiences and the supports or barriers that surround them.

**Qualitative-Data Processing**

All interviews were audio-recorded, transcribed, and imported into the qualitative data-analysis software NVivo that supports many different functions, such as coding, running relationship tests, and tools for organizing and managing qualitative data. The first step of data analysis was to establish a reliable coding scheme (Creswell, 2016). Codes represent themes identified in the data and are assigned to segments of interview text that represent those themes in expression of a single idea (i.e., unit of meaning). We used a combination of deductive coding, in which codes arise from pre-established themes, and inductive coding, in which codes arise during the data-analysis process (Creswell, 2016). A collection of codes comprises a codebook, which includes the code definitions and examples used as a guide to help analyze interview data (Creswell, 2016).

Codebook development began by first inductively identifying trends when conducting interviews and reading interview transcripts. For example, the research team recognized that each participant interviewed cited a financial contribution that either helped or hurt them during their undergraduate trajectory. This led to a code being created to depict this trend. These trends were then transformed into codes with specific definitions and guidelines. Following the previous example, one code in the codebook was named “financial support” and its descriptive
coding guidelines, which were also inductively defined, were referred to as supports originating with financial resources or money that can be mobilized toward the attainment of, engagement with, and/or participation in STEM, e.g., students living for free with family, merit-based or other financial aid/fellowship/scholarship, and access to extra resources such as a car or taking an entrance exam multiple times. Once the codebook was established, a team coding protocol was employed to add reliability to the data.

The coding team consisted of four expert analyzers in two teams of two for pair coding, which consisted of each pair coding all six interviews for half the codes in the codebook. For pair coding, each expert analyzer individually coded 1-2 interviews per week and then met with the other pair member to achieve consensus on the entire interview. Achieving consensus requires each segment of text and the assigned code to be agreed upon by both members of the pair. Weekly meetings with all four researchers were conducted to discuss overall coding challenges that arose during the individual and pair coding process. After six interviews had been completely analyzed and consensus was achieved for each pair, thirty percent of the coded text segments were selected and traded to the other team to code. Again, the coded segments were coded individually and consensus between pairs was achieved. The degree of consistency among multiple coders, referred to as an inter-rater reliability (IRR), was calculated after (Halgren, 2012).

**Analysis of Themes**

After codes had been established, refined, and tested for reliability, I identified prominent themes mentioned by several participants and assessed the significance of these themes. I identified emergent inductive themes by running coding queries in the NVivo system. Coding queries are used to find segments of coded text, a combination of codes applied to a text, or a participant with particular attributes, e.g., demographic or academic qualities (Run a Coding Query, n.d.). A researcher can query to test ideas, explore patterns, or identify connections among the themes, topics, or people and places relevant to the study. For example, I performed a query to identify the number of times participants mentioned financial barriers, which enabled me to analyze the significance of this code mentioned in comparison to other coded barriers. Queries were performed to find trends specifically surrounding the participants’ supports and barriers that had been mentioned in their interview transcripts.
I used the query results to inductively identify emergent themes that shed light on what barriers and supports students experience when pursuing STEM studies during their undergraduate tenure. In the findings section, I discuss themes that were broadly present across the sample population. Specifically, evidence of a theme had to be present in four of the six interviews and occur with relative frequency or importance to each participant, to be considered a “theme.” To identify relative frequency or importance to each participant, I looked for things that a single participant speaks about frequently or that they mention are impactful. I chose this criterion because it reflects a common experience encountered by the majority of students or an experience which was important to one participant. I did not include themes that were experienced by only a minority of the participants or were of little importance to them in their pursuit of STEM persistence. After theme identification, members of the research team confirmed theme presence, constituting a second check on theme identification.

**Methodology Caveats and Limitations**

It is important to note that quantifying qualitative data is controversial in qualitative research fields (Creswell, 2016). While the quantitative conversion of qualitative data can help to recognize patterns or extract meaning from the data, the primary goal of qualitative research is to describe the phenomenon under investigation in detail (Sandelowski, 2009). Saldaña (2009) cautioned that “If you are transforming words into numbers solely for what you believe may be more persuasive results and case-making, you may be doing it for the wrong reasons.”

In the findings, I present my analysis of supports and barriers reported by six students. While a minimum sample size of at least twelve participants would be ideal for a qualitative study (Crouch, 2006), the mention of a particularly impactful support or barrier by just a single participant could spark future research (Saldaña, 2009). Keeping in mind these best practices for qualitative research, I performed queries to identify the number of participants that mentioned a specific support or barrier as well as the frequency that participants mentioned a specific support or barrier. For example, I found that financial barriers were mentioned by four out of the six participants, but was only mentioned once by one of the four participants. The supports and barriers I describe were mentioned by four or more of six participants, which I interpreted as a common experience among participants.
Positionality

As a researcher, teacher, and student of STEM education, I am not only interested in researching supports and barriers undergraduate biology students face while trying to gain access to a STEM career, but I am also an advocate for improving their experiences and increasing the diversity in STEM. I am a first-generation college student studying Biology and Secondary Science Education. I am a white female who qualified for the Pell grant and attended the University of Colorado, Boulder. The coding team consisted of three other people, two undergraduates and one postdoctoral researcher, each of whom is passionate about science education and all identify as white females. The broader research aims and interviews were conducted in an academic research lab focused on education for action and change. My background, as well as that of the coding team and lab, inevitably influences the lens used to view participants accounts. While our positionality influences how participants’ experiences are described, I strove to retell their lived experiences as accurately as possible.

FINDINGS

Academic supports and barriers

Through the codebook refinement process described in the Methods, we defined an academic support as a support originating within an academic learning environment that can be mobilized toward the attainment of, engagement with, and/or participation in STEM. Examples of this code are supports related to a beneficial pedagogy, which included understanding disciplinary content, learning in a particular classroom, and having a skilled teacher. This pedagogy took place in high school classrooms, lab environments, and university settings. Academic supports were mentioned by five out of the six participants and were included in seventeen overall comments. Below is a quote from Emma, a white female, that explains an academic support pertaining to one class enhancing her interests:

“So, I really liked my degree, but I didn't ... up to that point I guess I didn't love it. I don't know, it was really cool, but I hadn't found a passion within it. I can do random things would interest me, but then when I took [that course]. I loved it. And, that was the first class I really crushed without so much stress. And, I kind
of had knack for it I think. And, then I asked her if I could work in her lab at the end of that semester and she said yes.”

Emma’s quote indicates that although she liked her degree program, she did not feel passionate about it until she took a specific course. She explains that the course afforded her the opportunity to connect with an instructor which lead to a future professional relationship. Next is a quote from Megan, a white/American Indian female, representing an academic support in a high school setting with an inclusive culture:

“I took [a specific course] in my high school, because that was one of the Science classes, where it wasn't an issue to be a woman, so I took two years of [this course], and I also TA'd for both years in [this course], so I've had essentially four years of high school [specific course].”

Megan explains that she took two years of a specific science course in high school because she was included as a female. She also went on to be a teacher’s assistant in this course, so she spent a total of four years surrounding this course. Megan also explains below an academic support that included a beneficial teaching style in a lab setting:

Interviewer: You interacted a lot, because [professor 1 and professor 2], they were there teaching the Lab?
Megan: Yes, and there weren't TAs, like it was the two of them teaching us, just two instructors dogging the 20 of us to do as much as we possibly can.
Interviewer: Yeah, and do you feel like you ... did you get to know them, and what was that like?
Megan: Yeah.
Interviewer: Did they influence your interest
Megan: Yeah, it's very difficult to sway me from the path of becoming a physician, but they did a pretty good job of it. They appealed to my interest in genes like, "Look, you can be an academic in Science, you could teach. You could do what we're doing right now. Doesn't that appeal
Megan states that her professors for a lab course taught the lab themselves instead of having TAs teach the lab, as is the norm in large science courses. There were two professors for twenty students which allowed them to spend a lot of time helping the students and encouraging them to persist in STEM. Although Megan was dedicated to becoming a physician, she considered a career path in this course content because of this beneficial interaction with her professors in a lab setting.

The opposite of an academic support is an academic barrier. We defined academic barriers as barriers originating within an academic learning environment that affects the attainment of, engagement with, and/or participation in STEM. Examples of this code are barriers related to stressful discipline-specific cultures and non-beneficial pedagogy. Four of the six participants mentioned academic barriers with five overall comments. Below is a quote, representing a non-beneficial pedagogy academic barrier, provided by Maria, a Pell grant-eligible white/Hispanic female who is a first-generation college student:

“The only class I took with them was [class name], or something like that. We didn’t do anything, there was no assigned textbook or anything. Then, the end project was to make a public service announcement video or something like that. We did nothing during the whole semester, and then we had to turn in this huge project at the end that no one really knew what was going on. Yeah. Then I dropped out.”

Maria’s quote indicates that she dropped out of a program due to a poorly structured class. This lack of structure included the absence of a textbook, unclear instructions, and a high-risk project at the end of the semester. Next is a quote from Matthew, a white male who is a first-generation college student, describing a stressful discipline-specific culture academic barrier:

Matthew: Yeah, totally. I think, in general, I feel like [my major] in general is incredibly stressful. I think just the whole pre-med atmosphere I thought was just, it was very malicious.
Interviewer: Really?
Matthew: Yeah, I just didn't think it was the best, and since I think a lot of people were very much gunning for their own, which is fine, but I think it was just very anxiety-provoking, and I just wasn't sure that I really wanted four years of that.

Matthew explains that he questioned taking a pre-medical pathway because the culture of the discipline was anxiety-provoking due to its competitive nature. Participating in four years of such a competitive atmosphere was not appealing to Matthew, which made him question his biology major.

Financial supports and barriers

Financial supports are defined as supports from financial resources or money that can be mobilized toward the attainment of, engagement with, and/or participation in STEM. Examples of this code included instances of students living for free with family, merit or non-merit based financial aid/fellowship/scholarship, and access to extra resources such as a car or taking an entrance exam multiple times. I found that four out of the six participants mentioned financial supports with thirteen overall comments. Below is a quote from Maria that represents the financial support of scholarships:

Maria: Yeah. Then, year three and four I was in the MARC U-STAR program, which covers 60% of tuition and I get a stipend every month.
Interviewer: Cool, was that on top of the full scholarship that you had?
Maria: Yeah. I get a little bit of returns from that, it would bounce back and you can use that for your living expenses.”

Maria’s quote indicates that she not only had tuition paid for, but she also received several scholarships that paid for living expenses. Next is a quote from Elena, a white/Hispanic female who is a first generation, Pell grant eligible college student, that represents the financial support of living with family:
“Well, I figured if I was gonna move to [the city], I wasn't gonna live anywhere else. My grandmother lives two miles away from the university. It would have just been a waste of money to live anywhere else.”

Elena explains that her grandmother lived near the university and it would be a waste of money to live anywhere but with her. This is a financial support because without her grandmother to live with, she would have to pay for other living arrangements. Below is a quote from Megan that represents an extra resource financial support:

Interviewer: So, you took [the MCAT] in June, and then again?
Megan: Mm-hmm (affirmative), because, the first time I got a 515, and the max you can get is 528, and my grandfather was convinced that I could get a 528, if I would just try a little bit harder, so he signed me up for another one.

Megan explains that she received a competitive score on the MCAT medical school entrance exam, but her grandfather was convinced that she could get a perfect score if she tried again. She had sufficient funds to sign up and take the MCAT again just to explore if she could get a perfect score.

The opposite of financial supports are financial barriers, defined as barriers associated with a lack of financial resources or money that can be mobilized toward the attainment of, engagement with, and/or participation in STEM. The main example of this code was students needing to work in non-university jobs, which took away time and focus from other opportunities. I found that four out of the six participants mentioned financial barriers with six total comments. Below is a quote from Emma that is representative of what the participants had mentioned about needing to work in college:

Interviewer: What were your jobs throughout undergrad?
Emma: I had so many. Okay, Freshman year I worked in the dining hall. The C4C. It was horrible. And, I actually only worked there a second semester freshman year.
Interviewer: Awesome. And, then any interest in biology cause you to participate in that activity?

Emma: Nope, just needing money and I don't know. It was a stupid job.

Emma’s quote says that she had a “stupid job” not for the experience or interest in biology, but purely because she needed money. This is representative of what other financial barriers were experienced by the participants. Interviewers would often ask “why did you have that job?” after a participant mentioned employment and Emma’s response was very common among the participants. The next quote is from Megan that represents a lost opportunity due to a financial barrier:

“Then, all of a sudden, [the faculty member] calls me into his office, and he was like, "I need you to work 20 hours a week", and I was like, "Um, why?" He was like, "Well, I don't think you should be in the lab if you don't want to work 20 hours a week." So, I was like, "I can't do that, especially unpaid, while I have all of this other stuff going on. It's not possible."

Megan explains that without this lab position being paid, she could not commit 20 hours a week to it. Her financial needs led to the inability to participate in the CE of working in a lab.

**Institutional supports and barriers**

*Institutional supports* are defined as supports associated with the university or the science field’s structures, policies, systems, or norms that can be mobilized toward the attainment of, engagement with, and/or participation in STEM. Examples of this support are dual enrollment programs, academic living environments, and lots of opportunities for CEs. I found that all six participants mentioned encountering an institutional support with twenty-seven total comments. Below is a quote from Miguel, a white/Hispanic male, about an academic living environment:

“Yes, I do remember how ... Coming across the program while I was looking for housing. So, when you were looking at all the different dorms you could live in,
they had like, this dorm is associated with this residential program and this dorm is associated with this one and so I selected [my dorm] based off of the fact that they had this health professions program available.”

Miguel says that there were many options for programs associated with the residential dorms at his university. He was able to participate in a health profession program through the dorm that he lived in. Next is a quote from Elena that represents a high school and college dual enrollment program:

“when I was in high school, I started my first college class. The counselor there at my high school said that because it was a free program ... I don't know. There was some sort of agreement between the university and the high school, so we would take classes”

Elena explains that her high school had an agreement with the university for students to take college courses for credit. Her high school counselor helped her sign up and she participated in college courses while still in high school. Below is a quote from Megan that represents opportunities for CEs as an institutional support:

Megan: Yeah, I did in fall of 2015, as a sophomore, that's when I did the shadowing on the physicians, physical therapists.
Interviewer: Oh, okay. What was that through?
Megan: That was actually through [the university health center]. I went through their Sports Medicine Center.

Megan states that she gained shadowing experiences through the university health center’s sports medicine center. She shadowed both physicians and physical therapists.

Institutional barriers are the opposite of institutional supports and are defined as barriers associated with university or the science field’s structures, policies, systems, or norms that impede the attainment of, engagement with, and/or participation in STEM. Examples of this barrier are poor academic advising, STEM and gender bias, and difficulty when trying to access
CEs due to institutional norms. I found that four out of six participants mentioned encountering an institutional barrier with twenty overall comments. Below is a quote from Megan that represents difficulty accessing lab work due to an institutional norm:

“Yeah, I went and talked to the undergraduate research coordinator and was essentially told, "Good luck", there are some labs that at some point in the past, have taken students, but most labs don't want undergraduate students, unless you're committing to only doing that lab, and only doing their projects. It was sort of discouraging to hear that, "You need to pick one, and I hope you really like it. Don't fool around. You can't mess around with stuff."”

Megan explains that when she was seeking lab experience as an undergraduate, the coordinator told her that most labs would not want undergraduate students in their lab unless she planned on committing to only one lab. Limited access to lab experience is an institutional barrier because it is a university or departmental structure that is limiting to its students. Lab experience is a CE that many graduate and medical school applications look for, and if there is limited access to it at the university level, it becomes an institutional barrier. The next quote is from Matthew who explains an example of poor advising:

Interviewer: The pre-health advisors, you found to be less helpful?
Matthew: Yeah, I think I found them to be less helpful. I think a lot of times they just inevitably stressed me out more. They're like, "Oh, you need to be doing research, you need to volunteer, you need to have leadership opportunities, you need to have amazing grades, you need to have phenomenal test scores," which I understand, but I think there's a much more effective way of conveying that than telling people everything they need to be doing or that they're not doing correctly.

Matthew says that the approach taken by the pre-health advisors to encourage him to gain more CEs ended up being less helpful than he thought it could be. He thinks that there are more effective ways to help students be competitive for graduate and medical school applications. He
states that the experience was stressful, which was representative of what other participants had said about pre-health advisors, and the STEM culture as a whole. Below is a quote from Megan that represents comments about gender bias in STEM:

“Then I had a Physics teacher that told me I couldn't do it because I'm a girl, so I had to drop Physics. That's the kind of thing that ... Yeah, I liked my Science classes, but it was really an uphill battle to take any of them.”

Megan explains that because she was a female, it was made difficult for her to take science courses at her high school. Her physics teacher told her that she couldn’t do something because she was a girl, which led her to drop the course.

**Personal Supports and Barriers**

A *personal support* is defined as a support originating with students' personal lives that affected their attainment of, engagement with, and/or participation in STEM. Examples of personal supports are emotional support and encouragement from family or friends, supportive family living nearby, or having ethnic cultural advantages. I found that all six participants mentioned encountering a personal support with twenty-six overall comments. Below is a quote from Matthew that represents a supportive friend group:

Matthew: Yeah. I think also it helped, too, a lot of my close friends from high school were also in [my major program], so that kind of pulled me back into focus, too.

Having that kind of support network.

Interviewer: Were these friends that you were living with in the dorms?

Matthew: Yeah, they all lived close to me. They didn't live in [my dorm] specifically, but they lived in the dorm next to me.

Interviewer: Did you meet them right away in classes?

Matthew: No, I knew them from high school.

Interviewer: Your friend group from high school was also med school oriented?
Matthew: Yeah. All of my friends from high school all did some aspect of science or engineering.

Matthew explains his network of friends not only lived close to him, but they were also all STEM oriented and often pulled him back into focus. This is a clear representation of a personal support because it includes multiple forms of support, such as a good friend group and people who understand the lifestyle of majoring in STEM. The next quote is from Elena and represents the personal support of having family nearby:

Elena: Yeah. A lot of my family lives here, so I'm currently in my grandmother's house. I've been living here since.
Interviewer: Okay, so you moved to your grandmother's house in [the city] your freshman year, and you've been there for the six years you were in undergrad?
Elena: Yeah.

Elena states that she has a lot of family nearby and she even had the opportunity to live with her grandmother all six years as an undergraduate. Below is a quote from Maria that explains an example of having ethnic cultural advantages:

“I think they waive the application cost for students who had been in the program, yeah. I think, as a minority, every school just waived my thing”

Maria explains that her application costs were waived for every graduate school that she applied to because she is of a minority ethnicity.

A personal barrier is defined as a barrier originating in students' personal lives that impairs attainment of, engagement with, and/or participation in STEM. Examples of this are medical problems experienced by the students or their families, unsupportive family or friends, and lack of experience with post-secondary educational norms. I found that all six participants mentioned encountering a personal barrier with twenty-three overall comments. The following
related quotes from Megan are representative of what the participants had mentioned about medical complications:

Megan: In December, that's when I had a [serious medical condition].
Interviewer: Oh my gosh.
Megan: So, that's fairly significant. I can definitely sort my life by pre-that, and post-that.
Megan: Yeah. I don't have, especially now, I have [lasting effects from the condition] so I know that [one career goal] is out of the options, that's not going to happen”

Megan states that she had a serious medical condition which affected her future career choices. This is a personal barrier because it is a medical condition that has negatively affected her participation in certain fields of STEM. The next quote is from Miguel and represents the lack of experience with post-secondary educational norms:

“My parents never really went to college here. They both studied in [a different country]. And so, when it came time for me to, like, declare a major or like decide what I wanted to do I wasn't really sure how to go about that. So, I mean when I declared as a freshman, I thought you had to declare going into college and that you could never change it. Or you were going to be really fixed to that. Which is kind of like what their experiences were like. They kind of choose a career path right after high school and they stick with that and that doesn't change.”

Miguel explains that his parents went to college in a different country, which makes Miguel a first-generation college student in the United States. The experience his parents had in college in another country influenced how Miguel expected college to be in the United States. He expected that after choosing a college major after high school that he would not have the opportunity to change it at any time. This represents how a student’s, or the student’s family’s, lack of experience can lead to confusion as an
undergraduate biology student. The last quote is from Elena and it represents having an unsupportive family member:

Interviewer: So, your dad wasn't into, like, for you being a mechanic?
Elena: Right. Or just like studying mechanics, because that's for boys. It was only as I got older, all of a sudden, I needed to be a girl.

Elena’s quote indicates that her father did not approve of her studying mechanics because she was a girl and studying mechanics was for boys in his view

**Professional social network supports and barriers**

A professional social network support is defined as a support originating in a student’s ability to build, maintain, or mobilize relationships with family, friends, peers, or professors/instructors/mentors/advisors toward the attainment of, engagement with, and/or participation in STEM. Examples of this support are family members in STEM careers, various program memberships, professor relationships, and lab faculty relationships. I found that all six participants mentioned encountering a professional social network support with forty total comments, which is the most frequently mentioned theme out of all supports and barriers. The following quote from Miguel is representative of what the participants had mentioned about lab faculty/staff member supports:

“She was like my mentor for this, like the thesis writing itself. So, I would go to her with, sort of, we'd plan the time out together of when I should get these different parts of the paper done and she proofread it and gave me suggestions on what to change and how to write it and so that was a cool thing that we were able to do together. And then when I gave my presentation for the [scholarship] program she was there as well.”

Miguel explains that he had a lab faculty/staff member who helped him write a thesis, from proofreading to being at his presentation. Miguel gained a good relationship with his mentor which lead to the opportunity of having a highly qualified thesis and presentation. Next is
a quote from Megan that represents how membership of a program granted her more participation in STEM:

“Yeah, well, I did, because as soon as the first summer went by, the director of our whole program decided that she really, really liked me, and I was just very excited, because I really, really like working for this program, so I did a lot of things that other teacher's aids, or office assistants wouldn't do. I did a lot of their financial stuff, with getting our stipend checks for the students, I substitute taught further classes, I ran weekend programs when the RAs needed a break”

Megan explains that the director of her academic program really liked her, therefore she had more opportunities to help with the group. She helped the program with their finances, teaching courses, and helped run weekend programs when needed. Megan gained extra CEs due to her good relationship with her program director. Below is a quote from Matthew that represents professors’ influences on many of the participants:

Matthew: Yeah. Just whenever I wasn't sure how I should really focus my career or my education, I would always email [that professor] and then just we'd set up a meeting, and we'd talk for a while, because one of her sons went to medical school as well, so-
Interviewer: She had advice for you about-
Matthew: Yeah, just about undergrad, about science, and medicine, and just other career options as well.

Matthew states that whenever he needed guidance, he would just email a specific professor and she would offer her advice on various things such as science, medicine, and career options. The last quote for professional social network supports is from Megan, which represents a family member working in STEM:

“My mother worked for [a university in a Biology lab]. I went to work with her. I think mostly I picked up the [organism] and put them in the wrong tanks, but I
was around all of that equipment, you know? So, I learned the names of all the 
equipment, how not to break it, how to store things, so I have that lab background. 
Yeah, so I've been steeped in Marine Biology since I was two.”

Megan says that her mother worked in a biology lab where she would spend a lot of time 
as a child. This experience led to knowledge of norms around working in a lab, lab procedures, 
and different names of equipment.

A professional social network barrier is defined as a barrier originating in a student’s 
inability to build, maintain, or mobilize relationships with family, friends, peers, or 
professors/instructors/mentors/advisors toward the attainment of, engagement with, and/or 
participation in STEM. Examples of this barrier are miscommunications with the university’s 
faculty or staff, misinformation from the university faculty or staff, and the lack of a student’s 
interpersonal connections. I found that all six participants mentioned encountering a professional 
social network barrier with nine total comments. The following quote from Elena gives an 
example for miscommunications:

“I didn't know the name of the plant that I helped study for a year, because this 
graduate student I worked with had an accent, and she would say it really fast, so I 
never really caught it. I asked her to repeat it a few times, but after that I was too 
embarrassed, and I was like, I'm never gonna ask again. I'm just gonna wing it, 
and like, we'll see what happens from here.”

Elena discusses the lack of knowledge for the name of the plant she was studying for a 
year due to not being able to understand the graduate student’s accent when she was first 
explaining the plant to Elena. This is a type of barrier that could have been an opportunity for a 
professional social network support but fell short and ended up being a barrier instead. The next 
quote is from Megan who describes an example of misinformation:

“When I went to apply, everyone that I talked to was like, "You don't have 
 enough research experience", and then of course, after I had submitted my 
MCAT, I went and talked to someone that had done that, and he was like, "Why
didn't you apply? You had plenty of research experience, you're fine." He was like, "I think the people you talked to, just really wanted you to strictly go to medical school." Because, I had talked to advisors here, I had talked to some of my professors. But, oh well, I can get a PhD later.”

Megan explains that when she went to apply to graduate school she was told by advisors and professors that she did not have enough CEs to apply. She then found out later from someone who had applied to graduate school that she had plenty of CEs and should have applied. The last quote from Emma describes a lack of connections:

“Yeah, when I first kind of thought I should get involved in research, because I felt like everyone was sophomore year. I just kind of shotgun emailed 30 people and I had no idea how to go about it, and no one replied. So, I kind of gave up for a year after that and then I realized you can't do it that way. You have to go meet them in person. You have to already know them. But, when you don't know, you don't know.”

Emma states that she attempted to get involved in research by emailing thirty people to ask for opportunities. Since she did not know any of these people, or anyone else involved in research, she did not receive an email back and did not have an opportunity to participate in a research lab. Along with Emma’s lack of social network connections also came a lack of awareness on how to make these connections.

**DISCUSSION**

In this section, I return to my research questions and describe how the supports and barriers identified in undergraduate biology students' lives may affect their persistence in a biology-career pathway. I then explain the limitations of my study and, finally, describe potential implications of my findings and make suggestions towards future research.
**Question 1: What supports do undergraduate biology students possess that promote attainment of, engagement with, and/or participation in STEM?**

In my study, I identified many different types of supports that the participants possessed as undergraduate biology students. There were 123 mentions of supports from the six participants that fell into five broad categories including academic, financial, institutional, personal, and professional social network supports. Each of the five types of supports consisted of unique, but related, supports. For example, a common trend in financial supports was the need for a student to work. I will focus here on the two most prominent themes throughout my findings, found in academic and professional social network supports.

The most common type of academic support involved accounts of positive classroom pedagogy. This was representative across many of the participants’ comments and included instances of group work and problem-based learning, which is when solving a problem guides a student’s learning (Klegeris et al., 2011). These academic supports benefited students by building their interest in STEM and improving access to the content. Group work and problem-based learning are both being recognized as “best practices” by the Next Generation Science Standards, which is a set of secondary science standards adapted by the majority of states in the United States (NGSS, n.d.). One reason group work in classrooms is highly valued is because working in a group is more collaborative for students than individual work (Gibbons, 2002). It also aids in differentiation for emergent bilingual students, which are students who use English as a second language (Gibbons, 2002). With group work, these students have more opportunities to interact with English speakers, which also promotes their language learning (Gibbons, 2012). Group work is also identified as a beneficial practice by undergraduate students, who state that group work helped them gain “insights on different points of view, improved interpersonal skills, understanding of personal strengths and weaknesses, and increased class attendance and subsequent involvement” (Seric, 2018).

Problem-based learning (PBL) is a pedagogical academic support found in my study, and throughout current literature. Studies have been conducted on traditional learning versus PBL on students in their first year of medical school (Hmelo-Silver, 2004). It has been found that when assessed, the problem-based learners gave more accurate hypotheses and explanations than students in the traditional curriculum (Hmelo-Silver, 2004). PBL has been described as an effective learning strategy that can encourage students to become self-directed learners and
develop transferable skills, such as critical-thinking skills, problem-solving skills, and teamwork skills (Kivela et al., 2005). An awareness of these pedagogical academic supports is particularly important for educators since they are able to create or promote them in the classroom for their students, which could ultimately affect their persistence in STEM.

Professional social network supports were the most frequently mentioned type of support, with mentions by all six participants and forty overall comments. Students experienced multiple kinds of professional social network supports as a result of either their participation in academic programs, lab research, or personal connections through family members. Participants frequently mentioned relationships and career advancement through directors and peers of programs such as residential living academic programs, Greek academic sororities or fraternities, or various science community programs. Participants mentioned making professional connections and gaining insight of opportunities as a result of participation in lab research, and specifically through faculty members, graduate students, and even peer mentors who assisted them in research studies. Lastly, participants’ families played a large role in supporting their trajectory in STEM through the influence of their own careers, shadowing connections, and access to knowledge and experience of what working in STEM may look like. The frequency of professional social network support mentions in my study is not surprising when considering Bourdieu’s (1986) theories on social capital. Social capital is a network of relationships a person possesses that can be mobilized as a certain currency, which in my study’s context would be engagement with STEM (Bourdieu, 1986). The participants in my study used their professional social network supports as a form of social capital and mobilized them toward engaging in STEM. These professional social network supports advanced the students’ opportunities in STEM by offering access to critical experiences or additional supports, including research projects, access to financial supports, and gaining a supportive cohort of peers.

Almost all supports found in this study can be connected to a CE that promoted students’ persistence in STEM. Supports often helped students gain access to CEs such as work in a lab, shadowing, and academic programs. All three of these CEs are not only considered essential for admission to graduate and medical schools, but have also proven to constitute their own form of support. For example, I found that when a participant worked in a lab, that usually led to a professional social network support because it put these students in close proximity to researchers, professors, and graduate students who helped the participant gain more opportunities
through these connections. Working on research also helps undergraduates’ awareness of what graduate school is like and clarifies interests in STEM careers (Russell, 2007). Shadowing looks good on an application, but also often led to a social network support by the students making connections with professionals in the field, that then continued their connections after graduation. Career shadowing can also improve students' career exploration, understanding of aspects of a desired career, and help connect course material to the field (Oswald, 2017).

Participation in an academic program or club is a CE that is an asset on applications, and, for many participants, also leads to professional social network, financial, and personal supports. By being a member of an academic program, these students made professional connections with directors and peers, qualified for specific scholarships and research grants through the program, and made supportive friends along the way. Although the initial focus of my study was the effect of supports on CEs, I found CEs, conversely, also have an effect on supports. A major take-away from my study is thus that the relationship between CEs and supports is cyclical and constitutes a feed-forward reaction.

**Question 2: What barriers do undergraduate biology students encounter that discourage the attainment of, engagement with, and/or participation in STEM?**

I identified many different types of barriers faced by participants as undergraduate biology students. These barriers, similarly to the supports, fell into five broad categories including academic, financial, institutional, personal, and professional social network barriers. Barriers were mentioned much less frequently than supports (63 and 123 mentions, respectively). Despite being mentioned fewer total times, every category of barrier was still mentioned by at least four of the six participants, and each different barrier type gave rise to different themes within that category.

A large trend in academic barriers was a stressful competitive atmosphere created by the biology major. Many participants said the competitive nature of getting into STEM graduate and medical schools translated into classroom settings and the mentality of professors and peers, which made it hard for the participants to reach out for help and gain access to CEs like working in a lab that were highly sought after. Many of these comments came from the first-generation college student participants. It has been found that American universities focus primarily on norms of independence, or students paving their own path (Stephens, 2012). These norms
contradict the interdependent norms of most working-class first-generation college students (Stephens, 2012). This could be one of the sources of stress the participants faced. This situation also affected students’ confidence in their ability to persist in STEM.

Professional social network barriers were often mentioned in association with a lack of connections. I found that the lack of connections that students had with professors, lab coordinators, advisors, and professionals in the field often prevented students from accessing CEs. Most commonly, students tried to gain work experience in a lab, and found that they had to know someone first in order to get a position. If they did not know someone with connections to a lab, they often missed out on the experience. As discussed above, this could be interpreted as a lack of social capital (Bourdieu, 1986). Even students who have the opportunity to work in a lab often say that to improve undergraduate research programs there needs to be increased or more effective faculty guidance (Russell, 2007) (Hanshaw, 2015). The lack of connections contributed to limited access to CEs, which could affect students’ persistence in a biology career pathway.

Although barriers were mentioned less than half as often as supports, it is important to note that the students participating in the study had all persisted and made it into a graduate or medical school. Thus, the frequency of mentioned supports they possessed in their undergraduate years could have contributed to their success in gaining admission to an advanced degree. It is possible that the more supports and fewer barriers a participant possesses, the more likely they are to persist in a STEM career pathway. This finding further supports my hypothesis and indicates that supports and barriers both, influence a student’s ability to pursue critical STEM experiences and persist in STEM career pathways.

**Limitations**

My study has various limitations that are important to recognize, with a main one being sample size. In qualitative research, it is ideal to reach saturation (see below) before completing data collection and analysis. Saturation is reached when no new trends emerge from the data and sufficient evidence supports these trends (Saunders et al., 2018). In the context of my study, this means that I would begin to hear the same supports and barriers over and over again until all participants are mentioning the same things. The number of participants I was able to interview was not sufficient to reach this saturation stage. My goal for future studies would be to have over forty participants with the goal of reaching saturation. However, my analysis of data from six
participants does serve as a foundation for future research in that it identified numerous supports and barriers to target in future participants’ accounts. Even once saturation is achieved in one study, it’s important to exercise caution regarding the generalizability of the findings in other contexts.

The small sample size of my study also contributes to other limitations, including under-representation and unequal representation of participants from diverse backgrounds. In my study, unequal or underrepresented groups include community-college students, male and gender-non-binary participants, and participants of different ethnic, racial, and socioeconomic backgrounds. While we recruited students from both the University of Colorado, Boulder and Florida International University to capture broad perspectives, these efforts should be expanded to gain a more representative sample. This, in turn, would enable us to generalize our findings across contexts and make suggestions at a national level.

Lastly, as with all qualitative research, the identities of the researcher, as disclosed in the positionality section, can influence how participants’ experiences are represented. Ideally, additional validity strategies, such as member checking or triangulation (see below) could be used (Creswell, 2014). Member checking involves asking study participants to verify that I am depicting their experiences in an accurate way, while triangulation involves additional resources derived from the participants, such as university transcripts and resumes, to build a more complete picture of participants’ overall experiences (Creswell, 2014). No such additional strategies were used due to lack of time and resources, but would be advised for future studies.

**Conclusions**

As indicated above, the SCCT framework was used as a lens to dissect my research. In this theory, distal and proximal supports and barriers affect a student’s interests, goals, and actions (Lent et al., 1994). I considered actions to be a student’s engagement with CEs necessary for persistence in a STEM career pathway. Overall, my findings support this theory. We began this study by recruiting students who already had interest in STEM and the goal to get into a graduate or medical school. This gave me the base to research proximal and distal supports and barriers that affected students access to different actions, or CEs, and their persistence in a biology career pathway. The supports and barriers I identified were categorized as academic, financial, institutional, personal, and professional social networks. All of these supports and
barriers either enhanced or discouraged participants’ access to CEs, which in this theory would affect students’ persistence in STEM as well.

**Future Directions**

Throughout this study, I identified and discussed different supports and barriers faced by biology students trying to persist in a biology career pathway. Due to the small sample size of participants, I did not, however, focus on students’ differential backgrounds and demographics in relation to these supports and barriers. The groundwork for identifying supports and barriers to target will allow further exploration of the causes and effects of these supports and barriers by future research. Future studies should recruit more participants from diverse backgrounds, such as community college students, students of all genders, all ethnicities, all ages, all socioeconomic backgrounds, and students from families with different educational backgrounds. This approach would allow for broader perspectives on how personal background affects supports and barriers encountered in post-secondary education.

**Implications and Suggestions for Next Steps**

This study addresses the problem of persistence in STEM by laying the groundwork for future research on supports and barriers in order to design solutions that offer students more supports and eliminate barriers in post-secondary education. Identifying supports and barriers is the first step needed to address these at several different scales, such as individual, instructional, and institutional scales. For example, to allow students access to more academic supports and reduce barriers, students could be exposed to various learning and studying strategies by creating clubs, gaining exposure to research, and having conversations with peers surrounding classroom and content learning. At the instructional level, high-school teachers and college professors could be better educated through pedagogical courses and educational conferences on strategies, such as PBL, to offer multiple different ways of learning for a diverse student body. Institutions, such as the university, could offer more opportunities for faculty professional development, require mandatory training for all professors on evidence-based teaching strategies, and offer more support for all students by expanding help-room hours and offering more study spaces.

To address the other supports and barriers, such as financial and personal, I suggest that teachers could educate themselves on where students can find more information on these
supports and act as allies to students trying to access supports like financial aid or medical accommodations. It is possible that many students do not access financial or personal supports due to a lack of awareness for such opportunities. For example, in 2017, 648,191 pell-eligible students did not fill out the federal application for federal aid (FAFSA) and left over two billion dollars of the Pell grant unused (Nerdwallet, n.d.). Institutional administrators can assist in promoting this awareness by using my study to improve programs that advertise for financial and personal support opportunities for students.

These administrators can also address institutional and professional social network supports and barriers by promoting connections between undergraduate students and professionals in the field. This could help first-generation college students gain experience with post-secondary educational norms and promote professional social network supports, while breaking down barriers. Many students were not able to access institutional and professional social network supports due to the lack of awareness of how to make connections with these professionals. It has been found that students who have spent more than two years at CU-Boulder were significantly more aware of research opportunities than students with 2 or fewer years at the university (Hanshaw, 2015). If the opportunities that already exist for undergraduates to connect with graduate students and university faculty, such as seminars and get-togethers, were advertised more, undergraduate students may be able to make more of these connections sooner.

One of the goals would be to connect professors with undergraduates to create more research opportunities for these students. It is my hope that these implications and suggestions could aid students’ experiences and future research on persistence in STEM.
Reference List


