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Early-year undergraduate research experiences: How students are mentored, how valuable they find this experience, and what kinds of costs they associate with it

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ABSTRACT

Undergraduate research has been considered as a high impact practice. Engaging in research in early college years are crucial to attracting and retaining students in research-related STEM careers. However, undergraduate research literature mostly focuses on the research experiences of students that are later in their undergraduate years. This dissertation is formed in an article-style format, which is a compilation of two separate research efforts to explore undergraduate students' research experiences in their freshman and sophomore years. This article-style dissertation is part of a larger investigation into the academic and social experiences of high-achieving low-income undergraduate students. The context of the studies in this dissertation was the National Science Foundation [NSF] funded the *Strategic Undergraduate STEM Talent Acceleration INitiative* [SUSTAIN] project and the twenty-four undergraduate researchers who participated in the project. Chapter 1 provides an introduction that discusses the need for studying students' early-year undergraduate research experience and explains the structure of the dissertation. Chapters 2 and 3 each present a complete study with an introduction, literature review, method, results, and discussion.

Chapter 2 includes a qualitative investigation of the mentoring structures and the types of support provided to early-year undergraduate researchers. The types of support participants received revealed differences in mentoring dyad or triad structure, as well as the amount of their research experience. Given the potential benefits to undergraduate researchers, undergraduate research programs should be designed to provide clear roles, responsibilities, and expectations from mentors to maximize the support provided to students. Chapter 3 is an exploratory study that utilizes the expectancy-value theory to investigate how much and in what ways early-year undergraduate researchers value their research experience, and which costs they associate with it.

Results indicated that intrinsic value and opportunity cost played the most important role in students' motivation to engage in research. This study contributes to the literature by providing preliminary evidence of the range of possible student experiences about the values and costs students associate with their research experience and identifies the most promising avenues for future studies to find ways to improve undergraduate research programs. Collectively, the studies in this dissertation help us better understand early-year undergraduate research experience from students' perspectives.

Keywords: Undergraduate STEM education, undergraduate research experience, mentoring structure, expectancy-value theory

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Dedication

This dissertation is gratefully dedicated to the loving memory of my dad,

to my dearest mum, my lovely sister, and to my beloved husband.

I am very thankful to you all for your contribution to the woman I am today.

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Introduction

The global environmental, technological, and economic demands have been changing rapidly. Correspondingly, there is an increasing need for science, technology, engineering, mathematics (STEM) graduates who are equipped with the skills and knowledge that are transferable to real-world problems to meet the demands of a sustainable global future (Organization for Economic Co-operation and Development [OECD] Education Indicators, 2018). Despite the growing demand for STEM graduates equipped with expected and desired skills and knowledge, universities in the U.S. are struggling to produce such professionals at a rate that respond to global competitiveness in STEM degree attainment (National Science Board [NSB], Science and Engineering Indicators, 2018; OECD, 2018). In 2015, U.S. higher education institutions awarded around 3.8 million post-secondary degrees, and only 25% of them were in science and engineering fields (NSB, 2018).

Specifically, colleges and universities in the U.S. are struggling to attract and retain a diverse pool of undergraduates to pursue a STEM major together with equipping them with STEM skills and knowledge (Chen, 2015). In 2018, more than twenty million individuals were enrolled in universities in the U.S. (NSB, 2018). Low-income and first-generation students comprise approximately 30% of this student population (NSB, 2018). Engle and Tinto (2008) reported that the dropout rate or switching to a non-STEM major of the first-generation and low-income students are four times more likely than their non-first-generation, non-low-income peers. One main reason stated in the higher education literature is that "underrepresented students often have less exposure to STEM career options" (as cited in Hernandez et al., 2013, p. 21).

Therefore, it is crucial to explore ways to engage specifically these students in STEM-related activities and to find the ‘best practices’ to keep them in the STEM fields.

In response to the challenges to attract, retain, and prepare STEM undergraduates for the 21st century needs, the Association of American Colleges and Universities (AAC&U) published a report characterizing a set of research-based educational practices, called ‘high-impact practices,’ which have significant impacts on student learning, engagement, and retention in higher education institutions (Kuh, 2008). In this report, Kuh (2008) emphasized the role of institutions on student engagement and suggested engaging students with effective STEM-related activities such as learning communities, study abroad, field experience, and undergraduate research (i.e., high impact practices) during college education. Kuh (2008) expressed that high impact practices help students “learn how to find and evaluate evidence, how to consider and assess competing interpretations, how to form and test their own analyses and interpretations, how to solve problems, and how to communicate persuasively” (p. 30).

Even though the content, extent, and the operating system of the high-impact practices may vary from one institution to another, they generally have key traits of (1) demanding a considerable amount of time and effort, (2) providing learning opportunities outside of the classroom, (3) promoting fruitful interactions with faculty members and undergraduates, and (4) reinforcing interactions with diverse others (Kuh, 2008). In the AAC&U report, Kuh (2008) identified a formal list of ten high impact practices, three of which were defined as high impact practices in the first year in college. These are learning communities, service learning, and undergraduate research. This study utilizes Kuh’s definition of high impact practices and will focus on one of the high impact practices, which is undergraduate research (UR).

Kuh (2008) suggested that institutions should aim for all students to participate in at least two high-impact practices throughout their college experience, one during the first year and one in the following years regarding the context of their major. One of the effective educational practices that have been found to make a significant contribution to students' engagement, positive learning outcomes, their success, and persistence is engaging them in UR (e.g., Kuh, 2008; Rowlett, Blockus, & Larson, 2012; Stanford et al., 2017; Thiry et al., 2012). UR is considered as a high-impact practice "because of the substantial educational benefits [it] provides to students" (Kuh, 2008, p. 1). Thirty years ago, UR was emphasized in the National Science Foundation [NSF] report (1989) as:

> It is clear that the academic community regards the involvement of undergraduate student majors in meaningful research ... with faculty members as one of the most powerful of instructional tools (p. 6).

The emphasis of UR in this NSF report attracted researchers and institutions, and student engagement in research activities has become a fundamental part of the STEM fields in higher education institutions (Hunter, Laursen, & Seymour, 2007; Kuh, 2008; Lopatto, 2010; Thiry, Laursen, & Hunter, 2011). Studies on UR reported associations with UR participation and several student outcomes such as higher rates of student-faculty interaction (Garvey et al., 2018; Schreiner & Tobolowski, 2018), higher perceived science identity (Chemers et al., 2011; Robnett, Chemers, & Zurbriggen, 2015; Robnett et al., 2018), persistence and higher GPA (Rodenbusch et al., 2016), and higher student engagement overall (Kuh, 2008). UR may guide students to "sink their roots in the culture of the discipline" (Merkel, 2003, p. 41) and explore career choices or participate in a graduate degree (Lopatto, 2010). Early engagement in UR might be beneficial and may result in different short-term and long-term outcomes than later experiences (Bowman &

Holmes, 2018; Hernandez et al., 2013). Therefore, this study focuses on undergraduate students' research experiences in their freshman and sophomore years, which is defined as early-year UR (Bowman & Holmes, 2018).

Although engaging in UR during the first year is becoming more common (Lopatto, 2010), annual results of the National Survey of Student Engagement (2018) revealed that students who engage in UR during their first year are 6%, whereas it is 26% for seniors. It is, therefore, no surprise that studies on UR mostly explore the research experiences of students that are later in their undergraduate years (e.g., Hunter et al., 2007; Hernandez et al., 2013; Maltese, Harsh, & Jung, 2017). Few studies investigated the freshman and sophomore students' research experience (i.e., early-year research experience) (Bowman & Holmes, 2018; Provencher & Kassel, 2017).

UR experiences in early college years are crucial to attracting and retaining students in research-related STEM careers and strong predictors of academic success in the following years (Russell, Hancock, & McCullough, 2007). Moreover, students who start engaging in research in their later years in college, i.e., junior or senior years, may have a more solid career plan such as going to graduate school (e.g., Bowman & Holmes, 2018; Lopatto, 2010; Thiry et al., 2012), so studying early-year research experiences may bring beneficial insights into some desired impacts of UR experience (Gardner et al., 2015). To address this gap in the literature, in this dissertation, participants of this study consist of early-year undergraduate researchers who engaged with UR in their freshman and sophomore years.

Structure of the dissertation

Although there is an increased interest about UR among undergraduate STEM education researchers, there are still gaps or understudied aspects of UR in the literature. To address two distinct understudied aspects of UR, this dissertation is formed in an article-style format which is a compilation of separate research efforts that is designed to stand alone. This format promotes the published contribution of my dissertation to science education research over traditionally formatted dissertations (Gilman, 1974; Stewart, 2017; Tofel-Grehl, 2013). Although these two studies have some common aspects such as both of them focus on undergraduate researchers' perspectives on their research experience and utilize the same data set, they are developed as two separate studies because they concentrated on different aspects of UR and explored different research questions. With this goal, Chapters 2 and 3 each present a complete study with an introduction, literature review, method, results, and discussion sections.

Chapter 2 focused on mentorship provided to early-year undergraduate researchers. The literature on UR mentoring mostly focuses on a student-faculty dyad, which is only one piece of the puzzle. Mentoring triad structure (i.e., the interaction among undergraduate and faculty and graduate students or postdoctoral associates) is understudied (Aikens et al., 2016; Aikens et al., 2017). The literature also does not adequately describe the mentoring triad structure provided to early-year undergraduate researchers. Therefore, the second chapter aims to better understand the undergraduate researchers' perspectives about the mentoring structure they experience in their freshman and sophomore years. Specifically, the primary goal of the second chapter is to explore what kind of support is provided to early-year undergraduate researchers when they experience different mentoring structures. Results revealed that participants reported receiving different types of support during their research experience depending on the mentoring structure and the amount of their research experience.

Chapter 3 focused on the motivational factors to better understand early-year undergraduate researchers' engagement with research (Eccles & Wigfield, 2002). The association with task values and STEM persistence are highly addressed in the literature, but task values on STEM-related interventions, such as UR, is little studied (Linnenbrink-Garcia et al., 2018). Therefore, the third chapter aimed to fill this gap and focused on how much and in what ways early-year undergraduate researchers value their research experience and what kinds of costs do they associate with it.

The vast majority of the participants revealed that their motivation to engage in research was influenced by their personal interest in the research project they involved in or the research process in general. The second most mentioned value type was the utility value indicating that participants found their experience useful. Attainment was the lowest commented value type implying only some of the participants commented on the personal importance of research or how being a researcher fits with their identity. Considering the costs participants associated with their research experience, only some of the participants associated a cost to their research experience and some of them associated more than one cost. The costs faced by participants varied by their gender, race/ethnicity, or the amount of their research experience but there was not a clear trend in the costs participants faced regarding different groups (i.e., gender, race/ethnicity, amount of research experience).

Researcher's Positionality

I am a female first-generation graduate student who had my undergraduate education in a science field. I faced similar challenges to those described in the literature related to female students in STEM fields. My science identity has been formed with the encouragement of many faculty and peer mentors. My experience is consistent with the research related to high impact practice participation and mentoring (i.e., higher student engagement, choice selection, persistence, higher graduation rates, and higher motivation). My own experience and the experiences of students I have worked with throughout my career as a teacher and as a researcher, I see the importance and value of this research.

On the other hand, I am an international student who has limited knowledge about the ethnic and racial differences and the challenges they face. This may help my interpretations be more objective but also may limit my assumptions, framing and communication of the conclusions. Considering my insider and my outsider roles in this study, it was crucial that I took the essential actions to ensure I judiciously managed my positionality. This was primarily done with having weekly project meetings with the SUSTAIN project research team to communicate and assure my interpretations and perspectives minimally influence the findings of the study. I also had monthly meetings with my advisor to discuss my research progress verbally and share the data analysis process. I updated my committee members about the process by sharing written explanations of what I did. Regularly communicating my understanding and interpretations of the study findings with my advisor, my committee members, and project research team helped minimize the impact of my positionality as a researcher.

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CHAPTER II: Mentoring structures and the types of support provided to early-year undergraduate researchers

Abstract

Research has shown that mentorship provided to undergraduate researchers affects the extent of research outcomes. Although a large body of literature focuses on the faculty-undergraduate dyad mentorship structure, little is known about the mentoring triads (i.e., the interaction among undergraduate, faculty, and graduate students or postdoctoral associates) or about the support provided to early-year undergraduate researchers. This study aims to investigate undergraduate researchers' perspectives on mentoring and the support provided to them in their freshman and sophomore years. Results revealed that participants reported receiving different types of support during their research experience. Participants who received postgraduate-only mentoring reported receiving only intellectual support, whereas participants who received faculty-only mentoring commented on receiving intellectual or professional support. Participants who received direct mentorship by faculty and postgraduate (closed triad) or direct mentorship by postgraduate and indirect mentorship by faculty (open triad) reported receiving intellectual support predominantly from postgraduates and professional, and personal/emotional support from faculty. The types of support participants received showed differences in open and closed mentoring triads, as well as mentoring dyads.

Keywords: Undergraduate STEM education, undergraduate research experience, mentorship, mentoring structures, community of practice

Introduction

Mentoring is a fundamental component of the undergraduate research (UR) experience (Dolan & Johnson, 2009; 2010; Robnett et al., 2018) because "mentors provide guidance, information, and support that help undergraduates become integrated into their disciplines" (Aikens et al., 2017, p. 1). UR literature points out that mentorship provided to undergraduate researchers affects the extent of research outcomes (Fuentes et al., 2014; Gregerman et al., 1998; Hunter, Laursen, & Seymour, 2007; Thiry, Laursen, & Hunter, 2011). Specifically, from Lave and Wenger (1991)'s community of practice perspective, mentoring has been found to be a predictor of higher science identity and students' commitment to STEM fields (Chemers et al., 2011). However, to increase the availability of UR for undergraduate students, undergraduate researchers in most research universities are not directly mentored by faculty (Dolan & Johnson, 2010; Thiry & Laursen, 2011). In these cases, graduate students or postdoctoral associates (together referred to as postgraduates in Aikens et al. (2016)) take on or share the mentorship role for undergraduate students in their research experience (Aikens et al., 2016; Bradley et al., 2017).

Aikens et al. (2016) listed different mentoring structures in UR, such as undergraduate researchers may only be directly mentored by faculty, only directly mentored by postgraduates, directly mentored by both postgraduates and faculty, directly mentored by postgraduate and indirectly mentored by faculty (see Figure 1). These direct and indirect mentorship designs that include faculty, postgraduates, and undergraduate students are referred to as a triad mentoring structure or mentoring network (Aikens et al., 2016). However, a large body of literature focuses on faculty-undergraduate dyad mentorship structure (Fuentes et al., 2014; Robnett et al., 2018; Schwartz, 2012; Thiry & Laursen, 2011). Little is known about the roles and responsibilities of different actors in the mentoring triad structure and what kind of support is provided to undergraduate researchers during this experience (Joshi, Aikens, & Dolan, 2019).

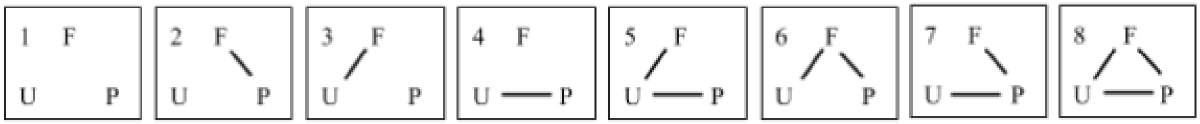

Figure 1. Undergraduate research mentoring triad structures. Undergraduate researcher (U), faculty (F), and postgraduates (P). Lines represent a direct interaction (i.e., link) between members of the undergraduate student's research experience (Aikens et al., 2016, p. 3)

Mentoring triads can take different forms depending on the institution, program structure, or the culture of the research laboratory (Aikens et al., 2016; Dolan & Johnson, 2010). All three members of the mentoring triad do not always directly interact with each other about the undergraduate's research experience, as illustrated in Figure 1 by a tie (Joshi et al., 2019). In Aiken et al. (2016)'s study, the most common mentoring structure among their participants was the closed triad, in which "undergraduates mentored by both a postgraduate and faculty member who also interact with each other about the undergraduate's research" (triad 8) (Aikens et al., 2016, p. 3). This triad type includes direct interaction among undergraduates, postgraduates, and faculty mentors about undergraduate's research experience. It was found to be the most beneficial regarding the highest reported personal and professional gains.

The second most beneficial triad structure was found to be the direct interaction of the undergraduate researcher with postgraduates and indirect interaction with faculty about the undergraduate's research experience (triad 7) (Aikens et al., 2016). In this triad type, the faculty mentor informs the postgraduate about the undergraduate's research, and the postgraduate consecutively provides daily guidance to the undergraduate (Joshi et al., 2019). Current literature regarding the mentoring structures provides significant findings for student outcomes. However, prior studies point out the gap in the literature about the mentoring triads and support provided to early-year undergraduate researchers (Aikens et al., 2017; Joshi et al., 2019). Further research is needed to provide an in-depth analysis of the mentoring provided to early-year undergraduate researchers (Robnett et al., 2018).

This study aimed to fill the gap in the literature in two ways. First, the literature does not describe the mentoring structures provided to freshman and sophomore undergraduate researchers. There are a few studies that focused on the comparison of novice and experienced undergraduate researchers, which still mostly includes junior and senior undergraduate researchers (Thiry & Laursen, 2011; Thiry et al., 2012). Engaging in research in early college years strongly predicts academic success in the latter years and is positively associated with persistence and higher student engagement (Russell et al., 2007; Bowman & Holmes, 2018). Undergraduates should be encouraged to participate in STEM-related activities starting in the early years in college (Kuh, 2008) because "involvement, or what is increasingly being referred to as engagement, matters and it matters most during the critical first year of college" (Tinto, 2006, p. 4). Also, Schreiner and Tobolowsky (2018) reported that UR is especially helpful to sophomore students as they are engaging more with their discipline, learning the skills and knowledge required in their major, and beginning to shape their future career options.

Second, the types of support provided to early-year undergraduate researchers are understudied (Joshi et al., 2019; Robnett et al., 2018; Thiry & Laursen, 2011). Thus, a better understanding of early-year undergraduate researchers' experience may help communicate their needs. This study aims to better understand mentoring provided by different actors of the mentoring triad structure – faculty, and postgraduates, who are members of a community of practice. Increasing our understanding of mentoring may help us identify the elements that can be modified to promote the efficiency of mentoring to guide newcomers to move from peripheral participation to an essential part in the community of practice. Therefore, the primary goal of this study is to investigate the mentorship and the types of support provided to undergraduate researchers in their freshman and sophomore years. Specifically, this study aims to answer the following question: among the mentoring structures, what types of support, if any, do early-year undergraduate researchers experience?

Undergraduate research as a community of practice

Situated learning theory indicates that within a community of practice, learning takes place in the actions of groups and through participating in the authentic activities of a community (Lave & Wenger, 1991; Wenger, 1998). Learning occurs through a process of enculturation, emphasizing the socio-cultural setting, and the activities of the people within the setting (Wenger, 1998). In this context, "learning is not an accumulation of information, but a transformation of the individual who is moving toward full membership in the professional community" (Hmelo & Evensen, 2000, p. 4). The experience is more than learning by doing, it is socially situated and embedded in an authentic context. UR provides an opportunity for students to learn in a situated context that involves social and cultural interaction to promote their intellectual development through participating in either the authentic or simulated activities of a community of practice.

'Newcomers' enter the community of practice as peripheral members who have limited responsibility for the project or research and its procedures. Lave and Wenger (1991) described the limited role of newcomers as "a newcomer's tasks are short and simple, the costs of errors are small, the apprentice has little responsibility for the activity as a whole" (p. 110). Through authentic engagement in the community and with the support and guidance of the senior partners, newcomers increase their roles and responsibilities within the community (Bowman & Holmes, 2018). Mentors in UR assume the role of the senior partner by helping undergraduate researchers to increase the benefits of their participation and enlarging authenticity in learning.

Mentoring in undergraduate research

Student-faculty interaction can be in various forms in curricular and co-curricular contexts that enable the interaction of faculty and students outside of the classroom setting providing various types of support to undergraduate students (Brackalorenz et al., 2017; Lopatto, 2010; Thiry & Laursen, 2011). Mentoring in UR can be a powerful context for effective student-faculty interaction (Amaya et al., 2018; Lopatto, 2010). Students who participate in UR claimed that research experience creates an environment for them to engage in substantial relationships with faculty, leading to greater motivation, engagement, academic performance and achievement (Brackalorenz et al., 2017; Garvey et al., 2018; Kim & Sax, 2009; Schreiner & Tobolowsky, 2018). The term mentoring has been defined in the literature within the context of research as:

> Mentoring is a personal and reciprocal relationship in which a more experienced (usually older) faculty member acts as a guide, role model, teacher, and sponsor of a less experienced (usually younger) faculty member or student. A mentor provides the mentee with knowledge, advice, counsel, challenge, and support in the mentee's pursuit of becoming a full member of a particular profession (Johnson, 2015, p. 23).

As given in the definition, mentors provide various types of support to undergraduate researchers to increase their engagement in the discipline (Dolan & Johnson, 2009; 2010; Robnett et al., 2018; Thiry & Laursen, 2011). Robnett et al. (2018) in their study with 66 undergraduate-mentor dyads reported that task-focused mentoring that provided informational support had the highest impact in explaining the students' science identity. Their findings, in line with the literature, promote the importance of skill-based support from mentors (Chemers et al., 2011; Syed et al., 2018; Thiry & Laursen, 2011). Although some studies indicated that informational, social, and emotional mentoring are significant dimensions of mentoring (Chemers et al., 2011, Robnett et al., 2018; Thiry & Laursen, 2011), Syed et al. (2018) reported that the two studies they conducted with undergraduate and graduate students to test the mediators of the research experience did find informational mentoring as a significant predictor of commitment, but not socioemotional mentoring.

The literature is clear about the importance of mentoring and faculty mentoring as a crucial component of UR, but it is only one piece of the puzzle. In the UR community, it is a common practice to have multi-mentors, especially in STEM fields (Bradley, 2017; Linn et al., 2015; Pollock et al., 2017). Pollock et al. (2017) stated that "multi-mentoring can be more effective than dyadic mentoring because of the collaborative interactions among diverse, skilled people" (p. 4). Even though there may be other senior members in the laboratory environment that play a role in the research experience of undergraduate researchers, such as postgraduates, their contribution to undergraduate researchers' experience is understudied in the literature (Aikens et al. 2016; Dolan & Johnson, 2010; Morales, Grineski, & Collins, 2018). The substantive roles, responsibilities, and types of support provided by different members in the research laboratory are not clearly defined (Limeri, Asif, & Dolan, 2019).

Dolan and Johnson (2010) reported that postgraduate mentors may provide technical and informational support to undergraduate researchers and they may be more likely to develop closer and/or more effective relationships with undergraduate researchers when compared to faculty mentors because of their more recent undergraduate experience. However, postgraduates can also have a negative impact on undergraduates by imposing high expectations, pressuring undergraduate students to work long hours, and establishing a sense of hierarchy in the research laboratory, which may result in decreased student gains in knowledge and skills, and thinking and working like a scientist (Dolan & Johnson, 2010; Morales et al., 2018).

The studies mentioned above provide valuable information about mentorship provided to undergraduate researchers by faculty and postgraduates but predominantly include junior and senior undergraduate researchers. Students who start engaging in research during junior or senior years may have different needs than freshman and sophomore undergraduate researchers. Exploring various domains of support in mentoring provided to early-year researchers may provide distinct insights into UR programs.

Methodology

Setting

This study was conducted at a large, research-intensive private university in the northeast United States. The primary setting was the *Strategic Undergraduate STEM Talent Acceleration INitiative* [SUSTAIN] project, a three-year longitudinal study funded by the National Science Foundation [NSF] to recruit and retain low-income high-achieving undergraduate students in STEM majors in the first and second years of their undergraduate study. The project provided academic, social, and professional support interventions, as well as financial support to twenty-eight low-income, academically-talented STEM students from diverse backgrounds in biology and chemistry departments in the first two years of their undergraduate study. The particular focus of the SUSTAIN project was on the disciplines of biology and chemistry as they are the two largest undergraduate STEM programs within the college of arts and sciences at the university, as well as the essential gateway majors for a wide range of STEM career professions. NSF determined the inclusion criteria as being high-achieving (which was defined as a high school GPA of at least 3.0), and low-income (which was defined as Pell Grant eligible based on the Free Application for Federal Student Aid [FAFSA] submissions).

The SUSTAIN project participants engaged with key programming elements, which were 1) STEM faculty mentoring and an early-immersion research program, 2) community-building activities, 3) STEM career awareness activities, 4) Peer-Led Team Learning, 5) professional living-learning community experience, and 6) a nature of science and inquiry themed first-year forum course (Tillotson et al., Under Review). This study focused only on the STEM faculty mentoring and the early-immersion research program provided to the SUSTAIN project participants in their freshman and sophomore years.

The SUSTAIN project is suitable for this study "because of its longevity, the support provided by administrators and faculty, the funding offered to participants, and the efforts to celebrate and showcase undergraduate research" (as cited in Buckley, 2010, p. 66). During the Fall 2017 semester, the project PIs contacted faculty in biology, chemistry, forensic science, neuroscience, and biochemistry programs to explain the purpose of the project, expectations from the STEM faculty, and asked if they would like to be the research faculty mentors for the SUSTAIN project participants. Faculty who volunteered received a $500 summer compensation per project participant they mentored. At the end of the Fall 2017 semester, the project PIs sent all SUSTAIN project participants an email including a list of the STEM faculty members who had agreed to serve as research mentors for the SUSTAIN project participants. Then, the participants were asked to rank their top five STEM mentor choices after reviewing their research profiles online.

The project team shared these tentative matches with the STEM mentors and shortly after held a breakfast overview meeting for the SUSTAIN project participants and mentors. One of the project PIs gave a brief presentation on the expectations from the mentors and the SUSTAIN project participants for the research experience. During this meeting, faculty mentors were asked to set clear expectations regarding the specific hours to be worked each week, what they would like the participant(s) to accomplish during the experience, the specific laboratory techniques/procedures they should begin learning, and the specific laboratory activities/routines they were expected to participate in (e.g., group meetings, colloquia, etc.).

Each SUSTAIN project participant was matched with an experienced STEM faculty mentor from biology, chemistry, forensic science, neuroscience, or biochemistry programs for both their freshman and sophomore years to have UR experience. When the matching process was completed, eighteen of the twenty-eight participants were matched with their first choice, two were matched with their second choice, and the other eight were still able to be paired with their either third, fourth, or fifth choice for a mentor. The participants completed the required 'Chemical Hygiene/Hazard Communication/Hazardous Waste' safety training that the university offers for those who work in a research laboratory.

After completing the training, the participants spent approximately 3-5 hours per week throughout the Spring 2018 semester observing and participating in research activities as deemed appropriate by their STEM faculty mentor. During their sophomore year, the participants spent approximately 5-10 hours per week in the research laboratory engaging in guided but more independent UR with their STEM faculty mentors using the knowledge and skills acquired during their first-year research experience. At the end of the Spring 2019 semester, the participants were encouraged to participate in the research poster fair in biology and chemistry departments, which was an opportunity for them to engage with other STEM students and STEM faculty that would contribute to their socialization within the STEM community.

Participants

The participants of this study were twenty-four of the original twenty-eight SUSTAIN project participants who have a full data set. Four of the SUSTAIN project participants were removed from the current study because of missing data. Two of the project participants left the university at the end of their freshman year. Another project participant did not participate in the project interventions including UR and switched to a non-science major at the end of his/her freshman year and did not participate in some or all of the data collection. One of the project participants had health issues and took a leave of absence and did not participate in some or all data collection in the sophomore year. Therefore, in total, twenty-four participants' data were used in the current study. The participants of the study were predominantly female (71%), first-generation college students (88%) and racially/ethnically diverse (13% Asian, 8% Black/African American, 8% Hispanic, 21% multiracial, 50% White). Participants' majors were biology (33%), biochemistry (13%), biotechnology (4%), forensic science (13%), chemistry (8%), and neuroscience (29%).

Participants in all placements had access to both faculty and postgraduates as possible mentors. Out of twenty-four participants, fifteen participants (64%) had female faculty mentors and nineteen participants (79%) had female postgraduate mentors during their research experience. Eleven out of seventeen female participants (65%) had female faculty mentors and fourteen female participants (82%) had female postgraduate mentors. Three out of seven male participants (43%) had male faculty mentors and two male participants (29%) had male postgraduate mentors. Therefore, the majority of the female participants had female faculty professors, whereas male participants almost equally mentored by male and female faculty professors. Both female and male participants were predominantly mentored by female postgraduates (see Figure 2).

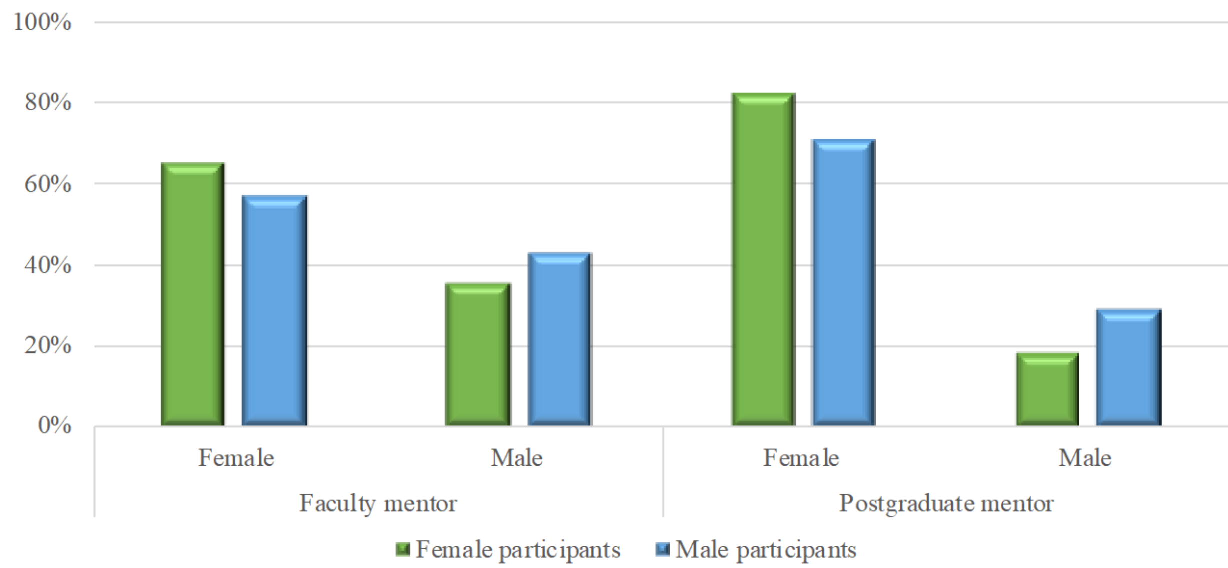

Figure 2. Gender distribution of faculty and postgraduate mentors

Amount of research experience

After the matching process, each SUSTAIN project participant started their UR experience at a STEM faculty mentor's laboratory in biology, chemistry, forensic science, neuroscience, or biochemistry programs during the spring semester of their freshman year. Participants had different amounts of research experience because some of them did not continue their research experience at the end of the first or second semester or some of them preferred to stay on campus during summer to continue their research. Two participants did not continue research at the end of their freshman year, in total, six participants did not continue research in the Spring semester of their sophomore years (see Figure 4).

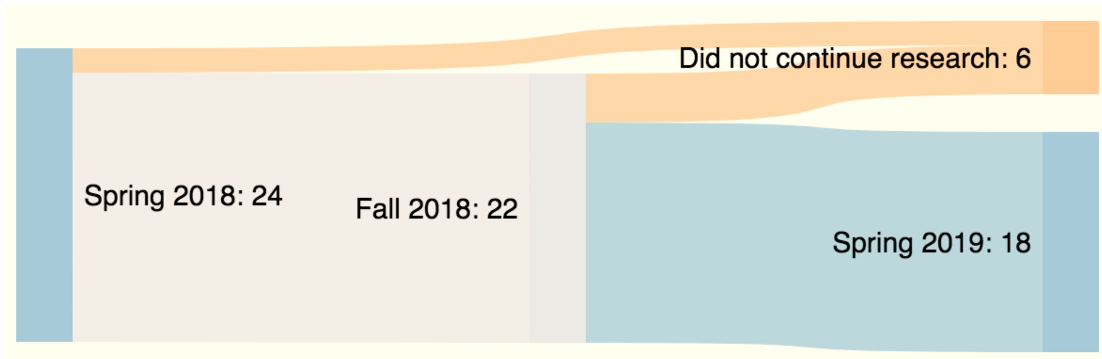

Figure 4. Riverplot that shows the number of participants' research experience in each semester

Four participants changed the laboratory they were initially matched during their research experience. One had to find another laboratory as her mentor left the university, one indicated that his interests changed, and two of them revealed that they realized they are not interested in the research being conducted in the laboratory they were assigned. Six participants who had two semesters or less research experience indicated that this experience helped them clarify their career path and made them realize they do not want to have a research-related future. Although these participants ended their UR experience early, they all reported that they appreciated having early research experience in their undergraduate studies. One of the participants who had two semesters of research experience commented on the positive and negative aspects of her research experience.

> Overall, my experience was a little positive and a little negative. It was positive in the sense that I learned a lot and met some pretty great people and got to be part of actual

> science. It was negative in the sense that lab was not my favorite thing, and most of the time I would rather have been doing something else. Research is still not my favorite thing, but I do see the value in experiencing the process.

In total, eight participants had three semesters and one summer, ten participants had three semesters, four participants had two semesters, and two participants had one-semester research experience (see Table 1). Therefore, the vast majority of the participants (75%) had three semesters or more research experience. Fourteen female (78%) and four male (57%) participants had three semesters or more research experience. Ten White (83%), two Asian (67%), both of the Black or African American (100%), one of the Hispanic or Latino (50%), and three multiracial (60%) participants had three semesters or more research experience.

Table 1. Amount of research experience of participants

Amount of experience	Race/Ethnicity	Gender	Number of participants
Three semesters and one summer	Asian	Female	1
	Black or African American	Male	1
	Multiracial	Female	2
	White	Female	3
		Male	1
Three semesters	Asian	Male	1
	Black or African American	Female	1
	Hispanic or Latino	Male	1
	White	Female	6
	Multiracial	Female	1
Two semesters	Asian	Male	1
	Multiracial	Male	1
	White	Female	2
One semester	Hispanic or Latino	Male	1
	Multiracial	Female	1

Research Design and Measures

Data collection methods and the inquiry approach. This study was designed to investigate how undergraduate researchers perceive the support and mentoring provided to them during their UR experience in their freshman and sophomore years. This study aimed to contribute to the literature by clarifying the possible relationships of mentoring and the type of support provided to undergraduate researchers, as well as to give preliminary evidence of the range of possible student experiences and identify the most promising avenues for future studies. As part of the larger project, mentorship data were collected from faculty, postgraduates, and undergraduates but this study focuses on student perspectives and data sources for the current study included semi-structured interviews with undergraduate researchers and their progress reports. The study instruments were reviewed and approved by the institution's human subject research review board. The researcher also obtained authorization from the review board to use the data sources in this study (IRB No. 19-045). Figure 3 below shows the data sources and data collection times. The semesters that the participants engaged in research are indicated in red color.

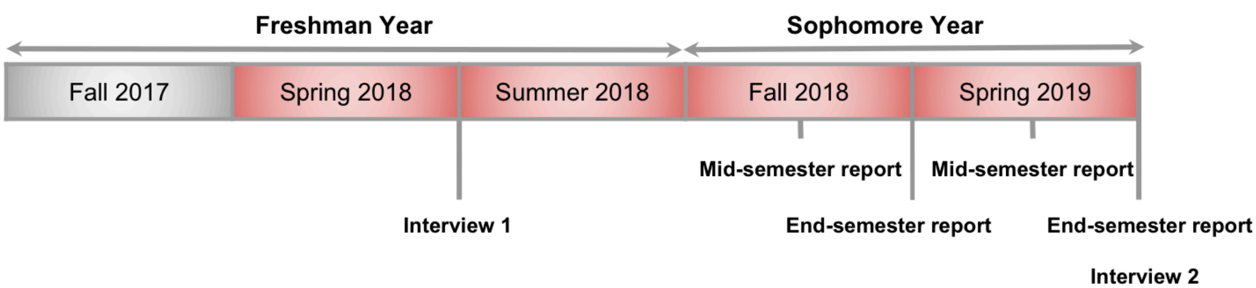

Figure 3. Timeline of the data collection

Interviews: Interview protocols were developed by the SUSTAIN project team, including two science education experts and three graduate students in science education. A pilot interview was conducted, recorded, and then reviewed by the project team to identify the possible procedural problems and the adequacy of the interview protocol. The first set of interviews were conducted in Spring 2018 semester to obtain the participants' first-year research experience, particularly the mentoring provided to them and in what ways the research experience helped the development of their science identity and their socialization into the STEM community, the value of this experience, and their level of satisfaction with the research experience (see Appendix A).

The second set of interviews were conducted at the end of the sophomore year of the participants in Spring 2019. Some of the questions from the first interview were kept the same and some questions were added to attain the participants' sophomore research experience, and determine if there was a difference between their first and second-year research experience, as well as the mentoring structures, the type of support provided to them, the value they attached to their research experience, and their overall satisfaction (see Appendix B). The two mentoring structure questions in the interview protocol were adopted from Aikens et al. (2016) to better understand the mentorship provided to the participants. During the interview, the diagram in Figure 1 was presented to the participants, and it was explained (e.g., F indicates faculty member, P indicates graduate students or postdoctoral associates, U indicates undergraduate student). Also, the question about the domains of support provided to the scholars was adopted from Thiry and Laursen (2011) to explore the different types of support provided to the students during their UR experience.

Both of the interviews were conducted with all the participants. If the participant did not continue their research experience after one or two semesters, the interview questions were asked to reflect on the semesters they participated in the research. All interviews were conducted face-to-face and audio-recorded, with an average duration of 45 minutes in length. The interviews were then transcribed.

Progress Reports: During their sophomore years, participants submitted mid-semester and end of semester progress reports (i.e., one mid-semester report and one end-semester report in Fall 2018 and one mid-semester report and one end-semester report in Spring 2019) (see Appendix C for the progress report guidelines). The goals of the progress reports were to obtain continuous information about the participants' research experience, their expectations and actual experiences, and the value of their experience so far. The participants were not asked to write a progress report in their freshman year because the goal of the freshman-year research experience was to introduce the participants to research as novice STEM students through observation, shadowing, and interaction with the research laboratory members. Participants who did not continue their research experience after one or two semesters wrote a report on how their STEM major interests and future STEM career plans have evolved since they joined the university and the SUSTAIN Project.

Data Analyses

NVivo Pro 12 qualitative data analysis software program served as the data analysis tool (QSR International Pty Ltd, n.d.). Each participant was coded with their SUSTAIN-ID numbers and identified as an individual case in the NVivo program. Interviews and progress reports of each participant were uploaded to the program to be organized and analyzed. Before data analysis, the first step was data cleaning and case coding (Feng & Behar-Horenstein, 2019). Each data source was assigned to the corresponding case. For instance, each interview and progress report for the participant with SUSTAIN-ID A was assigned to the case identified by A. After case coding, case classifications were coded regarding the participants' demographic attributes (gender, race/ethnicity, amount of research participation, and mentoring structure).

Once the case coding and classifications were completed, the patterns in the data that cluster around particular themes, called 'domains' were determined (Spradley, 1980). Three domains were determined for the support provided to the participants, which were intellectual support, personal/emotional support, and professional support. These domains represent the patterns in the data and also were based on previous studies (Aikens et al., 2016; Amaya et al., 2018; Bradley et al., 2017; Dolan & Johnson, 2010; Robnett et al., 2018; Thiry & Laursen, 2011). While conducting the domain analysis, the coding framework was constructed by reading and rereading the data, searching for the keywords (i.e., domains), and these domains formed the top-level nodes.

After conducting the domain analysis, a taxonomic analysis was conducted to organize the data under each domain "through a flowchart that presents the relationships among the terms in the domain" (Leech & Onwuegbuzie, 2011, p. 78). This process is also called a classification system that helps me determine the concepts that were in relation to the domain which involved looking for relationships and revealed the subcategories within each domain (Spradley, 1980). These subcategories were formed by reading the data in detail, as well as using the text search functions in NVivo. The taxonomic analyses helped me form the child nodes, which are represented by a flowchart. Once the initial domains and the subcategories were determined, various componential analyses were conducted to determine the relevance, similarities, and differences among different groups (i.e., gender, race/ethnicity, amount of research experience, mentoring).

Componential analyses were conducted by using the matrix coding function in NVivo which allowed me to make comparisons across and between various demographic categories (i.e., case classification attributes) with the participant responses (Feng & Behar-Horenstein, 2019). Code frequencies were calculated to rank how often particular concepts appeared in the student responses and used to analyze the data. The frequency of the codes was not used for statistical testing considering the small number of participants; instead, the code frequencies were used as a potential indicator of the value of the concepts.

Results

This research aims to explore mentoring structures and the types of support provided to early-year undergraduate researchers. The results are presented to describe the mentoring structures and the domains of support provided to the participants to address the research question: among the mentoring structures, what types of support, if any, do early-year undergraduate researchers experience?

Mentors and mentoring structure

Within the community of practice in UR experience, undergraduate researchers engage in authentic research with the guidance of their mentors. In their second interview, all participants were presented with Figure 1 and asked about the mentorship provided to them in both their freshman and sophomore years. In terms of the mentorship provided to the 24 participants, eight participants (33%) indicated that their primary mentor was the faculty professor in their freshman year and six participants (25%) indicated that their primary mentor was the faculty professor in their sophomore year. Thus, the vast majority of the participants indicated that their primary mentors were postgraduates during their research experience. When presented with mentoring structures as represented in Figure 1, seventeen participants (71%) expressed that they received direct mentorship by faculty and postgraduate (i.e., closed triad mentorship, triad 8). Eleven female (71%) and five male (71%) participants; all of the Asian (100%), three multiracial (75%), nine White (69%), and half of the Black or African American and Hispanic or Latino (50%) participants reported that they received closed triad mentorship (triad 8).

Table 2. Mentoring structures and amount of research experience of participants

Mentoring structure	Amount of experience	Gender	Race/Ethnicity	Number of participants
Direct mentorship by faculty and postgraduate (i.e., closed triad, triad 8)	Three semesters and one summer	Female	White	3
		Female	Multiracial	2
		Male	Black or African American	1
		Male	White	1
		Female	Asian	1
	Three semesters	Female	White	5
		Male	Asian	1
		Male	Hispanic or Latino	1
	Two semesters	Male	Asian	1
	One semester	Female	Multiracial	1
Direct mentorship by postgraduate and indirect mentorship by faculty (i.e., open triad, triad 7)	Three semesters	Female	White	1
		Female	Multiracial	1
	Two semesters	Female	White	1
Faculty-only mentoring (triad 6)	Three semesters	Female	Black or African American	1
	Two semesters	Female	White	1
Postgraduate-only mentoring (triad 4)	Two semesters	Male	Multiracial	1
	One semester	Male	Hispanic or Latino	1

On the other hand, three participants (13%) expressed that they received direct mentorship by postgraduate and indirect mentorship by faculty (i.e., open triad mentorship, triad 7); two participants (8%) received faculty-only mentorship (triad 6), and two participants (8%) received postgraduate-only mentorship (triad 4) (see Table 2). The vast majority of the participants who indicated that they had closed triad mentorship (triad 8) had three semesters or more research experience (88%), while 43% of the participants who reported that they received open triad (triad 7), faculty-only (triad 6) or postgraduate-only (triad 4) mentorship had at most three semesters of research experience.

While the study participants were a diverse group (including gender and race/ethnicity), in the data analysis, I did not find any pattern due to this diversity. Some preliminary trends were discovered based on the mentoring structures and the amount of research experience, which I discussed in the following paragraphs. Thus, the findings for the participants were reported as a group regarding their mentoring structures and the amount of their research experience, and not as particular to any of these potential subgroups.

Domains of support

Once the case coding and classifications were completed, the deductive and inductive analyses revealed that the participants commented on three domains of support; intellectual, professional, and personal/emotional support that was provided to them during their research experience. These domains represented the patterns in the data and also were based on previous studies (Chemers et al., 2011; Robnett et al., 2018; Thiry & Laursen, 2011). The definitions of the domains of support are given in Table 3.

Table 3. Category definitions of the domains of support

Domains of support	Definition
Intellectual support	Described the mentor(s) teaching them about research/project including the background information and its procedures; introducing the tools, equipment, and technology
Professional support	Described the mentor(s) providing advice on academic and career planning; values, standards, practices of the discipline; providing the big picture of the concepts, theories, and the language of the discipline; guiding students toward greater responsibility and independence
Personal/emotional support	Described the mentor(s) being accessible, encouraging, helpful, patient, understanding, and respectful

Overall, twenty-three out of twenty-four participants (96%) indicated they had received intellectual support, whereas twenty participants (83%) reported receiving professional support and seventeen participants (71%) mentioned receiving personal/emotional support from their mentors throughout their research experience. The above categories of domains of support were used to explain student perceived interactions and support provided by their mentors during their research experience.

Intellectual support about the project

Individuals are provided intellectual support to move from legitimate peripheral participation to a more central role in a community of practice (Lave & Wenger, 1991). Newcomer undergraduates may need to gain basic skill development and learn to use certain tools and techniques relevant to the project, as well as increase their understanding of the research and its procedures. By taxonomic analyses, the subcategories (i.e., child nodes) were formed within each domain. According to the analyses, the subcategories of intellectual support are (1) introducing the basic terminology, equipment, and tools used in the laboratory, (2) describing the subject-specific skills, techniques, and methods and (3) explaining the project(s) and its procedures. The vast majority of the support participants commented on was the knowledge of terminology and the use of types of equipment in the project, and a smaller number of comments were on the subject-specific skills, techniques, and methods regarding the procedures of the research project.

UR experiences in early college years are crucial to provide hands-on experience to students which may promote their understanding of the science concepts (Russell et al., 2007). Senior members in the laboratory help newcomer undergraduate researchers understand the concepts and the procedures of the project, along with promoting their scientific literacy. Laboratory group meetings provide a fruitful context for undergraduate researchers to experience how scientists communicate their studies, and for mentors to guide and support undergraduate researchers to increase their understanding of the project and its procedures (Thiry & Laursen, 2011). One of the participants mentioned that with the assistance of the senior members of the research group, she was able to have a better understanding of the project in the meetings:

> In the group meetings, they are great. They talk about all their research. And I might not understand it all, but I do get the gist of it. And they break it down. They can talk amongst themselves and all their different languages, and we would not understand, but they stop, and they break it down for us, so we do understand. So that is very helpful. It is very nice. They do not have to do that, but they do so we can understand.

Although twenty-three participants (96%) indicated they had received intellectual support during their research experience, participants' comments on intellectual support they indicated they had received showed differences when considering the mentoring structures and the amount of their research experience (see Figure 5).

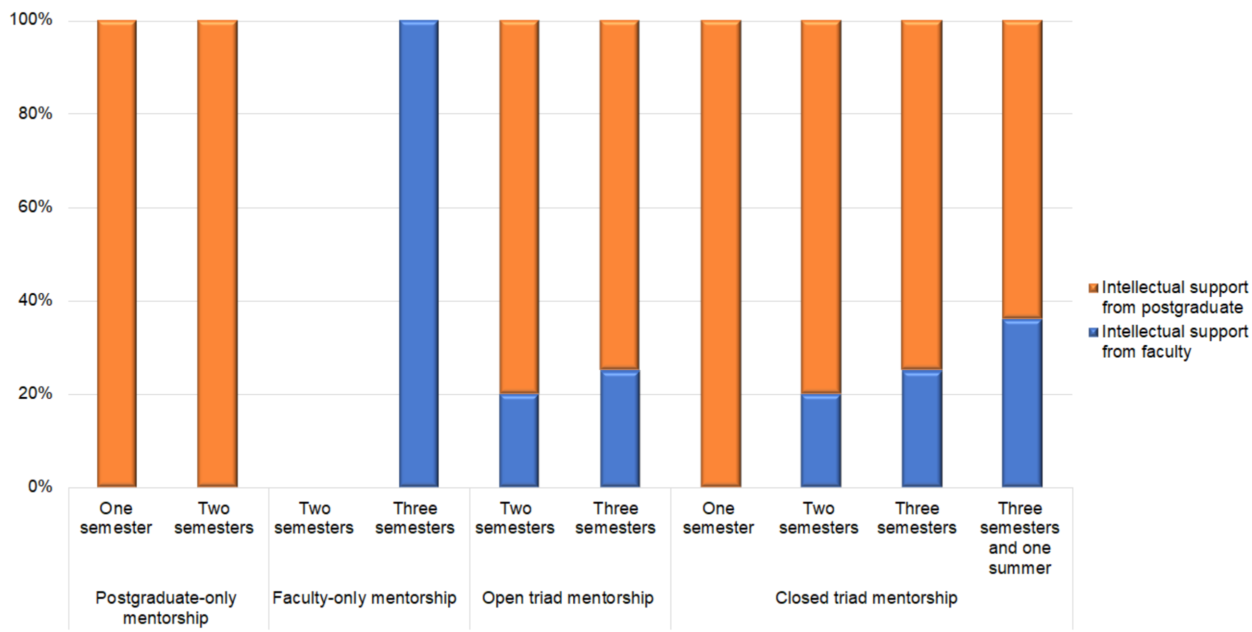

Figure 5. Percentages of perceived intellectual support from faculty and postgraduate

Participants who indicated receiving postgraduate-only mentorship (triad 4) expressed that the only support they received was intellectual support from postgraduates regardless of the amount of research experience. The support they reported they had received was on helping them increase their understanding of the basic concepts related to the research project and the use of the equipment. Even though both of them indicated they had received intellectual support from postgraduates, one of them, who had one-semester research experience, commented on the insufficiency of this support:

> I think they would mostly try to teach me things that I have never experienced. Because given that it was a Med Chem Lab, most of it was Orgo [Organic Chemistry]. Things that, at that point, I was not even aware of. The support I got was being guided for a certain task at a certain point and then just being thrown random information that did not really make sense to me. Just went in one ear, went out the other.

Of the participants who reported receiving faculty-only mentorship (triad 6), only one, who had three semesters of research experience, indicated receiving intellectual support from faculty (see Figure 5) and it was about providing guidance on promoting understanding of the research project and its procedures. Participants who indicated receiving open triad (triad 7) and closed triad (triad 8) mentorship commented on receiving intellectual support predominantly from postgraduates. These participants specified receiving support from postgraduates about basic scientific concepts and the use of tools, and support from faculty about research-related specific content knowledge. One of the participants explained this by stating:

> If it is big, conceptual things, like about my project specifically, then I would go to Dr. K. [faculty mentor]. If it is something like I do not know how to do something or I need a refresher on something, then I would go to the Ph.D. student.

One of the participants who reported receiving closed triad mentorship (triad 8), and who had one-semester research experience indicated that her primary mentor was a postgraduate and she had only received intellectual support from her about the use of the tools and equipment in the laboratory.

Professional support to undergraduate researchers

Learning is situated in social and cultural contexts within the community of practice (Wenger, 1998). With the support of old-timers within a community of practice, newcomers develop an understanding about the values, standards, and practices of the discipline, have a better grasp of possible career paths in the field, as well as improve professional interactions with their senior partners (Thiry & Laursen, 2011; Wenger, 1998). Differing from intellectual support, which includes support and guidance specifically about the understanding of the project and its procedures, as well as learning about the tools and techniques used in the project, professional support provides broader assistance to students about the field. The subcategories on professional support consisted of (1) academic and career advising, (2) modeling and guiding scientific ethos, and (3) professional socialization.

Academic and career advising are critical support systems provided to undergraduate students, especially in the early years of their undergraduate studies to attracting and retaining them in STEM fields (Bowman & Holmes, 2018). Participants' comments on academic and career advising included support on helping to choose which classes to take, presenting different career options, and guiding them to determine the career path they are willing to pursue. One of the participants expressed how her mentor provided academic and career advising throughout her research experience:

> I was pleasantly surprised by my professor mentoring me. I did not anticipate her being as involved in my schooling as she was. She gave me guidance in the lab but also offered advice on how I want to proceed in my undergraduate career. She has advised me on course scheduling and how to approach certain classes. She also gave me advice and

> guidance on what I plan to pursue post-graduation. With her guidance, I have decided to pursue a graduate degree and pursue a career in research instead of remaining pre-med and pursuing a medical career.

Some of the participants indicated that professional support promoted their engagement with the discipline and increased their understanding of the scientific community of practice. One of the participants mentioned how his mentor helped him see the connection of their research with the real-world that helped increase his understanding of the discipline:

> My mentor makes them [the content] clear, so they are not specific to our project. She tries to relate how our project and things that we are working on is impactful in all the STEM community and how we can sort of see the bigger picture of why we do this and why it is important. And so, I have learned a lot of stuff within my project, but the most changes have been the whole sort of encompass of why we do what we do.

Professional socialization, which is broadly defined as "the way in which individuals are assisted in becoming members of one or more social groups" (Grusec & Hastings, 2014, p.15), may promote students' authentic learning experience within a community of practice (Wenger, 1998). Although it was the smallest proportion compared to other subcategories of professional support, the participants indicated that this type of interaction helped them socialize in the scientific community. One of the participants explained this by stating:

> Something that I really like in the ecology lab is the lab meeting because our lab meeting for our lab is with other labs as well. So, I have gotten to meet some people like other mentors. They will come in at our lab meeting, and some of their grad students will be there. And it is really interesting to have, I guess, that interaction with other labs as well

so you are not as secluded. I think that is a really important aspect of the research experience is interacting with those that you are working [with].

Regarding the mentoring structures, professional support participants indicated they had received from faculty or postgraduate mentors also showed differences (see Figure 6).

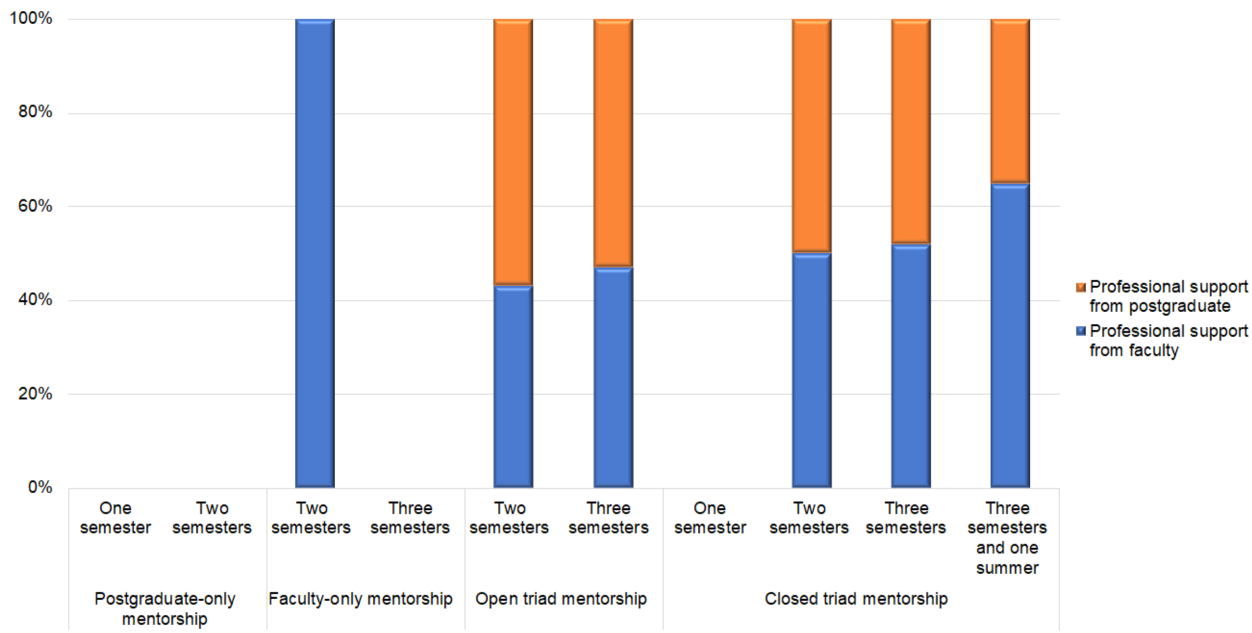

Figure 6. Percentages of perceived professional support from faculty and postgraduate

Participants who reported receiving postgraduate-only mentorship (triad 4) stated that they did not receive professional support during their research experience, regardless of the amount of their research experience. One of the participants, who also indicated that the intellectual support provided to him was insufficient, and who mentioned his incompetent feelings at the end of his first semester, stated that “I have not really talked about my career with them. But I have not really asked for it.” It may be crucial to communicate the needs and expectations of students and mentors at the beginning of the research experience.

From the participants who indicated they had received faculty-only mentorship (triad 6), only one of them reported receiving professional support from her mentor (see Figure 6). She stated receiving a little guidance on the standards and the practices of the biochemistry discipline. Participants in the open triad mentorship (triad 7) commented on receiving professional support from postgraduates slightly more than their faculty mentors (see Figure 6). These participants described receiving academic support from postgraduates in terms of which classes to take, when and from whom to help them plan their academic schedule.

Participants in the closed triad mentorship (triad 8), who had more than three semesters of research experience, commented on receiving professional support mostly from faculty (see Figure 6). Their comments mainly included receiving long-term academic and career advising from faculty such as presenting career options after finishing their undergraduate degree or giving tips about research-related careers. They also commented on their faculty mentor's support on professional socialization, especially during lab meetings that help them interact with other faculty professors and postgraduates. One of the participants in this group indicated receiving support from both faculty and postgraduates on her socialization in the professional community and stated that "like their conferences, they would always tell me who they met, who they talked to, what it was about... Or even if someone came into the lab to talk, always introduce me, always included me in everything." As seen in Figure 6, participants who indicated receiving open triad (triad 7) or closed triad (triad 8) mentorship and who had two or more semesters of research experience reported receiving professional support.

Personal/emotional support

Personal/emotional mentoring includes providing social and emotional support to strengthen students' emotional development and social engagement within a community. The participants' comments on personal/emotional support included describing their mentors as being accessible, encouraging, helpful, patient, understanding, and respectful. One of the participants indicated that "Dr. S. was the best and most ideal mentor I could ask for. She was always understanding and patient throughout my journey. Most importantly, she was always there for me when I needed any sort of help or advice." Another participant explained the personal/emotional support she was receiving from postgraduates and how this interaction opened her mind about potential academic careers:

> My lab team makes me feel extremely welcome, and I regularly swing by the lab to study and get work done. The environment of the lab is extremely friendly, but also very beneficial. I look up to all of the graduate students who work in the lab and learn from each of them. The graduate students are a good example of what pursuing a Ph.D. would look like. Working in the lab has opened up my mind to potentially applying to MD/Ph.D. programs after graduation. I would have not seen this as a possibility had I not been exposed to graduate students, who have taught me about the demands of becoming a Ph.D. candidate.

Like other mentoring support dimensions, participants' comments on personal/emotional support revealed differences regarding the mentoring structures and the amount of research experience (see Figure 7).

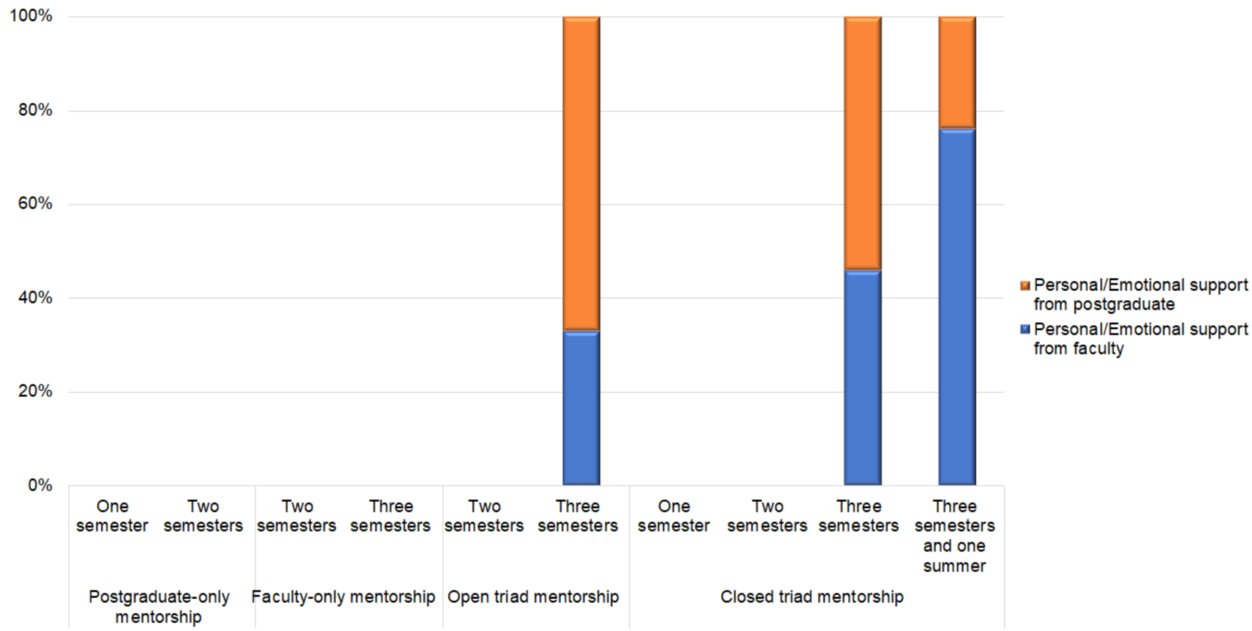

Figure 7. Percentages of perceived personal/emotional support from faculty and postgraduate

Participants who had received postgraduate-only (triad 4) or faculty-only (triad 6) mentorship, regardless of the amount of their research experience, indicated they did not receive personal/emotional support during their research experience. Two of the participants, at the end of their freshman year, expressed the lack of social and emotional support, and complained about the unavailability of their mentors. One of them stated that "if professors were more available to talk about their research it would be awesome."

Participants who indicated receiving open triad (triad 7) or closed triad (triad 8) mentorship, and who had two semesters or less research experience did not indicate receiving personal/emotional support from their mentors (see Figure 7). Participants who indicated receiving open triad mentorship (triad 7) and who had three semesters of research experience reported receiving personal/emotional support mostly from their postgraduates and commented on how accessible, patient, and friendly their postgraduate mentors were. Participants who indicated receiving closed triad mentorship (triad 8) and who had three semesters or more research experience reported receiving personal/emotional support mainly from faculty mentors (see Figure 7). One of the participants indicated that it was scary to reach out to his mentors during the first semester of his research experience:

> I think that the mentors should have a closer relationship with the scholar in my experience. My mentor is there, but it is a scary talking to them at the time because I believe that they expect me to know more than I actually do.

However, in his second interview, he expressed a positive difference in his relationship with his mentor during his sophomore year research experience, stating:

> It was completely different. When they are making lab meetings, they try to incorporate my schedule into that meeting as well as make sure I am able to attend. I was able to lead a lab meeting this year, kind of see what information that I might be miscommunicating, make sure that I understand fully what is going on. I have had a lot more meetings with my mentor, not necessarily just about the research but about my overall time here, how has it that I am doing in my classes. Academically, what is it that I want to do for my future. So, he has played more of a mentor role than a research PI. So definitely a huge difference.

Summary of the findings regarding the perceived domains of support

Participants who had received postgraduate-only mentorship (triad 4) indicated receiving only intellectual support. Participants who had received faculty-only mentorship (triad 6) expressed receiving intellectual or professional support during their research experience. On the other hand, participants who indicated receiving open triad (triad 7) or closed triad (triad 8) mentorship and who had three semesters or more research experience mentioned that they had received all three types of support, whereas participants in these groups who had two semesters of research experience mentioned receiving intellectual and professional support (see Figure 8). Therefore, according to the analysis in this study, when participants were provided open triad (triad 7) or closed triad (triad 8) mentorship and when the participants had three semesters or more research experience, they reported receiving all three types of support.

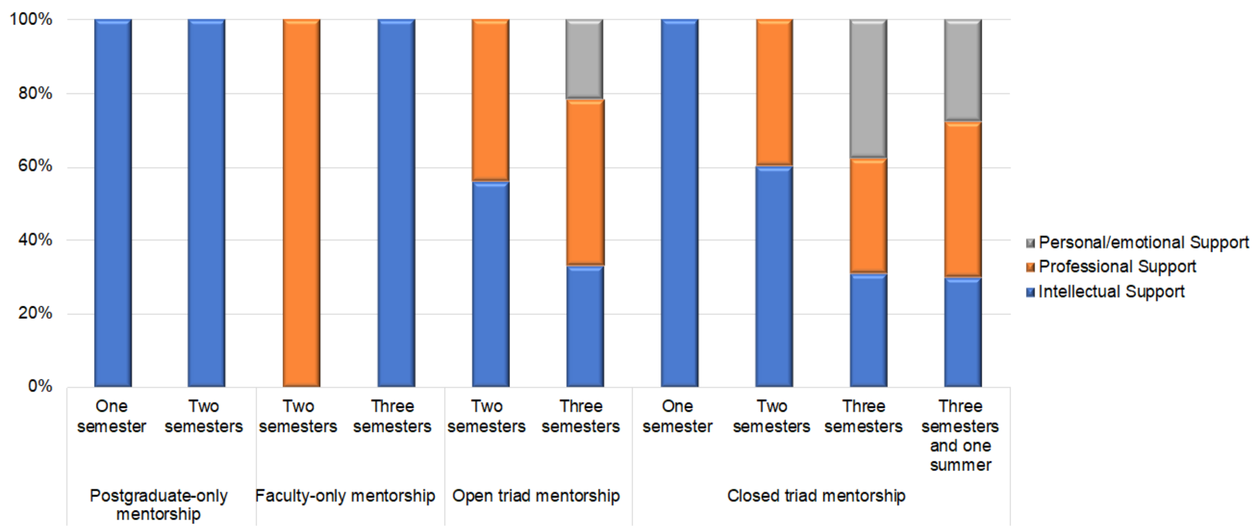

Figure 8. Perceived domains of support regarding the mentoring structures and the amount of research experience

Types of support participants indicated they had received from faculty and postgraduates revealed differences according to their mentoring structures (see Table 4).

Table 4. Frequencies of the coding references regarding the domains of support provided to the participants from faculty and postgraduate

	Support from faculty			Support from postgraduate		
Mentoring structure	Intellectual support (%)	Professional support (%)	Personal/ emotional support (%)	Intellectual support (%)	Professional support (%)	Personal/ emotional support (%)
Postgraduate-only mentorship (triad 4)	0	0	0	100	0	0
Faculty-only mentorship (triad 6)	50	50	0	0	0	0
Open triad mentorship (triad 7)	9	22	4	30	26	9
Closed triad mentorship (triad 8)	7	25	19	20	17	12

Participants who indicated receiving postgraduate-only mentorship (triad 4) had only mentioned receiving intellectual support from postgraduates. Participants who indicated receiving faculty-only mentorship (triad 6) had only commented on either receiving intellectual or professional support from faculty. Participants who indicated that they had received open triad (triad 7) or closed triad (triad 8) mentorship reported that the most mentioned support they had received from faculty was professional support, and intellectual support from postgraduates (see Table 4).

Participants who indicated they had received closed triad mentorship (triad 8) had almost equal amounts of coding reference for the total support provided by faculty and postgraduates. Their comments included more professional and personal/emotional support from faculty and more intellectual support from postgraduates. Participants who indicated that they had received open triad mentorship (triad 7) reported receiving intellectual support predominantly from postgraduates. Their comments included a similar amount of coding reference for professional support from faculty and postgraduate, and much less personal/emotional support compared to participants who indicated they had received closed triad mentorship (triad 8).

Discussion and Conclusion

Prior research on mentoring structures revealed that undergraduate researchers in different mentoring triads reported having different outcomes (Aikens et al., 2016). Particularly, participants in the closed triad mentorship (triad 8) reported more positive outcomes compared to other mentoring structures (Aikens et al., 2016). A better understanding of the undergraduate researchers' support networks can help better communicate the needs of undergraduate researchers in different mentoring triads and find ways to improve outcomes of UR (Bradley et al., 2017). Therefore, it is crucial to investigate mentoring interactions and the types of support provided to undergraduate researchers during their UR experience. Findings of this study indicate differences in the perceived domains of support described by early-year undergraduate researchers in their interviews and progress reports. These differences illustrate various support mechanisms considering the mentoring structures and the amount of research experience, which reveals several implications of the study and recommendations for UR program developers and researchers.

As the participants in this study had their research experience in their freshman and sophomore years, their content knowledge about the field or subject-specific knowledge about the discipline, and their skills are limited, which influences their understanding about the project and its procedures. Early-year undergraduate researchers may need more intellectual support than their junior and senior peers in the community of practice. Moreover, postgraduates, who are also mentored by the faculty, may have limited mentoring abilities (Dolan & Johnson, 2010; Limeri et al., 2019). As Aikens et al. (2016) stated: "postgraduates are not able to fully broker the resources that faculty can offer" (p. 12). Therefore, postgraduate-only mentorship (triad 4) may demonstrate a higher risk for insufficient mentoring and may result in discouraging undergraduates from pursuing research-related career paths (Dolan & Johnson, 2010).

Analysis of this study revealed that participants who indicated that they had received postgraduate-only mentorship (triad 4) reported receiving only intellectual support from their postgraduate mentors regardless of the amount of their research experience. One of the participants in this group reported the insufficiency of the support provided to him and also indicated "he did not ask for it." Therefore, the findings of this study suggest that postgraduates need to be provided with opportunities to improve their mentoring skills. Moreover, UR programs should be designed in a way to communicate the student and mentor expectations, along with clearly defined roles and responsibilities to increase the efficiency of the research programs.

Participants who indicated that they had received faculty-only mentorship (triad 6) reported receiving intellectual or professional support from faculty. Faculty professors are key actors in the mentoring structure, and prior research reported the positive outcomes of direct interaction with faculty for undergraduate researchers (Dolan & Johnson, 2010; Joshi et al., 2019). Especially early-year undergraduates, who are also new to the field highly benefit from the direct student-faculty interaction in a research context (Fuentes et al., 2014). However, training undergraduates, particularly early-year undergraduates who are lacking the basic skills and knowledge of the discipline, and providing high-quality mentorship takes additional time and effort. Faculty professors' support, by itself, may not be enough to provide the necessary guidance and assistance to engage undergraduates in a community of practice. UR programs should be designed to provide direct interactions with faculty mentors as well as postgraduates to increase the support provided by both members of the mentoring triad which may play a role in undergraduate researchers' engagement and commitment with research.

Even though the majority of the participants indicated that postgraduates were their primary mentors, most of them reported also having direct or indirect interaction with a faculty mentor in the laboratory. Participants who indicated receiving open triad (triad 7) or closed triad (triad 8) mentorship and who had three semesters or more research experience reported receiving all three types of support. Participants' comments in the open triad mentorship (triad 7) included more support from postgraduates, whereas participants in the closed triad mentorship (triad 8) commented equally to receive support from faculty and postgraduates, but the type of support provided to them revealed differences, more professional and personal/emotional support from faculty, and more intellectual support from postgraduates. Newcomers need various types and amounts of support within a community of practice (Wenger, 1998). Findings indicate that direct mentorship by faculty and postgraduates result in the distribution of the roles in mentoring structures. Supporting the literature, this may contribute to higher levels of research outcomes (Aikens et al., 2016; Joshi et al., 2019). Given the potential benefits to undergraduate researchers, UR programs may be designed to provide clear roles, responsibilities, and expectations from mentors to maximize the support provided to students.

Findings also indicate that participants in the open triad (triad 7) and closed triad (triad 8) mentorships mentioned receiving personal/emotional support when they had three semesters or more research experience. Participants in the closed triad mentorship (triad 8) commented more on receiving personal/emotional support compared to the participants' comments in the open triad mentorship (triad 7) and their comments were mostly on receiving personal/emotional support from faculty. Students found to be at a higher risk of leaving the field or less inclined to choose a research-related career when they are not socially or intellectually integrated into a community of practice (Thiry et al., 2011). We suggest that mentors start providing social and emotional support early in undergraduate researchers' experience to increase student engagement and their commitment to scientific practice (Robnett et al., 2018).

This study provided preliminary evidence of the range of possible student experiences and illustrated the possible relationships of mentoring and the type of support provided to undergraduate researchers and identified the most promising avenues for future studies. In this study, the vast majority of the participants who had closed mentoring triad (triad 8) had three semesters or more research experience, while less than half of the participants who reported receiving open triad (triad 7), faculty-only (triad 6) or postgraduate-only (triad 4) mentorship had at most three semesters of research experience. Different amounts of research experience participants experienced may indicate their interest and commitment to the field in general or a research-related career in particular (Thiry et al., 2012). Although most UR programs are designed to provide single, short-term research opportunities for students in order to increase the number of undergraduates who can benefit from this experience (e.g., Research Experiences for Undergraduates (REU) programs that are funded by NSF), findings of this study support the literature on the benefits of multi-year research experience (Thiry et al., 2012).

Limitations of the study and future work

The investigation of the SUSTAIN project participants' research experience provides an in-depth understanding of the mentoring structures and the types of support provided to them in the context of a large research-intensive private university in the northeast U.S. during the time of this study. However, this study has several limitations. First, sample selection is a limitation of the study. The participants of this study were the participants of the SUSTAIN project who were a selected group of high-achieving low-income undergraduate STEM students in biology and chemistry departments at one private research university. Participants of this study were predominantly female, first-generation, low-income college students from diverse backgrounds. The findings are limited to reflect the perspectives of this group of students' research experience in this context. Although the findings of this study cannot be generalizable, this study may provide insight into student groups in comparable conditions (Creswell & Poth, 2018).

Another limitation is that this study includes only student perspectives and does not include faculty mentors' or postgraduates' perspectives, who are the two other essential pieces of the triad mentoring structure. In this study, interviews and progress reports revealed detailed information about the perceived support provided to the SUSTAIN project participants and their experiences in the research laboratory. Given the potential benefit of high-quality multi-year research experience to students, future research is necessary to explore faculty and postgraduate mentors' perspectives about mentoring structures, the types of support provided to undergraduate researchers, together with their challenges, needs, and concerns (Joshi et al., 2019).

Finally, participant observation throughout their research experience was not used to triangulate the interview responses and progress reports. Multiple in-depth interviews and progress reports over time provided in-depth exploration (Creswell, 1998). As an alternative, further research may include participant observations to explore the actual experiences of all three actors of the mentoring triads. Furthermore, this study focused only on the type of support provided to early-year undergraduate researchers. Future research needs to investigate the amount, quality, and impact of support to undergraduate researchers related to the development of the identity as a scientist.

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CHAPTER III: Early-year undergraduate researchers' reflections on the values and perceived costs of their research experience

Abstract

A motivational approach may be particularly useful for understanding early-year undergraduate researchers' engagement with research. The current study utilizes the expectancy-value theory of achievement motivation to explore how much and in what ways early-year undergraduate researchers value their research experience and what kinds of costs they associate with it. Results revealed that intrinsic value had the highest expression in participants' motivation to engage in research. The second most expressed value type was the utility value of undergraduate research with regards to obtaining the desired outcomes, and attainment value played the least important role in participants' motivation to engage in research. Findings also indicated that some of the participants associated a cost(s) to their research experience. The highest mentioned perceived cost was opportunity cost, where participants commented on losing other valued alternatives when engaging in research. Participants commented on the time, effort, or amount of work needed to engage in research, and a few participants commented on the emotional cost associated with their research experience in terms of the fear of failure. Findings of this study can form the basis for future work on exploring ways to increase the values and decrease the costs students experience in their undergraduate research experiences.

Keywords: Undergraduate STEM education, undergraduate research, motivation, expectancy-value theory

Introduction

> A motivational approach for addressing the "leaky pipeline" is particularly useful as students who have the skill and initial desire to pursue STEM careers often leave because they no longer believe they have the skills to be successful or no longer find the field interesting or personally valuable (Linnenbrink-Garcia et al., 2018, p. 182)

The term "motivation" stems from the Latin word "movere," which means "to move" (Eccles & Wigfield, 2002, p. 110). Therefore, the study of motivation is the study of action, and in the literature, motivation is broadly described as the process(es) that affects one's participation and intention to pursue an activity (Eccles, 1994; Eccles & Wigfield, 2002). Seymour and Hewitt (1997) pointed out the crucial role of motivational aspects in STEM retention, stating that losing interest and motivation to engage in STEM-related activities is the most common reason for students' decision to switch away from STEM majors. Although student gains and outcomes of undergraduate research (UR) experience have been well-discussed in the literature, systematic and empirical research to clarify the motivational factors, perceived drivers and barriers of the processes of the research programs is limited (Adedokun et al., 2013; Gardner et al., 2015; Linnenbrink-Garcia et al., 2018). Mostly, evaluation and research studies regarding UR experience focus on reporting program outcomes with less emphasis has been put on exploring contextual factors (e.g., the design of the program and institutional features), sociocultural factors (e.g., socialization, mentor-student relationship), and participants' psychological factors (e.g., motivational beliefs) (Adedokun et al., 2013; Linnenbrink-Garcia et al., 2018).

Much of the early literature on STEM persistence, using either concurrent or retrospective reports, indicated that students in STEM majors listed interest and enjoyment as the primary reasons for their persistence in STEM fields (Lopatto, 2010; McGee & Keller, 2007; Seymour & Hewitt, 1997). The first two years in college are significant periods for shaping the choices and decisions that lead to academic success and persistence in STEM, but relatively understudied (Provencher & Kassel, 2017). Although there is a growing literature on the influence of expectancy and value-related beliefs on STEM persistence (e.g., Appianing & Van Eck, 2018; Ball et al., 2017; Perez, Cromley, & Kaplan, 2014), there is limited research on the development of STEM motivation in the early years of college (Robinson et al., 2018).

Understanding student motivations during early years in college can be particularly crucial to support motivation, achievement, and persistence in STEM fields (Cromley, Perez, & Kaplan, 2016). The National Academies of Sciences, Engineering, and Medicine (2016) also points out the importance of understanding the role of motivational factors in STEM persistence. Therefore, it is essential to better understand students' motivation in STEM-related activities such as UR in early-years in college. The current study utilizes the expectancy-value theory of achievement motivation to explore which values students attach to their research experience. Moreover, engaging in a task usually comes with a cost "precisely because one choice often eliminates other options" (Eccles & Wigfield, 2002, p. 118). Even though the expectancy-value model includes perceived cost as a crucial component, it is not widely studied in the literature (Flake et al., 2015). With this goal, this study aims to answer the following research questions:

- How much and in what ways do early-year undergraduate researchers value their research experience?

- Which costs, if any, do early-year undergraduate researchers attach to their research experience?

Research Framework

Motivation theories focus on the relationship between the action and the beliefs, values, and goals linked to it (e.g., Eccles, 1994; Lent, Brown, & Hackett, 1994). Although theories of motivation have derived from different psychological roots, this paper focuses on those that are most closely associated with value-related constructs. One of the most commonly used motivational theories that focus on academic motivation and career aspiration is the expectancy-value theory ([EVT], Eccles, 1983). EVT provides a comprehensive framework for the study of academic and career interests/choices based on expectancies, subjective task values, and career goals (Eccles, 1983; Wigfield & Eccles, 2000). EVT integrates students' value perceptions and their beliefs about their abilities for a specific task to explain their association with career interests and career choices (Wigfield & Eccles, 2000). Specifically, EVT designates the central role to students' values of the task in describing their intentions/decisions to persist in their major (Wigfield & Cambria, 2010). According to EVT, students are more motivated to persist and achieve a task if they value the achievement of the task (e.g., reasons for finishing a task) (Wigfield & Eccles, 2000).

Task value was described as "a quality of a task that contributes to the increasing or decreasing the probability that an individual will select it" (Eccles, 2009, p. 82). Prior research utilizing EVT suggests that task values are "the most immediate or direct predictors of academic engagement and career choices" (Wigfield & Cambria, 2010, p. 36). According to EVT, task value is divided into four categories (Eccles & Wigfield, 2002): (1) attainment value, (2) intrinsic value, (3) utility value, and (4) perceived cost (Eccles 1994; 2009; Wigfield & Eccles, 2000).

The *attainment value* is the importance individuals attach to doing well on a task or how well the given task fits with the individuals' identity (Wigfield & Eccles, 2000). Eccles and Wigfield (2002) associate attainment value to "the relevance of engaging in a task for confirming or disconfirming salient aspects of one's self-schema" (p. 119). Perez et al. (2014) provided an example to illustrate attainment value:

> A student who chooses environmental biology as his major because the major is consistent with his identity as an environmentally conscious person or environmentalist. The major would be important to this student beyond its usefulness in getting an environmental science job in the future. (p. 16)

Thus, it can be said that tasks may be valued partly because of the consistency of the task with the person's identity. Therefore, participating in STEM-related activities, such as UR, may fit with the students' identity, support their connection to STEM fields, and may promote their persistence in their STEM major (Linnenbrink-Garcia et al., 2018).

The *intrinsic value* is the interest and enjoyment individuals gain from engaging in a specific task (Wigfield & Eccles, 2000). Intrinsic value is similar to intrinsic motivation, which is described as "doing an activity for the inherent satisfaction of the activity itself" (Ryan & Deci, 2000, p. 71). An example that illustrates the intrinsic value is a student who chooses a biology major because she/he has an interest in biology and enjoys biology (Eccles, 2009). Similarly, students who participate in UR may express the value of the research experience by indicating the enjoyment she/he gets from conducting research, being part of the research laboratory, or the personal interest she/he has in research.

The *utility value* is the usefulness of a task to individuals' current and future goals (Eccles & Wigfield, 2002). For example, when college students "take a math class to fulfill a requirement for a science degree," they may not necessarily enjoy the math course but may be motivated by their aspiration to attain a degree in science (Wigfield & Eccles, 2000, p. 72). Engaging in UR may fit into the short or long-term goals of the student, who may be motivated by the utility value of the research experience.

Another construct included in the expectancy-value model is the *perceived cost*, which is the perceived drawbacks of engaging in a task such as the effort needed for engagement, lost opportunities to engage in other tasks, and psychological or emotional costs (Eccles & Wigfield, 2002). For example, a student may consider "is working this hard to get an A in math worth it?" or "do I do my math homework or call my friend?" (Wigfield & Cambria, 2010, p. 40). Likewise, a student may consider the perceived cost of participating in research because UR requires spending a certain amount of time and effort in the lab and engaging in research may preclude the student from other academic or social activities.

Literature has supported the role of task values in students' academic choices and performance in various domains and tasks (Cooper, Ashley, & Brownell, 2017; McGrath et al., 2013; Mosjowski et al., 2017; Perez et al., 2014). According to the EVT, individuals may assign one or multiple values to a task, and the degree of value they attach to the task may differ for different individuals as well (Cooper et al., 2017; Peters & Daly, 2013; Wigfield & Cambria, 2010). Based on the current literature, UR programs can function as a powerful contextual factor for the model of EVT (Hernandez et al., 2013; Linnenbrink-Garcia et al., 2018; Robnett et al., 2015). However, the existing literature is limited, and there exists a significant need to gather more in-depth empirical evidence to explain students' task values associated with their research experience. Increasing our understanding of early-year undergraduate researchers' task values on their research experience may help us further understand their motivation to engage in research, which may be crucial for improving the benefits of the research programs in the design of future interventions.

Value-related beliefs and STEM persistence

Drawing from EVT, expectancies and task values are direct predictors of performance, persistence, and task choice in various contexts (Eccles & Wigfield, 2002). EVT has been applied to various fields and domains, including academics, sports, and arts (Wigfield & Eccles, 2000). Mostly quantitative measures have been used to measure the expectancy, and value-related constructs (e.g., Wigfield & Cambria, 2010) and recently qualitative studies have been conducted to investigate the association of these constructs with performance and persistence (e.g., Cooper, Ashley, & Brownell, 2017; Masson, Klop, & Osseweijer, 2016; McGrath et al., 2013). For this paper, only academic implementation of the EVT has been reviewed. Based on the current literature, task values are essential factors for achievement performance of the task and choice selection in STEM fields (e.g., McGrath et al., 2013; Perez et al., 2014; Robinson et al., 2018).

McGrath et al. (2013) used a qualitative study design to investigate how first-year engineering students perceive engineering to increase our understanding of why some students persist while some others leave the program. Their findings revealed that task values were the strongest indicators of students' decision to persist or leave with the largest Cohen's D effect size on the intrinsic value and followed by the perceived cost. On the other hand, their findings related to utility value contradicted with the literature indicating a slight negative correlation with persistence (e.g., Eccles & Wigfield, 2002; Linnenbrink-Garcia et al., 2018).

In another study, Perez et al. (2014) conducted a short-term longitudinal study with 363 diverse undergraduate students to investigate the role of science identity development processes on the motivational beliefs and intentions/decisions to persist in the STEM majors. Their study is unique because they not only explored the attainment, utility, and intrinsic values, but also investigated the cost value deeply by including the three types of cost value in their research models, which are effort cost, opportunity cost, and psychological cost. Supported by the career development literature, their findings revealed that identity development procedures are mediated through students' motivational beliefs (Perez et al., 2014). The authors explained their finding by stating "students who made commitments to a STEM career after identity exploration were likely to be more motivated in their major, which in turn was related to their intentions to stay in the major" (Perez et al., 2014, p. 325). Their findings also revealed that the association between perceived cost and choice behavior is stronger than the link between perceived cost and academic performance (Eccles, 2009).

In a recent study, Appianing and Van Eck (2018) developed and validated the Value-Expectancy STEM Assessment Scale to measure female undergraduate students' value for and expectations regarding STEM fields and careers. Similar to the literature, the findings of the study revealed that female students with higher expectations for success and higher value perceptions are more likely to persist in a STEM major (Eccles, 2011; Perez et al., 2014; Wigfield & Cambria, 2010). Moreover, their findings also supported the literature by finding a strong association between expectation for success and the value students attach to their STEM majors (Eccles & Wigfield, 2002; Eccles, 2009). Although literature regarding the subjective task values and STEM persistence provide important insights, exploring the values undergraduate students attach to STEM-related experiences, such as UR, may help us further understand the motivational factors to engage in STEM-related tasks.

Subjective task values students attach to undergraduate research experience

Based on the premises of the EVT, we would suppose that the task values in STEM-related activities are crucial aspects that may be helpful to promote careers in STEM fields (Appianing & Van Eck, 2018; Linnenbrink-Garcia et al., 2018; Perez et al., 2014; Robinson et al., 2018). For instance, Linnenbrink-Garcia et al. (2018) conducted a comparison study with 587 undergraduate students and used the EVT framework to investigate whether the UR program supports students' science motivation (perceived competence, self-efficacy, attainment, utility, and interest values) and whether these constructs predict science persistence. They have reported that greater perceived competence and values in STEM-related tasks predict students' persistence in STEM majors. Specifically, engagement in a research program significantly predicted science motivation (self-efficacy and task values) and showed significant direct and indirect impacts of task values for students' intentions to pursue a STEM research career (Linnenbrink-Garcia et al., 2018). Although this study is valuable in providing insight about the benefits of UR on improving students' science self-efficacy, task value, and their science persistence, the researchers did not include students' cost perceptions for participating in research in their model. However, the literature pointed out the importance of perceived cost in achievement, performance, and persistence (e.g., Flake et al., 2015; Perez et al., 2014; Wigfield & Cambria, 2010).

Hernandez et al. (2013) conducted a longitudinal analysis with 1,046 underrepresented undergraduate students from 38 universities to investigate the role of scientific self-identity, task values and faculty interaction on the goal orientations of undergraduate STEM researchers as well as the effect of these values on the performance of the students and their persistence in STEM fields. The researchers found that increasing engagement in research experiences and enhancing science-identity have a strong positive influence on "growth in the task and performance-approach goals," but only task values positively impacted students' GPA (Hernandez et al., 2013, p. 18). Findings of the studies explained above are valuable to clarify the directional paths of the goals, self-efficacy and science-identity constructs on students' research experience, yet there is a need for an in-depth exploration of undergraduate researchers' motivations to engage in research to determine how much and in what ways they value their research experience and what kinds of costs they associate with it.

Methodology

Context and Participants

The participants of this study were twenty-four low-income, academically-talented STEM students from diverse backgrounds at a large research-intensive private university in the northeast United States. Data for this study were gathered from a portion of a larger NSF-funded project, the *Strategic Undergraduate STEM Talent Acceleration INitiative* (SUSTAIN), which aimed to provide a coherent ecosystem of academic, social, financial, and professional support systems on a diverse cohort of high-achieving, low-income STEM students during their first and second year of undergraduate study (Tillotson et al., Under review).

Researchers recruited students through two main application and selection processes. Researchers first launched a national recruitment campaign targeting high-achieving, low-income students, including underrepresented minorities, women, and students from high-need urban and rural schools from across the United States. Then, researchers targeted matriculated applicants from the pool of intended STEM majors at the university who had declared their interest in biology or chemistry departments as they are the two largest undergraduate STEM programs within the college of arts and sciences at the university, as well as serving as essential gateway majors for a wide range of STEM career professions. From a database consisting of eligible students, twenty-eight students were selected to participate in the SUSTAIN project, and the project has awarded them with $10,000 of financial support annually for their first two years of academic study.

The participants of this study were twenty-four of the original twenty-eight SUSTAIN project participants who have a full data set. The participants of the study were predominantly female (71%), first-generation college students (88%) and racially/ethnically diverse (13% Asian, 8% Black/African American, 8% Hispanic, 21% multiracial, 50% White). Participants' majors were biology (33%), biochemistry (13%), biotechnology (4%), forensic science (13%), chemistry (8%), and neuroscience (29%).

As part of the SUSTAIN project, the participants were matched with a STEM faculty mentor from the biology or chemistry departments and spent approximately 2-3 hours each week working in their mentor's laboratory during the spring semester of their freshman year. The participants observed and engaged in the ongoing research activities of the faculty mentor's laboratory and were encouraged to participate in weekly research group meetings. During their sophomore year, the participants engaged in guided, but increasingly independent UR with their STEM faculty mentors using the knowledge and skills acquired during their research experience in their freshman year and spent approximately 5-10 hours each week in the laboratory. Participants were encouraged to participate in weekly research group meetings held in their mentor's lab and to attend the department colloquia featuring local and national STEM speakers to further their networking opportunities in the STEM community.

Participants had different amounts of research experience because some of them did not continue at the end of the first or second semester of their UR experience or some of them preferred to stay on campus during summer to continue their research. In total, eight participants had three semesters and one summer, ten participants had three semesters, four participants had two semesters, and two participants had one-semester research experience (see Figure 1). Therefore, the vast majority of the participants (75%) had three semesters or more research experience. Even though participants were provided with the same opportunity, some of them preferred not to continue their research experience. Thus, this study is crucial to explain their motivation to engage or not to engage in undergraduate research.

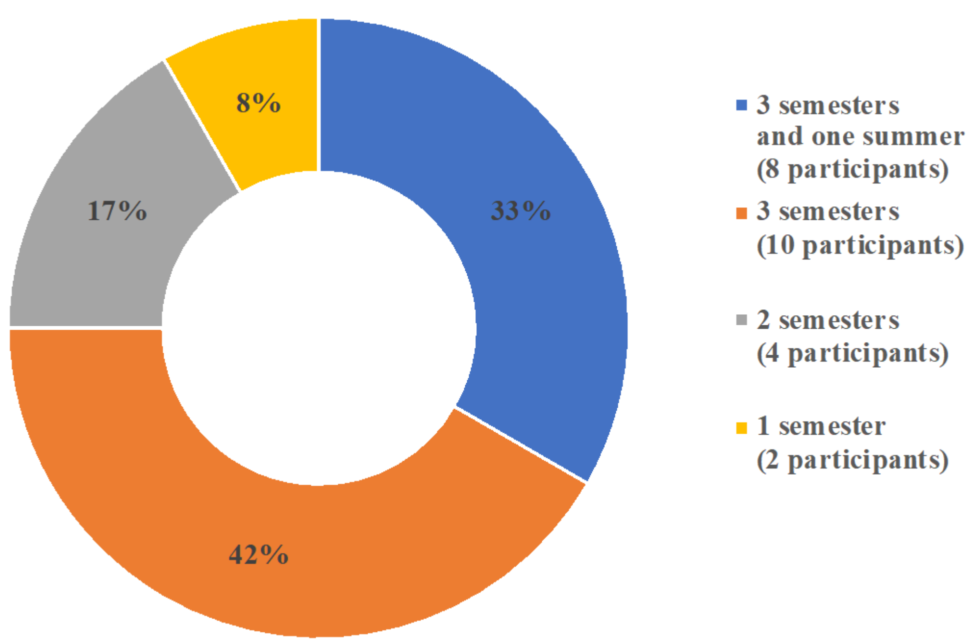

Figure 1. Amount of research experience of participants

Research Design and Measures

This exploratory study was designed to investigate how much and in what ways early-year undergraduate researchers find their research experience valuable and whether they experience a cost in engaging with research. This study aimed to contribute to the literature by addressing the motivations of undergraduate researchers to participate in research, along with giving preliminary evidence of the range of student experiences to provide a basis for generating programs to attract students in UR and to communicate their needs and expectations.

The EVT as the theoretical framework was adopted, and a qualitative approach was used for this study because qualitative research seeks to provide a rich and detailed understanding of a topic (Creswell & Poth, 2018). Previous research, using quantitative measures like participant surveys, has produced valuable information about the role of task values on the outcomes of UR experiences (e.g., Hernandez et al., 2013; Robnett et al., 2015). These quantitative studies did not offer a qualitative analysis of what kind of and how much value students placed on participating in UR, and how students believed they benefited by engaging in UR. There is a lack of qualitative inquiries of UR in various STEM fields, which limits the understanding of the complexity of these experiences (Buckley, 2010). With the lack of qualitative, in-depth exploration, the relationships among the task values and the outcomes of UR experiences are not fully understood. Therefore, to answer the research questions, semi-structured individual interviews, and student-generated progress reports were used as data sources in this study. The study instruments were reviewed and approved by the institution's human subject research review board. The researcher also obtained authorization from the institution's review board to use the data sources in this study (IRB No. 19-045). Figure 2 below shows the data sources and data collection times. Also, the semesters that the participants engaged in research were indicted in blue color.

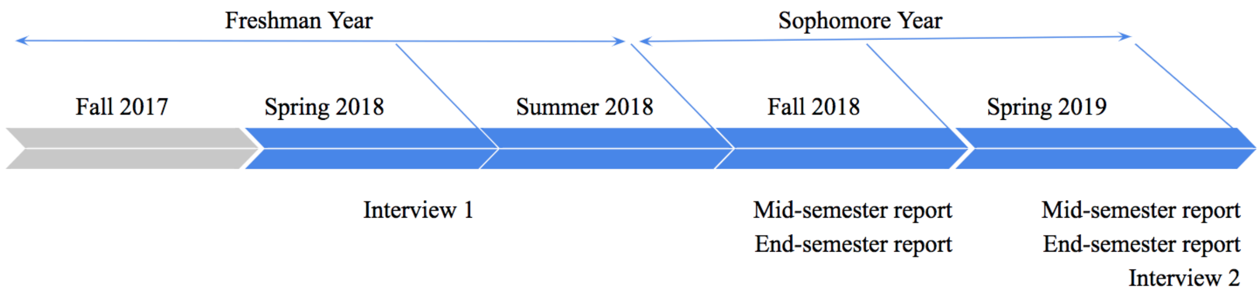

Figure 2. Data sources and data collection times

Interviews: The SUSTAIN project team developed interview protocols for each interview. The first set of interviews were conducted at the end of the freshman year of the SUSTAIN project participants in the Spring-2018 semester, which was developed to obtain the participants' first-year research experience, as well as the mentoring provided to them and in what ways the research experience helps the development of their science identity and their socialization into the STEM community, the value of this experience and their level of satisfaction with their research experience (see Appendix A). The second set of interviews were conducted at the end of the sophomore year of the SUSTAIN project participants in Spring-2019 (see Appendix B).

Some of the questions from the first interview remained the same to explore the support provided to the participants, the value they attach to their experience, and their overall satisfaction. Some new questions were added to attain the participants' sophomore research experience and to investigate if there is a difference between their first and second-year research experience. Both of the interviews were conducted with all the participants. If the participant did not continue their research experience after one or two semesters, the interview questions were asked to reflect on the semesters they participated in research. All interviews were conducted face-to-face and audio-recorded, with an average duration of 45 minutes in length. The interviews were then transcribed.

Progress Reports: SUSTAIN project participants provided mid-semester and end-semester progress reports during their sophomore years (i.e., one mid-semester report and one end-semester report in Fall 2018 and one mid-semester report and one end-semester report in Spring 2019) (Appendix C). The goals of the progress reports were to obtain continuous information about the progress in the participants' research experience, their roles and responsibilities, expectations and actual experiences, and the value of their experience so far. Each progress report reflected their progress within that period. For instance, for the mid-semester report in Spring 2019, participants shared their experience after the end-semester report in Fall 2018 up to that time.

The participants were not asked to write a progress report in their freshman year because the goal of the freshman-year research experience was to introduce the participants to research as novice STEM students through observation, shadowing, and interaction with the research laboratory members. Participants who did not continue their research experience after one or two semesters wrote a report on how their STEM major interests and future STEM career plans have evolved since they joined the university and the SUSTAIN Project.

Data analyses

The interviews were transcribed and then analyzed using the NVivo qualitative data analysis software program. The data collected through the progress reports and interviews were analyzed through deductive coding into predetermined thematic categories (Fereday & Muir-Cochrane, 2006). The predetermined concepts that were used to analyze the subjective task values deductively were 1) attainment value, 2) intrinsic value, 3) utility value, and 4) perceived cost. These predetermined concepts were based on the EVT framework and previous studies (e.g., Eccles, 2009; Eccles & Wigfield, 2002; Wigfield & Cambria, 2010). In each of the data sources, the participants' comments were highlighted regarding the type of value and the cost they placed on their research experience. Following the deductive analysis, the data were also analyzed inductively to identify the codes based on emergent patterns in the data (Patton, 2002).

Data analyses were conducted chronologically, and codebooks were developed, respectively. The entire data set was read, reread, and coded multiple times, to ensure that all emergent codes, categories, and subcategories were identified. There were differences in the emphasis participants gave to each value type. Thus, following the deductive and inductive data analysis, each participants' responses were analyzed considering the relative amount of discussion to determine the importance of each value type for the participants. For each participant, the frequency of discussion about each type of value was ranked, with three representing the most expression and one representing the least (McGrath et al., 2013; Peters & Daly, 2013). In some cases, relative discussion of some value types was very close, whereas in other cases there were substantial differences in the amount of discussion about the value types. As also mentioned in the literature, the difference between the ranks were not equal and "value types with the same rank across multiple participants indicate the order of rank, but rank order does not mean that the participants placed the same weight on that value type" (Peters & Daly, 2013, p. 252).

Results

The results from the interviews and progress reports were explained to identify how valuable students find their research experience and whether they associate a cost to participate in research regarding the expectancy-value model. While presenting the results, at first, each value type was discussed separately to provide an in-depth explanation of what ways participants value their research experience. The EVT framework was used in the analysis of values, but also the categories of the types of values were subdivided according to the inductive analysis. Some preliminary trends were discovered based on the level of emphasis given to each value type, which will be discussed in the comparison of the values section of the results. Then, findings related to the participants' comments on the costs of participating in UR were presented at the end of the results section.

Motivating values for undergraduate researchers

This section focused on the first research question: How much and in what ways do early-year undergraduate researchers value UR? Data showed that participants engage in research for a variety of reasons. Regarding both deductive and inductive analysis, attainment, interest, and utility value participants attach to their research experience was presented, subcategories were explained by providing participants' comments. Finally, the weight of each value type for each participant was discussed.

Attainment value. The attainment value refers to the importance of performing well on a task and how this task fits one's identity (Wigfield & Eccles, 2002). As the attainment value is related to the self-image of individuals, participants' comments relating their self-image to the researcher and their perceptions of self as a scientist were considered in this value type. However, attainment value was not mentioned by nearly half of the participants (46%). These participants commented on the alignment of research with their sense of self, personal importance of engaging in research, or the contribution of research on their science identity (see Table 1).

Table 1. Attainment value definition, subcategories, and examples of participants' statements

Category	Definition	Subcategories	Sample participant statements
Attainment value	Participants indicated that engaging in research is important for them and fits their identity	Alignment with the sense of self	We are working on women's infertility with mice. And since I am trying to be a medical doctor, I think it is the perfect fit for me. I am learning a lot even though I do not know half of the stuff they are talking about right now because it is super advanced. But just seeing how everything works and trying to understand, reading the research articles so I could get a better understanding of what is happening so that in the next couple of years I am going to understand too.
		The personal importance of engaging in research	Not many freshmen receive the opportunity to join a lab, and I would forever be thankful because it has taught me things I thought I would never learn in my life. I now know the value of working in a highly credited neurological research lab and to be mentored by a highly knowledgeable scientist.
		Recognition of self as a scientist	I just know that I know what I am talking about more. I know what I am doing more after doing research. I feel more competent as a scientist. I just feel more confident in myself because I know what I am doing. If I could handle that, I could handle a hard science class. So I think it just helps because it makes me more competent as a scientist.

Some of the participants with different amounts of research experience did not associate research with their sense of self. Even though these participants expressed the value of having research experience during their freshman and sophomore years, they also indicated that research does not match with their self-schema. One of the participants who had three semesters of research experience indicated that she likes the experience as an undergraduate researcher but also revealed that it is not for her and it does not fit with what she wants to do:

> It is just lab work, just not for everybody. I want to be in the field. I want to be at the crime. I do not want to be in the lab testing the stuff. I want to be the one figuring everything out. And being in the lab made me realize I like it, I enjoy it. I know I am learning, but it is not something I want to continue to do.

Intrinsic value. Intrinsic value refers to one's interest and enjoyment of engaging in and/or finishing a task (Wigfield & Eccles, 2002). Except for one participant, all others expressed evidence of interest and enjoyment of UR experience. The vast majority of the participants revealed that their motivation to engage in research was influenced by their personal interest in the research project they engaged in or the research process in general (see Table 2). One participant stated, "if it was not enjoyable, I would not have been able to delve as deeply into the research as I have wanted. I think I would have kind of pushed it away instead of accepting it." As seen in Table 2, some of the participants expressed their interest in and enjoyment of the positive relationships in the research laboratory.

Table 2. Intrinsic value definition and examples of participants' statements

Category	Definition	Subcategories	Sample participant statements
Intrinsic value	Participants indicated their interest and enjoyment of engaging in research	Finding research and/or research process interesting, exciting, and enjoyable	Research is pretty different from what we do in class and stuff, so I found that really interesting. It is not just memorizing things, it is actually trying new things and coming up with your own ideas, which I thought was really cool.
			Once you see your data and once you see the results and it is something that you expect, that is just that surreal feeling that you are actually doing something right. It is important in that you are actually trying to make a difference somehow because as humans, we all make a difference whether we like it or not. We all thrive to do that. But it gives you that surreal feeling of saying, "Hey, I am involved in research."
		Finding the relationships in the laboratory interesting and enjoyable	I think I learned there are a lot of different positions in labs with the grad students and undergrads. They all work together though, and they are all really good at delegating things. I think that was really interesting. But they all have a really good relationship with everyone, and especially they took me into the lab and showed me how to do everything, so I think that is it in terms of relationships even though I am an undergrad student, they are very respectful. I do not just do busy work, and they include me into the work.
			The people who I work with have made it more enjoyable. If I did not talk to the grad students as much as I did, if I did not have my weekly meetings with my professor, I do not think I would have liked it as much as I do. I figure it would have made it much more difficult and not as nice to go to every day.

A few participants indicated that they do not find research interesting, exciting, or enjoyable. Some of these participants expressed that their disinterest in research did not influence their interest in the field, and one of them stated, "I am not a fan of being in the lab. If I did not have that experience, I would probably still be in chemistry." However, one of the participants who had one semester research experience stated that she did not like the research experience and reflected a disinterest in continuing in the STEM field, stating:

> I did not even like it. I do not really like being in the lab or research. So, it kind of taught me a lot. It showed me what my life really would entail in the future if I was to continue to pursue biology or chemistry or anything in the STEM field. So, it gave me great insight.

Utility value. Utility value refers to the usefulness of engaging in a task (Wigfield & Eccles, 2002). Participants differed in their explanation of the utility of their research experience (see Table 3). For the majority of the participants, the utility of engaging in UR was increasing their knowledge and skills about the discipline and feeling more well-rounded. One of the participants mentioned how the skills she learned throughout this experience helped her academic, personal, and professional development, stating:

> This experience has been beneficial in allowing me to use the skills I learned in labs in order to develop my own research questions as well as conduct research. I have improved my critical thinking skills as well as my ability to collaborate and function as a team.

Only a few participants commented on the utility of engaging in research on their STEM courses. Some of the participants indicated that research conducted in their laboratory is not related to their STEM courses. One of the participants explained this by stating:

> The research was very specific concepts and it did not help with the general concepts of my classes. I feel like the classes I struggled the most with, like ecology and evolution, it is not related to my lab so it does not really have a correlation.

For some of the participants, research experience was useful in building professional relationships early in their college years and was useful in providing new opportunities for them. Five participants received a grant from the Undergraduate Research and Creative Engagement Scholarship program at the university, two participants received a scholarship to attend a summer research program in Austria, one participant received a position at INVENT@SU in NYC over the summer, one participant received the Gershon Vincow Award for Excellence in General Chemistry at the university, and one participant received internship with a neurosurgeon at Upstate Medical University.

Table 3. Utility value definition, subcategories, and examples of participants' statements

Category	Definition	Subcategories	Sample participant statements
Utility value	Participants indicated the advantages and usefulness of having research experience in their undergraduate education	Feeling more well-rounded	I feel like I have learned a lot from being in a lab, things that I could not have really learned, I guess, on my own and as quickly because, as a sophomore, I feel like it is kind of rare for people to have been in a lab since their freshman year. I just feel like it has benefitted me in so many ways.
		Helped clarify career goals	The experience has broadened my horizons and has given me a better idea of what I want to do in the future.
		Helped build professional relationships	I got to meet new people and people that are in a higher ranking in the field that I am in. Building a relationship with Professor T. also helped, not only because she was my research mentor, but because she was my professor as well. So, when your professor knows who you are, it kind of helps because it's a familiar face.
		Provided new opportunities	Due to my research experience, I was fortunate enough to present my research at the 2018 Meredith Symposium. In addition, my research led me to be the Goldwater Nominee for Syracuse University for the 2019 Goldwater Scholarship. Also, I will be presenting this research at two poster sessions in the spring. All of these exciting benefits of research help to cultivate my growth as a chemist, a student, and a researcher.
		Helped with the STEM courses	Being in the lab also helped me with my classes. What I was learning in the lab also coincided with what I was learning in my classes, so that helped me understand my classes better.

A few participants revealed that they do not have a clear career plan yet, whereas the majority of the participants (87%) commented on the utility of their research experience as helping them to clarify their career goals and intentions. For some participants, research experience changed, enhanced, or confirmed their career goals and they consider a research-related career by stating "I definitely want to pursue research now, and I think my lab has been a huge part of that decision", while for others, research experience clarified their career goals, helping them discover that they do not want a research-related career. One of the participants expressed how his research experience helped him shape his career intentions, stating:

> I think it is useful in starting to direct what I want to do in the future because it narrows down all the opportunities that I want to do. I do not want to be a researcher anymore, and I want to look more towards more industry-related work and private work and not just work for academia.

Comparison of value types

Although participants were not asked to rate the value types, participants gave a different amount of emphasis on the value types. The relative amount of participants' discussion of each value type was determined by ranking the frequency of comments about each type of value, with three representing the most expression and one representing the least, and NA representing participants did not comment on the value type (i.e., not applicable). This ranking was based on the emphasis participants placed and the presence (or absence) of the values of each participants' explanation of their motivation to engage in UR. Relative discussion of some value types was very close for some participants, while it was disparate for some other participants. The trend of each participants' value expressions was given in Table 4.

According to the analysis, intrinsic value was the primary motivation for the participants' engagement with their research experience. For most of the participants (67%), intrinsic value was the most emphasized, revealing that participants found their research experience interesting, exciting, or enjoyable. The second most mentioned value type was the utility value indicating that participants found their experience useful. Attainment was the lowest commented value type implying participants did not comment on the personal importance of research or how being a researcher fits with their identity (see Table 4). Nearly half of the participants did not comment on the attainment value, whereas only one participant did not comment on intrinsic value and all of the participants commented on the utility value of their experience.

Even though the sample size was small, some patterns were detected considering the gender and race/ethnicity of the participants, but no pattern was detected regarding the participants' amount of research experience (see Table 4). Although the ranking of the value types was the same among female and male participants, female participants commented more than their male peers on the intrinsic value of their research experience. One of the female participants expressed the encouragement she was feeling about being a woman in STEM because of her mentor's being a role model for her and stated: "She sets an amazing example for someone who survived an undergraduate career in STEM." Male students, on the other hand, commented more than their female peers on the attainment and utility value of their research experience. The utility value has the highest rank for Asian participants, followed by the intrinsic and the attainment value. The highest emphasis on the intrinsic value of the research experience came from Hispanic or Latino participants. Even though attainment value was ranked the least among three value types in all groups of participants, Black or African American participants commented more on the attainment value of their research experience compared to other groups.

Future research with larger sample size is necessary to explore the patterns to make generalizations among various student groups.

Table 4. Weight given to types of values associated with the research experience

Amount of research experience	Participants	Attainment value	Intrinsic value	Utility value
Three semesters and one summer	P1	1	2	3
	P2	1	3	2
	P3	1	3	2
	P4	1	3	2
	P5	2	3	1
	P6	NA	2	3
	P7	NA	2	3
	P8	NA	2	3
Three semesters	P9	1	3	2
	P10	1	3	2
	P11	1	3	2
	P12	1	3	2
	P13	1	2	3
	P14	2	3	1
	P15	NA	3	2
	P16	NA	3	2
	P17	NA	3	2
	P18	NA	2	3
Two semesters	P19	1	2	3
	P20	1	3	2
	P21	NA	3	2
	P22	NA	3	2
One semester	P23	NA	3	2
	P24	NA	NA	3

Note: 3 represents the most expression, 1 represents the least, and NA represents not applicable, where participants did not comment on the value type

Costs of engaging in undergraduate research

This section focuses on the second research question: Which costs, if any, do early-year undergraduate researchers attach to their research experience? Data from individual interviews and progress reports showed that some participants expressed the costs they associated with their research experience. Based on deductive and inductive analysis, types of costs participants associate with their research experience were grouped in effort cost (i.e., costs associated with the effort needed to engage in research), psychological or emotional cost (i.e., participants' concerns and/or emotional consequences of failure), and opportunity cost (i.e., loss of valued alternatives) (see Table 5).

Table 5. Perceived cost definition, subcategories, and examples of participants' statements

Category	Definition	Subcategories	Definitions	Sample participant statements
Perceived cost	Participants indicated sacrifices involved in engaging in research	Effort cost	Participants indicated costs associated with the effort needed to engage in research	I do not think I would be able to do a PhD program and do research day after day on the same project and everything because it is just so microscopic that sometimes I have a hard time connecting it to the real world and seeing that impact on the real world. I want to do things that will have an impact on the real world, but I think the projects that I would do in a research lab are going to take years to do that.
		Psychological/ emotional cost	Participants indicated their concerns and/or emotional consequences of failure	Everything that is done is interesting to me. But doing it myself, I find it very boring and not something that I would like. I guess I do not have the brain capacity to do because, I feel kind of dumb in my lab. And I feel like I would not know what to look for and what things to research in that kind of context.
		Opportunity cost	Participants indicated a loss of valued alternatives	I think it was valuable for my personal and academic growth. It definitely came at a cost. I did not have a lot of time to do other things that I may have wanted to do on campus, other things that require a time commitment because I had to commit a certain amount of time.

Effort cost. Some of the participants commented on the time, effort, or amount of work needed to engage in research (see Table 5). These participants described the stereotype image of the research process and the researcher in their minds. One of the participants explained how her perception of conducting research and the amount of effort scientists put forth in research changed throughout her research experience:

> I did not know what it takes to do research before I came here. I did not know that people spend their entire lives doing this kind of stuff. For me, when I thought about research, it was like a bigger impact, and you are discovering something huge, and your name is going to be on the papers, and your picture is going to be on the papers. It was kind of like discovering the cure for cancer kind of picture that I had. And I was like, "Oh, yeah, if I do one year of research or something like this-- if I spend enough time on this problem, then I can gain success and everything," and I do not think it was realistic. But after working through it, I think you need a much more practical view on it to do it because your experiments are going to fail hundreds if not thousands of times. And if you just give up after the first ten times, then you are not going to be able to go on and do the next step and the next step and the next step. And there are so many things that you have to do. And even after that, you are not guaranteed that you are going to get success, and you are going to get the results you want. So having the patience to do research is-- I think I learned you need a lot of patience to do it.

Even though the SUSTAIN project provided financial support to project participants, some participants still worked in various jobs to meet their financial needs as a college student. A few participants commented on the difficulty of the time commitment to engage in research while trying to balance with their jobs and classes. One of the participants explained this by stating:

> I need the money more this semester because of things that I have going on. Working 12 hours in a lab does not seem that bad until you are actually having to schedule around your other classes and then two jobs. It gets difficult. But it is like you have to make time for it. Ultimately, I feel like it is benefitting me because I am getting something out of it. So it is not like I am just going to the lab for no reason and giving up time to work. So it is worth it, I feel.

Psychological or emotional cost. A few participants commented on the emotional cost associated with their research experience in terms of the fear of failure (see Table 5). One of the participants who had one semester of research experience expressed the burden of not knowing what to do or how to do it in the research laboratory, stating:

> In the little research that I did, I was exposed to creating gels that they would use for Western Blotting, which I found very cool. But that is an entire process on its own that just drained me a lot. Because it is like how do I do this? I have never been taught this. And being taught again and again makes you feel almost pathetic, because it is so you do not get it the first time and then you want to keep doing it, but you just keep failing. It was hectic for me.

Opportunity cost. The highest mentioned perceived costs among the participants were opportunity cost, where participants commented on losing other valued alternatives when engaging in research (see Table 5). Particularly, participants who had two semesters or less research experience commented the most on the opportunity cost of engaging in research. One of the participants who had one semester of research experience stated, “I should have invested my time elsewhere rather than there. But it served as an eyeopener for the most part, so I appreciate that." Another participant who had two semesters of research experience stated that not devoting time to research let him dedicate his time to broaden his academic background in other ways, stating:

> Since I am no longer a part of a lab and do not seek to be, I have been spending the semester developing my professional brand and worked on my resume, applied to internships, and focused on what future profession I want to pursue.

Some of the participants who had three semesters or more research experience, on the other hand, stated that they do not see research experience as causing them to forgo engaging in other valued tasks by stating "I never thought that it was a waste of my time or I could be doing something better" or "I do not feel like I miss other opportunities by going to the lab. I feel like I am learning more by going to the lab." One of the participants expressed the importance of time management and organizational skills to balance academic and social life, stating:

> I am still involved in everything else that I want to be involved in. I just learned how to cut back in some areas and give more time to research if I am doing my experiment. But I also know, if I am not doing my experiment, there are other things in the lab that I could be doing that do not require as much time, and I can still balance everything. So, I think as long as you have good organizational skills, good time management skills, you can have it all.

Comparison of costs

According to the analysis of the interviews and progress reports, not all participants associated a cost to their research experience, or some participants associated more than one cost. The costs faced by participants varied by gender, race/ethnicity, or the amount of their research experience. All the participants who had two semesters or less research experience emphasized at least one type of cost. Male participants, Hispanic or Latino participants, and participants who had three semesters and one summer research experience commented more on the effort cost of engaging in research than other groups considering the time and the amount of work researchers need to spend in research. Females and Black participants commented more on the psychological or emotional costs related to the fear of failure. Moreover, females and participants who have mixed race/ethnicity, as well as participants who had two semesters or less research experience mentioned more than their other peers on the opportunity cost. Even though there were differences, there was not a clear trend in the costs participants faced regarding different groups (i.e., gender, race/ethnicity, amount of research experience). This lack of certain trends in the costs that participants expressed may illustrate the complexity of the motivational factors associated with early-year UR experience.

Discussion and Conclusion

Prior research reported that motivational beliefs that individuals attach to specific tasks predict continuing motivation and persistence in the task (Eccles & Wigfield, 2002; Linnenbrink-Garcia et al., 2018; Wigfield & Eccles, 2000). Early-year undergraduate researchers’ motivation to engage in research can be explained as a function of their expected value of research participation and the costs they associated with it. Framed in the expectancy-value model, this research explored how much and in what ways early-year undergraduate researchers value their research experience and which costs they associate with engaging in research. The findings of this study revealed preliminary evidence of student experiences regarding the value and the cost they attach to their UR experience and identify the most promising pathways for future studies to find ways to increase the value and decrease the costs students face during their research experience.

Values undergraduate researchers attach to their research experience

The results of this study showed that intrinsic value had the highest expression in participants' motivation to engage in research. This finding aligns with the literature on the significance of interest in motivation, engagement, persistence, and academic success in various contexts (Perez et al., 2014; Robinson et al., 2018; Torsney, Lombardi, & Ponnock, 2019). When individuals engage in tasks that are intrinsically valued, there are significant psychological, cognitive, and behavioral consequences (Wigfield & Eccles, 2000). As the participants of this study were in their early college years, their interest in undergraduate research may play a crucial role in their motivation to continue in research-related pathways (Bowman & Holmes, 2018). However, as in the findings of this study, the opposite may be the case: when individuals do not intrinsically value the task, there may be various consequences.

In this study, some of the participants expressed their disinterest in research and some of them reflected their disinterest to continuing in the STEM field whereas others indicated their research experience did not influence their interest in the STEM discipline. This finding is particularly significant, and future research is necessary to explore the depth and the nature of intrinsic motivations of undergraduate researchers to engage in research. UR programs should bear this fact in mind and aim at developing students' nascent STEM motivation. Also, future research is necessary to focus on understanding which features of the research experience students find valuable, in which aspects they experience more cost, and how they associate the research experience with their overall interest in STEM helps us to better respond to their needs and present other STEM-related activities. Everyone in the STEM field does not have to enjoy conducting research. Being a researcher is not the only career option in the STEM field. It is one of the many career options. Institutions should provide potential pathways to students, especially in their early years in college to help them clarify their career intentions and increase their persistence in the STEM fields.

Literature also revealed gender differences in the intrinsic value of individuals. Females express less intrinsic motivation to STEM-related tasks (e.g., Eccles, 1994; Morgan, Gelbgiser, & Weeden, 2013). Morgan et al. (2013) stated that "young women develop lower levels of confidence in STEM-related coursework and, through a process of subjective valuation, come to regard STEM-related courses and careers as less interesting, and of less personal value, than other courses or other careers" (p. 992). Female participants in this study, however, commented more than their male peers on the intrinsic value of their research experience. It may be because the majority of the research mentors were female, and gender concordance results in high student gains (Morales, Grineski, & Collins, 2018).

One of the female participants expressed the encouragement she was feeling about being a woman in STEM because of her mentor's being a role model for her. She stated that "she is extremely encouraging and gives me a glimpse into what it is like to be a successful woman in STEM." Moreover, Kuh (2008) stated that students from underrepresented groups, including women, African Americans, and Hispanics, usually come to college with a limited understanding of science and science career options. UR provides them an environment to work closely with scientists and interact with their senior partners in the field. Therefore, students from underrepresented groups benefit from UR experience (Thiry, Laursen, & Hunter, 2011) and may intrinsically motivate them to engage in research. Future research should explore differences among individuals with different demographics to better respond to their needs.

Among the participants, the second most expressed value type was the utility value of UR with regards to obtaining the desired outcomes (Wigfield & Eccles, 2000). All of the participants commented on the utility of UR, but they differed in their explanation of the utility of their UR experience. Participants emphasized the utility of UR in terms of increasing their knowledge and skills about the STEM discipline, clarifying their career goals, providing new opportunities, and helping with their STEM courses. The variety of the usefulness of UR may be that the experience of early-year research created different benefits, opportunities, and paths for the participants. Utility value interventions were found to have a significant impact on course performance and persistence in a STEM discipline (Canning et al., 2018). UR may be a fruitful context for utility value interventions. UR programs may develop utility value interventions to better communicate and enhance the utility of UR for undergraduate researchers. Future research may be designed to particularly focus on the utility value of UR for early-year undergraduate students to communicate personal relevance and usefulness of conducting research.

UR experience provides a "scientist-in-training" environment for students, and it may promote students' science identity (Thiry & Laursen, 2011, p. 773). Higher science identity is theorized to be important both because it facilitates an individual's personal attainment and provides them with a sense of need satisfaction from engaging in an activity at which they feel effective (Chemers et al., 2011). Although identities are formed through practice (Wenger, 1998), fitting the task with identity takes time (Eccles & Wigfield, 2002; Carlone & Johnson, 2007). When considering the value of the UR experience, attainment value, which is related to the personal importance of the task or a reflection of how well the task fits with one's self-identity, played the least important role in participants' motivation to engage in research. In this study, nearly half of the participants commented on the personal importance or how well research fit with their identity and there is no pattern according to their demographics or the amount of their research experience. It may be because recognition of self as a scientist may require a deeper engagement with the activity (Carlone & Johnson, 2007). It may also be that attainment value is sparse when science identity is low during the early years in college.

The findings of this study suggest that UR programs and student support interventions should emphasize students' science identity development throughout their research experience, which may promote the attainment value of UR and increased motivation to continue engaging in research. More research is necessary to explore the identity formation of early-year undergraduate students and the role of UR experience on the science identity of students.

Costs undergraduate researchers attach to their research experience

Although the expectancy-value theory has been widely used in various fields to better understand the individuals' motivation to engage in specific tasks, "one component of this model, cost, has been largely ignored in empirical research" (Flake et al., 2015, p. 232). Understanding individuals' perceptions on what they have to give up engaging in a task or how much effort they anticipate completing the task helps us better understand the individuals' motivation to engage in and pursue certain tasks (Wigfield & Cambria, 2010). Some of the participants in this study commented on the costs they experienced by engaging in research.

Students, especially in their early years in college, may not be aware of the STEM-related activities they can engage in, may not know how to access them, or may feel incompetent (Kuh, 2008). Institutions should seek ways to reach out to undergraduate students and increase their awareness and motivation to engage in STEM-related activities. UR programs or SUSTAIN-like projects may help provide opportunities for undergraduate students to participate in research projects. For instance, one of the participants indicated she would be unaware of undergraduate research, would not be motivated to participate, or would feel unqualified if the SUSTAIN project did not provide her the opportunity to participate in such research, stating:

> If it was not for SUSTAIN, I definitely would not have gone and been an undergraduate researcher here because I would not think I would have the time or I would not think I knew what I was doing or thought you would have to be a genius to be in there and stuff. But working there the last two years has been great, and I have learned a lot of things. Not only academically but socially and within the STEM field that I would not have in a biology lecture or chemistry lecture.

Students' beliefs about their expectations of the task and how much time and effort they need to spend to be successful in that task may influence their motivation to pursue engaging in the task (Wigfield & Cambria, 2010). Students usually come to college with unrealistic science and scientist images. Previous studies pointed out students' high expectations about the STEM field (Ball et al., 2017; Linnenbrink-Garcia et al., 2018), which may be related to stereotypical images of science and scientists. Explicit communication of the nature of science may help students set realistic expectations for their research experience and may increase our understanding of their selection behaviors and their engagement level with research. Also, knowing students' expectations and perceptions about the effort costs they associate with research may help design and develop effective research programs.

Engaging in research requires time commitment. Some of the participants did not anticipate the time and amount of work scientists devote to their research. This is a learning experience and may differ in each research setting, and usually is not easy to foresee unless seeing the approximate daily work needs to be done to conduct the research. Providing an early research experience to college students may give them an idea about the lifetime of a research project and the amount of time and work needed to engage in the tasks (Kuh, 2008). Participants of this study were a selected group of low-income students. Even though the SUSTAIN project provided financial support to project participants, some of them still felt the need to work in external job(s) to support their financial needs. Therefore, a few participants commented on the indirect financial burden of engaging in research as it was hard for them to find part-time jobs while trying to engage in research for several hours a week. To decrease the financial burden, and give students the feeling of professionals, UR programs, institutions, and research centers should seek financial support for undergraduate researchers.

Another cost that participants associated with their research experience were the psychological and emotional costs, which were described as individuals' concerns and/or emotional consequences of failure. Only a few participants commented on the psychological cost of their research experience. Most of the participants indicated their and their mentors' awareness that they are freshman and sophomore undergraduate students whose content knowledge and laboratory skills are limited. Research experience of early-year undergraduate researchers may be improved by setting clear expectations of the laboratory experience for both students and mentors such as amount of time and work expected, the extent of the teaching and learning experience, and the structure of the laboratory and members in order to decrease the psychological or emotional cost of engaging in research.

Opportunity cost, on the other hand, was the highest mentioned cost among the participants. Mostly participants with two semesters or less research experience commented on the opportunity cost of engaging in research and expressed the loss of valued alternatives. Conversely, as expected, participants who had three semesters or more research experience expressed that their research experience did not make them feel like they are missing other valued tasks. Future research may investigate which aspects of the research experience made students feel the highest opportunity costs and what can be done to reduce the costs of engaging in undergraduate research.

Limitations and future directions

This study has several limitations. Like other qualitative studies, findings of this study can not be generalized to a population because of the limited sample size and utilization of convenient sampling (Maxwell, 2013). While the sample size was sufficient to explore the research questions of this study, it was not large enough to reveal if there are significant differences within the population of early-year undergraduate researchers. The study was also limited to a selected group of high-achieving low-income undergraduate students in a private research university. There may be differences with different student groups and at different types of institutions, but this study cannot predict these differences. The study is also limited by data collection tools. Interview protocols and progress reports were structured to let participants express their experiences, drivers, and barriers associated with their research experience. This method may have hindered the possibility of promoting to explain different types of value or costs.

The findings of this study contribute to the current literature pointing out that a motivational approach may be useful for understanding early-year undergraduate researchers' engagement with research. As perceived cost is the least studied in the EVT framework (Flake et al., 2015; Wigfield & Cambria, 2010), this study contributes to cost values within college students, particularly about early-year undergraduate researchers. Findings of this study can form the base for future work on values and costs in undergraduate research experiences. Future studies may focus on the motivational factors of early-year undergraduate researchers by extending the population or in-depth exploration of subpopulations within early-year undergraduate researchers. Further research may also focus on the evaluation and improvement of existing UR programs.

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Appendix A: First Interview Protocol

STEM knowledge & Research Experience

1) Now that you have spent some time in a research lab, what has your experience been like working with your faculty mentor?

2) Would you say your primary mentor is the faculty member, a post-doctoral researcher, a graduate student, or an undergraduate student?

a. To whom in the lab do you direct your questions?

b. In what ways have you felt prepared or unprepared for doing research?

3) What, if any, have you learned from your research experience thus far?

4) Has working in a lab helped you learn about science content and scientific practice (doing research)? If so, how?

STEM experience & Major declaration

5) What have been the most positive aspects of your STEM learning experience(s) thus far?

6) What have been the most negative aspects of your STEM learning experience(s) thus far?

7) Have the SUSTAIN activities helped you be successful in your STEM courses? If so, how? If not, why not?

8) Have the SUSTAIN activities affected the major you intend to declare? If so, how?

9) Have your career goals changed over the course of your first year? If so, how, and what factors contributed to this change?

Appendix B: **Second Interview Protocol**

Science identity & Research Experience

1) In which lab were you in during your freshman and sophomore years?

2) Approximately how many hours a week did you spend in the lab?

3) What was your role/responsibility in the lab in your first year/second year? Tell me about your research. Describe some of these things you did.

   a. How is your second year similar to or different than your first-year research experience?

4) What have you learned that you might not have learned without your research experience(s)?

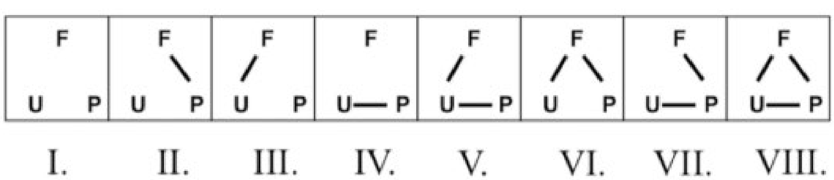
5) What have you learned about the difficulties of doing research? Was there a challenge you faced during your experience?

6) Do you think you have grown or changed as a result of this experience? If so, how? What experiences contributed to this growth and change?

7) To whom in the lab do you direct your questions?

8) Would you say your primary mentor is a faculty member, a postdoctoral researcher, a graduate student, or an undergraduate student?

9) Please look at the diagram and indicate which structure best represents your relationships with the postgraduate and faculty members with whom you worked.



10) How frequently do you interact with your faculty mentor?

11) What kind of support, if any, do you think was provided to you in the lab?

12) How satisfied are you with your research experience?

- What has contributed to your level of satisfaction (or dissatisfaction) with your research experience?

13) How valuable was this experience for you?

14) Has your research experience changed, confirmed, or enhanced your ideas about your career?

Appendix C: Mid-semester / End-semester Progress Report Guideline

Please submit one or two-page progress report regarding the progress in your research study. While writing your progress report, please answer the questions listed below and use one or two key aspects provided in Table 1.

1. Before you begin your research experience, what did you think the lab experience would be like?
2. What did you think participation in the lab would be like?
3. Has your experience differed from your assumptions? If so, are these differences positive, negative or a combination of both?
4. How valuable, if at all, was this experience for you?

Table 1. Effective mentoring to promote knowledge integration (Linn et al., 2015, p. 2)

		Elicit ideas	Add ideas	Distinguish ideas	Reflect
MENTORING	**Develop practices**	Identify or formulate a question in the context of the lab's research goals	Conduct experiments, collect and organize data	Analyze and interpret data Evaluate evidence Critique conclusions	Make final conclusions and plan next steps
	Expand content knowledge	Articulate hypotheses and questions about the research topic	Read literature, attend seminars, discuss with the research team	Consider the quality of evidence and relevance to the argument	Synthesize experimental results
	Understand the nature of science	Express expectations for science research experience	Attend lab meetings, experience experimental failure	Present progress reports and compare ideas in group settings	Consider how discoveries emerge from iterative processes
	Develop identity in science	Share goals for the undergrad. research experience relative to personal and career aspirations	Participate in the social network of the research team	Experience how the process of criticism contributes to research progress; share ideas as a team	Recognize strengths related to career aspirations

VITA

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EDUCATION

Ph.D. in Science Education, Syracuse University, NY, USA, 2019

M.A. in Primary Education, Boğaziçi University, Istanbul, Turkey, 2016

B.S. in Primary Science Education, Boğaziçi University, Turkey, 2005

Certificate in Primary Mathematics Education, Boğaziçi University, Turkey, 2005

WORK EXPERIENCE

Research Assistant (2014 – 2016, 2018 – Current)

Department of Science Teaching, Syracuse University, NY, USA, 2018 – Current

Department of Primary Education, Boğaziçi University, Turkey, 2014 – 2016

Teaching Assistant (2014 - 2018)

Department of Science Teaching, Syracuse University, NY, USA, 2016 – 2018

Department of Primary Education, Boğaziçi University, Turkey, 2014 – 2016

Middle School Science Teacher (2005 - 2013)

TED Istanbul College, 2012 – 2013

IELEV Istanbul Private Middle School, 2009 – 2012

Istanbul Çevre College, 2006 – 2009

Istanbul Science Education Center, 2005 – 2006

PUBLICATIONS

Ceyhan, G. D., Thompson, A., Sloane, J. D., Wiles, J. R., & Tillotson, J. W. (2019). The socialization and retention of low-income college students: The impact of a wrap-around intervention. *International Journal of Higher Education*, 8(6), p. 249-261. doi:10.5430/ijhe.v8n6p249

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Ceyhan, G. D., Thompson, A., Sloane, J. D., Tillotson, J. W. & Wiles, J. R. (2019). Exploring how the Strategic Undergraduate STEM Talent Acceleration INitiative (SUSTAIN) influenced students' understanding of the nature of science. *International History Philosophy and Science Teaching (IHPST) Conference Book of Proceedings*, p. 523-529.

Ceyhan, G.D., & Mugaloglu, E.Z. (2019). The role of cognitive, behavioral and personal variables of pre-service teachers' plausibility perceptions about global climate change. *Research in Science & Technological Education*, p. 1-15. https://doi.org/10.1080/02635143.2019.1597695

Saribas, D., & **Ceyhan, G. D**., & Lombardi, D. (2019). Zooming in on scientific practices and evidence-based explanations during teaching NOS: A study in pre-service teacher education program. *Elementary Education Online*, 18(1). doi: 10.17051/ilkonline.2019.527626

Evren-Yapicioglu, A., Atmaca, S., Akbulut, A., **Ceyhan, G. D.**, Durmus, Y., Akaydin, G., & Demirsoy, A. (2017). Journey to the natural history museum in the perspectives of children. *European Journal of Science and Mathematics Education*, 5(4), p. 365-375.

Saribas, D., & **Ceyhan, G. D.** (2015). Learning to teach scientific practices: Pedagogical decisions and reflections during a course for pre-service science teachers. *International Journal of STEM Education*, 2(7). https://doi.org/10.1186/s40594-015-0023-y

BOOK CHAPTERS

Mugaloglu, E. Z., Can, N., & **Ceyhan, G. D.** (2017) Kanıta dayalı fen eğitimi: Model kanıt ilişki şeması [Evidence-based science education: Model-evidence link diagram]. Mutlu Pınar Demirci Güler (ed.) *Fen Bilimleri Öğretimi: Kuram ve uygulama Örnekleri*. Pegem. 255 - 273.

PUBLISHED RESOURCES/ TECHNICAL REPORT

Erduran, S., Mugaloglu, E. Z., Kaya, E., Sarıbas, D., **Ceyhan, G. D.,** & Dagher, Z. (2016). Learning to Teach Scientific Practices: A Professional Development Resource. University of Limerick. doi: 10.13140/RG.2.2.31352.44806.

ACADEMIC GRANTS, AWARDS, & SCHOLARSHIPS

2019

- Certificate in University Teaching, Syracuse University
- Sandra K. Abell Institute for Doctoral Students, National Association for Research in Science Teaching
- Summer Dissertation Fellowship, Syracuse University
- School of Education Creative & Research Grant, Syracuse University
- Travel Grant, Graduate Students Organization, Syracuse University
- Travel Grant, School of Education, Syracuse University

2018

- Journal of Research in Science Teaching Doctoral Student Mentored Review Initiative
- Outstanding Teaching Assistant Award, Syracuse University
- School of Education Creative & Research Grant, Syracuse University
- Moynihan Institute of Global Affairs Middle Eastern Studies Summer Research Grant

2017

- Himan Brown Trust Scholarship, Syracuse University
- Travel Grant, Graduate Students Organization, Syracuse University
- Travel Grant, School of Education, Syracuse University

SELECTED PRESENTATIONS

Sloane J. D., **Ceyhan G. D.,** Thompson A. N. & Tillotson J. W. (2019). Undergraduate Research Experience as an Early Intervention for At-Risk STEM Scholars. Association of American Colleges & Universities (AAC&U) Conference, Chicago, IL, USA.

Tillotson, J. W., **Ceyhan, G. D**., Sloane, J. D., Wiles, J. R., & Aksoy, S. (2019). Strategic Undergraduate STEM Talent Acceleration INitiative (SUSTAIN): Impacts on Underrepresented College Students' STEM Learning Experiences. *National Association for Research in Science Teaching (NARST) Annual Conference*, Baltimore, MD, USA.

Ceyhan, G. D., Sloane, J., & Tillotson, J. W. (2018). The Impact of Faculty Mentoring and Early-immersion Pre-research Experiences: The Strategic Undergraduate STEM Talent Acceleration Initiative (SUSTAIN). *Northeast Association for Science Teacher Education (NE-ASTE) Regional Conference*, Burlington, VT, USA.

Ceyhan, G. D., Saribas, D., & Lombardi, D. (2017). Pre-service teachers' thinking about evidence and evaluations of trustworthiness of the claims in socio-scientific issues. *National Association for Research in Science Teaching (NARST) Annual Conference*, San Antonio, TX, USA.

Ceyhan, G. D., & Mugaloglu, E. Z., (2017). The role of cognitive, behavioral and personal variables on preservice teachers' plausibility perceptions of global climate change. *International History Philosophy and Science Teaching (IHPST) Biennial Conference*, Ankara, Turkey.

Ceyhan, G. D., & Mugloglu, E. Z. (2016). Teachers' ideas about the benefits and challenges of teaching climate change through evidence-based thinking, *International Conference on Education in Mathematics, Science & Technology (ICEMST)*, Bodrum, Turkey.

Saribas, D., & **Ceyhan, G. D.** (2015). Implementing scientific practices: An auto-ethnographic study for the professional development of an instructor in pre-service teacher education program. *National Association for Research in Science Teaching (NARST) Annual Conference*, Chicago, USA.

Can Al, N., Azuz, B., **Ceyhan, G. D.**, Cebi, E., Kose, M., & Olgun, B. (2014). The role of parent involvement, academic and social self-concept on the academic achievement of fourth-grade students. *International Congress of Educational Research*, Ankara, Turkey.

Atmaca, S., Evren, A., **Ceyhan, G. D.**, Akbulut, A., Durmuş, Y., Akaydın, G., & Demirsoy, A. (2012). Journey to the Natural History Museum in the perspective of children. *1st Cyprus International Conference on Educational Research*, The Republic of Cyprus.

SERVICES TO THE ACADEMIC COMMUNITY, THE SCHOOL, AND THE UNIVERSITY

- Vice-president – Graduate Science Policy Group, Syracuse University, 2018 - 2019
- Jury member – Best Educational Practices Conference, Sabanci University, 2013 - 2015
- Graduate Students' Vice-President – Bogazici University, 2013 - 2014
- Graduate Student Representative – Bogazici University Institute for Graduate Studies in Social Sciences, 2013 - 2014
- Featured Member - Commission for the Protection of the Natural Life, Bogazici University, 2013 - 2014
- Team Manager – TED Istanbul College Destination Imagination, 2012 - 2013
- Eco-Schools Project Coordinator – IELEV Private Elementary School, 2009 - 2010; Istanbul Cevre College, 2008 - 2009

PROFESSIONAL MEMBERSHIPS

- The Association of American Colleges and Universities (AAC&U)
- American Educational Research Association (AERA)
- International History, Philosophy, and Science Teaching Group (IHPST)
- National Association for Research in Science Teaching (NARST)
- National Science Teachers Association (NSTA)
- Turkish Science Education and Research Association (SERA)