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Retaining First-Generation College Students in STEM programs: A Qualitative Analysis

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ABSTRACT
This study employs a qualitative approach to help examine the factors that influence first generation college students in their path to attaining a STEM degree. The qualitative analysis involved a sample of 40 North Carolina first-generation college seniors preparing to graduate with STEM degrees. Other national studies have used quantitative data only, which creates a notable gap in the literature and begs the need for more robust analysis. In this study, we argue that background attributes, pre-college experiences, institutional characteristics, as well as social and academic integration influence the performance of first-generation college students in STEM. The qualitative findings suggest the vital role that pre-college influences play for first generation college students in STEM, when compared to their non-first-generation peers.

KEYWORDS: First-generation college students, STEM, disparity, qualitative methods

As the United States and other developed nations of the world come into the twenty-first century, the need to have a highly trained workforce and an educated citizenry has become more important than ever. Americans have long pointed out that degree attainment is one of the major drivers of social mobility (Wright et al., 2023). Scholars have highlighted the role of human capital in a technologically advanced global economy. According to Goldin and Katz (2009), human capital is the most important determinant of economic wealth in today's world. They argue that the economic polarization in the United States arises from the gap between unskilled labor and skill-based technological change. Their analysis further suggests that the income inequality and skilled workforce decline in the United States are consequences of an education system that is out of pace with a rapidly changing world economy (Goldin & Katz, 2009).

Some current research indicates that in the United States, the STEM workforce may be inadequate for the demands of the economy soon. Atkinson (2013) discusses the gap between the number of sciences, technology, engineering and math (STEM) graduates being produced by colleges and universities and the increasing workforce demands of the economy. Indeed, an area of untapped potential for increasing the number of STEM graduates in the United States is the pool of first-generation college students (FGCS) who are currently enrolled in colleges and universities. First-generation college students constitute a large portion of the growing college-student

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population; and their underperformance in STEM is part of the troubling pattern that researchers highlight (Benson & Lee, 2020; Soria & Stebleton, 2012; Capriccioso, 2006).

To that effect, this study seeks to ask the question: "What personal and educational experiences do first-generation college students have that differ from non-first-generation college students in the path to graduating with a STEM degree?" To answer this question, this study uses a sample of qualitative data from a set of 40 in-depth interviews of students here in North Carolina.

Our study found that that positive pre-college experiences and having effective math and science teachers can make a difference for first-generation college students in North Carolina. Hence, improving K-12 science and math instruction could be essential for increasing STEM retention and STEM graduation in college students (Dike & D'Amico, 2016).

Although there is extant literature on the performance of first-generation college students in STEM, prior studies have used mainly quantitative analysis to assess the role of first-generation status on STEM outcomes (Mau, 2016). This study uses a qualitative lens to investigate first-generation status and other factors that mediate the effect of first-generation status on STEM graduation. This study further demonstrates the social and academic challenges faced by first-generation college students in STEM, when they do not have the skill, knowledge, and requisite resources that are available to their non-first-generation peers (Armstrong & Hamilton, 2013; Rondini, 2015; Wilbur & Roscigno, 2016). Wright et al. (2023) also argue that first-generation college students experience a disadvantage in certain types of post-secondary education. They point out that this might include being underrepresented in fields of study that lead to lucrative jobs after graduation (Cataldi et al., 2018; Van Noy & Ruder 2017).

The Need for More STEM Graduates

The U.S. Department of Education data suggest that 75% of the nation's growing occupations require proficiency in one or more STEM subjects (DeReamer & Safai, 2004). The State Education Technology Directors Association (SETDA) predicts that with declining enrollment in STEM programs, there will be a shortage of scientists and engineers in the workforce soon (Crisp et al., 2009). Considering the competitive and technologically advanced global economy, the education of a nation's populace is necessary to maintain relevance in the global scene (Carnevale et al., 2011). For the United States, it is therefore necessary to increase college enrollment and graduation rates in STEM.

The National Science and Engineering Indicators, published by the National Science Board (NSB, 2012), called attention to the disparity in STEM attainment among students of different backgrounds. These indicators depict the continued under-representation of first-generation college students in STEM degree attainment (NSB, 2012). Hence, first-generation college students, who are disproportionately women, and underrepresented minorities, constitute a source of untapped human capital for increasing the country's STEM workforce (CEOSE, 2012; Ong et al., 2011).

The STEM literature is replete with descriptions of the challenges faced by first-generation college students in STEM. Lowery (2010) and Strayhorn (2009) portray the rates of underrepresented minorities (who are predominantly first-generation college students) in engineering do not persist to graduation but rather switch to non-STEM disciplines. Researchers suggest that a holistic approach to addressing this issue is one that considers the experiences of first-generation college students during their pre-college years, throughout college, and after graduation; and compares these experiences to those of their non-first generation college peers (Harper & Quaye, 2010; Hicks, 2003; Hurtado et al., 2007; Murphy & Hicks, 2006; Pascarella & Terenzini, 2005).

Prior explanations of college retention centered on the psycho-social aspects of the college experience, which did not include academic and social integration dynamics. However, in the last thirty years, one of the major frameworks that has provided a multifaceted approach for explaining student persistence is Vincent Tinto's longitudinal model of college retention. Tinto distinguishes between the academic and social dimensions of college. His model places variables in relationship with one another to advance our understanding of student retention by going beyond the typical use of regressions and correlations to the use of longitudinal data and path analysis, which provide sequence and causality among the variables in the model (Stage, 1988).

The New Face of College Students

The increased enrollment of first-generation college students in colleges and universities has changed the profile of undergraduate students regarding gender, ethnicity/race, and socio-economic status (Grawe, 2018; Hacker et al., 2005). A study by Saenz et al. (2007) found that one in six students at American four-year colleges is a first-generation college student, but more than a quarter of them do not complete their first year of college (Banks-Santilli, 2014). However, as Pascarella et al. (2004) point out "the needs of first-generation college students are not solely economic, they are also social and cultural." In college, these students wrestle with understanding the rules of the game and figuring out the right way to act. Then, at some point, many of them start to question whether they belong in the college setting. Not having a sense of belonging could make some first-generation college students withdraw from their major or the institution altogether (Johnson et al., 2011; Ostrove & Long, 2007;). Moreover, since this new crop of students comes from families where no other family member has received a college education, a large percentage of them do not have what Lohfink and Paulsen (2005) refer to as "the intergenerational benefit of information about college." As a result, many first-generation college students are likely to have a challenging college experience (Carnevale & Fry, 2000; Stephens et al., 2012).

Hence, even in the face of expanded educational opportunity for first generation college students, the question of retention and attainment in STEM continue to arise. According to Chen's (2005) study using NELS Postsecondary Education transcript data, first-generation college students who were enrolled in higher institutions were more than twice as likely to drop out (from both two and four-year colleges) without earning a degree, when compared to non-first-generation students (43% and 20% respectively). Engle (2007) notes that only 24% of first-generation college students who graduated from high school in 1992 enrolled in college and earned a degree by the year 2000 compared to 68% of non-first-generation college students.

Pascarella et al. (2004) extend the evidence of how first-generation college students are impacted by not having parents who attended college. Their finding is consistent with other studies that found that first-generation college students are less likely to persist in college when compared to students whose parents have a college education (Guyer, 2013; Lam et al., 2005). Explanations for this disparity have largely been attributed to individual and institutional attributes, or lack thereof. For example, Engle (2007) suggests that inadequate pre-college preparation and poor financial support from family is central to the difficulty experienced by first-generation students in college (Engle, 2007). Studies also show the moderated effect of a college degree for first generation college students, who are more likely to enter college with limited resources, knowledge, skills, when compared to those whose parents have already attained a college education (Lee, 2016; Wilbur & Roscigno, 2016; Wright et al 2023,).

The higher education literature is replete with studies that show that first-generation college students are less likely to persist and graduate when compared to their colleagues whose parents have a college education (Atherton, 2014; Banks-Santilli, 2014; Harackiewicz et al., 2014; Housel

& Harvey, 2009; Lohfink & Paulsen, 2005; Jehangir, 2010; Saenz et al., 2007; Soria, & Stebleton, 2012). In this study, I define first-generation college students as those who come from homes where no parent or guardian has attended college; a common definition used in prior studies (Hoyer, 2011, Ishitani, 2006). However, some studies define first-generation college status using the degree threshold-: that is a family where no parent/guardian has earned a baccalaureate degree (Choy, 2001; Kuh, 2001; Pike & Kuh, 2005; Stephens et al., 2012).

As prior research suggests, first-generation college students are more likely to have lower educational aspirations, lower levels of academic preparation, and very little tangible support to attend college from their parents who themselves did not attend college (Engle & Tinto, 2008). With all these cards stacked against them, the literature suggests that these factors and others reduce the likelihood of first-generation college students choosing STEM or graduating from a STEM major (Cataldi et al. 2018; Cohen & Deterding, 2009; Crisp et al., 2009; Jack, 2014; Lee, 2016; Wilbur, 2021; Wilbur & Roscigno 2016).

As a researcher, I have a connection to this project being a first-generation college student myself. This paper is part of a larger mixed methods study that also used Beginners Post-secondary Students longitudinal study, which is public data from the National Center for Education Statistics (NCES). My goal for the study overall was to investigate the factors that can predict the success of first-generation college students in STEM programs.

I must confess that conducting interviews for this project and speaking to these students directly had a profound effect on me. Hearing their stories and their journey revealed to me the value of qualitative research as an approach that goes beyond the numbers to exploring deeper reasons why we have certain outcomes. The interviews in this study are powerful as well informative. They provide reliable data to support the need for better math and science instruction in high school. In addition, they provide a justification for strong mentorship programs for students who intend to pursue a STEM degree.

Research Design

In this study, I utilize a qualitative approach to examine the overall experience of first-generation college students in STEM as compared to non-first-generation college students. The study uses interview data from North Carolina first generation college seniors to answer relevant research questions. The review of extant literature in the previous section informed the hypotheses in this study and raised the central question that this study will examine.

Hypothesis 1: First-generation college students are less likely to graduate from a STEM major than a non-STEM major when compared to non-first-generation college students.

Hypothesis 2: The likelihood that a first-generation college student will graduate from a STEM major is explained by factors such as, (a) personal and family attributes, (b) pre-college characteristics, (c) institutional characteristics, and (d) social and academic engagement.

Q1: “What personal and educational experiences do first-generation college students have that differ from non-first-generation college students in the path to graduating from a STEM major?”

(a) How do pre-college experiences influence first generation college students in their path to graduating from a STEM major?
(b) How do personal and family situations influence first generation college students in their path to graduating from a STEM major?
(c) How do college institutional characteristics and experiences influence first generation college students in their path to graduating from a STEM major?

(d) How do social and academic integration influence first-generation college students in their path to graduating from a STEM major?

I investigate the primary research question described in this study using a qualitative approach.

Qualitative Data and Analysis

Previous research suggests that students who have first-generation status are less likely to declare STEM and graduate from a STEM major when compared to their non-first-generation peers (Wilbur 2021; Berg, 2020; Wildhagen, 2022). However, for one to determine why this situation exists, it becomes necessary to turn to the qualitative data. In this case, to provide reasons why first-generation college students perform lower than their non-first-generation peers in STEM outcomes, I turn to the accounts of 40 in-depth interviews conducted by Roots of STEM.

Selecting Respondents

The Roots of STEM Project (Stearns, Mickelson, Dancy, and Moller, 2010) is multimethod investigation of 2004 North Carolina high school seniors who matriculated into one of the 16 campuses of the University of North Carolina system. The project's first phase involved creation of a longitudinal data set with quantitative individual, family, secondary school, and college indicators from 7th grade through college graduation. I employ data from the second phase of the Roots of STEM project, which involved a series of 317 interviews conducted with a self-selected purposive sample of University of North Carolina (UNC) system seniors in the spring of 2013. The project team interviewed select seniors who were enrolled in one of the sixteen schools within the UNC system. These seniors were contacted through e-mail addresses provided by their Offices of Institutional Research; the students were asked to complete an online screening survey. Students who completed the online screening survey were promised a $25 gift card if they were among the first ten students in their university to complete the online survey. Also, the students would qualify to have their names included in the drawing of a grand prize of a $100 gift card.

The screening survey created a self-selected sampling frame of individuals willing to be interviewed. Answers to the survey helped the Roots research team determine the participants who could be part of the sample frame, and whose STEM experiences or lack thereof would help to answer the research questions being posed in the study. The students who indicated willingness to participate in the next stage of the research were categorized as follows: (a) students who majored in STEM ("majors"), (b) students who withdrew from a STEM major ("leavers"), (c) proficient students who chose not to pursue a STEM major ("avoiders") even though they had good quantitative SAT scores. The project leaders then created lists of a purposive sample of potential interviewees, identified by their race, gender and major. STEM majors were determined based on National Science Foundation (NSF) classification of college majors.

Purpose Interview Sample Used in This Study

In the online screening survey administered to seniors in the sixteen campuses of the University of North Carolina system, two questions were asked about first-generation status. They are:

(a) Did your parents attend college?
(b) Did your parents graduate from college?

Of the 317 students interviewed, about 70 are first-generation college students. I selected forty of these respondents as a sub-sample for the qualitative analysis. I selected the forty to achieve a purposive sample with the necessary balance between STEM and non-STEM majors, first- and not first-generation students, and Black, White, and Latino students.

Coding Interview Data

The coding of the interview transcripts entails reading through the interview transcript and reflection notes of the interviewers to identify significant statements and emerging themes within the data, then developing codes and coding categories for them (Braun, & Clarke, 2006; Creswell et al., 2007). "Coding is the process of identifying and labeling data linked by a common idea or concept" (Gibbs, 2007).

I analyze the in-depth interviews of first-generation college STEM majors comparing them to those of non-first-generation college students who are STEM majors to determine how the STEM path of first-generation students is distinctive.

Tables of Transcribed Interviews

For my qualitative data, I have elected to analyze a total of 40 female students, 20 of whom are first-generation college, and the remaining 20 non-first-generation college student. I have selected female respondents only, in effect controlling for gender. Among the respondents, there are first-generation college and non-first-generation college students of different races/ethnic backgrounds that are historically underrepresented in STEM.

Table 1:
Descriptive characteristics of sub-sample chosen for this study.

Females	STEM	Majors	Non-STEM	Majors	Total
First-generation	10 Black White Latino	Engineering Computer Science Chemistry	10 Black White Latino	Psychology Social work Sociology	20
Non-first generation	10 Black White Latino	Engineering Computer Science Chemistry	10 Black White Latino	Mass communication Exercise science	20
Total	20		20		40

Discussion of Qualitative Research Findings

This section presents the accounts from a sample of 40 in-depth interviews used in the study to better understand the reason for the STEM retention gap between first generation college students and their non-first-generation peers. Five major themes emerged as influencing the retention of first-generation college students in STEM, they are:

- Guidance in choice of school, major and career
- Familial responsibility versus family support
- Financial support from family

- College and institutional factors
- Pre-college experiences

Choice of school, major and career

Several first-generation STEM students report that though they have some idea of what career they wish to pursue after graduation. However, they are typically unsure about how to achieve those career goals. While they have broad aspirations, they report having challenges in how to navigate the decision process. While Tinto (1993) points out that background characteristics can influence college retention. This study pinpoints some of the reasons why a student's family background and first-generation status can be a disadvantage in STEM retention. In this case, lack of guidance emerged as a major theme for first-generation college students in STEM.

From the sample of first-generation college students in STEM, 8 out of 10 of them report having to find guidance outside their family circles. Only 2 out of 10 in the sample of first-generation college students in STEM report receiving guidance from their families on how to navigate school. No one from the sample of 10 non-first-generation college students in STEM reported having challenges getting guidance for selecting a school, major or career.

A Latino first-generation college female majoring in computer science described her experience of navigating the college admissions process:

> College, high school, I think it is just basically—well I guess for my generation, nobody knew. Like nobody knew what college was like or at least your parents didn't know. They would just okay you know America is good for education and you'd go you know do the education part and then when you get to college they have no idea. We must do us on FAFSA. We had to figure that out and be like okay parents just give me your taxes and I'll go and fill this out kind of thing. It is mainly on us and if we don't know how to do it and like obviously, we can't like to inform ourselves of everything that's out there and the possibilities then yeah, we just don't know.

Even though families of first-generation college students are proud of their academic accomplishments, these families are unable to provide much needed guidance to the students in terms of school, major and career. A Black first-generation college female in biological sciences discusses the lack of guidance she faces from her family. She said:

> Um, I think my family was just, um, they had like us conversating that was just like go to college no one ever, you know, helped me decide what it is that I wanted to do or- but sometimes I think that maybe why I can't figure out what I need to do but my family they never- they've never been the type to say well, you know, you should do this or that but they always just said go to college. [Laughs] That's it and that's what I did. I didn't have a plan really. I mean, I had sort of a plan but not really, you know? As far as funding and decision making and what I'm going to major in they didn't really, you know, they didn't really participate in that part. It was just like, ok, yes, you're going to college. That's all that matters. That's kinda what they were.

A Black first-generation college female majoring in chemistry at a predominantly White Institution (PWI) discussed her experience of needing some guidance in making her career decision. She said:

> Well, for one except for one thing, I mean, I wouldn't mind, you know, just sometimes simply just having somebody to talk to, you know, about what I'm going to do when I graduate or if this doesn't happen then what, you know, cuz I don't want to graduate and be working at Papa John's (fast food pizza franchise). You know what I mean?

A Black first-generation college female in engineering at a PWI said she had to become very independent because her parents were too busy with work to give much attention to her academics:

> I've always kind of been the independent child so it wasn't until high school that my mom started paying some attention to my academic life or my career, like I've always made good grades so she wasn't—well her—my mom and dad were in the military so they weren't there all the time and even when she was there she was like you know I'm too tired so I wouldn't be reading to you tonight.

In contrast to the reports of first-generation college students in STEM, non-first-generation college students report that they receive guidance from their parents or siblings. For the group of non-first-generation college students in STEM, 6 out of 10 reports having parental and sibling guidance. In the case of a non-first-generation Black female in engineering, she had a brother in college who was majoring in a STEM discipline. She talks about his influence on her growing up. She said:

> My elder brother was into technology, I'm gonna assume when I was younger, he probably pulled me toward I can remember him being frustrated trying to figure out how to do one of his transformers and showing me, me thinking it was so cool that they were able to make something that could change shape as a little kid. Um think those were some of the factors that led me to get interested in STEM.

A non-first-generation Black engineering female at a historically Black institution discusses how she was guided by her parents in course taking with a view to going into STEM. She said:

> Um because I knew when I go to college, I needed to have that background that uh base to be able to keep going in college. So, like I said I took different math's and took the equivalent of advanced math at my school which AP Calculus, even though I didn't have to, but I took it because I didn't want to go to school and blindly be there and not know what was going on in my classes. So as part of the—as part of the college prep they actually—I had to take like AP US History and just different things that's supposed to help you be ready for college.

Family responsibility versus family support

Tinto (1993) suggests that having family dependents or working outside campus can constitute an external factor that can impact a student's retention. I found in the qualitative data that first-generation college students are more likely to identify with family responsibilities in their families and other family issues. From the sample of first-generation college students in STEM, 5 out of 10 reports having family issues and responsibilities that affect their studies. This is in comparison with only 1 out of 10 non-first-generation STEM students sampled in this study. I have included some respondent accounts below.

A Black first-generation college female in chemistry transferred from her institution to another institution where she would be closer to her sick mother. Fortunately for her, she was

already very close to completing her degree in chemistry. She shared how she had to shuttle back and forth between her school and her home to act as a caretaker for her mother. She said:

> I took care of my mom and sister. Over time my mom got sicker I took care of her, so I changed her bandages. I did everything that, like, sometimes the nurses didn't need to come out cuz I had already done everything that a nurse could do. Um, and then being that I'm so focused on graduating it's kinda hard to focus on being in the lab because I have to, you know, I'm taking care of a sick parent right now so I have to focus on that first, then I have to focus on my quest, so I can actually get out of school in December and so it kinda makes it hard for me to do anything extra.

Having this kind of family situation or having a child or sibling dependent can impact a student's retention because of time away from their schoolwork. Another respondent who is a first-generation Black female majoring in STEM shared her own family situation. According to her:

> I had a little bit of family issues. My father passed like my second year at Stanville State. So, I was taking more of like a parental responsibility for my brothers, helping my mother out and I started working so I didn't really have time to focus on school, and I decided I think year three maybe that it was time for me to go. Like if I didn't leave, I was gonna end up being like everybody else I graduated with and I was gonna be stuck in Stanville for the rest of my life.

One of the respondents talked about how she took care of her little sister and her mother by going to school and working full time. According to her:

> Um, it was just, um, kind of me- well, when I left for college I was the only working person in my household because my sister was young, my mom didn't work, so when I left it was kinda like they still I guess needed that support from me so it was kinda like, ok, well, I'm making money for myself but I'm to like send it home to help my parents or my sister who's still at home. I can't, you know, I still have a little sister to support so I can't just go off to college and forget that she's there because when I was there I was the one who was supporting her so it was kinda like, uh, I was kinda overworking myself a little bit to make sure that they had the things that they needed, particularly my sister.

A Black first-generation college female majoring in chemistry at a PWI became responsible for her younger sister, even financially. She worked more than one job to ensure that her sister's needs were met. She is also a mentor to her sister and counsels her on her academics. She also provides for her mother who is sick and incapacitated. She reported leaving school on many occasions to go and take care of her mother. She said:

> I must make sure my mom is taken care of and that my sister has funds, you get what I mean? Some days I'm like; I can't do this anymore because I am so tired of running back and forth.

Then she continued:

> I'll tell you one thing, it's gonna—it's funny but at the same time not funny. My sister I'm like her dad. They say who your daddy (respondent's name) that's my daddy. My mom no—if um we only have one car so whenever we—I'll have, I'll take the car go to work, she'll go to school and I go to work or whatever. Well, whenever [unclear] oh you forgot to pick your kids up on time, so my mom and my sister are my kids. Those are, you know,

> my children, I'm the mom. It's funny but um at the same time I mean yeah, I had to grow up real fast, growing up without a father.

Some of the first-generation college students shoulder more family responsibilities at a young age than their non-first-generation peers. This may impact student success by taking away from instructional or study time. A first-generation college student in biological sciences discussed her intention during her grandmother's battle with cancer.

> Um, I just recently well, my grandmother passed not too long ago and I think it might have been- I think it was around the time we had to pick out our schedule for the next semester I called her because she- she was starting to lose the battle with cancer then. And I was just like, if you want me to come home, I won't register till next semester, just tell me you want me to come home. Cuz like, you only get one and at that point at time, I mean, yes, it was taking me forever to finish school, but I was like I would stop now and pick it up later if I knew that it would make her happy that I came home to take care of her, but she told me not to. Cuz I mean, you- they give you a time frame, but you never really know when and she do- if she picked up the phone and told me she wanted to see me today, I'm gonna be on the highway, I don't care what class, I'll turn in my work early and I'll be on the highway.

Literature shows that first-generation college students are disproportionately from low-income families (Soria, & Stebleton, 2012). As a result of their low-income family status, they start early to take-on family responsibilities.

Financial support from family

Families of first-generation college students see a college education as the ticket to steady employment and a higher quality of life. Since education is correlated with income, some first-generation families report having financial difficulties from time to time. Tinto (1993) points out that those students from low-income backgrounds are less likely to graduate from college due to financial challenges in their families. In this study, many first-generation respondents report that they had little financial support from their families.

In the first-generation STEM group, 5 out of 10 of them report that they had no assistance from their families. None of the 10 respondents in the non-first-generation group reported lacking financial support from their families. A Black first-generation college student majoring in STEM at a PWI shared her experience in regard to family financial support:

> Um I wanna say either my freshman or sophomore year, sophomore year. I got to school—I don't know if you know but they raised tuition, cut back on scholarships or whatever cut back on financial aid so I got back to school and I owed maybe a 1,000, $2000 which that ain't much but at the time I was fresh out of high school I was like where I'm gonna get this money from. Can't call my mom you know like she can't help me, she needs help herself so I was like whatever I'm gonna work to get this money and I just thought about it you know like my grandpa called me ok, I'm like yeah, but I don't really got no money and I owe the school.

First-generation college students relied mainly on grants and loans for their upkeep. One of the Black first-generation STEM students described her state of mind when she was attempting to register for college. According to her:

> You know I could stay in Townsville, and you know, just find a trade, you know just do like a medical assistant program, take a test and get the CNA license to be a certified nursing assistant. I was like maybe I should go to community college and then work my way up. Maybe I'm just not really cut out for college; I don't have the money to go, I don't have a car, I am not sure what will happen. I guess my confidence level was just low at that time, you know, she said.

A Black first-generation college female majoring in engineering at a PWI report joining her classmates for a two-month program at a research university, but she almost dropped out of the program out of worry for how she would survive without family financial assistance. According to her:

> I am not the only child, and I don't really have parents that are providing for me like funds to be in school. Since I was six hours away from home, I had to figure out how I was gonna get money, get food, make it period um, if that makes sense.

A first-generation college student shares her experience when she needed private tutoring for one of her challenging courses. She recounts that her family encourages her to stay a school and graduate, but do not offer any financial assistance:

> So that's what I did and like, I told my family about it, and they were just like, ok, like nobody's like really interested in kind of supporting me. Like, this guy was like 60 dollars an hour. Like, you know, nobody's supporting me like with money, with time, with just talking about it. I think everybody kinda has his or her own things going on.

College and institutional support

Students receiving institutional support came up as being relevant for STEM retention. In Tinto's (2012, 2007, 1993) writings, he strongly recommends institutional support for at-risk students. Tinto is credited with encouraging institutions to take more responsibility for student success (Tinto, 2012, 1993). Institutional support can come in different forms, tuition support, lab equipment, and career support. Also, support from advisors can benefit first-generation college students in STEM.

Institutional support was discussed by 7 out of 10 first-generation college students in STEM compared to 3 out of 10 non-first-generation college students in STEM. Some of the first-generation college students, who are less likely to get support from their families, report that they benefitted from different forms of institutional support. For one first-generation Black female STEM major the assurance of tuition funding by her institution helped take some financial burden off her shoulder. As a result, she had no student loan debt. She describes it this way:

> So, um, I do think, you know, with me not having any support it did kind of alter, um, what I did so, um, of course this school they gave me a full ride, you know, I went there for free, I never had to take out a loan, I would end up- it wouldn't really matter cuz there I was more comfortable because when I worked so I could have money for myself. I wasn't working to my tuition.

Getting support from her institution allowed her to focus more on her other needs. Also, when she got a job in the chemistry lab, she was able to save up money to buy a car According to the respondent:

> So, it did really help and I do feel like sometimes if I had not picked that school I would have never been offered some of the opportunities that I was offered. Like, I have, um, done a lot of things with that school that no one else at any other school could say that they've done, and I think that means a lot and I think um, that's one of the reasons I chose that school because I didn't have any support. I knew I could go there, and I could get transfer papers from my job in Townsville, which is Papa John's and I could go work there so I knew that at least I would have, you know, money so I don't have to do anything extra and so then when I got the chemistry job I was able to buy me a car.

A first-generation college Black STEM female reports a similar experience of receiving tuition funding from her institution, and how that benefitted her academically. She said:

> The college I went to was Browsby College; they're a tuition free school. Basically they take low income students that have like—they have potential academically to make a difference you know and they have this huge board of trustees and a whole bunch of donors who give money to the school to help support these students so it's like not having to pay anything versus having to pay something and not knowing if I could make through another year and then also at the school you're required to do work study and here it's optional there's it's not an option, so for them you're giving back to the school it cuts down on cost because all the students are working so they don't have to hire so many outside people and then it touches you like responsibility and you got a bunch of rich people giving you money and they don't want to feel like you're just laying around and you appreciate it so when you're working and making good grades they're like I want to give more money cause this school represents something great ya know.

A first-generation Latino STEM respondent recounts how she was impacted by not getting adequate support on some of her programming classes. When asked by the interviewer if she is happy about her decision to major in computer science, she said:

> Lately, I haven't been but overall, I think I will be. It is just I feel the school doesn't do a good enough job teaching it. Like, I wish I had stayed in SIS because I would have learned more. Um, knowing now like who the teachers are and their teaching style it gets harder when you get into like the 3000, 4000 classes because it is less, at least here, it is less hands-on work and trying to show you how to program and it is more like here is the work you have to go figure it out and, you know, like struggle on it yourself. So, lately I haven't been as um happy as I was when I first came into it and I have been thinking about dropping the major.

Non-first-generation college students also raised the issue of institutional factors and their impact. A non-first-generation Black female in STEM was narrating her initial challenge for not taking chemistry courses earlier than she did because they did not have the necessary lab equipment at her high school. She said:

> I had a bad chemistry experience at my school I went to before Science and Math, like my—like my teacher we didn't even do—we didn't do any experiments, we didn't even see why water boiled like to look at the boiling point or how water melts—well ice melts, we didn't even do that, we didn't even watch popcorn pop I mean it was—it was just that dead like I really just didn't like chemistry, it didn't make sense it—it was just really dead

> and so I put it off until my senior year there but I wish would have taken it my junior year so I could have taken some of the more advanced chemistry classes my school offered but I didn't and took like the I don't wanna say the basic chemistry class, more so the required chemistry class my senior year but I will say that chemistry class definitely prepared me for college cause the first two basic chemistry class my freshman year were extremely easy and exposure was one of the things I would say that just…if you—like if you're not exposed to something you're not going to—you're not going to know what to kind of investigate or research on to see if it's the right fit for you.

A White non-first-generation STEM female also shared the support she receives from her advisor on grant opportunities. Referring to her advisor, she says:

> So, actually, um, so Michigan does this thing- they have a graduate symposium in the fall, and I remember my chemical engineering advisor- she sends out all these emails all the time with opportunities for things and so she sent out some emails about a travel grant to go to Michigan for the graduate symposium. and, um, at that point, I had never flown. I was not considering Michigan. I don't know, I thought it would be a neat opportunity to, um, go on my first plane trip. I was not fond of Michigan at that point in time, um, but because I went to that, they sent me an email later encouraging me to apply to their REU program — a research program for undergraduate students in engineering.

For first-generation non-STEM students 4 out of 10 sampled discussed institutional factors that affected their academics. A White first-generation college female who left the STEM shared some of her experience of attending a school that did not offer a lot of math and science classes. She recounts it this way:

> Um, we were only really allowed to have like one math per year, or per semester. I can't remember how it was set up. But that's all the school allotted for us, time wise. So, there wasn't, unless you like really tried to get into extra math classes, there was no way to do it. Um, I don't know. Um, I don't remember really having science when I was elementary school, at all. We had like English, math, and PE and that's pretty much all I remember. I don't remember having science.

The account below suggests that this school did not provide many opportunities for students to learn math skills. This same respondent also recalls not getting tutoring help on concepts she did not understand. She says:

> Oh, um, that started way back when I was like in 1st grade, 2nd grade. Like I remember I had to like to look down and cheat on my tests because I just didn't understand it and none of my teachers really took the time to explain it. Just all memorization and you know, but I didn't understand why anything, why any of it was happening. I didn't really grasp it at all, so it goes back for me all the way back to my elementary days.

Pre-college Experience

Several first-generation STEM students mentioned a high school teacher who had an impact on their lives. Tinto makes the point that a student's pre-college performance contributes to their retention in college. In this qualitative data, I found that pre-college experience was a major theme

in the respondent accounts. At least 8 out of 10 of the first-generation college students in STEM give credit to their pre-college experiences in learning math and science for the decision to choose STEM. This is compared to their first-generation college peers in non-STEM majors; about 3 out of 10 say they had positive experiences in learning math and science. Though some of the non-first-generation college students in STEM spoke about having good pre-college experiences in math and science, most of them gave credit to their parents and/or siblings for helping them choose STEM.

Most of the respondents tied their love for math and science to their love for the teachers who taught them in high school. The teachers that were identified as effective by the respondents were those who they could relate to in and out of the classroom.

A White first-generation chemistry major from Crimson University recalls teachers from pre-college days who made impact on her choosing STEM:

> All the science and math teachers that I had did really well presenting it. Algebra two and AP stat teacher even won for Durham County…won the teacher's award the year after I left. They were wonderful teachers. Most of my science and math teachers were wonderful teachers and taught the information in their own style, so we absorbed the most that we could.

When the interviewer asked a respondent about her math classes and if she felt her math teacher was interested in her success, one White first-generation college female from a PWI said:

> Oh yeah, I mean these are teachers I will be able to joke with, that if I saw out in public, I will say hi to them and you know go out of my way to say hi to them or whatever. They were very cool teachers to have you know, they were nice to you. They treated you like a person, which was a good thing.

Some of the first-generation college respondents report having teachers who later became their mentors. A Black first-generation college student in biological sciences at a PWI shared her experience with a teacher who supported her which led her to choose STEM:

> Um, most definitely, her name was Lisa Smith (not real name) and, um, Ms. Smith taught- she taught college algebra and I think she taught like this little other theoretical math class, um, but she was really, she was a really good teacher. Like, even when I went up to the upper math, I could go back to her and say, I don't understand this, like, you have to help me, and she's like more down to earth. She was a, you know, an African American woman who kinda like understood where I was coming from, like, with my- you know, my family situations and everything and she would, you know, say, oh, we can meet at the coffee shop and I can show you how to do it, or, you know, with just anything, like, she even picked me up because she knew I didn't have a car.

The non-first-generation college STEM students also raised pre-college experience at a benefit to STEM retention. A non-first-generation college White female majoring in computer science at a PWI points to her teacher as helping her develop her interest in computers. She told the interviewer:

> I had a teacher in my senior year of high school that did engineering. She taught us how to take apart a computer and put it back together. Um, and she was really into the technology. I was thankful for that because she really got me interested even more in computers. I had a lot of good helpful

> teachers. I think they were happy to see someone show interest in science, so they were really focused on helping.

A student who left the STEM recounted her pre-college experiences as impacting her capacity to declare STEM:

> Um, you know I was good at it when it was you know in elementary school but high school like I guess I just lost interest in it and it just wasn't really you know—I don't know. I just lost interest and I just didn't really—I wasn't good at it. And then I took a break because I graduated early from high school and I had like a semester break before I went off to college and I think you know that was maybe part of like you know what made me want to kind of step out of my comfort zone and major in kinesiology you know because I was like you know well maybe you know college is different and maybe I will give science another try you know and maybe major in something that was like primarily science-related.

These quotes illustrate that first-generation college students who had positive pre-college experiences in math and science are more likely to persist in STEM compared to first-generation college students who did not have positive pre-college experiences. They provide further insight into the reason why the gap in STEM retention exists. This also reinforces the results from table 5 which indicate that first-generation college students are 30% less likely to graduate from STEM compared to their non-first-generation peers.

Summary of findings

The aim of this study was to answer the question of "What personal and educational experiences do first-generation college students have that differ from non-first-generation college students in the path to graduating from a STEM major?"

(a) How do pre-college experiences influence first generation college students in their path to graduating from a STEM major?
(b) How do personal and family situations influence first generation college students in their path to graduating from a STEM major?
(c) How do college institutional characteristics and experiences influence first generation college students in their path to graduating from a STEM major?
(d) How do social and academic integration influence first-generation college students in their path to graduating from a STEM major?

The findings of this study do not reflect a paradigm shift in higher education research; rather they add modestly to the accumulated knowledge about these problems and potential solutions that advance the understanding of retention and success of first-generation college students in STEM. Given the findings of this study on the importance of high school math and science, a focus on pre-college course-taking for first-generation college students, women, and students from working class families can help policy makers begin to address the disparities in terms of gender, first-generation status, and race/ethnicity in STEM attainment.

The findings in this study is both an acknowledgment of the work of other scholars (Berg, 2020; Wilbur, 2021; Wildhagen, 2022) about the need to investigate the performance of first-generation college students in STEM programs and a modest contribution to the body of work by exploring the effect of pre-college experiences on a sample of diverse students in North-Carolina. Below I lay out the study implications and recommendations.

Study Implications and Recommendations

Findings from this study indicate that positive pre-college experiences and having effective math and science teachers can make a difference for first-generation college students.

- Improving K-12 science and math instruction is essential for increasing college STEM retention. Therefore, hiring and retaining talented and passionate teachers could encourage more students to consider the STEM path.
- This study found that most students who persisted in STEM referenced the influence of a teacher. Hence, the impact of teachers for first-generation college students on the STEM path cannot be understated.
- Availability of more math and science classes in high schools will provide more opportunities for students from diverse backgrounds to expand their knowledge of concepts in those areas.
- Some of the first-generation college students interviewed in this study reported attending schools with few or no advanced placement classes. Providing opportunities for students who are interested in STEM to be exposed to mathematical concepts early will help increase their comfort level with upper-level math concepts before they get to college (Tyson et al., 2007; Tyson, 2011)
- The effect of gender is still a notable predictor for graduating from STEM, so reversing this trend will require the deconstruction of the social bias against women in STEM.
- Early socialization of girls is critical for identity development and self-efficacy; socially constructed roles for women are antithetical to the optimization of the potential of the girl child.

Limitations of the Study

No research model is perfect; this study is no exception to that axiom. The qualitative data employed in this research are from a self-selected sample of students from North Carolina, and like most qualitative data cannot be generalized even though the state of North Carolina is, in many ways, like the overall United States population. Any self-selected sample from a purposeful sampling frame offers findings that illustrate themes that emerge from the sample itself.

Conclusion

Although there is extant literature about the experience of first-generation college students, very few studies have explored the unique experience of first-generation college students in their path to graduating from STEM majors. This study helps give voice to the experience of this group of students. Findings from this study are the basis of recommendations for policies to enhance retention in STEM. What I have tried to do in this study is to show the effect of parents' education on college retention, particularly STEM retention. This research shows what policy makers can begin to do differently to help improve STEM retention rates for first-generation college students, who are also disproportionately underrepresented minorities (Ong et al., 2011).

While the findings of this research can help educators and policy makers improve STEM attainment rates for first-generation college students, they also help advance the goal of diversifying the STEM workforce for women, students from working class families, and underrepresented minorities. Considering the current global competition for scientific advancement, harnessing the current talent pool that consists of women, first-generation college

students, and underrepresented minorities can improve the chances that the United States will meet its workforce needs in the coming years.

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