From where does it STEM? An analysis of why females and racial and ethnic minority youth elect to pursue STEM education and careers

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Abstract

In the recent years there has been a greater focus on science, technology, engineering, and math (STEM) education in American education. However, with this greater focus, there has also been a growing concern about the gender and racial/ethnic composition of those pursuing STEM. This study served to examine what encourages undergraduate students to pursue STEM, in addition to what supports they need to continue in STEM education. It utilized a theoretical framework constructed from the Social Cognitive Career Theory (SCCT). In-depth interviews were conducted to better understand what factors led female and racial/ethnic minority students to select and pursue STEM education. Interview data was examined through the three aspects of SCCT: self-efficacy, personal goals, and outcome expectations. On the surface, the present study found that interest in these areas for students stemmed from their childhood experiences such as the enjoyment of science and math or ease of understanding those subjects in elementary school. As students grew older, social factors such as the influence of teachers, family, and friends were also important in rooting their interests in STEM. 8 out of the 9 students had some idea that they were going to pursue STEM careers before enrolling at Tufts. And at the university level, it was a mix of personal growth such as the acceptance of being different and better organizational skills, and social factors such as passionate professors and advisors that aided students in their pursuits. However, when examining the issue further, students often indicated a status of “otherness” as opposed to identifying as being included in the STEM community, which related much to their outcome expectations and previously formed conceptions of STEM culture. Recommendations such as formalized mentoring structures and creation of communities of different kinds were made in order to further support these students.

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Introduction

In recent years, there has been a particular focus on increasing the science, technology, engineering, and math (STEM) workforce through improving and expanding STEM education in both K-12 settings and in university settings. Many believe that the solution is simply to provide the opportunities to practice STEM in and outside of school (Sanders, 2008). However, the issue has proven to be more complicated when identifying who are the individuals who will study and practice STEM? Are these opportunities available to all individuals, regardless of age, socioeconomic status, gender, race, and ethnicity? Even given the burgeoning STEM fields and opportunities, will women and people who come from a variety of racial and ethnic groups elect the kind of education needed to pursue careers in STEM-related fields? Oftentimes, that is not the case.

This is evident when looking at the percentages of girls and students of underrepresented minorities who took the Advanced Placement Computer Science (AP-CS) exam in 2015. Taking the AP-CS exam can be an indication of interest and a step towards pursuing a STEM career. Out of the 50,000 students who took the exam, only 22 percent were female and 13 percent were students of color (Munoz & Smith, 2015). This issue is more drastic when looking at the distribution of these students that took the exam. In 10 states, fewer than 10 high school girls took the AP-CS exam. In addition, in 23 states, fewer than 10 African American students took the exam. These stark numbers first make us ask, why are girls and students of color not taking AP-CS exams, when passing scores can go towards college credits? One response to this question is that it is an issue of inequity and access to STEM education (Munoz & Smith, 2015). Another response is that even if girls and students of color go to a high school where AP-CS is offered, AP-CS is an elective. By this age, students may have already developed strong stereotypes about their abilities, their sense of belonging to STEM communities, and/or general interest or disinterest in computer science (Yongpradit, 2015).

In his 2016 State of Union address, President Obama proposed the Computer Science for All Initiative. This initiative includes $4 billion in Obama's 2017 budget and $100 million to be distributed directly to school districts (Klein, 2016). This particular investment in expanding computer science opportunities was meant to address the lack of women and people of color in STEM-fields. Thus, this initiative, if approved, may be a partial solution to addressing inequalities in STEM education. However, what other supports are needed to inspire and encourage women and people of color to elect STEM education other than just providing opportunities? What other factors will help us address other issues like stereotyping that may deter girls and students of racial and ethnic minorities from electing to pursue a STEM career?

This study aims to examine what factors have gotten female and students of color to decide to pursue a major in STEM and a STEM-related career path. To what extent is the availability of courses in high school important? What role, if any, does having teachers who are female or people of color play in inspiring students to pursue STEM? How important is having media role models? What kinds of supports are necessary for students in STEM courses on the college level? How important is having a peer group pursuing similar fields?

In many ways, taking on this topic has been an extremely personal pursuit. When I was a wide-eyed college freshman, I was pretty lost in choosing what I wanted to do. However, I had always been interested in science because I liked mathematics. Thus, during my second semester of my freshman year back in 2013, I decided to pursue chemical engineering and dove right into STEM courses. I was very out of my comfort zone and that semester proved to be one of my most difficult semesters. I struggled immensely through my courses and decided to abandon my pursuit of chemical engineering in particular, and STEM in general. Thinking back to that semester, I remember how unprepared I felt. I come from a low socioeconomic background and from a high school that did not offer any Advanced Placement (AP) science courses at the time. I attribute much of my struggle to those contextual factors.

Many studies have taken this same approach in attempting to answer why students of low socioeconomic status, females, and students of color have not been succeeding in STEM pursuits, even given the opportunities. Most studies seek to understand what is lacking and what is not working. It is easy to point out these deficits as I have done with my own experience. However, I am more curious about what *is* working and what exists currently either contextually or internally for students to persevere and pursue STEM careers, as well as the factors that inspired them, hence the purpose of the current study.

Literature Review

This literature review will examine studies and theories that have attempted to answer why women and people of racial and ethnic minorities have shown lower academic achievement in STEM fields. Studies addressing other factors such as extracurricular activities and the media's potential role in influencing STEM perceptions will also be explored. Ultimately, this review serves to inform the current study through providing background information and setting up a theoretical framework, as well as highlighting what methods, study designs, and perspectives might have been missing in answering similar research questions.

Women's and People of Racial and Ethnic Minorities' Participation in STEM

Significant evidence suggests that fewer women than men choose to pursue STEM fields (Correll, 2001; Hill, Corbett, & St Rose, 2010; Shapiro, 2011), as well as fewer racial and ethnic minorities (Nelson & Rogers, 2003; Riegle-Crumb & King, 2010). Studies reveal that White men have dominated STEM fields especially at the university level (Campbell, Denes, & Morrison, 2000). According to a recent *Survey of the American Freshman* (Eagan, et al., 2013), 33.5% female and 45.8% male freshmen intended to major in science and engineering fields, including social and behavioral sciences. These numbers significantly decrease in the engineering-specific field, 3.9% female and 18.3% male. The numbers further decrease for females of color according to this report – 3.6% Black females compared to 18% White males in engineering and 1.1% Hispanic females compared to 3.5% White males in physical sciences (Eagan, et al., 2013).

This existing state in the STEM fields is concerning because recent research literature suggests that women and ethnic minorities do not consistently lack interest or aspirations in the subject matter throughout their lives (Riegle-Crumb, Moore, & Ramos-Wada, 2011). In particular, Riegle-Crumb et al. (2011) developed a quantitative study that examined a national cohort of early adolescents to better understand the correlation between gender, race, and ethnic backgrounds and aspirations for future science or math occupations. They found that Black and Hispanic boys have aspirations comparable to their White male peers at this early age (Riegle-Crumb, Moore, & Ramos-Wada, 2011). Other studies have shown that STEM interests can change over the course of high school experiences. Sadler et al. (2012) found that though the percentage of females interested in STEM at the start of high school was lower than that of males, that percentage further decreased by the end of high school, while the percentage of males interested in STEM stayed relatively the same throughout the four years, thus widening the existing gap.

Even when women and individuals of color have decided to pursue their STEM interests at the college-level, they still have low rates of success compared to their White male peers. Only 16,367 females were awarded Bachelor's degrees in engineering in the United States in 2012 compared to 71,394 males. In addition, only 3,587 African Americans, 7,203 Hispanic Americans, and 355 Native Americans were awarded degrees compared to their 59,007 White peers (Engineering Workforce Commission, 2012). More recently, Bachelor's degrees in engineering were awarded in 2014 to 19.9% females in engineering and 80.1% of males in engineering. Out of those degrees, 65.9% went to White undergraduates, 13.1% to Asian Americans, 10.1% to Hispanics, and 3.5% to African Americans (Yoder, 2014).

Researchers have attempted to explain disparities in achievement at the college-level. Established beliefs about intelligence, stereotype threat, self-assessment, and implicit bias and discrimination from professions in the field and the workplace may form possible barriers to women's success in this field. (Hill, Corbett, & St. Rose, 2010; Rosenbloom, et al., 2008). Nelson & Rogers (2003) also attributed this disparity to the lack of underrepresented minority women faculty at research universities, which they deem to be "almost nonexistent" (p. 1). The lack of role models may instill and reaffirm established beliefs, biases, and discrimination. Thus, women and people of color are evidenced to have more obstacles in their STEM pursuits and achievement, asking for us to reexamine the established system and explore what supports are needed to break through these barriers and reduce these disparities.

Some studies have attempted to examine what helps individuals, regardless of gender and racial/ethnic identification, persist and graduate from college (Kuh, Kinzie, Buckley, Bridges, &

Hayek, 2006). However, these studies, which were based on generalizing from huge datasets, identified risk factors that were often out of an individual's control, such as being academically underprepared for college-level work, being a single parent, having to care for children at home, being a first-generation college student, and attending college part-time. Through identifying risk factors, these studies are examining what is wrong instead of what is working. These risk factors may not contribute towards creating solutions for students because they are often times highly case-specific. For example, solutions cannot be created to change a first-generation college student's status to the status of a third-generation college student. Thus, it is important to examine what is working for students, regardless of present risk factors.

Social Cognitive Career Theory

Many studies have attempted to examine career development through the Social Cognitive Career Theory (SCCT) perspective. SCCT explains that self-efficacy, personal goals, and outcome expectations that have been personally developed in relation to environmental factors are the foundations to an individual's career trajectory (Lent, Brown, & Hackett, 2002). These pieces are necessary in order for individuals to exercise personal agency and control over their career development. This theory puts much emphasis on individuals' self-initiative and action. In relation to this study, Lent, Brown, & Hackett (2000) reported that individuals who have traditionally been victims of oppression perceive immense career barriers that may play key roles in support or deterring individuals from persisting in their career interests; however, these barriers are often perceived inconsistently and vaguely.

Navarro, Flores, & Worthington (2007) tested the SCCT by examining its relation to Mexican American middle school students' goal intentions in math and science. They found support for the theory, discovering that math and science past academic accomplishments and perceived parent support were good predictors of math and science self-efficacy, which led to high math and science outcome expectations, interests, and goals. They also reported that it was not necessarily race-orientation that predicted academic performance, but rather social class. Thus, it is important to consider that this research topic may not only be a concern with regard to gender and race disparities, but also may be a concern in socio-economic status. The rest of the literature will examine the different aspects of SCCT in terms of self-efficacy, personal goals, and outcome expectations.

Self-efficacy: Achievement in Science & Math

Positive achievement such as getting high test scores and grades in science and math, especially at early ages, can be reinforcing and build self-efficacy in students, or do the reverse with negative achievement. In addition, performance in the subjects of math and science can be an external indicator of later success or failure in STEM fields, leading to the decision of whether or not to major and pursue a career in STEM (Barron, 2006). Many studies have affirmed this assumption: studies reflect that academic performance, particularly in math, can be an early indication of future career aspirations as academic performance gives direct feedback of one's capabilities (Bouchey & Harter, 2005; Shapka, Domene, & Keating, 2006). Consequently, adolescents may internalize this feedback and blame themselves for their failures, set lower expectations for themselves, and adding to a self-fulfilling prophecy with regard to lower academic achievement (Brantlinger, 1990). Youth may also have certain beliefs about science in general: some believe that science material learned in the classroom has no application outside of the classroom and that a science career is much harder than science in the classroom (Archer, et al., 2010), thus possibly contributing to greater lack of confidence in achieving science careers outside of school.

If academic achievement can be an early indicator of later STEM success, then how have low-income students and particularly students of racial and ethnic minorities been doing in terms of academic achievement and performance? In addition, what leads them to this particular achievement? Much research has started to answer these questions by seeking to understand contextual factors that may affect academic performance in low-income students and students of racial and ethnic minorities. Contextual factors include lower parental expectations and/or confidence in their children that can affect science and math achievement negatively (Eamon, 2005; Jacobs, 1991; Jacobs & Harvey, 2005; Jeynes, 2002;), stressors such as family income and poverty that can cause low achievement in general (Eamon, 2005; Johnson, 1992), and lack of role models achieving in science and math who look like the youth that may also discourage achievement (Bages & Martinot, 2011; Lockwood, Jordan, & Kunda, 2002; Zirkel, 2002).

Johnson (1992) suggests that it is additional socioeconomic and societal stress, such as stress due to poor families, racism, and discrimination, that causes students who live in these conditions to be underachieving academically. According to the National Center of Education Statistics' report of *The Condition of Education* (2015), high-poverty schools, where 75% to 100% of students receive or are eligible to receive free or reduced-price lunch, have comparably lower 12^{th} grade mathematics scale scores in calculus than do students who attend a low-poverty school. Hispanic and Black youth were the lowest scoring of the student population. Much of the aforementioned literature has come to the consensus that students of racial and ethnic minorities and students from economically disadvantaged backgrounds are more likely to struggle in math and science.

Many studies, in general, have taken a quantitative approach to examining this phenomenon, often conducting national studies (Bouchey & Harter, 2005; Jacobs & Harvey, 2005; Shapka, Domene, & Keating, 2006). Though this approach often produces generalizable results, it does not pay attention to individual differences as to how these possible contextual factors may affect youth's performance. Qualitative data, which may provide richer, more in-depth stories of the issue, is far less frequently reported in published studies on this topic.

Personal Goals: Cultivating Interest in STEM

Certain supports have shown to be important in cultivating interests and future, personal career goals. According to Gushue & Whitson's (2006) study that applied the SCCT, parental and teacher support have been shown to be strong shapers of African American ninth-grade students' self-efficacies and career outcome expectations. However, past research has shown that cultivation of interests may start much earlier during elementary or middle school (Bouchey, 2004; Crowley, et al, 2001; Jacobs & Bleeker, 2004; Newcombe, et al., 2009). Parents can have a central role in fostering children's interests in science and math. Dierking & Falk (1994) found that children learn science better and feel more confident in their science abilities when their parents do science activities with them in informal settings like the home. This parent-child interaction provides positive feedback and feeds into children's self-efficacies, giving them the positive reinforcement to continue to engage in their science interests and scientific goals. Jacobs & Bleeker (2004) further confirmed parents' powerful role in cultivating science interests. They discovered through their longitudinal, quantitative study examining elementary school children's and parents' beliefs about science and math that parental intention to promote science and math interests is related to their children's later science and math interests and goals.

Teacher support is another contributor in fostering STEM interests and is particularly unique as it can potentially foster intrinsic motivation and interest depending on the teaching style (Newcombe, et al., 2009). Contextualization of science concepts, personalization of teaching, and choice in learning are important teaching styles that can increase motivation in students as well as the depth of engagement in learning (Cordova & Lepper, 1996). When teachers go out of their way and break traditional teaching of science and math as presenting abstract information, students feel more connected to the subjects and can understand how scientific concepts may apply to their everyday lives. This connection may further increase their intrinsic motivation and interest in STEM and may support their goals in pursuing STEM careers. At the university level, professors have taken this approach in teaching their own students in STEM courses. For example, Professor Tammy Tobin at Susquehanna University used active learning to help students further engage in scientific concepts (Waldrop, 2015). As one of her assignments, Tobin gave a scenario of a viral outbreak and asked students to identify the pathogen, investigate how to track it, and develop a way to treat it. Through similar assignments, students were able to gain a much deeper understanding of science and retain the concepts much better than "passively listen to answers" (Waldrop, 2015, p. 2).

Outcome Expectations: Media's Potential Role

Media may play a large role in influencing social constructions and these social constructions may deter or encourage individuals from participation because of various developed outcome expectations, especially if the constructions feed into negative or positive self-concepts (Norris, 2014). Many studies have revealed that children's television can be a primary source of where children may get their perceptions of scientists in general (Benli, Dokme, & Sarikaya, 2011; Potts & Martinez, 1994; Steinke, et al., 2007). Potts & Martinez (1994) showed concerned in cartoon's negative portrayals of scientists. They found that children with higher amounts of cartoon viewing were more likely to view scientists negatively, showing some evidence that frequent viewers of television programming may incorporate images into their belief systems. In a related study, children were asked to draw a scientist and write down the source of the information for their drawings (Steinke, et al., 2007). Researchers demonstrated that for this sample of 304 seventh-grade students, boys most often drew male scientists while girls most often drew female scientists. The students indicated that their primary source was media, thus bringing up the question of whether children are more attuned to images in media that more closely resembles themselves.

However, there has been much criticism of the "Draw-a-Scientist Test" (DAST) tool used as an assessment of what individuals believe to be their true perceptions of who scientists and engineers are. Several studies reported that DAST did not adequately capture children's perceptions of scientists compared to other measures such as a survey, and that it may be limited by children's drawing abilities – often being an oversimplified version of their conceptions (Hillman, Bloodsworth, Tilburg, Zeeman, & List, 2014; Losh, Wilke, & Pop; 2008). In a review of science communication literature, Stocklmayer (2001) suggested that having children draw their conceptions of stereotypes is flawed because it inherently encourages individuals to "perpetuate a ubiquitous media image of scientists" (p. 4). Because media does not only entail images, but also full narrations, it is also important to consider how character personality traits, character development, and interconnecting storylines may contribute to the larger, fuller idea of scientists and engineers that individuals may have. The focus should not only be on stereotypical images.

Even at older ages, individuals may still use media to momentarily dispel or uphold establish perspectives of a STEM career (Jennings, McIntyre, & Butler, 2015). Other researchers performed content analyses on popular children's television shows and feature films and have concluded that in general, there are more male characters who are scientists than female characters (Steinke & Long, 1996; Steinke, 2005). Female scientists also most often played the romantic interest, were attractive, and were often assistants instead of expert scientists (Steinke & Long, 1996). In sum, though media do include some images of female scientists, the majority of these images still uphold other gender stereotypes.

Much of the literature has assumed that children have become passive in their media consumption. On the other hand, some literature has indicated that youth are taking initiative and are using the Internet and media to explore their interests, especially their STEM interests (Barron, 2006). There has also been a greater push to use media to foster scientific application and interest. Mares, Cantor, & Steinbach (1999) conducted a study to examine techniques to use in children's television to foster more children engagement and interest in science. They found that children enjoyed the content more when it was presented in a related feature story and was not explicitly labeled as science. Related to cultivating interests above, this technique is very similar that of teachers applying theory to real-world contexts. Using media and technology to teach science can also help break stereotypes of who is a scientist. Benli, Dokme, & Sarikaya (2011) showed that technology teaching materials prompted 6^{th}-grade children to abandon stereotypes of scientists. The children in the experimental group believed that a scientist can be anyone who makes observations and he or she did not have to wear eyeglasses.

Identity Development Theoretical Framework

So far the SCCT has been used as a lens to better understand past literature on supports or lack thereof that may contribute to an individual's career development. However, it is interesting to also consider how self-efficacy, personal goals, and outcome expectations may also contribute to individuals' identities as STEM people, such as seeing themselves as scientists or engineers. Various studies have examined STEM identity development through multimodal narratives (Holmegaard, Madsen, Ulriksen, 2014; Tucker-Raymond, Varelas, Pappas, Korzh, & Wentland, 2007). Examining identity development narratives offers a view into how individuals see themselves in the framework of various times and spaces, which ultimately informs their present identity. Multimodal narratives also allow explorations of conceptions of self (Tucker-Raymond, et al., 2007). Thus it can be used as a tool not only for outsiders to better understand an individual's identity formation, but it can also be a way for individuals to better understand and delve into their own identity construction.

However, it is important to consider that identities are not just simply multimodal narratives that can be presented in various ways, but can also be enactments in times, spaces, and relationships (Moje, Tucker-Raymond, Varelas, & Pappas, 2007). An identity is not static because the present and how individuals view their future selves, or "possible selves," continually inform their present identity. It is also important to consider which and what identity is recognized by others, how others understand the individual, and how these identities relate to social interactions within communities also contribute to how individuals view themselves and make sense of their present identity (Aschbacher, Li, & Roth, 2010).

Ultimately, how individuals view themselves, currently and in the future, informs what opportunities they may take offered to them inside and outside of the classroom (Moje, et, al, 2007). There is an exchange between how individuals construct their identity and how they interact with the world, thus their identity development may inform what supports they have, need, and want. In return, their surrounding supports, choices, and desires may affect their self-confidence and passion. Even at a young age, children begin to have ideas and imagine their future career choices (Howard & Walsh, 2010). Though children at first choose careers associated with fantasy and magical aspects, when they reach the end of elementary school, children begin to evaluate themselves and think about future careers in terms of their personal interests and abilities. Thus, individuals' choices in career and pursuits of interests are inherently related to their identities and how they understand their identities.

This study will examine the ongoing relationship between the three main aspects of SCCT: self-efficacy, personal goals, and outcome expectations, and identity development through the exploration of multimodal narratives as enactments of identity. The way that students talk about themselves serves as a presentation and understanding of their identity. This study will also highlight how students view themselves, how they perceive what supports and contextual factors have helped them choose to pursue STEM careers, and what supports they still believe to need.

Current Study

This literature review has presented various contextual factors that may influence youth's achievement and pursuit of STEM interests under the SCCT framework. A noticeable theme in the self-efficacy literature and achievement is that it is deficit-oriented. Research has focused much on the underachievement or lack of achievement of women, students of racial and ethnic minorities, and students from economically disadvantaged backgrounds. Much of the research has examined their performance in science and math based on standardized testing scores, and generally blames their lack of resources and adult support. The achievement literature also accounts for lack of role models, discrimination, and low socioeconomic status.

On the other hand, the personal goals literature is most often shown through a strength-based perspective. Parental and teacher support seem to be two big influential supports that may have encouraged youth to engage with and pursue their STEM interests. However, because the statistics paint a bleak and negative portrayal of underachievement, I am curious about other supports and contextual factors that may also be key in encouraging STEM interests and career paths. In addition, can media play a bigger role than we had anticipated especially in the context of developing outcome expectations?

I addressed these issues in the current study by investigating college students who have chosen to major in a STEM field and plan to pursue STEM careers. However, because recent studies have shown that fewer women and students of racial and ethnic minorities actually graduate with Bachelor's Degrees in STEM, I believer that it is also important to examine what other supports undergraduates need in order to keep a higher retention in STEM. In that case, the main research question is,

> "What contextual factors and supports have influenced college students' imagining of future selves and decision-making throughout their professional development in science, technology, engineering, and math (STEM), especially for students of color and women who have been historically underrepresented in these fields?"

Sub-questions included,

1. How do the supports that students received contribute to their identity development?

2. What future supports do they perceive to need in order to continue their STEM pursuits?
3. What are professionals doing to address this issue?
4. Are there disparities between what students perceive and what professionals are currently doing to address this issue?
5. Can media be an impactful factor?

These questions are aimed to not only capture what students perceive to determine what has helped them pursue STEM and what they continue to desire, but also to inform current policies and practices by attempting to recognize if there is a disconnect between students and professionals. Ultimately, the purpose of this study is to better inform students and professionals about various viewpoints, so that if necessary, changes in current policies or practices can be made to better support women and students of racial and ethnic minorities who pursue STEM careers.

Another theme that was salient throughout much of the review of literature is that research in this field has been done quantitatively. Often times, studies were reliant on big data sets and correlations to capture full pictures of the issues. Large quantitative studies have highlighted the issues in broad strokes and have shown us the surface of where the issues may stem. However, the focus on supports and on how these effects are manifested requires a finer-grained approach; qualitative work compliments the existing literature to add depth, nuance, and to put personal narrative into the conversation about a very important issue.

Methodology

The present study implemented a mixed-methods design to answering the research questions. The first part included a short survey that recorded demographic information such as age, gender, and race/ethnicity, STEM interests, and media usage, and a follow up 30-to 45-minute interview with students. 9 students who majored in various STEM disciplines at Tufts University, from biology to mathematics to electrical engineering, were recruited, surveyed, and interviewed. Of the 9, 6 students were female and 3 were male. The students also ranged in age, from sophomores to juniors to seniors. The second part of the study aimed to answer the sub-questions specifically through interviewing professors and media professionals. 8 professors across STEM disciplines, from biochemistry to learning technologies to mathematics to engineering, were interviewed. 7 of these professors were from Tufts University; meanwhile 1 professor from another university was interviewed because of his expertise in STEM representations in children's media. 2 media professionals from WGBH Digital department who develop content relevant to STEM fields were also interviewed to gain their perspectives on the role of media.

In the first aspect of the study, students were given a survey for the purpose of capturing the demographic of the participants, as well as the varied STEM interests and levels of media usage. For the demographic data, only major/intended major, age, gender, and race/ethnicity were reported. The STEM interests were subdivided into various categories such as biological sciences, agricultural sciences, and computer science. Students were asked to rate their interest level through a Likert scale that ranged from "Strongly Uninterested" to "Strongly Interested." Lastly, students were asked to reflect on and to report their media usage based on age of usage, from childhood to adolescence to adulthood, and within media categories, such as television/movies, books/magazines/newspapers, videogames, and internet searches. Again, students were asked to rate their usage according to a Likert scale that ranged from "Never" to "A few times a week" to "More than once a day." (The full instrument may be found in Appendix E).

Students then proceeded to participate in a 30-to 45-minute interview. They were asked an array of questions that included, "When did you become interested in your major?" "What AP science and math courses did you take in high school?" "What is currently helping you do well and stay in STEM?" "What do you see yourself doing with your major in the future?" and "What is your proudest STEM related achievement to date?" Questions about STEM-related media and perceptions of media in relation to diversity were also asked. (See Appendix F).

Professionals experienced a similar interview process, as their interviews also ranged from 30 to 45 minutes. However, they did not partake in a survey. University professors were asked about their teaching styles, their opinions on diversity in STEM fields, what supports they believe are helping students, their desires for future supports, and their interpretations of media messages related to STEM. Media professionals were asked about media's role in shaping STEM interests and how STEM-related content and characterizations are constructed. (See Appendices G and H for a complete list of questions).

Analysis

The survey data served as a preliminary illustration of students' interests in STEM subjects and media usage. Data from the STEM interest scales was consolidated and divided into categorizations of "interested" and "strongly interested." The Likert scale ratings for the media usage were assigned numbers: "Never" = 0, "Less than a few times a month" = 1, "A few times a week" = 2, "About once a day" = 3, "More than once a day" = 4. Media usage for each age section was averaged to determine overall amount of media use at different points in the students' lives.

The interview data was reviewed through the lens of SCCT: self-efficacy, personal goals, and outcome expectations. Lent, Brown, & Hackett's definitions of SCCT were modified to fit the present study (2002). Self-efficacy was defined as being formed through personal performance achievement, vicarious learning, and sense of proficiency and accomplishment. Personal goals are usually informed by self-efficacy. And finally, outcome expectations are beliefs of possible futures of specific decision-making and may involve imagined consequences based on some intrinsic or extrinsic reinforcement. These themes were broken down to presentation of themes and what has contributed to its development. Themes and examples of those themes that fit underneath each aspect of SCCT were recorded, analyzed, and later presented in this paper. They were also analyzed through different time frames that students mentioned they were salient: childhood, high school, and university. These categorizations served as a way to better understand interview data to see which themes were most pertinent in forming self-efficacy, personal goals, and outcome expectations in students, and which themes were prevalent in which time period of students' lives. The discussion first examines salient themes that were analyzed and coded for in the interview data. The latter half of the discussion will examine what has been a salient theme unique to females and students of racial and ethnic minorities.

Results

Students

Each individual's overarching STEM interest and media usage is captured below. These survey results serve to present a fuller picture of the participants:

1. Computer science major, female, White: interested in biological sciences and computer science. Highest media usage reported to be in Adolescence (age 12-18) with an average of 2.8 in media use, meaning about a few times a week to once a day in media use.
2. Mathematics major, female, White: interested in agricultural, physical, and computer science, and mathematics & statistics. Highest media usage reported to be in Adolescence with 2.8 average, meaning about a few times a week to once a day in media use.
3. Biology, female, White/Hispanic: interested in biological sciences, biomedical engineering, and civil & environmental engineering. Highest media usage in Adolescence and Adulthood (age 18+) with a 3.2 average, meaning about once a day to more than once a day in media use.
4. Biochemistry, female, White: interested in biological sciences, chemical/biological engineering, and biomedical engineering. Highest media usage reported to be in adulthood at a 2.8 average, meaning about a few times a week to once a day in media use.
5. Electrical engineering, female, White: interested in chemical/biological engineering, biomedical engineering, civil & environmental engineering, physical sciences, computer science, electrical & computer engineering, mechanical engineering, and math/statistics. Highest media usage in Adolescence with a 2.6 average, meaning about a few times a week to once a day in media use.

6. Computer science, male, Asian: interested in biological sciences, biomedical engineering, computer science, electrical/computer engineering, and mathematics& statistics. Highest media usage in Adolescence at a 2.8 average, meaning about a few times a week to once a day in media use.
7. Computer science, male, Asian: interested in physical sciences, computer science, electrical/computer engineering, and mechanical engineering. Highest media usage in childhood (age 0 – 11) and Adolescence with averages of 3.2, meaning about once a day to more than once a day in media use.
8. Chemistry, male, Hispanic: interested in biological sciences, biomedical engineering, physical sciences, and math & statistics. Highest media usage in Adolescence and Adulthood with an average of 2.2 in media use, meaning about a few times a week to
9. Biology, female, Asian: interested in biological sciences, chemical/biological engineering, biomedical engineering, agricultural sciences, computer science, and math/statistics. Highest media usage in Adolescence with an average of 2.8, meaning about a few times a week to once a day in media use.

Supports and Factors that Helped Students Pursue Their STEM Interests

<u>Self-efficacy</u>

Ease of understanding a subject was the one salient theme that students expressed across their childhood, high school, and university experiences. When talking about her elementary school experiences, a female, White mathematics major attributed her love of math to her ease of understanding of the subject. She commented, “I had always like liked math throughout elementary school, because I found it pretty easy, and like it was right or wrong and it was quick." This was also true for a female, Asian biology major who reflected on her high school learning experience of biology. "[L]ike the teacher taught it in an easy way, but half of it felt like the material came easier to me than other things. And I was more interested in it," she said. A biochemistry female echoed that it was her ease of understanding the subject that brought her to feel confident in choosing biochemistry as her major. She remarked, "And [introductory and organic] chem clicked really quickly for me."

Enjoyment of a STEM subject was also a theme that stemmed from childhood experiences. When asked about why she had initially thought a pre-veterinarian track and a biology major at the start of college, the female biology major expressed, "Because I love animals. Like it's something that has – I've always always loved animals and I still do." Her enjoyment and interest in animals, though may not initially be STEM-related, ultimately connects to her choice in major in college. She later expanded on how her love and enjoyment of learning about animals as a young child led her to her choice in play as a child. "I just liked playing a lot with animals like Pokémon things…. Yeah I [also] liked playing with [real] animals. I [also] had stuffed animals."

Other students also expressed that their enjoyment also connected to why they chose and still continue with their STEM major at the university level. The same biochemistry female who found ease in understanding chemistry reported, "I really enjoy organic chemistry and biochemistry so that's why I declared that as my major." Students of other disciplines like the female electrical engineer mentioned broader enjoyment of STEM, "I love math and science and all the STEM fields." Meanwhile, the female mathematics major also found enjoyment in computer science when asked to learn some programming for an internship, even though she found math easier to understand. She said, “I just kind of did the programming, which I enjoyed.”

Similar to much of the achievement literature, *performance demonstrated through high academic achievement and exemplary projects* also contributed towards students’ self-efficacies and were prevalent in their high school and university experiences. The female electrical engineer, when asked about her proudest achievement, discussed an exemplary project she completed in high school. She narrated:

> [C]oolest project I ever did was we – senior year of high school – we launched weather balloons into space, to measure like pressure, temperature, and wind speed or something. We like launched them and then drove around for 2 hours tracking our GPS that we programmed and we got - we were able to recover a balloon and got perfect temperature and pressure curves and got like pictures of space. It was the coolest project ever. And that I was pretty proud of.

Her achievement, which was reflected in her STEM project, further solidified her interest in STEM and resonates deeply with her.

Other students in the sample demonstrated their high achievement through being proud of high test scores on recent tests. “You know it’s like you know getting an A in organic chemistry like realizing that every single time I succeed on an exam and like I show that I can do it, is the most proud moment like Orgo 2, the – the average on the exam – this past exam was a 65, I got an 82. I was crying with joy,” narrated the female biochemistry major. A female White/Hispanic biology major responded, “Oh I got a 98 on a – on a bio test. The same test that I had gotten a 40…the previous year,” when also asked about her proudest STEM-related achievement. High achievement may go farther than just test scores. A male Hispanic chemistry major proudly stated, “I’ll be able to graduate with a Bachelor’s of Science in Chemistry.” As a graduating senior, he reflected that graduation marked a significant achievement because he had not taken many AP science courses in high school. He also felt pride because he acknowledged that he was the only Hispanic student in his class: “I think that’s huge cause like you don’t really see much diversity in the sciences.” A female computer science student concurred the significance of her achievements as a senior. Her proudest achievement included an exemplary project: “[L]ast year for a final project, we had to write like a web proxy. And recently for like a job [application], they wanted me to submit code. So I took it, I cleaned it up, and I sent it to them. And they really liked it. And they were like very happy with it.” These external, positive feedbacks for these students in return aided their self-efficacy development.

Students also indicated that *community building through smaller classes* at the university level was also a factor that contributed to their self-efficacies. Two female students, the biochemistry and the electrical engineering majors, emphasized the importance of having a support system within their major through smaller classes in creating a sense of belonging and that they were not alone if they were to encounter pitfalls. “We suffer through [the coursework] and we help each other…[W]e’ll just sit there and explain things to each other and be like, ‘What does this slide say?’ And someone in the room will know. And we all can figure it out. And that has been really helpful – like that support system has been great,” said the biochemistry student. The electrical engineering student echoed, “I know that we’re all in it together. We all spend hours in Halligan in the same room, we have to support each other. And having a small environment, smaller class is – and professors who care has really, really been helpful.”

Finally, the last big theme that was salient among many of the students interviewed was the *applicability of their coursework.* Students build more confidence and solidity in their STEM pursuits when they are able to apply their work to real life experiences, reinforcing that their learning is worthwhile and interesting. The male Hispanic chemistry student emphasized that his favorite course was "Analytical Chemistry," because "…it was really cool…[Y]ou got to make your own data and then you got to analyze it to see if it's viable data…you also learn a lot about kind of if you want to publish data, like the sorts of things that you would need," which related a lot to his prospects of pursuing a graduate degree in chemistry. The female White/Hispanic biology student related much of her veterinarian experiences to her biology coursework: "see[ing] those things applied and to see how like processes work and all that stuff was so cool. And I think that really kept me and like revitalized my interest in [biology]."

Other factors and supports that students in the sample mentioned to have helped them pursue STEM, especially in terms of developing their self-efficacies. The male, Hispanic chemistry student attributed receiving special attention from an English-as-a-second-language (ESL) teacher during childhood and the university bridge program towards his confidence in himself. He responded positively towards older adults mentoring him. Meanwhile, the female electrical engineer attributed advice from professors, Tufts' general acceptance of being different, and collaborative learning towards her development as a STEM person. The female White/Hispanic biology major focused more on her personal growth as a student, attributing her development to her organizational skills and comfort with failure.

Personal goals

Dedication to a career choice and *family support and expectations* were the most salient themes in shaping personal goals across all time spans: childhood, high school, and university experiences. 7 out of the 9 undergraduate students narrated their dedication to their careers choices at different ages. Some students had set personal goals and had chosen their careers during childhood. A male chemistry student stated, “But I had always like thought that I, you know, wanted to be a doctor.” The female mathematics students who was interested in teaching expressed, “I felt like I always kind of like was like interested in teaching. And then I just throughout college I always like think, like oh maybe I could do this maybe I could do that, but like when I teach I want to – it’s kind of like I’m always thinking about teaching.” The female, Asian biology student narrated, “So this is gonna sound super cliché but it’s kind of something I’ve always wanted to do,” when asked about when she first was interested in veterinary sciences.

Dedication to a career choice was also pertinent in some of the students’ high school experiences. A female, White/Hispanic biology student who was also interested in becoming a veterinarian expressed that sometime during high school, “before I came to college I was like…I really wanted to be a vet.” The setting of personal goals and dedication to a discipline was evermore evident in students’ university experiences. The female biochemistry student stated a short-term goal that may lead to a long-term one: “I’m actually interested in applying for the early assurance program through the medical school... It’s my general goal of being a doctor.” A male, Asian computer science student who is currently doing research with a professor narrated, “I’m trying to pursue what you know an academic route would be - doing research and going to grad school. So if I…really like this research thing that I’m doing through the summer, I publish a paper, I get nice recs or something like that, and I look good for graduate school, well that – that’ll incline me towards academia I guess.” His dedication to a career choice consisted of setting up smaller goals like continuing to do research and publishing a paper. Meanwhile, the female computer science student echoed dedication to long-term goals: “my like big plan is to like work really hard for the next couple years to get good at something. Cause like you know, comp sci's so broad just like every other field, where you have to like specialize a little bit."

Family support and expectations were also present throughout childhood, high school, and university experiences for some students. A female computer science student expressed that her parents were always supportive, even from a young age. She stated, "I mean they've always been like okay with anything I decided to do. So they've never like discouraged me from anything. I ask, they'll offer an opinion. But, it's never not – it's never like you can't do this or yeah." Meanwhile, other students experienced strong opinions and expectations from their families during high school when they began thinking about college and their future goals. A male, Asian computer science student expressed that his parents wished him to be successful: "success through that and they saw stereotypical doctors and lawyers [laughs] as the example of like well, if you study hard enough, you will not be in economic crisis, potentially." Another male, Asian computer science student echoed a similar experience. He said, "[B]oth my parents like were very pushy of like going to college obviously but then like engineering type job." Family support was critical for a White/Hispanic female student when she was deciding between pursuing a career in photography or a career in veterinary sciences.

She narrated:

> [T]hey kind of just sat me down and was like, "Look, it's between photography and vet and you could wake up any day of your life and could decide to go into photography, but you can't wake up any day of your life and say I want to be a veterinarian if you're 65. You just can't do it. So – or it's really hard." So I was like, "that makes a lot of sense. I think I'm just gonna go do that."

Some of the students, especially for the biochemistry female and the computer science male whose parents wished him to be an engineer, vocalized that their family support and expectations continued when they entered university, further shaping their personal goals. The biochemistry student said, "[T]hey're like my my cheering squad cause I'm very hard on myself." Meanwhile, the computer science students' family support encouraged him to take a computer science course to even begin with. "Like I was encouraged by my brother …[to] take a computer science course," he said. On the other hand, when the female biology student expressed to her parents that she wished to explore doing research rather than following the pre-vet route, she said, "Like they were really disappointed when I told them I wasn't going to be pre-vet." Ultimately, her parents' disappointment faded as she continued to pursue a possible career path in research.

Exploration of different STEM fields was also salient in childhood and university experiences in order for some students to decide on a career path and to create personal goals. The biochemistry student, before deciding to dedicate herself to a medical career, had once considered engineering because her father is an engineer himself. She said, "I considered [engineering] once when I was younger cause my dad and I – we made like um a Rube-goldberg machine where it's like like it's you know it's like a slinky going down the stairs." On the other hand, the Hispanic chemistry student wanted to explore different STEM fields in order to make sure that he was making the right choice. He has considered going to paramedic school after college, but then now plans to work in the chemistry industry. From his perspective, because he enjoys chemistry so much, he does not want to risk going straight to medical school and "regret and then go back into trying to do chemistry." He also showed concern in the opposite scenario: "[W]hat if I don't like chemistry but I like medical school more."

Self-drive and *STEM-related extracurricular activities* were the two main themes that seemed to be most prevalent in shaping personal goals in high school and university experiences. One computer science male who was interested in doing research reflected on his high school experiences and expressed that it was always his self-drive and initiative that propelled his exploration and dedication to a career in computer science. He said, “It was always my initiative to learn how to code by myself. To seek out resources for myself. And in that way you know I never stepped farther than where I was enjoying myself in that way. And it just happened to fall in line that way.” Self-drive is evermore evident in college experiences. A female, electrical engineer expressed that she was interested in a career in scientific journalism, something very far away from the traditional engineering route. Because of this unique interest, she narrated that professors and advisors pushed back on her pursuit of scientific journalism, thus she had to drive herself and push herself towards her personal goals. She reported, “I am lucky in that I’ve shifted like my mentality and I’m just gonna pursue what I think is the best route and what I’m most passionate about.” Meanwhile, the female, mathematics major viewed internal drive came from her desire to independently accomplish in math. She expanded, “I want to actually do it on my own. Because at the end of the day when the test comes around, it’s not – it’s not gonna be me in a group. It’s just gonna be me.”

STEM-related extracurricular activities in both high school and college helped some student either solidify their dedication to a career choice, or decide to find other career options. A female, Asian biology student who hopes to pursue research expressed that one of her proudest accomplishments was when she participated in Science Olympiad. She stated, “I did Science Olympiad for like 1 or 2 years like it was really low key.” She and a friend had signed up for one of the tests which was an animal identification quiz.

She continued:

> [W]e ended up winning second place…I like never expected [it]. We were like wow. But I think it says a lot to like how passionate I am in animals and like how easy it is for me to learn about animals because I'm so interested in animals. Um and like I'm doing better in my conservation biology class better than any biology class I've taken.

She related this specific STEM-related high school activity to her passions and to her academic performance in her current biology course. Meanwhile, the female, computer science student said, "I did math team where you go to competitions, but I was terrible at it. Everyone at my school just did it to get into the honor society." Thus, though she always felt confident in her math abilities, that extracurricular activity gave negative performance feedback and was not taken as seriously as the biology student had taken Science Olympiad. This experience led her to not consider a career in math, but to explore other STEM careers where her positive academic performance in math could become useful.

Extracurricular activities at the university level served a different purpose. They often served to give more hands-on experiences in potential career paths and to solidify dedication to career choices. For the pre-health students in the sample in particular, these experiences were critical in their career dedication. The Hispanic chemistry student stated, "I feel like TEMS [Tufts Emergency Medical Services] has just definitely kept me up with the whole idea of wanting to be a doctor." His hands-on experiences in helping people in the medical field was extremely valuable. Similarly, the White/Hispanic biology major narrated, "I've…been there to assist…techs and doctors with like routine things like…urinary blockages - that's really popular among cats. So I'll like administer the sedative which was a lot of fun. I've breathed for animals before with like the balloon in like emergency situations. So like I've done a lot of hands-on stuff." These experiences shed light on the type of work that she could be doing in the future, which solidified her purpose and self-drive to pursue a veterinarian career.

Different types of people seemed to play salient roles in helping students shape and pursue their personal goals. *Influential high school teachers* and *friends who were also interested in STEM* were important in high school experiences; meanwhile, *passionate professors, passionate advisors,* and *networking* were more prominent in university experiences. Both the female, biochemistry student and the female, computer science student had influential biology teachers during their freshman year of high school. The biochemistry student stated, "I don't think I would love bio as much if it weren't for [my teachers]. Cause I took Honors Bio freshman year. And then AP Bio junior year. So I had each [biology teacher] once and they're just so passionate about it. And they really wanted us to know how we can make bio part of our career." The computer science student echoed, "Like I loved my freshman year bio teacher. She was awesome. I would like stay after and talk to her about random science stuff." The female, mathematics student related that she "liked a lot of [her] teacher," and that she still kept in touch with many of them today.

Having friends in high school who were also interested in STEM was a dominant theme amongst some of the students. A male, Asian computer science student reflected, "I think generally the closer – the friends that I was closer to had more of a engineering mind… but my – my closest friend was also from a Chinese-American family, like he was interested in becoming a doctor potentially." Even a female, Asian biology student had similar experiences. She said, "I would say that most of my friends are going into STEM. Like my closer friends from high school." The female computer science student further discussed why it may be important to also have friends interested in STEM. She explained, "I think it's helpful talking to people who are also interested in the topic. Like learning is not something you can do on your own. Like you can but it’s way easier or more helpful if you have others to discuss things with…Like friends about stuff like that.”

At the university level, a shift from personal relationships with others interested in STEM towards reaching out to others who students may not know initially was present. The female electrical engineering student emphasized the importance of having passionate professors in keeping her engaged with the material and her STEM pursuits. She articulated about one of her favorite professors: “He was like, ‘I am not a tenured-professor. I am here because I want to teach you guys.’ And having that has been awesome. Like having a professor like, ‘no this is what I want to do. Like it’s my choice to be here.’ That’s been helpful.” Meanwhile, the male chemistry student identified a specific dean who was not only able to honestly advise him, but also who introduced him to other individuals who have helped him in his medical career pursuits. The other pre-health student, the female, White/Hispanic biology student, echoed her reliance and gratitude towards her advisor. She narrated, “And I would go – freshman year, I was in his office every week like crying – being like I don’t know what I’m gonna do with my life. … But, I got a lot of help from that and I did feel adequately supported in making my choices.” She had felt especially unprepared for her introductory biology course her freshman year because of her lack of taking AP science courses in high school. Her advisor nonetheless was encouraging and directed her to resources such as tutoring. Both students expressed that ultimately networking and making connections have significantly helped them in their pre-health pursuits. The chemistry student stated, “main reason is those connections really. Even like now that’s I’m like graduating and I’m like looking for a job like a lot of the people that I have talked to are like alumni who have reached [out].” The biology student similarly emphasized the important of “networking with [her] professors and like older people who are connected.”

Outcome Expectations

Exposure to STEM professionals was a salient theme throughout the students’ different age periods, which informed their outcome expectations of pursuing STEM careers. During childhood, students’ exposure to STEM professionals came from the fact that their family members were STEM professionals themselves. The female, computer science student expressed, “[M]y parents do something with computers and my brother who’s 6 years older than me, he originally went to college – he went to RIT for a year to do computer science.” She was thus able to see the outcomes of pursuing a career in computer science because she was living and seeing it everyday. Meanwhile, the female electrical engineering student’s parents took different routes to pursue STEM careers. Her parents’ stories thus impacted her perspective on career trajectories, making her further believe in her decision to pursue scientific journalism as an engineer.

She said:

> [My parents] both are software engineers but – so they’ve both kind of taken round about paths too. My mom thought she was going to do genetics math and then software engineering. They both were doing their schooling process in the 70s and they kind of like stumbled across computers. My dad actually went to art school for college… I wish like more people realized that you didn’t have to follow the paths that are laid out by people before you.”

Other students also experienced exposure to STEM professionals who pursued STEM fields closely related to their career pursuit during high school. The biochemistry student reflected on her AP Biology class. “So like part of my junior year AP Bio class, we did like job shadowing projects where we actually went out and saw what biologists are doing in the field. So it was like I went to a couple of different labs, I saw like – I went to um where they do X-ray crystallography at Boston University,” she said. Her exposure to these professionals deepened her understanding of and passion for science. Meanwhile, the male computer science student reported, “My brother was – was graduating when I was in high school with a degree in Web Design. And he’s doing web development now.” This exposure connects to his brother’s encouragement of taking a computer science course.

Though this viewpoint was not shared by the other students in the sample, the male, Hispanic chemistry student indicated that the learning of different, famous STEM professionals in elementary school classrooms contributed towards his formation of outcome expectations. Originally having grown up in Mexico, he reflected that his learning of different scientists in the classroom was very singular and unrelatable. He explained:

> So like moving here, you don’t – in elementary school – you don’t hear about like this amazing Mexican scientist sort of like. You know a lot you hear about all this super super smart scientist who were usually either European because that’s where science really got going or Americans – you hear like even starting elementary school you hear about like Newton and like all this big shot scientist, but you never really – I guess I never really thought about those sorts of things. Like it was just always like what’s popular – so obviously you have to know about Newton.

At a university level, exposure to STEM professionals served to explore complexities of what it means to be a STEM professional. The biochemistry student learned more and formed outcome expectations from speaking with a female doctor, while the White/Hispanic female student interacted with STEM professionals who reaffirmed and dispelled STEM stereotypes. The biochemistry student narrated:

> His wife went through Harvard medical school, got – went through residency, is a certified pediatrician, at that point realized how male-dominated the field was, how she would never be able to have the life that she wanted, it would not support her like you know like having children and stuff like that. She decided, after going through all of those years, to stop. She has never practiced a day in her life.

This story further impacted what it meant for her as a female in pursuit of a medical career. She further expanded on how this story influenced her decision-making and outcome expectations. She said:

> [I]t sounds like if you want to be a woman and you want to have a family and have children, you have to go into a smaller practice that usually is more women… I've decided to keep pursuing like medicine, because I want to like – like this is what I want, this is what I enjoy. And like you know what, you don't know what's gonna happen, you don't know – like I don't know if I'm gonna get married, I don't know if I'm gonna have children. That's still like up in the air. So like – and I also – but I also know I wanna be a doctor. So I'm just gonna keep going for it and then I'll figure it out when it comes. Like I value family and that part of my life as much as I like value my career at this point even though I'm still a student, so like I'm gonna just keep doing what I'm doing and I'll figure it out as it comes.

Meanwhile, the biology student stated, “I feel like a lot of people have this like stereotype of scientists and being super hard and like can’t communicate with people. And that’s definitely true. Like I’ve had professors like that and teachers. But they are like the exact opposites. They like people before they’re professors.” This student therefore further explored what it meant to be a scientist, informing her outcome expectations if she were to become a biologist.

Hypothetical results of various scenarios were most salient in high school and university experiences in shaping outcome expectations. An example of hypothetical thinking was already presented earlier when the female, White/Hispanic biology student discussed how her family sat her down during high school and discussed choosing between a career as a photographer or as a veterinarian. Other examples of hypothetical thinking included advice that the female biochemistry student would give to freshmen. She said, “[W]hat would you want to do with the major? I’m very practical that it’s like, is this going to be useful to you?” The male, computer science echoed practicality in his career choice when he was deciding between becoming a psychology major or a computer science major as a freshman. “Cause if I was to look for a job in software anyway, it seems like no one really cares about psych,” he said. Meanwhile, the female, electrical engineering student used hypothetical thinking to question her abilities and belonging in the engineering world. She reported, “Am I like – do I have like enough talent to do this? And like that made it seem like I didn’t fit into the world I guess.” For the female, mathematics student, disagreeable outcome expectations did not deter her from pursuing a career in teaching because of her dedication to it. She explained, “I want to try teaching. But I do worry about the pay. Because you don’t get that much. And it’s – it’s frustrating to be – I would be making like 30,000 a year when I have a math degree and I have like a comp sci thing and I could be making bank. So that’s frustrating. But I just kind of figured like I’m gonna give it a go.”

Two other factors seemed very present in forming outcome expectations at the university level: *classroom composition* and *present conceptions of scientists and engineers.* Students noticed when they were the only female or the only student of a racial or ethnic minority in a class. The male, Hispanic chemistry student narrated multiple accounts of being the only Hispanic student in a course:

> It's like – it happens a lot like I was in the – I actually realized that when I took Math 36…, the professor asked like – it's usually for engineers, so the professor asked like, "Oh how many non-engineers are in the class?" And there's like only 2 of us that raised our hand…And then – so it was like really awkward. So he's like, "Oh ok." So he's like, "Put your hands down." And I didn't even think about it then until like someone was asking me about the class and it was just the only 2 people who raised his hand was me, Mexican kid in the seat in the back, and then this other girl who turned out to be African American.

Females in the sample also noticed when there were fewer of them or when there were not many female professors and teaching assistants. The female electrical engineering student reported, "I think there's like 4 of us in my grade…Compared to like 30 or 40 guys…. but then that's also – I don't know if that's something that bothers me because it's like the majority are guys." The female biochemistry student said, "I was sitting in [Organic Chemistry] and I was look at the room. I realized Professor… was a male, and all of the TAs were guys and I like – I didn't see a single female up there." For this particular student, the lack of representation of women in the staff concerned her enough to seek out a female chemistry professor to further inquire the possible difficulties of a woman pursuing a science career. The classroom composition of students and professors may then lead students to form outcome expectations if they were to pursue a STEM career themselves.

When asked about what comes to their mind when they think of a typical individual in their specific discipline, students responded with an array of answers based on their different experiences. For the pre-medical track students, the female biochemistry student based her conceptions on the physicians she's met in real life while the male chemistry student based his conceptions on stereotypes. It is unclear as to where and how these stereotypes were formed. The female biochemistry student explained:

> There were 2 kinds of physicians. There were the younger ones that were just like running back and forth… And then there was the older ones, who was like head of the department just kind of walked in every morning, "Hi ..." They were just really relaxed and I want to be like you…. I usually I imagine them – imagine someone dressed very professionally in the white lab coat like you know like papers in their arms like like ready to talk to you and sound very eloquent and be like very much so on top of everything and very knowledgeable.

Meanwhile, for the same discipline, the male chemistry major responded:

> I would say like [doctors] would be White – most likely White. You know, in terms of like what they do, um, you know would be the – the well work – regular work then like activities – they play golf or hike. You know, they go like to the country club, they have like a country club membership. You know they play tennis and like all those things.

The computer science students in the sample also expressed mixed views of a typical computer science professional. The male, Asian computer science student expressed, "I see it as bachelors basically. It's all guys mostly and they all like have a very immature sense of humor and they kind of very like you know like drinking, videogames, and like I don't know like like all these modern cultural sensibilities." Meanwhile the female, White computer science student relayed, "I have the perfect image of like of a – it's like a white guy in lighter blue jeans that are like kind of too big, and then they're wearing like the white new balance sneakers, and like in like a just a random T-shirt like a Hackathon or like just something free. And like a bowl haircut." When asked about where that specific image originated, she laughed, "Because there's so many people who look like that in the department and I notice them."

Future Supports for Students

With regard to the kind of support that students felt they might need going forward, respondents mentioned an array of different issues. The biochemistry student, female electrical engineering student, and one of the male computer science students expressed a desire for *smaller classes* for various reasons. The biochemistry student wished for more interactions with professors, which inherently comes with a smaller class size. She said, "I wish accessing the professors could be a little easier and like especially for like [Organic Chemistry 1], if that was a little smaller and we could have had a smaller environment, that would have been great." Meanwhile, the female electrical engineering student liked the community effort in smaller courses: "I definitely feel like at least personally I learn a lot better when it's a smaller group and interacting with a professor instead of a giant lecture hall." The male, Asian computer science student echoed his dislike for big, lecture style courses. However, his reasoning for smaller classes was to gain more confidence in speaking up in his STEM courses. "Like I'm not very comfortable speaking in classes – like any of my classes here at Tufts. Whereas in high school, everyone was my friend, I didn't mind…It's also like the lecture style's really boring. Like I can fall asleep." To him, being able to know everyone in his class was important to his self-efficacy and ability to actively participate in class.

Both of these female students also expressed strong opinions about wishing that some of their professors had showed students *more respect*. They narrated instances of students feeling disrespected by professors and how that disrespect discourages participation in a course. The biochemistry student explained, "[S]o it's like and it's also like you go and ask questions and that like…I feel like especially with some of the older professors, I feel like I'm talked down to sometimes, which is frustrating [be]cause I'm just trying to understand." The electrical engineering student echoed:

> I've had other professors who students ask questions and they just like look at them, like, "Why are you interrupting my lecture? Like why are you asking a question?" But that should be how teaching works. You should ask questions. Teachers should provoke questions in students.

However, the other future supports that respondents reported were very unique to each individual. The female mathematics student spoke about desiring a *less stressful high school environment*, because she felt that her high school experience and that of other students' were very busy with balancing homework and extracurricular activities in order to gain college admittance. The female, White/Hispanic biology student expressed a desire for *more tutoring services* in particular because of her current struggle with her introductory chemistry course. She also wished for *congregated resources for pre-health students* because of her experience of having to seek out the information herself. She responded, "[J]ust something for where I can look for internships, and I can look for what schools require what. That would be really helpful because I mean [veterinary school] is the end goal and like I would stalk those websites that have that information but like separately." The male, Asian computer science student wished for more *formalized opportunities to work with professors in their research*, because he felt that his research endeavors were due to chance. He stated:

> [Be]cause then at Tufts… they don't really have like a formalized way of like stepping into a professor's research projects. You basically find the – maybe I guess you find them in office hours or you know someone who's already doing research and you're friends with them or like, you know, meet a TA or – it's very informal.

The female, Asian biology student also expressed her desire for *formalized work opportunities* and added a desire for *formalized mentoring systems*. However, her desired future supports were stemmed from her strong perspective of being a first-generation college student. She stated:

> Because I think like yeah there are internship opportunities, but like the competition you're up against with people who have come from privileged parents have hooked them up with connections. And they have relevant experience because of those connections. It's like you know. But having more internship opportunities like with that in consideration I just like yeah having more resources. I mean, they have tutoring here so. I guess. But internship is definitely a big thing.

In addition, she added, "So I think that like doing a mentoring system similar to that and like being there for each other, um is like what's most important."

The Role of Media

When asked about STEM-related media consumption in their lives, students in the sample responded *identifying with media characters* in their childhood and high school experiences, while also *using media to better understand the lives of STEM professionals* in their high school and university experiences. The male, Asian computer science student explained his identification with a tech-oriented character. "I would say I did relate to like Freddy from *iCarly* a lot, or like I would always feel really bad for him when people made fun of him…[H]e was white. But still, I could relate. Cause I was nerdy. Yeah I wear glasses."

During their high school experiences, the female biochemistry student and the female computer science student identified with characters as well as used information from television shows to inform what they might come to expect from pursuing STEM careers. The biochemistry student watched *House,* a medical drama, in high school and explained how she related to a female doctor because she had looked similar to the student, and to another female doctor because of personality traits. She said:

> There was one physician. She was a – in the ER. And she had blonde hair – she looked a lot like me and I liked her – what's her name – Cameron. Her name was Cameron. Dr. Cameron yeah… I always saw myself in different characters in different ways. There was another female physician who I really – in that show – who I really liked as well. And like I think my personality was more like hers so I identified more with her.

In addition, she was able to relate the medical drama's content to real lives of physicians. "It was interesting cause like now when I'm looking at medicine, it's like a lot of times you talk about doctors marrying doctors because like they understand the lifestyle – it was actually what you see in the show," she reported. Meanwhile, the female computer science student related to a character from *Criminal Minds,* a procedural crime drama television show, because they shared the same hair color and interests. She stated, "There's like this one girl she has like like bleach blonde hair. She like the computer lady, but she's also like really quirky. So like fit in with that like stereotype." In addition, she also watched *House* like the biochemistry student, but used the media content to inform her on the expectations of being a doctor, which dissuaded her from pursuing a medical career. She explained:

> Then in high school I really liked *House*. I loved watching *House*. And I liked the mystery of the diagnosis. And I was like, "I'll be a doctor." And I was like, I don't want to be a doctor. I don't – I didn't want to like – like touch people. Like I didn't wanna – like you watch other medical shows and they have to be like cut people open and hurt them.

Even at a university level, students may still interpret and criticize media portrayals of their discipline. Both male, Asian computer science students mentioned the show *Silicon Valley* which exhibits the lives of computer scientists. Though both students still watch the show and enjoy it, the student interested in research commented, "I don't think there was any portrayal of a computer scientist that was like true to life [laughs] like like that isn't like a stereotypical nerdy hacker or something like that."

Many researchers have investigated the significance of the role of media in informing students' interests in STEM and their pursuits of STEM opportunities. A professor from George Mason University studying this issue expanded on the importance having individuals of racial and ethnic minorities play active roles in television shows. He states that it is not enough to simply have individuals from underrepresented groups play the role of scientists, but for them to also play lead roles. He explained his research:

> African American and Latino kids consume the most television, you know 10 – 13 hours. And when you look at what's in that content, you – you see that little of it represents them, and of the content that does represent them, you look at then the STEM media, you really don't see African American and Latinos in an active role in STEM media. So you

> may see a scientist, but, you know, that scientist is helping somebody. Or, you know, when you look at, a perfect example is when you look at TV and you look at all these procedural crime shows, right?…The medical examiner is always a person of color, right?...And their job is to help the main character, um, figure out the murder. They aren't the ones who are the focal point.

He expanded on the possible impact of these media representations:

> So what that does is that when you're talking to young people and you're trying to get them interested in STEM careers, they see it not as a entrepreneurial, self-sufficient, you know, leadership, focused, uh, discipline or career. They see it as, "Oh, I'll be in a lab. I'll, I'll be running tests to give to somebody. I'll be," you know. And so one of the things that we've tried to kind of move the conversation towards is to begin to look at how we tend to have media depict girls and students of color in more active leadership roles to show that these are roles that are for everyone. Because we know that kids and – that kids typically in early elementary and primary school, they pretty much select what they're gonna do in terms of a career or or major. And that often times are based on the media they are exposed to. And what they're exposed to in that community. So unless you're seeing it in your community, or you are seeing it on television, it doesn't – it's not something that you – you, well you know, that you decide to do, you know. If you don't see an astrophysicist, chances are you're not gonna say, "You know what? I want to be an astrophysicist." But if you do see, you see, you know Neil deGrasse Tyson or Steve Hawking, you're gonna want to do what they do.

Exposure, as mentioned above, to students' intended career paths was salient in the student interview data. All students were exposed to some sort portrayal or understanding of their intended career paths at some point in time. Media can be a contributor to exposure, as the male learning technologies professor mentioned above. This was reaffirmed when the male, Asian computer science student mentioned not only did his brother encourage him to take a computer course, it was also "like social media and everything." He later explained that he had heard about computer science through the popularity of the creation of social media platforms.

The learning technologies professor also discussed the importance of leading roles in younger children's television:

> So when you look – so for young kids when you look at children's media, you see more diversity like you seldom see singular leadership…So *Wordgirl*, she's by herself, right? She's in charge. She has no sidekicks… [W]hen you look at *Cyberchase*, you know, like my kids love *Cyberchase*. Look at *Cyberchase*. There's a clear leader and an ensemble cast. And so the what typically happens is that cause creators and networks are trying to create diverse audiences, they'll – they'll create these ensemble casts, right? Well they'll have, okay, 2 girls, 2 boys, you know. And you can tell. They look deliberate…But when you look at the roles that the girls are playing the roles the boys of color are playing and some cases, they aren't the proactive leadership.

Two WGBH digital producers were also interviewed to gain their perspectives on the role of media in helping young children learn STEM, how individuals may identify with characters, and how lives of STEM people are portrayed. Through WGBH new interactive digital media like *Plum Landing* which engages children to explore the environment or *Design Squad* which encourages students to make projects and share them, one producer commented on their goals in terms of science and engineering:

> What we're trying to do is teach kids to be scientist and see themselves as scientists, and to think of that in a good way. What does it mean to step through the scientific inquiry process? To seek – to identify the problem, to predict what might happen if you do something because that's solutions, to communicate results.

It is more than just learning content, "like knowing what a swale is." STEM content is attempting to teach skills that children can apply to other areas of study and to other areas of their lives. A producer in particular believed that when you help children build "habits of mind," it gets rid of the stigma that often comes with science and engineering that certain people can achieve in it. "It becomes a more open field," she said. In terms of math, new WGBH content such as *Gracie and Friends* which is a collection of apps engaging in mathematical skills, aims to help children gain skills like partitioning and subitizing that they may not be receiving in traditional mathematics classroom curriculum.

In expanding on the role of STEM-related media for children, the two producers echoed that media can provide role models for children to identify with who are modeling the process of science and engineering. The characters featured in digital media actually began from producers developing short biographies and personality traits for each character, and from there designers drafted character designs that emulated the personalities that producers desired. They also recognized the importance of trying to resonate with the culture of the children they're trying to reach out to, which were children who come from low-income neighborhood. A producer explained that the little details such as adding a rainbow pearl necklace and bows in Zoey's hair in *Sesame Street* made characters more relatable. These two producers specifically are executing projects to co-design with children, so that their media content is further informed and relatable and relevant to young children.

Professors

Several Tufts University professors were also interviewed to gain their perspectives of what supports that are currently in place to aid students in their pursuits of STEM careers, what future supports they believe that students still need, and their opinions on the role of media. Some professors emphasized the importance of *community building* to support students. A female, mathematics professor relayed, “So it’s pretty important to me that students, you know, start to develop a community sensibility around the work.” She elaborated that collaborative efforts and learning were important to making students feel like they belonged to the mathematics community. A female, electrical engineering professor expanded and explained that community building is not exclusive to a particular group; for example, women organizations should not only include women. She stated:

> [W]hen we’re talking about these women organizations where women get together, there – there’s guys that go too. Because they’re like really – the Women in Engineering, one third of the membership is guys, because when you think about it, they want to support their daughters, their wives, their girlfriends, and you know like my dad, he wanted his daughter to have support. So people are joining to show support.

Professors also expressed that they believed students benefitted from having good *mentoring* from upperclassmen and professors. A male, mechanical engineering professor discussed a mentoring system in place for engineers. He said, “[T]he idea was to really try and get the upperclassmen to help mentor the lowerclassmen – younger classmen.” The female, electrical engineering professor also discussed the role of professors with regards to mentorship. She reflected, “I think good mentoring helps bring [confidence] out in people and helps you develop the skills you need to get - to achieve your dreams, and that's been my entire life goal as being a professor. It's not about me anymore. It's about what can I do to make sure young people don't go through what I went through."

Another salient theme that came across professor interview data was that professors believed that students need to be more *comfortable with failure*. The female electrical engineering professor explained how comfort with failure and perceptions of success may inherently be gender-biased. She discussed this idea further:

> Another thing is girls take to heart success and failure. Engineering is all about failing and getting up to go again. And we teach girls that, you know, they have to be perfect, everything has to be perfect…You say that [she has to be good at math and science] to a girl, A+ – you say that to a boy, eh, a C/C- as long as they pass…[P]erception's everything.

A female biology professor echoed that students should understand that mistakes are normal, especially in the role of research. She said:

> Mistakes are the order of – you know, that's just the order of business in research. We make mistakes. And sometimes we feel stupid, so if they feel stupid, that's nothing new. You know, I tell my people, "When you're doing research, you're doing something people haven't done before. Nobody knows the answer. So if you feel stupid, that's a normal response. But you just have to not be bothered by it.

Being able to not be bothered by mistakes and to shift what it means to fail are important in supporting students, according to professors.

Other than the three above supports that students from which may benefit (*community building, mentoring,* and *comfort with failure),* a large portion of the professors interviewed named other supports such as *students working one-on-one with professors in their research*, more funding in the *Summer Scholars* program, the *bridge programs* on campus, *networking*, and *exposure to STEM professionals* through career panels and guest lectures.

Similar to the students, professors were also asked about their interpretations of media in the role of informing STEM pursuits in students. Two professors out of the seven interviewed had attributed media as a factor before the interviewer had mentioned the topic of media. A male, African-American chemical engineering professor discussed media's role in informing his prospects of pursuing a medical career in high school. He explained:

> I think media really does a good job of portraying sort of a – this – the medical profession is a highly used profession particularly used in TV and movies or whatever so, from the sciences you really can see people doing medicine. And also too when you're a young child going to the doctor and you just – it's just one of those professions that I think that most people – parents, teachers – are able to readily describe as a successful science-based career.

The female, electrical engineering professor discussed media's role in influencing young girls and what she wished from media. She reflected:

> [Y]ou turn on the TV, you don't see smart women, they're – they're eye candy. They're trophy wives. You know, they - they have to look good and be pretty, you know, and that's it. That's all that matters… I'd like them to stop showing just stupid rich girls wasting time and money just looking good. And – and seeing – and think about if, you know Kim Kardashian went out and did some technology project – even if she's not into technology but what she did is something to benefit humanity other than just throwing money at it."

However, many of the professors in the sample reported different views of what they perceived that their students could benefit from, but these factors are not generalizable. These other supports included classroom management styles such as knowing names and student active participation, students knowing what to call a professor, collaborative learning amongst the students and between professors and students, working one-on-one with professors during office hours, promoting large solution diversities, development of portfolios, all students learning how to problem solve, learning how to study material, students needing more freedom in their educational pursuits, open-ended project-based learning, professors using different teaching styles for different audiences, respect from professors, addressing mental health on campus, and students having passion.

In terms of personal goals, professors in the sample believed that there is a need to get students to think ahead, reassuring students of their career choice, more research resources from the university, a need in a shift in perspective of what success is, and cohesiveness amongst bridge programs. The bridge programs specifically on campus, including Bridge to Liberal Arts Success at Tufts (BLAST), Bridge to Engineering Success at Tufts (BEST), and Promoting Retention in Science and Engineering (PRISE), all serve the same goals: to help students from disadvantaged backgrounds transition into and success in university settings. However, the male chemical engineering professor who works closely with one of the bridge programs expressed:

> They are separate. They are similar goals. Um, part of what I've been trying to do is create more cohesiveness across the programs. First starting with PRISE and BEST because those are programs that we directly run through the Center for STEM Diversity. But PRISE has a cohort of students that are science related. So finding ways to work with

them as well. There had been some – some talks about finding ways to create more cohesiveness. But for a number of reasons, that hasn't happened.

Thus, even though there are programs on campus that serve to support certain students, they may benefit more from overall communication and cohesiveness in the programs.

And lastly, in terms of outcome expectations, professors also discussed the importance of exposure through faculty websites (such as the website that a male, mathematics professor has put together for students), seeing a community of scholars at Tufts, and admission statistical breakdowns. Other supports that did not fit within SCCT include the need of a tough female personality to be successful in STEM. A female chemistry professor expressed her opinions as to why there may not be many women who pursue chemical research:

> It's just that I think women are – yeah kind of shy away from it in some way…I think you just have to – you just carry on and keep going and I think it's true sometimes where like I run into situations where I'm like if I was a man, like this you know, wouldn't be an issue or something. But I don't know, I just take it in stride I guess is the best way. And I think you know for students like that one, I feel like that's great. I'm glad that I was here to say like, "Screw them. Like just do it, you know." And she's going to. Who knows what she'll do?

Other supports that professors discuss include professors needing to have industry experience, according to the female electrical engineering professors, and the need for a physical room in the department for students to talk to other students or faculty members, expressed by a male mathematics professor.

Perceptions of Diversity

One of the goals of this project was to better understand how to address the issue of diversity in STEM fields. However, through the interviewing process of all the Tufts participants, it was interesting to find that everyone, even those who come from the same department, interpreted "diversity" differently. Many viewed diversity in terms of gender and race/ethnicity. Others viewed it in terms of socioeconomic diversity. And others thought of it as an amalgamation of people who spoke different languages, not purely based on visuals. Once I clarified that my study wanted to define diversity more in terms of gendered and racial/ethnic diversity, I found it interesting that each person perceived diversity in their discipline in similar and different ways.

The following is a collection of the different views of STEM in terms of diversity:

Chemistry:

A female chemistry professor said:

> I wanna say I think the male – female ratio is, I mean, I haven't noticed, I think it's about 50%. Students of color, I don't know what the – I don't know how different it is from the overall diversity at Tufts. So that's to say that, you know, there are some students of color in the class. They're not the majority. And, yeah, so may – I wanna say it's like off the top of my head, maybe 10 to 15% of the class students of color.

A male, Hispanic chemistry student reflected:

> Like if you go into like [general chemistry], or like Bio 13, there's like – well, Bio 13 has like 400 kids in the class. And like yeah you'll see a little bit of diversity there but once you get higher and higher up the ranks, like now in my – like that [chemistry] seminar class, that's 6 of us, first of all I'm the only undergrad in the class. And then I'm the only non-white kid in the class. And that's not just that seminar.

Biology:

A female, biology professor said:

> [I]t is a majority-female campus actually already. Among undergrads…And certainly in biology, it's majority female.

A female, White/Hispanic biology student partially agreed:

> [I]n terms of pre-health students, I've noticed an equal –or I think I notice an equal distribution. But when it comes to it being in class, it's usually a lot of guys and a lot of white guys and yeah so but at the same time like I think that it's not as inimi-like I don't find it as intimidating. I'm kind of – and I don't know if it's just like me as a person or it's just our society like being way more open than it used to be. Like I'm totally willing to go in and be like the only girl there.

Math:

A male, mathematics professor said:

> Um, maybe 6 years ago, for a long time it was half women, half men math majors, and now it's somewhat more men. I can look and figure it out sort of. And I didn't know why.

A female, White mathematics student agreed:

> Also my math classes are you know predominantly guys. My math class last semester was 2 girls and like 14 guys… Girls are a lot quieter in class…The girls don't speak. There's 1 girl in my math class that speaks. But there's a lot of boys that speak.

Computer Science:

A female, White computer science student said:

> There's definitely less women than men. It's weird though because after a while you like stop noticing it until I took – I took a Calc class. And I like – I was like wow, there's a lot

> of girls in here. And I counted and it was like no, it was 50/50. But it feels like there are way more men than there are women right now because I'm like so used to it being like skewed the other way… There's like some diversity. There's like, you get like decent international students. Cause like some kids from India, a decent people from China, and like a handful of students from Africa like maybe 1 or 2. But the majority of it is American white people.

A male, Asian computer science student agreed in terms of racial and ethnic diversity:

> I feel like, especially at Tufts, and especially in the comp sci department, we do a better job at that. I know there are like a good amount of like females, good amount of minorities, but I also think computer science industry also caters a lot of Chinese people and like Indian people.

Electrical Engineering:

A female electrical and computer engineering professor stated:

> Well, there's still less than 21% of women that get graduate degrees or undergraduate degrees 'cause – maybe 18%. So if you looking at all the women just getting Bachelors of Science degrees, it's already low… Diversity here is still a challenge. This – this first question about more women? Depends on the major. And again, that's all socially stigmatized. So right now, chemical and biomedical are very [in stable] – are very doing okay with women. And the reason for that is women like seeing the bigger picture. So cleaning up the environment or developing medicines to cure cancer or developing assistive technologies for whatever. There's a lot of human benefit. "I see that my work benefits humanity." Now let me ask you what an electrical engineer do that benefits humanity. Most people can't answer that.

A female, White electrical engineering student echoed:

> I think there's like 4 of us [females] in my grade…Compared to like 30 or 40 guys.

It is interesting in examining quotes from interviews that in general, many of the participants agreed on who participates or what the classroom composition looked like. These perceptions of what the Tufts STEM community looks like may further influence students' outcome expectations and how they feel in terms of belonging to that community.

Discussion

What contextual factors and supports have influenced college students' imagining of future selves and decision-making throughout their professional development in science, technology, engineering, and math (STEM), especially for students of color and women who have been historically underrepresented in these fields?

Contextual factors and supports examined through SCCT related to students' decisions about pursuing and studying STEM, as well as related to how they view themselves as STEM people. Student's enjoyment of STEM subjects and ease of understanding STEM material that contributed towards building self-efficacy were present in childhood for some students. Dedication to a career choice, family support and expectations, and exploration of different STEM fields were also present in childhood. These factors carried across high school and university experiences to develop personal goals. With regard to forming outcome expectations, exposure to STEM professionals and exposure to media involving STEM characters also stemmed in childhood. Though students at that age may not have chosen their permanent STEM careers, they still developed career prospects and support systems that carried on throughout their lives to ultimately help them make decisions when it comes to whether or not to pursue a STEM career. Because of the exposure aspect to STEM and confidence and happiness from interacting with STEM, students were able to perceive STEM to be relatable and positive from a young age. These attitudes may have been critical in combatting the stigma that STEM is hard and not meant for certain groups of people, especially for the females and students of racial and ethnic minorities in the sample.

During their high school experiences, high achievement and exemplary projects demonstrated students' abilities and contributed to self-efficacies. What was unique to some students' high school experiences was that they began to become more engaged in extracurricular activities, interact with influential science and math teachers, and develop a concrete group of peers who shared similar STEM interests. Factors that supported their STEM interests and pursuits expanded beyond themselves, and became more social. This is also the time period when students expressed that their families had strong opinions, expectations, and support because of their college preparation and their college applications. The engineering students specifically already had to know that they wanted to pursue engineering in order to apply to the Tufts Engineering School rather than the Arts & Sciences. These decisions were likely influenced by the social factors that helped students explore and decide whether or not to pursue a STEM career. It is interesting to point out that only one out of the ten participants indicated that he entered college intending to major in a non-STEM major. The male, Asian computer science student originally intended to major in psychology because he was genuinely interested in it, but also took the introductory computer science course because of external encouragements. The other participants already had a developed interest and desire to pursue a STEM career previous to college, especially in their high school years. It is also interesting to point out that 7 of 9 students took AP science courses in high school, and all of them have taken some sort of an Honors science course.

Once students entered college, the factors and supports that contributed much to their retention in the pursuit of STEM careers revolved around personal growth and social interactions that contributed to all aspects of SCCT: self-efficacy, personal goals, and outcome expectations. Some students had to better understand how they best learn and engage with a subject and become comfortable with being different. For example, the male Hispanic chemistry student, the female White mathematics major, the female White electrical engineering student, the female White computer science student, and the female White/Hispanic biology student all at one point or another in their interviews stated that they did not mind that they were different from the majority. Whereas the Hispanic chemistry student did not mind being the only student of a racial or ethnic minority because he saw himself as an accomplished person, the female students emphasized that they would go along "doing [their] own thing." Students who share classes with the participants, supportive professors, advisors, and professionals met through networking also contributed towards the participants' retentions in their STEM pursuits at the university level. These social interactions gave students a sense of belonging and reaffirmed their decision-making when it comes to which extracurricular activities to participate in, which internships to look for, and which courses to take.

During childhood, many of the supports and factors that have helped students were to establish a base in an internal dedication to STEM. High school experiences offered social factors and interactions with people interested in STEM to further dedicate the student to STEM. And finally, so far, factors in university experiences have involved both personal growth and social interactions that have supported these students in pursuing STEM careers.

However, it is important to note that many of the themes that were found in the interview data affirmed what the literature already knows about supports that may contribute to success in STEM fields for all students, not just for female students or students of racial and ethnic minorities. Enjoyment of a subject, ease of understanding of science and math, and high performance and feedback from Honors or AP STEM courses or from a cool project aligned with the achievement literature. Positive achievement contributed towards reaffirming self-efficacies. According to SCCT, these positive feedbacks in relation to being in environments that were conducive to students' science and math learning contributed towards a sense of proficiency and accomplishment in these students. Family and teacher support as reported by these participants also aligned with the literature on social influences in informing personal goals in STEM. Positive achievement in STEM in addition to positive feedback from family members and teachers may contribute towards high levels of self-efficacy and inform personal goals. All participants in the sample thus seemed to share these support systems that can benefit all students, as suggested by past research.

It is also interesting to examine the inverse. Many of the participants felt that they were grateful for their accomplishments and that they were lucky. But what about the students who may not have access to school systems with Honors and/or AP science and math courses, high-quality, engaging teachers, and families who have the time to engaged in their children's academics? The above contextual factors have shown to have helped the participants and are known to be helpful for all students in their STEM pursuits according to existing literature. Thus, the issue of why females and students of color are not as well-represented in STEM fields compared to their White, male counterparts may be much more complicated and nuanced when considering issues of socioeconomic status and income inequality. This finding reaffirms

Navarro, Flores, & Worthington's (2007) previous analysis that social class was a predictor of math and science self-efficacies.

But what is different from previous findings in the existing literature? When considering outcome expectations aspects of SCCT, expectations that have been formed due to exposure to different STEM professionals, STEM media portrayals, and STEM classroom compositions showed to influence the participants' beliefs of their possible futures and how they see themselves relating to STEM communities. Students' collections of ideas of what "STEM" is and means, and the community associated with STEM often times influenced their identifications of being the "other."

Students in general identified as a STEM individual because of their chosen majors or chosen careers paths. When students discussed supports and their goals in the interview process, some students generally identified themselves as a STEM person, whereas others attempted to label themselves as specific STEM professionals. For example, because of the male, chemistry student's current indecision about whether or not to pursue a career in researching chemistry or to pursue medical school, he identified himself as a science person. The female computer science student also shared an indecision: though she knew she was pursuing computer science, she saw computer science's flexibility as an open opportunity to explore other STEM fields. She discussed how she can apply her computer science skills to other disciplines like biology if she so chooses in the future. Thus, students' general STEM identities were often narrated through their indecision and desire for flexibility in their STEM career decisions if they later found that they were unhappy with their pursuits.

Meanwhile, the female, White/Hispanic biology student did not identify herself as a biologist. She saw herself as a pre-health student aiming to become a veterinarian. She attributed some of that to her conceptions of what it meant to be a scientist: "I like even now still hearing the word scientist just sounds so like crouched over bench pipetting things. Even though like I'm in the science field and I know scientists can be policy makers and women you know. But I always just pictured a lab coat." Because of her extracurricular experiences and interactions with veterinarians where she had hands-on experiences and saw herself in the field, actively helping animals, she could not relate to the idea of a scientist, even though she is majoring in biology. Therefore, dedication to a career choice and exposure to what STEM is and means, both factors that were salient even during childhood, may contribute towards students' identity development and how they see themselves relating to STEM. These students found inclusion in the idea of the general STEM professional or as specific STEM individuals.

However, identifying as a STEM community participant became more complicated and nuanced when students discussed how they see themselves fitting into their STEM community. Many mentioned how they notice that females and/or students of racial and ethnic minorities are not well-represented in their STEM classes, specifically at Tufts University, as seen from the "Diversity" section of the "Results." Some students discussed how they are unsure about how they feel about being the "other;" meanwhile, some students use their status of being the "other" as an indication of accomplishments, such as the male, Hispanic chemistry student who deemed being a Hispanic individual graduating with a Bachelors of Science as one of his proudest accomplishments.

This status of "otherness" inherently informs how these students seek for supports. For instance, the female, White biochemistry student sought out a female chemistry professor because she had felt "other-ed" and not as a welcomed participant in chemistry community due to the lack of female representation in her class. She wanted to hear from female STEM professional and to seek advice in overcoming the possible barriers that arise for females pursuing science. In another example, the female, Asian biology student did not explicitly identify that it was being a woman or a student of a racial minority that made her the "other," but rather it was her identification with being a first-generation student that cultivated this feeling of "otherness." Thus, she sought for more more sensitivity to her being a first-generation student and a general understanding that not everyone comes from the same background when it comes to applying for internship opportunities. Thus, feeling a status of "otherness" is not constricted to race, gender, and ethnicity, but also socioeconomic status as well.

This status of "otherness" may have begun when outcome expectations began to form at young ages, and this status was reaffirmed or opposed throughout their lives. Throughout the interview data, students discussed their ideas of the STEM community and STEM professionals, and how their conceptions of these ideas were influenced by exposure or lack of exposure to STEM professionals along, by media portrayals of some STEM professions, and by their classroom composition of students and professors. The SCCT states that from these outcome expectations, individuals imagine consequences of their decision-making and possible futures (Lent, Brown, & Hackett, 2002). I argue that the interview data suggests that because these female students and students of racial and ethnic minorities have developed outcome expectations for themselves as STEM people and in general have noticed the lack of representation of individuals who are *like* themselves, not just individuals who *look like* themselves, they may view themselves as the "exception" or the "other."

Media portrayals and media messages surrounding STEM in particular may be influential in supporting or deterring constructions of outcome expectations and conceptions of what it means to be a STEM professional. Many students and professors were able to pinpoint characters that they related to or were able to express opinions on STEM media portrayals. This relation to media characters or ideas surrounding STEM showed some influence in reinforcing or challenging previous conceptions of scientists and engineers. Because media can bring exposure of STEM professionals to the lives of children who may not see scientists or engineers in their neighborhood, researchers and WGBH professionals are harnessing the potential of media and aiming to use it in a way that engages students and in a way that helps young children relate to STEM characters. This may mean more for students of racial and ethnic minorities with regard to exposure to STEM professionals through media and the lack of people of color in STEM fields. As the George Mason University professor explained, African American and Latino children tend to be heavier media users. Previous content analyses have also shown that the representations of females and individuals of color have been unbalanced and show a lack of these individuals playing active STEM roles (Steinke & Long, 1996; Steinke, 2005). Other literature also suggests that because of these unbalanced media portrayals and dearth of STEM role models in media, students of color in particular may express lower self-esteem because they do not often see character who look like themselves portrayed positively (Greenberg, Mastro, & Brand, 2002; Rivadeneyra, Ward, & Gordon, 2007). In return, because students of color with heavier media use in particular may be exposed to more of these images and messages, which might be a contributing factor in the dearth of people of color in STEM. However, the issue of seeing media characters who look like the students of color may be nuanced that originally anticipated.

This study began as an examination of how positive achievement and with supportive individuals such as family members and teachers coupled with seeing those who look like themselves in terms of race, gender, and ethnicity, may be important contributions to students' successes in STEM. However, the issue may be larger than just the scope of race, gender, and ethnicity. Socioeconomic class and the status of "otherness" may also be contributing barriers that may influence students' perceptions of themselves and as participants of the culture surrounding STEM. Lent, Brown, & Hackett (2000) allude to the influence of perceived career barriers in supporting or deterring individuals from persisting in their career interests. The status of "otherness" in of itself is already a barrier. Additional barriers for females and individuals of racial and ethnic minorities who wish to pursue STEM careers may include established beliefs about intelligence, stereotype threat, self-assessment, and implicit bias from professions in the field (Hill, Corbett, & St. Rose, 2010; Rosenbloom, et al., 2008). My initial solution to these barriers was that we need more role models that looks like the students who are trying to pursue these careers. However, taking into account the issue of "otherness," the solution is not simply just having individuals who look like the students present in STEM fields and media, but rather having individuals who relate to students on various levels, including socioeconomic status or first-generation status. From connecting with individuals who are similar to students in multi-dimensional ways, students can further identify themselves as welcomed participants in the STEM culture, instead of recognizing the stereotypes or lack of role models and believing that they are the "exception" or the "other."

The SCCT aims to explain that the three different components such as self-efficacy, personal goals, and outcome expectations interact with environmental factors (Lent, Brown, & Hackett, 2002). These environmental factors include the career barriers that were previously stated. It is important the highlight that the three components are internally constructed; however, they are immensely influenced and informed by the intersections of the systems, people, power, and existing barriers that individuals perceive. Ultimately, students' successes in STEM are not due to factors that are purely internally constructed and driven, but rather their constructions of self-efficacy, personal goals, and outcome expectations *in relation to* outside influences and barriers, and how they identify with the culture, which may be reaffirmed or influenced through media, and the community they are attempting to participate in.

The two most salient supports that suggests success for female students and students of racial and ethnic minorities in STEM fields that professors and administrators should pay special attention to is the desire for a mentoring structure and the creation of communities of different kinds. The benefits of a formalized mentoring structure within the university system is that it provides students to connect with other students of similar backgrounds, beyond just the issues of race, gender, and ethnicity. This connection may be tremendously important in influencing students' perceptions of being participants, rather than being the "other," in their STEM fields. However, in addition to these mentoring structures, it is important to build communities of different kinds. Students throughout the interview data repeatedly stated the importance of feeling like a part of a group that goes through the obstacles of students in STEM *together*. Bridge programs on campus attempt to create these communities; however the problems of creating communities of individuals of similar backgrounds may inherently cause these students to isolate themselves and revert back to a state of "otherness" rather than a state of belonging. The male, Hispanic chemistry major who has participated in a bridge program explained that he felt that students in the program may isolate themselves and creating an environment of seclusion. He stated,

> It's just like yeah, it's 6%, but like how many of those share the same major? Like how many of those have like done the same activities? Live in the same dorm? You're not really increasing diversity – it's just the same thing. You're taking them from their

> environment and just moving them and creating another secluded area for them here at Tufts.

So though there a community to be built around bridge programs, some students still may feel like outsiders and not integrated into the Tufts community as a whole or the STEM community as a whole. I believe that it is important to have a balance of the two – creating relationships between those who may share similar life experiences and well as creating participatory communities made up of different individuals so that new relationships built may transcend these barriers of isolation due to the "otherness" status.

Professors generally agreed with the importance of community building, good mentoring, and developing a comfort with failure in students in order to help students, especially female students and students of racial and ethnic minorities, continue to pursue and succeed in STEM fields. Often times, professors related what supported students to what had helped or did not help them during their personal pursuits of STEM. For example, a female electrical engineering professor voiced the difficulties of being a woman in engineering. She often faced hesitation or lack of encouragement from advisors. In return, she believes that helping students achieve their dreams, regardless of how big that dream is, is key in supporting students.

It is also important to note that much of the discourse that revolved around what supports professors are doing to help students pursue STEM revolved around a discussion of what would help all Tufts students, not just females and students of racial and ethnic minorities. Often times, professors would emphasize that the supports they named would be helpful to all students, but may mean even more for students who may feel marginalized due to their gender or race or ethnicity. For example, knowing each student's name was a salient practice amongst many professors. A female math professor stated, "I think it's crucial to learn everyone's names early...And I think students especially from minority groups really notice when you know their names…it has an outsized importance and it's relatively easy." This practice may be particularly important for female students and students of racial and ethnic minorities because if professors know their names, that is one less barrier removed from students feeling separated and "other-ed."

In cases where female students or students of color feel particularly "other-ed," professors recognize the importance of getting to know those students and asking what they can do better in order to help the students feel included. For example, a male, mathematics professor commented,

> I'd…want to talk to them about what – like what's going on and why they feel isolated. Is it just because they're one of two women in the math class, or is it that either I or other students are doing something not right?... I don't teach in [the] BP [building] so I teach in a place where I'll try to get to the class a little bit early and get there on time and everything's all set and so I talk to a range of students and ask them how they are and all that in hopes that they'll feel sort of involved and connected and that I'm not a mean old guy, or whatever.

Overall, the issue of what supports and contextual factors may influence female students' and students' of color successes in STEM is much more nuanced and complicated that originally anticipated. The scope of the issue is larger than just race, gender, and ethnic representation in STEM fields. It may span to income inequality and the status of "otherness" that was created through the interaction of how students identify themselves as members of the STEM culture and community and of the existing barriers.

Limitations

The present study had many limitations. First and foremost, the sample size precludes any type of assessment beyond it. This study should not be generalized beyond the small sample of 9 Tufts students and 7 Tufts professors who described their interpretations and desires specific to Tufts University culture around STEM. Even with this small sample size, the experiences of the participants were extremely varied and could not, at times, be generalized within the sample. In an effort to overcome this limitation, this study attempted to capture the wide range of views instead of simply making overarching assumptions. Regardless of this limitation, these nuanced views are important contributions towards the existing literature and dialogue surrounding the question of how to support more females and students of color in their STEM career pursuits. Much of the existing literature examines these issues from a deficit-oriented perspective, looking for what students lack and what they are doing wrong. This literature inherently places the blame of the students themselves, rather than acknowledging that student success and failure may be the results of individuals' interactions with existing obstacles. In addition, past research often examines these issues from quantitative approaches that may not capture how nuanced and complicated the issues may be, which this study has done.

In asking much about past supports that helped students choose to pursue STEM today, students had to rely much on memory. This limitation was very pronounced when asked about their media consumption as a child, many said that they could not remember it very well and had to probed to help them remember media images. Thus, it is important to not making large assumptions or generalizations over the impact of media in this study. It is also unclear whether media professionals' efforts with new techniques may help or deter present STEM stereotypes in media, although their efforts are appreciated and may merit some value in influencing and shaping young children's interests in STEM. Another limitation of this study was that when students were asked about their conceptions of a typical scientist or engineering. It is important to consider previous criticisms of the DAST tool: asking individuals to stereotype something may inherently reinforce that stereotype and limit their conceptions. A way that this study attempted to get around that limitation was through interpreting where those conceptions came from and what role it played in student's pursuits.

Overall, there were also limitations that are inherent with self-reported data in terms of validity and accuracy. Firstly, participants may not be honest to the researcher and/or they may not be honest to themselves. Participants may sometimes fabricate information for various reasons like not wanting the researcher to know some information. Secondly, participants may forget some key information because they are speaking from their own perspectives. These perspectives may not encompass all the factors that may have contributed to their identity formation or decision-making. In addition, there are many factors that may be internalized subconsciously, leading participants to approximately speculate what factors have attributed towards their choices in STEM education.

It is also important to highlight that some of these issues, such as students being first-generation students, or students coming from low-income neighborhoods are socioeconomic issues, not just issues of gender and race and ethnicity. Therefore, though some of the female students and students of racial and ethnic minorities in the sample may come from lower-socioeconomic backgrounds, we cannot assume that all females and students of racial and ethnic minorities come from lower socioeconomic backgrounds. A limitation to this study was the complication of attempting to separate gender and racial/ethnicity experiences from socioeconomic experiences when discussing general life experiences. Again, it is difficult to generalize these perceived supports because of various life experiences.

Conclusion and Directions for Future Research

As seen from the above discussion, an array of conclusions can be made to inform current practices and policies that help support students. The SCCT showed the importance of self-efficacy, personal goals, and outcome expectations in influencing career pursuits and trajectories. Many of the themes found in the interview data categorized under the three aspects of SCCT can be applied to all students who wish to pursue STEM careers. However, what was unique to the female participants and students of racial and ethnic minorities was their outcome expectations which were informed through their exposure to different STEM professionals and media portrayals. Their outcome expectations were particularly influenced through their classroom composition and how the STEM culture they are attempting to participate in was different from the individuals themselves. This may have influenced their identification with being the "other" or the "exception" to the rule.

I propose that in order to support students, especially in the aspect of students viewing themselves as the "other," a formalized mentoring structure should be in place in order to connect individuals who are pursuing STEM careers and those who have succeeded in STEM with similar backgrounds to create a larger feeling of inclusion. To balance this connection, I also believe that the creation of welcoming communities of different individuals is also important to avoid the inherent problems of isolation and seclusion.

In order to improve diversity in STEM fields in terms of gender and racial and ethnic diversity, future researchers should further conduct qualitative studies that will be to capture student perspectives and to further examine the nuances and complexities of these issues. The benefits of more qualitative studies on the issue of supporting females and students of racial and ethnic minorities in STEM fields also include capturing the unique experiences of these students and giving them a voice in the existing literature that seems to erase individual stories. Some future researchers may also find it beneficial to conduct case studies of schools where STEM departments may be more gendered, racially, and ethnically diverse, and asking students there what has helped them pursue STEM careers.

Other future research should also attempt to conduct a longitudinal study of females and individuals of racial and ethnic minorities from a young age to adulthood through a case study. That way, accuracy of memory and validity of information cannot limit the study. Though these proposed studies will take a lot of time and resources, I believe that they are worth doing because evidence from past literature and from this study has shown that interest in STEM can start from a very young age. From a longitudinal study, researchers can look at these issues from a human development perspective, allowing us to better understand what supports or practices actually do lead to retention overtime, how the role of being first generation or being from an economically disadvantaged background may impact students' STEM trajectories, and what actually happens when students become STEM professionals themselves. These studies may also be worth doing from a critical theorist paradigm, where school supports can be adjusted as they are being discovered and reported. This perspective may not only help us gain a better picture of what best supports females and students of color, who are traditionally underrepresented in STEM fields, but also may help make a change and inherently support those who wish to pursue STEM and increase diversity in STEM.

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Appendix A: Recruitment Letter to Students

"Dear all,

My name is Michelle Nguyen and I am a senior at Tufts University. I am currently working on my Senior Honors Thesis in Child Study & Human Development. I am interested in college students' experiences and what factors have shaped their imagining of future selves and their decision-making in terms of pursuit of interests. Ultimately, this study will serve as a means to better inform policy and practice to increase diversity in science, technology, engineering, or math (STEM) fields. This is an opportunity for your views to be heard.

I am seeking participants for my study on your experiences that have led you to pursue your STEM interests. This study will be a part of my thesis. The study will also examine what further supports you believe you still need to further achieve in STEM.

Individuals are eligible to participate if:

- You are an undergraduate student AND
- You are intending to major/are majoring in a STEM field.

This study welcomes individuals from various STEM majors, from biology to computer engineering.

As a participant of this study, you will partake in a short survey that will last 5 minutes and an interview that will last 30 to 45 minutes. Participation is completely voluntary.

Please contact me at michelle.nguyen@tufts.edu if you are interested in participating in this study. Thank you very much.

Thank you,
Michelle Nguyen"

Appendix B: Recruitment Letter to Professionals

"Dear [insert name of professional],

My name is Michelle Nguyen and I am a senior at Tufts University. I am currently working on my Senior Honors Thesis in Child Study & Human Development. My thesis explores college students' experiences and what factors have shaped their imagining of future selves and their decision-making in terms of pursuit of interests in science, technology, engineering, and/or math (STEM). Ultimately, this study will serve as a means to better inform policy and practice to increase diversity in STEM fields.

I am currently seeking participants for my study. A part of this study is to interview professionals about their current policies and practices that engage students in STEM, cultivate interests, help students imagine their future selves as STEM professionals. I am interested in hearing from you what you believe is working to help students achieve in these fields.

Individuals are eligible to participate if:

- You are a professional who directly works on policies or projects involving STEM education.

As a participant of this study, you will partake in an interview that will last 30 to 45 minutes. Participation is completely voluntary.

Please contact me at michelle.nguyen@tufts.edu if you are interested in participating in this study. Thank you very much.

Thank you,
Michelle Nguyen"

Appendix C: Consent Form for Students

Consent to Participate in Research Study: Students

Contact Information:
Email: michelle.nguyen@tufts.edu
Tel: (408) 515-4742

"Contextual factors that have students' imagining of future selves and their decision-making throughout their professional development in STEM: What students say and what professional are doing."

I am a senior at Tufts University studying Child Study and Human Development. I am conducting this study as part of my Senior Honors Thesis. You have been asked to participate in this study and I am grateful for your participation.

What is the purpose of this study?
The purpose of this study is to examine college students' experiences and what factors have shaped their imagining of future selves and their decision-making in terms of pursuit of interests in science, technology, engineering, or math (STEM). Another part of the study is to also explore what professionals (professors, researchers, media and program producers) are doing to help students of various, diverse backgrounds pursue and achieve in STEM. Ultimately, this study will serve as a means to better inform policy and practice to increase diversity in STEM fields.

What will you be doing?
As a participant of this study, you will partake in a short survey that will last approximately 5 minutes and an interview that will last approximately 30 to 45 minutes. The survey and interview will take place at the same location. The short survey will ask basic demographic information, STEM interests, and questions about your media use. The interview will ask questions about your interest in STEM, future aspirations, past factors that supported your achievement in STEM, and media messages about STEM that you have encountered. Participation in all parts of this study is completely voluntary. You may choose to not answer specific or all questions.

What are the risks to being in the study?
There are minimal risks in this study. This study serves to be strength-oriented, meaning that it hopes to explore positive supports. Thus, minimal risks in emotional harm are part of the study. If you feel uncomfortable answering a question, you may choose to not answer it.
As a part of the interviewing process, I will be audio-recording the interviews so that I can be sure that I can hear and accurately transcribe everything you say. I will be the only who one will have access to the recording and it will be destroyed after I have listened to it. If you are not comfortable with my recording of our interview, you can ask to have it not recorded. There are no consequences if you do not wish to answer certain questions or if you wish to not have your interview recorded.

What are the benefits to being in the study?

You can use this study as an opportunity to reflect on your past experiences and on what strengths have gotten you to pursue your interests in a STEM career. Another aspect of the study is to ask you what supports you believe you further need in order to keep your pursuits and achieve in STEM. The study's report will serve to better inform professionals of what students like yourself need. In addition, professionals will benefit from this study because they will be able to hear from you and will be able to learn how they can better serve other students like yourself.

Will there be compensation for your participation in this study?
No, there will be no compensation provided for your participation in this study. Participation is completely voluntarily.

How will your answers be kept private and confidentially maintained?
Physical surveys containing demographic information and audio recordings will be stored and be password protected. Files will be kept in a locked drawer and I will be the only person who will have access to it. Audio recordings will be stored on a password protected flash drive. The password to the flashdrive will be written down and kept separately from the flash drive. Each audio recording of an interview and survey will be assigned a number so that they can be matched up later. Also note that your name will not be recorded and that emails sent between us will be deleted at the end of the study. There will be no electronic documentation of the password and of the information linking identifiers with personal information. The audio recordings will be viewed on a password-protected laptop with the wireless internet and other network connections turned off. After audio-recordings have been used for transcription purposes, they will be deleted immediately. Physical documentation will be kept for three years following the study. At the end of the three years, they be shredded to ensure confidentiality. Though you are not providing any identifiable information, it is possible that given your reported gender, race/ethnicity, and major that will be discussed in my thesis, you may be recognized as a participant of this study. If you are uncomfortable with this possibility but still wish to participate in this study, you may choose to not report such information.

Who can you contact if you have questions?
If you have any questions about the study, please feel free to contact me through the contact information above. You may also contact the Faculty Advisor for this project, Professor Julie Dobrow, at julie.dobrow@tufts.edu. If you have concerns related to the safety or confidentiality of subjects, please contact Dr. Lara Sloboda of the Tufts Institutional Review Broad at Lara.Sloboda@tufts.edu or (617) 627-3417.

What if you wish to withdraw your participation in this study?
Your participation is completely voluntary. Should you decide at any time during the study that you no longer wish to participate, you may withdraw your consent and discontinue your participation without penalty or loss of benefits.

Please check off one of the boxes below:

☐ Yes, I agree to be audiotaped during the interview process.

□ No, I do not wish to be audiotaped during the interview process.

SIGNATURE: I confirm that I understand the purpose of the research and the study procedures. I understand that I may ask questions at any time and can withdraw my participation without prejudice. I have read this consent form. My signature below indicates my willingness to participate in this study.

____

Participant Signature Date

____

Printed Name of Participant Date

____

Researcher Signature Date

____

Printed Name of Researcher Date

Appendix D: Consent Form for Professionals

<u>Consent to Participate in Research Study</u>

Contact Information:
Email: michelle.nguyen@tufts.edu
Tel: (408) 515-4742

"Contextual factors that have students' imagining of future selves and their decision-making throughout their professional development in STEM: What students say and what professional are doing."

I am a Tufts University student who is studying Child Study and Human Development. I have conducted this study as part of my Senior Honors Thesis. You have been asked to participate in this study and I am grateful for your participation.

What is the purpose of this study?
The purpose of this study is to examine college students' experiences and what factors have shaped their imagining of future selves and their decision-making in terms of pursuit of interests in science, technology, engineering, or math (STEM). Another part of the study is to also explore what professionals (professors, researchers, media and program producers) are doing to help students of various, diverse backgrounds pursue and achieve in STEM. Ultimately, this study will serve as a means to better inform policy and practice to increase diversity in STEM fields.

What will you be doing?
As a participant of this study, you will partake in a short survey that will last 5 minutes and an interview that will last approximately 30 to 45 minutes. The short survey will ask basic demographic information, should you feel comfortable answering these questions. The interview will ask questions about your interest in STEM, future aspirations, past factors that supported your achievement in STEM, and media messages about STEM that you have encountered. Participation in all parts of this study is completely voluntary. You may choose to not answer specific or all questions.

What are the risks to being in the study?
There are minimal risks in this study. The potential risks, though minimal, may include feeling uncomfortable with answering a question. This study serves to be strength-oriented, meaning that it hopes to explore positive supports. Thus, there is minimal risk for emotional distress. As a participant, you may feel uncomfortable about being audio-recorded. The audio-recording only serves to be used for transcribing purposes and will only be accessible to the PI. If you would not like to be recorded, your voice will not be recorded and you may still participate in the study if you would like. There are no consequences if you do not wish to answer certain questions or if you wish to not be recorded.

What are the benefits to being in the study?

Student participants can use this study as an opportunity to reflect on their past and to better focus on their strengths that have gotten them to pursue their interest in STEM careers. Another aspect of the study is to ask them what supports they believe they further need in order to keep their pursuits and achieve in STEM. The study's report will serve to better inform professionals of what these students convey that they need. In addition, professionals will benefit from this study because they will be able to hear from students and will be able to learn how they can better serve them.

How will your answers be kept private and confidentially maintained?
Physical surveys containing demographic information and audio recordings will be stored and be password protected. Files will be kept in a locked drawer and the PI will be the only person who can have access to it. Audio recordings will be stored on a password protected flash drive. The password to the flashdrive will be written down and kept separately from the flash drive. Each audio recording will be saved under identifiers such as "Participant 1" and "Participant 2." Surveys will also be labeled by “Participant 1,” etc. and will be kept separately from the flash drive. There will be no electronic documentation of the password and of the information linking identifiers with personal information. The audio recordings will be viewed on a password-protected laptop with the wireless internet and other network connections turned off. The audio recordings will be kept until 3 years after the end of the study. At that point, recordings will be deleted and physical documentation will be shredded to ensure confidentiality. Results from this study will be discussed in my Senior Honors Thesis. However, no identifiable personal information will be used.

Who can you contact if you have questions?
If you have any questions about the study, please feel free to contact me through the contact information above. You may also contact the Faculty Advisor for this project, Professor Julie Dobrow, at julie.dobrow@tufts.edu. If you have concerns related to the safety or confidentiality of subjects, please contact Dr. Lara Sloboda of the Tufts Institutional Review Broad at Lara.Sloboda@tufts.edu or (617) 627-3417.

What if you wish to withdraw your participation in this study?
Your participation is completely voluntary. Should you decide at any time during the study that you no longer wish to participate, you may withdraw your consent and discontinue your participation without penalty or loss of benefits.

SIGNATURE: I confirm that I understand the purpose of the research and the study procedures. I understand that I may ask questions at any time and can withdraw my participation without prejudice. I have read this consent form. My signature below indicates my willingness to participate in this study.

Participant Signature Date

Printed Name of Participant Date

Researcher Signature Date

Printed Name of Researcher Date

Appendix E: Survey for Undergraduates

<u>Demographic, STEM Interest, & Media Use Survey</u>

If you would like to skip or not answer any of the following questions, please feel free. This survey is completely voluntary. Your information will be kept confidential.

Intended Major: ____

Age: ______________

Gender: ☐ Male
☐ Female
☐ Other (fill in the blank) ______________
☐ Prefer not to say

Race/Ethnicity: ☐ White
☐ Hispanic or Latino
☐ Black or African American
☐ Native American or American Indian
☐ Asian/Pacific Islander
☐ Mixed Race
☐ Other (Please specify): _________________________________

Level of Interest in Different Areas of STEM:

STEM Area	Strongly Uninterested	Uninterested	Undecided	Interested	Strongly Interested
Biological Sciences					
Chemical and Biological Engineering					
Biomedical Engineering					
Agricultural Sciences					
Civil and Environmental Engineering					
Physical Sciences					
Computer Sciences					
Electrical and Computer Engineering					

Mechanical Engineering					
Mathematics and Statistics					

Media Usage: Please mark approximately how often you used each media category at different stages of your life according to your memory

Age	Media Category	Never	Less than a few times a month	A few times a week	About once a day	More than once a day
Childhood (ages 0 – 11)	Television & Movies					
	Books, Newspapers, & Magazines					
	Videogames					
	Internet Searches of Your Interests					
	Social Media (Facebook, Instagram, Google+, etc.)					
Adolescence (ages 12 – 18)	Television & Movies					
	Books, Newspapers, & Magazines					
	Videogames					
	Internet Searches of Your Interests					
	Social Media (Facebook, Instagram, Google+, etc.)					
Adulthood (ages 18+)	Television & Movies					
	Books, Newspapers, & Magazines					
	Videogames					
	Internet Searches of Your Interests					
	Social Media (Facebook,					

	Instagram, Google+, etc.)					

Appendix F: Interview Questions for Undergraduates

****Note that not all questions were asked during the interviews. These were the questions that were approved by IRB.***

Instrumentation Interview Questions: Students

<u>Introduction Questions:</u>
Tell me about yourself. Where are you from?
What are you majoring or intending to major here at Tufts?
What courses are you taking right now? How many are for your major? How many are electives?
Why have you chosen your electives? Are they related to your other interests other than your major?
What were the most interesting courses you've taken at Tufts? Why were they most interesting to you?

<u>STEM-specific Questions:</u>
Are either of your parents/guardians engineers or scientists? If so, which one? Or both?
Did you go to science or creativity museums when you were younger?
Do you remember the first time you started being interested in science? What about engineering? And math? Tell me about it.
What sorts of STEM toys did you like the most when you were younger? Building blocks? *Lego's*? Chemistry kits?
Did you attend any summer camps when you were younger? If so, were they STEM-related?
When you were younger, who did you think could become a scientist or engineer?
Let's talk more about high school. What extracurricular activities have you done in high school? Were they STEM-related? Like Math Olympiad, Science Olympiad, etc.?
Did you have friends who were also interested in STEM?
Was there an influential teacher that helped you pursue you interest in STEM? Were there other role models in your life?
What was the science/math requirement at your school? Did you take Advanced Placement (AP) or Honors courses in math or science? What did you like about them? How did you do in your science and math courses in high school?
Did your family often talk about you going to college or what you would do after high school?
Why have you chosen to major in STEM? With this major, what do you see yourself doing in the future?

<u>Policy-related Questions:</u>
What kept your interest in STEM in high school? What about now in college?
What/who is currently helping you do well and stay in STEM?
What kind of support do you think you need more of to be further successful in STEM?

<u>Practice-related Questions:</u>
How would you categorize your learning style?
How do you learn and do STEM coursework?
Is it different from the way you learn and do non-STEM coursework?

Media-related Questions:

When you were a child, did you watch any shows that were STEM-related? Like *Magic School Bus, Bill Nye,* or *Zoom*?

Were there any characters you recall who were scientists or engineers? What were they like? Male/female? Race/ethnicity? What do you remember most about that character?

What about news stories? Are there any math or science related news stories you recall from childhood? What do you remember most about them?

Do you remember seeing characters who were scientists/engineers who resembled or looked like you?

What about now? What shows do you watch? *Big Bang Theory?*

What do you notice about the scientists/engineers in media today? How do you feel the way they are being portrayed?

Do they resemble or look like you?

When you think of a typical scientist or engineer, what image comes to your mind? What images do you associate with these occupations?

Do you think it's important for children to have media models who look like themselves and are successful in STEM fields? Why?

Closing Questions:

What factors do you attribute to you being here today pursuing a STEM career?

What is your proudest STEM-related achievement to date?

Appendix G: Interview Questions for Professors

Instrumentation Interview Questions: Professors

<u>Introduction Questions:</u>
When and how did you first become interested in your field?
Along your path to your STEM career, were there any difficulties you encountered? If so, what were they?
Did you ever doubt your career choice? If so, why?
What supports helped you through those difficulties?
What research projects or community initiatives are you working on now?

<u>STEM-specific Questions:</u>
What courses are you teaching this semester? Do you work more often with undergraduates or graduate students?
What have you noticed about students when they learn STEM? How are they learning? Do they ask a lot of questions?
In your opinion, do students learn STEM and understand the material better through traditional lecture teaching styles? Or when they apply their knowledge to projects?
How often do students reach out to you about their scientific interests?
If a student was somewhat interested in your field but was still unsure about his or her own interests, what advice would you give him/her?
In the perspective of an advisor, should advice on pursuing STEM careers be the same, or tailored to each discipline? How would advice to a student pursuing a computer engineering career be different from a student pursuing a biology career?

<u>Policy-related Questions:</u>
What do you think are the most important supports that professors can give students in order for them to be successful in their pursuits in STEM?
What have you noticed has changed in the past 5 or 10 years in terms of students being interested in STEM? Are there more students interested in STEM? Are there significantly more females? What about students of different racial and ethnic minorities?
What do you think has changed that has caused this increase or decrease? If nothing has changed, why do you think that?
Do you think that female students and students of racial and ethnic minorities may still struggle to achieve in all STEM fields? What does this mean, in general? You mean all STEM fields? What about your own field? Why or why not?
What is currently being done in your field, or at this university, to promote underrepresented populations to pursue STEM?
President Obama recently proposed the Computer Science for All Initiative which seeks to expand access to computer science courses in schools. It also seeks to ensure that students have the chance to participate in high-quality computer science learning opportunities, including girls and underrepresented minorities. What is your opinion on this proposal?
What is your opinion on the President's focus on promoting computer science? Is there too much of a focus on computer science? What do you think that means for other fields of STEM?

What other policies would you like to see be implemented in high schools that would promote interest and participation in your field?

Practice-related Questions:

What do you think educators or parents/guardians should do to help a student/child who seems interested in STEM but struggles with it academically?

There are various media programs that seek to promote interests in STEM and to teach STEM outside of the classroom. For example, there are virtual games that teach environmental science. What do you think needs to be featured in these media programs in order for them to be successful in teaching STEM and really grasping students' interests? Does it need to be challenging? Does it need to relate the STEM material to real-world experiences?

Media-related Questions:

What do you think about media's images of scientists and engineers?

Do you notice any trends of how science-fiction television shows that feature scientists or engineers? For example, in some shows, these scientists and engineers are creating super humans. What message or impression does this specific representation give you?

What about television shows that feature scientists and engineers as geeks and nerds? What do you think about this specific representation?

When you think of a typical scientist or engineer, what image comes to your mind? What images do you associate with these occupations?

What do you think of science apps or games as effective ways for students to learn STEM? Or Massive Open Online Courses (MOOCs)?

Do you think engagement with a lot of science media can change student's perceptions of themselves as scientists?

Closing Questions:

In your opinion, what improvements, if any, are needed in the current policies and practices in STEM teaching to help students pursue and achieve in STEM?

Appendix H: Interview Questions for Media Professionals

Instrumentation Interview Questions: Media Professionals

<u>Introduction Questions:</u>
What is your specific role in the production of STEM-related media?
Do you come from a STEM-related background?
If so, how have you been using that STEM experience in your current work?
If not, do you believe it limits your ability to understand how STEM can be taught or learned?
How have you applied your academic and professional background to these STEM-related projects?
What has made you interested in working on STEM-related projects?

<u>STEM-Production Questions:</u>
Tell me more about the STEM-related media projects you are working on.
Why have you chosen these specific STEM topics to feature in the projects?
What age groups are these projects targeted towards?
How have you adjusted general STEM curriculum so that it is appropriate for this age group?
How do you develop the STEM curriculum that these projects are based off of? How do you prioritize what information is most important?
Do you have other professionals help with the production of these projects?
Do these projects serve to replace existing STEM curriculum or to aid it?
Let's talk about a scenario in which a child is not doing well in science or math at his school. Then you introduce this media project. How can this project help him become more interested in science/math? How can it help him do better academically? What evidence do you have to back up these claims?
How would this project look different for various age groups? Elementary school children? Middle school students? High school students? And college students?
In your opinion, other than media, what other supports do you think students, especially female students and students of racial and ethnic minorities who are traditionally underrepresented in these fields, need to pursue their interests and be successful in STEM?

<u>Media-related Questions:</u>
How do people get access to this media program?
How do you make media characters relatable to the children watching or interacting with them?
How intentional are the design of the characters in media programs? Do you specifically intend to create a diverse cast with females and males of different races and ethnicities? Why or why not do you think creating a diverse cast is important?
What stereotypes are you following or breaking in the creation of this cast? For example, breaking the stereotype that males can only be scientists or that being a "nerd" is unpopular in school.
What messages are you hoping for children to get from your intentional design of characters?
What role do you think media in general plays in shaping what children think about who can become a scientist or engineer?
In your opinion, what are the short-term and long-term effects of STEM-related media programs?

Closing Questions:

Why are there so many STEM projects going on at WGBH now?
What other STEM-related projects is WGBH taking on in the future?