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ORIGINAL PAPER

What can we learn from the science identity narratives of first-generation college students?

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Abstract

First-generation college (FGC) students—students who are the first in their families to attend a 4-year university—represent a crucial rising demographic toward increasing the numbers of STEM majors and professionals. Unfortunately, when compared to their non-FGC peers, FGC students not only leave STEM programs at higher rates but are also more likely to completely exit higher education. The development of an identity related to science is an important component toward fostering increased retention and graduation in STEM programs. The science identities of FGC students are still an area of prudent investigation due to their substantial overlaps with underrepresented students, and their unique dialectic tensions that create complex challenges for these students. This study examines interview data from thirteen FGC students and employs a critical event narrative analysis of their stories relating to science. Results reveal that many of the participants in this study have well-established identities related to science well before entering a four-year university. This study also presents evidence suggesting that weakly developed identities are more susceptible to deteriorating or being "re-written" when confronted with traditional academic and cultural barriers during their early years at a university.

Keywords Narrative inquiry · First-generation college students · Science identity · STEM

Introduction

Science, technology, engineering, and mathematics degrees

The U.S. workforce is expected to suffer a deficit of science, technology, engineering and mathematics (STEM) professionals over the next decade (President's Council of Advisors on Science and Technology 2012). Unfortunately, students are

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either voluntarily leaving or failing out of STEM degree programs at rates that make addressing this deficit challenging. Additionally, significant demographic biases in course performance, degree success, and retention are pervasive within many STEM disciplines and add confounding factors toward reaching new populations of students (Cundiff et al. 2013; Eddy et al. 2014; Estrada et al. 2016; Kost-Smith et al. 2010; Levine et al. 2008; Matz et al. 2017; Toven-Lindsey et al. 2015). While the numbers of traditional college students have remained consistent, the number of first-generation college (FGC) students have been increasing in post-secondary institutions over the last decade (Hoyer 2017). FGC students represent an important sub-population of interest not only for increasing the numbers of STEM majors but enhancing the diversity of students entering and graduating from STEM programs. Beyond a rote increase to the numbers of STEM professionals, FGC students also bring significant skills and knowledge to STEM fields (Smith and Lucena 2016). Despite the intrinsic value that FCG students can bring to STEM programs, they often disproportionately struggle or fail to persist in a traditional university setting regardless of academic ability. FGC students are more likely to come from a demographically biased groups which often encumbers them with "unique and persistent challenges"—in terms of both academic and social achievement at a university—not usually encountered by their non-FGC peers. (Dika and D'Amico 2016).

Persistence in STEM

Factors influencing student persistence in STEM are well studied (Graham et al. 2013; Hanauer et al. 2016; Toven-Lindsey et al. 2015). Influences on STEM persistence range from experiences in the high school such as the level of mathematics preparation and enhanced interests in science, or with external factors such as parents' education and parents' income (Gayles and Ampaw 2011), as well as standardized test scores (Whalen et al. 2010). Within the post-secondary setting, a six-year study conducted by Whalen et al (2010) found that factors such as GPA, financial resources, and residency status all predicted students' persistence in STEM.

Other studies have consistently suggested a series of six constructs that positively predict the degree to which a student will persist through their undergraduate education to complete a STEM degree (Hanauer et al. 2016). Those constructs are: (1) emotional project ownership, (2) content project ownership, (3) self-efficacy, (4) science community values, (5) science networking, and (6) science identity. Emotional and content project ownership characterizes the degree with which students get to choose their methods of inquiry, research questions and project focus; as well as their emotional investment in those choices (Hanauer and Dolan 2014). Self-efficacy (Bandura 1977) deals with a student's perception of their ability, and correlates positively with persistence amongst diverse groups of students (Estrada et al. 2011, 2016; Robnett et al. 2015). Science community values is the perception to which an individual associates with the established values of science (Hanauer et al. 2016). Science networking is the frequency that students interact with science faculty and post-docs as well as how often they talk about science with family and friends. Lastly, science identity is the degree of salience with which a student

perceives themselves as a scientist and is strong predictor of persistence in STEM (Hanauer et al. 2016). Occupying a region of overlap between science community and science networking, positive interactions with STEM faculty members is also correlated with increased tendency to stay in a STEM degree program (i.e., Gayles and Ampaw 2011).

Science identity

An identity related to science is a crucial component of a student's interest and persistent in college STEM programs (Verdín and Godwin 2019). For example, students' interests and preferences also play an important role in science identity development (Hazari et al. 2013).The influence of an individual's science identity on STEM persistence is also modeled in the Persistence Framework developed by Graham et al. (2013). Graham et al. state that persistence works like a feedback loop revolving around an individuals' confidence and motivation to learn and do science that reciprocally reinforces their identity as a scientist. Factors such as early research experiences, effective instructional pedagogy, and participation in learning communities have been shown to positively reinforced both an individual's ability to do science and their identity as a scientist (Graham et al. 2013). This concept of a feedback loop is also supported by Robinson et al. (2018) stating that the more salient a student views science as part of their identity, the more they will think and make decisions as if they *were* a scientist.

While an individual's science identity is influenced by a myriad of educational factors, those factors can be grouped into three distinct but overlapping dimensions: performance, recognition and competence (Carlone and Johnson 2007). In this model, science identity is enacted when an individual "does" scientific tasks (performance), is confident in their ability to be a scientist and feels they "fit" in the scientific community (competence), and that they perceive themselves as scientists and are "seen" as a scientist by peers or mentors within the scientific community (recognition). Carlone and Johnson's study focused on the science identities of female underrepresented minority (URM) scientists and found that while performance and competence were important, it was recognition that was the crucial factor in developing science identities for women in their study. Recognition was often an interplay between an individual's self-perception as a science person, their recognition from *meaningful* others as a science person as well as their racial, ethnic and gender identities. Building on Carlone and Johnson's work, Shein et al. (2019) added a fourth dimension which they labeled "interest". The interest dimension encompasses students' attitudes toward science, curiosity to learn about science, as well as their aspirations to be a scientist or work in a scientific field.

The development of a person's identity relating to science is closely aligned with the aspirations of young people. Students' aspirations can be grouped into three themes: capital-related inequities, dominant representations of science, and educational factors and practices (Archer et al. 2020). Archer et al. define the term science capital to summarize a students' perceptions, knowledge, and attitudes relating to science. This concept of science capital is important because the greater amount of

science capital a student has the more likely they are to pursue science after high school. For example, Archer et al. found that 83% of students who were qualified as having "high" science capital continued with science after the age of eighteen (Archer et al. 2020). The cultural and social representations of science and scientists also play a significant role in developing identities relating to science. Dominant educational and social representations of science, such as who is seen as a scientist and who is seen as thinking scientifically, have significant impacts on the gender, racial, and ethnic biases present in most major scientific disciplines. For example, young boys are more likely to be praised for their "cleverness" and therefore be seen as thinking more scientifically than young girls (Archer et al. 2020). Lastly, educational factors relating administration or district practices and educational practices such as a teacher's pedagogical beliefs can impact a student's scientific aspirations. Notably, Archer et al. (2020) revealed that students with higher levels of science capital received more academic support for science.

First-generation college students

FGC students are an important and growing demographic in post-secondary institutions. They can offer unique skills and perspectives to STEM degree programs. However, FGC students pose substantial challenges to educators working to recruit and retain them in STEM degree programs. There are numerous categorical overlaps between students who identify as first-generation with demographic and socioeconomic sub-groups that are often confronted with significant cultural and academic barriers in higher education. FGC students are statistically more likely to come from lower income families, comprise a greater proportion of under-represented minorities (URM), and include higher proportions of English as a second language (ESL) students (Dika and D'Amico 2016; Estrada et al. 2016; Hoyer 2017). Many of these factors can hinder the success of FGC students. FGC students are also typically less academically prepared (Engle 2007; Saenz 2007) and have lower SAT scores, and these factors can put FGC students at an early classroom disadvantage compared to non-FGC students. Even after embarking on a post-secondary STEM degree, FGC students are more likely than their non-FGC peers to leave STEM programs, and they are also more likely to entirely exit higher education (Chen 2005; Ishitani 2006). After earning a STEM degree, FGC students are often still disadvantaged because they tend to carry a higher proportion of student debt (Riehl 1994), and they are also less likely than their non-FGC peers to continue on to graduate school (Pascarella et al. 2004).

Involvement in the classroom and other forms of extracurricular academic experiences at universities have a strong positive impact on student success. Unfortunately, FGC students still have several factors impeding their willingness—or ability—to engage in the social and cultural opportunities that take place outside of the classroom. FGC students are less likely than their non-FGC peers to live on campus or to participate in extracurricular activities. They are also less successful at socially and culturally integrating themselves at traditional universities (Fernandez et al. 2008). The decision to not live on campus, which is commonly a combination of financial

factors and family factors (Orbe 2007), often severely limits FGC students' opportunities to interact in many of the socially oriented academic and non-academic activities. Collectively, these factors work toward limiting their social capital (Pascarella et al. 2004). Outside of academic factors, social capital and social connections are arguably one of the most valuable outcomes of attending a university. In addition to being less prepared than their non-FGC peers (Engle 2007; Saenz 2007), FGC students are more likely to avoid informal academic activities such as studying in groups that help build this social capital, social connections, and academic success. This is again in part due to the limitations of their financial and living situations, and in part rooted in their strong perception of "not fitting in" or viewing all other students as coming from a too dissimilar and "privileged" of a background (Orbe 2007, 2008). There are numerous times during a student's tenure at university where familial support is a crucial component of their success. Due in some part to their socioeconomic backgrounds—as well as their parents' lack of familiarity with higher education—FGC students can receive little support from family while they are enrolled at a university (Orbe 2007; Raque-Bogdan and Lucas 2016).

FGC students' academic identities

Prior studies on the academic identity of FGC students reveals that they are often caught within several dialectic tensions, or "conflicting worlds", that influence their self-concepts, but also influences their interactions with peers and family. Orbe (2008) concluded that FGC students are constantly negotiating amongst multiple frames of their identity, and these frames—or alternate versions—often oppose or contradict one another. For example, FGC students often want to establish their own identities at college separate from their families but often actively suppress that individuality at home to been seen as "part of the family." Another example is grounded within their social frames. FGC students often express a strong desire to be seen as "just another student" while at the same time vehemently voicing their pride in the perception of their "uniqueness" of having to "work" for their educations. Additionally, while many students take pride differentiating themselves from "other" students, they rarely openly communicate their first-generation status with friends or roommates for fear of being seen as "different" (Orbe 2007).

Interviews with FGC students have also revealed a high degree of variability in the salience with which students identify as first-generation. URM and female students often describe the highest degree of saliency about their FGC status while white, male students of European decent identify the least saliency (Orbe 2007). FGC students' perceptions of other FGC students and other college students are also often highly contradictory. For example, many FGC college students do not feel any sense of community with other FGC students. This is particularly interesting because most interventions aimed at increasing the success of FGC students often place them into communities with other FGC students (Ives and Castillo-Montoya 2020). FGC students also typically have the impression that most students they meet at college as someone coming from a family of privilege and extensive college experience (Orbe 2007). These conflicting perceptions warrant further investigation into

how FGC students develop an identity relating to science and how that identity fits within their existing concept of *identity*.

Study framework

Science identity, like other forms of individual identity, is a difficult psychological construct to investigate because it is multi-dimensional, and in some cases, unique to a particular individual and their life experiences (Carlone and Johnson 2007; Conrad et al. 2009; Hecht et al. 2003). To better characterize this complexity, studies investigating individual and collective identity have often employed qualitative methods (i.e., Aschbacher et al. 2010; Carlone and Johnson 2007) or some form of mixed- or multi-method investigation (Archer et al. 2020; Chemers et al. 2011; Estrada et al. 2011; Hazari et al. 2010, 2013; Potvin and Hazari 2014). Seminal work on identity states that a person's identity "is inherently a communicative process and must be understood as a transaction in which messages are exchanged" (Hecht 1993, p. 78). Hecht (1993) developed the communication theory of identity (CTI) based upon the idea that identity is created and reciprocally influenced by our communication with other people. Due to the highly communicative nature of personal identities like science identity, both the CTI and Carlone and Johnson's three dimensions of science identity provide appropriate analytical lens and framework for the current study. The literature on science identity and the identities of FGC students is robust. However, there is limited work exploring how FGC students begin to develop an identity relating to science. Given the importance of FGC students to the future needs of STEM disciplines, as well as the significance of an identity relating to science toward a student's persistence in STEM, this study sought to investigate the following questions:

(1) How do FGC students talk about their identities relating to science?
(2) During what times of their life do FGC students describe when they started to develop an identity relating to science?
(3) How do FGC students choose to describe their identities—or lack of—relating to science?

Method

This study employs a narrative inquiry of longitudinal interview data. Narrative analysis, or more broadly, narrative inquiry, is the investigation of stories (Kohler-Riessman 2000). According to Bold (2014), "narrative is central to human experiences and existences…It [narrative] helps to define self and personal identity." The analysis of the stories shared by students about science and their lives also parallels the central communicative component of the CTI developed by Hecht et al. Understanding narratives that people create to communicate aspects of their psyche are a critical component toward understanding individual—and scientific—identity. Our personal identity is shaped by what we share with others, and personal identities

are shaped by the interactions and experiences of an individual's life. The importance of understanding "lived experience" is one of the leading explanations for the increase in narrative inquiry studies over the last twenty years (Atkinson and Delamont 2006).

Stories derive their power not from verifiability but from their verisimilitude; they will be true enough if they *ring* true (Mertova and Webster 2019). While stories have been used as a medium of communication for millennia, the concept of analyzing narratives as a methodology was initially formalized by Labov (1982) and was later expanded upon by Labov and Waletzky (1997). The method developed by Labov viewed all forms of narrative as following a defined structure based around formal guidelines of traditional linguistic narrative. Labov's method assumes that all narratives recount past experiences and organizes narratives around a setting, an action, a result, and finally the coda. This methodology has been criticized for its overly restrictive and formalized structure that can limit the application of narrative inquiry and overlook many of the significant types of informal narratives people use in their everyday lives (Clandinin 2016; Connelly and Clandinin 1990; Mertova and Webster 2019). It is these informal narratives that provide the focus of my examination of students' identity relating to science.

In contrast to Labov's method of narrative analysis, a more general—less constrained—form of narrative inquiry has been applied to a wide variety of qualitative studies with themes ranging from education (i.e., Clandinin and Clandinin 2019; Clandinin and Connelly 1998; Craig 2011; Mertova and Webster 2000) to personal identity (Aschbacher et al. 2010; Bamberg and Georgakopoulou 2008; Georgakopoulou 2006; Kohler-Riessman 2000; Wiles et al. 2005). Modern narrative inquiry has evolved to be more of a "lens" for looking at qualitative data rather than being defined by a strict methodology. This move toward a broader umbrella of narrative inquiry was first summarized by Connelly and Clandinin (1999). Within the broader umbrella of narrative inquiry, this study employed a method of narrative analysis called critical even narrative inquiry. Critical event narrative inquiry is described in Mertova and Webster (2019) and organizes narratives into three broad types: critical events, like events, and other events. Like other forms of narrative inquiry, critical event analysis focuses on the temporal aspects of interview segments and consequently seeks to identify the stories of past, present, and future events that are important to the storyteller (Mertova and Webster 2019). When evaluating narrative as either critical, like, or other events; *typically,* the greater the elapsed time between the event and the interview, the more profound that event. Critical event analysis also provides a way of qualifying the wide variety of narratives share by participants in this study.

Critical events are typically stories that altered the storyteller's perception of the world or how they saw themselves fitting within their worlds. This parallels the idea that identity is something socially constructed and often negotiated amongst groups and individuals. Like events are often contextually similar to critical events (Mertova and Webster 2019), and in my analyses I interpreted like events to either build upon a critical event or discuss different events using the same context as a critical event. Other events are narratives that are not contextually related to a critical event, nor profound enough to be considered critical. Mertova and Webster

(2019) describe other events as "corridor encounters, lunchtime conversations, and the many informal associations" (p. 78). It is important to note, however, that the type—or number—of like and other events can be used to provide a greater degree of verisimilitude for a critical event narrative. I guided my narrative inquiry on the idea that there are specific events, experiences, or interactions in students' lives that either shape—or suppress—the development of a "science identity". Consequently, I employed a type of narrative inquiry that focuses on critical events to better interpret narrative segments within my interviews and to outline a semi-formal hierarchy within those narrative segments.

Participant selection

Participants were undergraduates enrolled in a large public research university in the Pacific Northwest. Participants were recruited in the beginning of the Fall semester of 2017 through an email solicitation sent to all enrolled students in introductory biology. The email covered basic information about the study as well as describing how students would be compensated for their time and the requirements to be eligible for compensation. The focus of the study—science identities of FGC students—was never revealed to participants. The final list of participants was the result of purposeful and random participant selection. From the initial list of students who volunteered to participate in the study, students were place into two bins: FGC and non-FGC college students. Each of those bins were then stratified by gender. Next, ten participants were randomly selected from each gender bin within FGC students and were invited to take part in the study. Of the twenty students invited, thirteen students agreed participate (Table 1). After final selection of the study participants, an additional email was sent out describing the process of scheduling their first interviews, when to expect the follow-up interviews, and additional information on the general premise of the interviews, which was explained as experiences in undergraduate science courses.

Interviews

One-on-one interviews were conducted in a private room and recorded using a digital audio recording device. Interview locations were chosen based on input from the participants. I tried to give each participant as much freedom as possible to choose the date, time, and location of each interview. This was done to foster a positive relationship, support the feeling that their time was valuable, and to demonstrate my appreciation for their participation. The first round of interviews took place during September 2017. Initial interviews were open-structured. The second round of interviews took place between May 2018 and June 2018. The second round of interviews was more structured, and each set of structured questions was based off the topic from participant's initial interview. Reminding participants of their descriptions, thoughts, or opinions from their initial interview is an interviewing method known as prospective focus. A prospective focus reminds participants of what and how they described phenomena, and then asks them to reflect on how those descriptions have

Table 1 Demographic, academic, and interview data for all thirteen interview participants

Pseudonym	Gender	Race	Ethnicity	SAT	Academic year	Degree	1st Int	2nd Int
John	M	AK Native	Am. Indian	1340	Sophomore	Environmental Science	X	X
Allison	F	White	Hispanic	1380	Freshman	Pre-health	X	X
Casey	F	Chinese	Asian	1140	Freshman	Pre-engineering	X	X
Shay	F	Blk-Africa Am	Afro-Am	1040	Sophomore	Public Health	X	X
Heather	F	Multi	Asian	1360	Freshman	Pre-science	X	X
Abby	F	Multi	Chinese	1260	Freshman	Pre-science	X	X
Julie	F	Vietnamese	Asian	1260	Sophomore	Engineering	X	X
Matt	M	Chinese	Asian	1310	Freshman	Environmental Science	X	X
Rachel	F	White	Caucasian	1100	Sophomore	Pre-science	X	X
Christine	F	White	Caucasian	1430	Sophomore	Pre-science	X	X
Will	M	White	Caucasian	1150	Freshman	Earth & Space Science	X	
Robert	M	White	Caucasian	–	Sophomore	Pre-science	X	X
Margaret	F	White	Caucasian	1280	Sophomore	Engineering	X	X

An (–) in the table indicates that data were not available from the registrar. A blank in the 2nd Int. (interview) column denotes that participant was unable to participate in a follow-up interview

changed. Prospective studies avoid many of the biases found in retrospective studies that rely on asking participants to recount their thoughts or feelings about a phenomena (Farrall 1996). A prospective focus works well within narrative inquiry because I was able to ask participants to directly reflect on the stories they shared and about how more recent experiences may, or may not, have changed the value or importance of those narratives.

Data analysis

Organization, notation, and analysis of the interview data were completed using Atlas.ti version 8.4.4. Coding began by highlighting important interview segments and making notations for each highlighted segment. These notations, and my reflective journal entries on participant interactions during interviews, were used to group highlighted segments and to begin the process of developing codes. As codes became more defined, initial codes were linked to each other based on their level of association and whether they related to a similar narrative. The connections amongst codes and highlighted statements unique to each participant were used to construct a network map providing a visual representation of the qualitative data for each participant. Network maps are graphical representations of a part of a project created in Atlas.ti that show codes and their interpreted relationships (Smit 2010). Network

maps assisted me in visualizing the large volume of highlighted statements, codes, memos, and other notes created for each participant. The network maps also allowed to see which narratives met the criteria for a critical event by analyzing which stories had the most connections. The last step of data analysis used the information in the network maps to code particular narrative as either critical events, like events, or other event narratives. Critical events were stories that had a substantial amount of coded connections, and many of those supporting stories were coded as like events.

Results

Critical event narratives

A wide variety of critical event narratives were identified from the participants in this study. While each participant's narrative is unique, there are some similarities amongst the temporal contexts of the narratives, as well as the interpreted meaning and importance of each critical event narrative. Many of the participants described strong connections to the natural world—or with science—rooted in formative experiences with family or friends. Temporally, most of these events occurred when the participants were young, well before they were thinking about science professionally and academically. For example, Allison described her experiences that inspire her interest in science:

Allison Well, definitely my parents' belief, I guess. They consider themselves science people. I was always –

Interviewer What does that mean when you say that?

Allison As in we would spend time together as a family learning about the world, and my dad would talk to me about new discoveries and fun, scientific things. I mean, we'd do little experiments together. If I ever had a question about something, we'd try to do it, right? I always had fun doing the science projects things. I think the fact that being scientific is so conducive to learning was really helpful, too, because I learned way more watching mold grow on bread myself in comparison to what liquids they were in to understanding why I shouldn't leave food out on the table. If you can get to a point in scientific discovery where you're doing it hands-on, I think that's the best learning I've ever had. It's interesting, and you feel like it's actually making an impact.

In her recounting, Allison describes how science was important to her parents and is an important part of her everyday life. Matt describes a contextually similar narrative involving early experiences with the natural world:

Interviewer I guess that brings a point, do you see yourself as a scientist or a science person?

Matt Yeah, I honestly think I do. I watch a lot of films, I watch a lot of documentaries, and it just interests me. And then even after watching, I just think about it sometimes. I just lay down or during dinner, I just think about it. Why did this and this happen? Why does that happen? What did they do that?

Interviewer So, you think you've got a lot of passion for that?

Matt Yeah.

Interviewer Have you always been like that or is there something particular in your life that you remember kind of sparking that...But if there was something you remember that particularly facilitated this interest in science?

Matt I think it was a buildup. Elementary school, we went on the shore, and we collected animals. And then I collected something, and then I got a prize for it. Okay, that's one small step. And then another small step would be I started watching about animals, and then I Oh, I like animals a lot. That's another small step. And then in middle school, I went to the ocean, and we would get clams and all that. I would just look inside. I was like, Oh, that's cool. Why is it colored like that? Why does it have that? So, it's small steps that got me into it, not one big step, like, Oh, that's smart.

Interviewer It wasn't a class, or a course experience, or anything like that?

Matt There were courses that interested me, but it was just smaller steps to figuring out that I actually feel like a scientist.

Parallel to those narratives describing early events with family and the natural world, several participants had similar early experiences with science that range

temporally from early childhood to late K-12 years. For instance, Robert had close family friends that exposed him to authentic and highly formative experiences. He describes one such experience in the narrative below:

Robert For me, before that, I always had the idea of medicine in my mind.

Interviewer What do you mean by that, "the idea of medicine"?

Robert Just I thought medicine was cool. I thought that being a doctor was cool. Like most people do, but I didn't really understand exactly what it implied. We had not family members but friends who are physicians. I hear about what they do, and I really enjoy it because it's like you're doing a career where you're doing your best to help people, but you're getting paid to as well. That's, I guess, not really a job at that point. I thought that's sort of the mindset that I went in, so I was like, oh, there's a class that sort of lines up with that, and then took that class starting sophomore year and just continued with it. That's sort of what really set [it] in stone that passion for me.

Casey's narrative, in many of the same ways as Robert's, also conveyed early authentic experiences with science that shaped her passions and interests in becoming a scientist.

Interviewer Okay. I guess why engineering?

Casey It goes back to when I was a kid. I always liked figuring out how things worked and, actually, one of my favorite stories is when I was little I was playing with the stereo at home and I accidentally turned it on at full volume and it scared me really badly. But I've always liked taking things apart. I got into robotics middle and high school.

Interviewer Cool!

Casey And so, I bounced around between software and hardware and design.

Interviewer In high school?

Casey Yeah, in high school. But then I settled in hardware.

Interviewer Okay.

Casey Then also just something I do is I like watching "How It's Made" on TV.

Interviewer Oh, yeah, the show, yep. Okay.

Casey Yeah, I used to watch that a lot.

Interviewer So, that got you into engineering?

Casey Yeah.

Other participants' passions and interests in science, as well as the reasons why they tend to think of themselves as "scientists", are rooted in critical event narratives that involved emotionally impactful experiences with family and friends. Abby relates a narrative involving a family member who became troublingly ill when she was younger:

Abby Well, I was looking into anesthesiology, and I thought that was really interesting. And I've talked to peers, and they said that biology would be a good pathway into that career field. But to be more general, I wanted to do something STEM related because since the start of high school, I created this passion to help others because I was really involved in volunteering and all those extracurriculars that would be involved into volunteering, so I thought that would be a good correlation and jump into the real world because just of the general idea of helping others. And at the same time, I wanted to go into STEM because I have a family member that passed away from cancer, so I wanted to be a contribution to just the overall STEM field.

Interviewer So, you think it feels more like a personal thing to you with biology and chemistry.

Abby Mm-hmm.

Abby's narrative about why she feels like a scientist was also deeply personal and involved an early experience in her life where she feels she could make a difference as a scientist. Julie also described a very personal experience involving a family member, a medical condition, and science:

Interviewer I know what you mean. So, that brings another question then, why a doctor? Why do you wanna [sic] be a doctor?

Julie That's a good question. I have a hard time answering the question every time I….

Interviewer That's okay. I mean, I said they're easy questions, but sometimes these are not easy questions. Julie: It's kinda like, "What do you hope to be doing in 5 years? I don't know. Something.

Why do I wanna [sic] be a doctor? Because with all the bio exposure, and I know that I wanna [sic] major in bio, and doctor has a lot to do with bio. And also, it's because one of my personal story that my dad got when he [inaudible] back in Vietnam, when I was five, six, my dad got really sick with TB, and so that just kind of piqued my interest in a sense because in Vietnam, back then, they didn't know what kind of TB was having, so they made him intake more than 10 pills every time he took his medication.

And it just bothered me how they couldn't explain it. They weren't able to explain it, and during the time, my parents wouldn't let me to come closer to him. So, I guess my personal experience with disease.

Interviewer So, that whole experience made a pretty big impact on you?

Julie Mm-hmm.

Interviewer Diseases and stuff.

Julie And then with the exposure, doing high school was tough, too. So, that kind of added on more.

While several of the interview participants discussed events in their past that laid the foundations of their identities toward science, other participants passionately describe a strong feeling that they have "always" identified as a science person or a scientist. For example, Will could remember he always knew what he wanted to be, regardless of what other people in his life told him:

Will Not really, no. I got told growing up that being a paleontologist was a really stupid idea. I got told that a lot, so I ended up switching to something more practical like being a doctor.

Interviewer It is very practical.

Will And then I ended up taking a class on dinosaurs here at the University of Washington, and I was just like, Screw all of you. That's what I like, I'm gonna do it.

Interviewer So, you've been interested in paleontology for some time?

Will My entire life.

Interviewer Oh, really?

Will Yeah. I mean, I was one of those little kids that could list off just about any dinosaur you put in front of me, and I could spell it before I could spell my own last name. And everyone was like, That's just stupid.

Interviewer Who's everyone?

Will All of my teachers –

Interviewer Teachers, really?

Will Yeah.

Interviewer That's depressing.

Will Yeah, it was. Because it's a very far out there thing, and if you don't know much about it, you don't know that there's always fossils being discovered. They're like, "By the time you're to that point, all of them are gonna be found. That's really stupid. You gotta change it.

Interviewer That doesn't even make sense. It's like saying all the science will be done by the time you get your PhD. It's just a ridiculous [inaudible].

Will I realized when I switched.

Will's critical event is built around an identity based on his resistance to the opinions of others. This critical event narrative is a powerful example of how even some negative events in an individual's life can help shape their identity. Rachel is another participant that always saw herself going into science or medicine. Her critical narrative communicates the excitement she has toward a future working as a surgeon:

Interviewer Did you have an idea of what you wanted to do before coming to college?

Rachel So, I did know that I wanted to be a surgeon. I had the idea I was going to med school and everything. It's just I changed my major or intended major from biochem [sic] to the two that I am now.

Interviewer Okay. So, then why surgery? Why a surgeon?

Rachel I just love it. Like, I love watching it. People get grossed out by it but it's just so –

Interviewer No comment [audible laughing].

Rachel It's sooo [emphasis added] fascinating. Like, my grandpa had to have open-heart surgery and I was really jealous I couldn't watch it but it's just so cool how the body works and, I don't know, I'm really fascinated by the heart because I want to be a heart surgeon.

Interviewer Okay.

Rachel And just like how it does what it does by itself and how everything works together is so cool.

Interviewer And you can't be on that machine for very long because I think it stops the impact, or at least the efficiency of it decreases severely over time, which is really interesting. Have you—I guess that brings up have you always been interested in it? It seems like you've always been interested in surgery stuff. Is there anything particularly in your past that was the defining moment of, man, surgery, I totally want to cut people open and look at their insides?

Rachel When you say it like that it's kind of weird…I guess not surgery as much but I've always kind of known that I wanted to go into medicine and help people. My mom when she was pregnant with my little sister, who is now 5, it was just not good on her at all. She had to have an IV on her constantly and she had a Zofran pump. I don't know if you know what that is.

Interviewer No.

Rachel But it's like –

Interviewer My wife has had a baby, but I don't remember that being mentioned.

Rachel Right. It was really hard on her. She didn't have to have it with any of her other kids. It's like this little tiny needle (very small) that's in her stomach constantly and it's just pumping in Zofran. It kind of reminds me of an insulin-type thing for diabetes but it's not. But it just kind of reminds me of like how insulin works for when you have it. But I was essentially her home nurse for her because she refused to stay in the hospital because she is very stubborn, and I would have to put the medicine into her IV bag and change her pump of Zofran.

Interviewer So, were you all about that? Were you all excited?

Rachel Well, back then I think I was a freshman in high school, and I would wake up at 1:00 a.m. and do it and 3:00 a.m. and –

Interviewer Just like a nurse.

Rachel So, I was like this is terrible but after I think about it, I'm like, you know, I'm really glad that I did that. I don't know. I think it helped me become more involved in it and look at it as kind of a little bit of what I'm going to be doing, yeah.

Christine also shared a narrative that is contextually like Rachel's where she states that she always had this interest in science and medicine. In addition to describing the "always thought of myself that way" her narrative also incorporates emotionally significant events and interactions with individuals that helped shape her identity:

Christine I think it's just it's a highly specialized major, neurobiology is. There are different things within neurobiology, but it's also the research is very important that is involved with it, not that research in anything else isn't important. I've heard from also some people that are majoring in neurobiology that a lot of people self-select out because they're like, "Oh, I'm not gonna get into it. It's too hard," so that made me feel a bit better because I talked to someone about that yesterday. But I think it's just they have high standards for what you need to have for your biology grades and all sorts of things.

Interviewer So, I guess the big question is: Why neurobiology?

Christine It's so just a base question, but I love the brain so much. It's my favorite thing to study. I had the opportunity to take anatomy and physiology at my community college, and when we did neuroanatomy and neurophysiology, those sections, those were always my favorite to study. I've always just been really interested in the brain. It's what makes us who we are. It's such an incredible organ, and it has more processing power than any computer that's ever been made. I'm fascinated with how it works, and I want to find out more about that.

Interviewer How long do you think you've had this strong interest in life sciences?

Christine Probably since I was in about 8th grade, so when I was 13, 14. I've always really liked biology. That was my favorite subject always, and I kind of went away from it for a little bit because I had some – I don't want to put it on the teacher, but I just had some teachers that I didn't necessarily agree with their teaching style, and so it made it difficult for me to learn, and so I was like, "Oh, maybe I don't like science." But then, I had an incredible chemistry teacher my freshman year, and he reintroduced me to everything. So, really, since then, I've been really into the sciences.

Interviewer Freshman year at?

Christine High school.

Interviewer Okay, high school. Yeah, I keep forgetting. So, what made that experience different than previous ones?

Christine That teacher, he did a pass-or-fail learning style, so –

Interviewer In high school?

Christine Yeah, so that was interesting. But he focused heavily on learning and self-learning, so it was really we held ourselves accountable.

The critical event narratives shared by participants discussed above voiced both contextually similar and contextually unique aspects. However, the participants discussed in the preceding section all tended to see themselves as medical professionals, scientists, or science person. The critical events discussed below are from participants who I interpreted as having an interest in scientific information, science, or the natural world but did not incorporate a strong identity toward the fields of science or medicine in their narratives. For example, Margaret states that she has always been interested in math, but her narrative does not convey a strong identity toward science despite her interest in math:

Margaret I've always really actually liked math, surprisingly. I liked math, and I liked sciences, and I liked the idea of being able to have both together. And then, for a while, I was actually thinking bioengineering. So, then, there's also my Mom is in the medical field, so combining the medical field in with the engineering was really cool to me. But then, I realized after I took Math 307 –

I wish I had stopped at Calc 3. After that, I just realized, I was like, "I don't want to take any more math," and I just realized I didn't really want to be an engineer. And I thought maybe if I stuck more to the medical field, or maybe

becoming a pharmacist, or even just going full forward, just going and becoming a doctor or a surgeon or something. And then, biology fit in with that better, especially because I was thinking chemistry for a while too, but I didn't want to do chemistry. It was way too hard and way too competitive.

It is important to highlight that my analyses identified this as Margaret's critical event narrative. Compared to the narratives already presented from other participants, Margaret's lacks strong emotionality, excitement, and does not reference events that have a significant temporal component. She mentions mathematics but does not include any discussion of some form of a close or personal association with the field. The next two narratives from John and Heather also do not explicitly identify themselves as a science person or scientist as much as they voice a strong connection with family and nature but want to explore that passion in a field that is not scientific. John's critical event narrative discusses the importance of family and nature, but he wants to pursue a more legal-oriented path to engage with that passion rather than a scientific path:

John: If I did get into property law, I can really take over some of the work for my grandpa or my uncle who own property. And up there in Alaska, I have lots of family who work for tribal corporations. So, Alaska didn't get reservations because the Native's sort of fought it. And plus, everything that happened to the Native's here, lower 48, happened to the Native's up there a lot later. So, they had some more bargaining power and some history. So, they created tribal corporations instead, and these are big powerhouse corporations now. Sea Alaska [sic], which is one a lot of my family works for, is, I'd say, probably the biggest company based in Alaska, easily. And they're the biggest land owner in southeast Alaska.

Interviewer That's not bad. Even for any class. So, when you say that stuff about science, do you see yourself as a science person?

John Not really. That's why law, I like it, and that's why my ESRM, [Environmental Science and Resources Management] I picked it because you get sort of the surface of it. And a lot of my classmates sort of complain about last quarter, that class I was telling you about, because it was supposed to be in-depth Pacific Northwest, but it really wasn't. It was the surface of every environmental issue. We started learning about soils and forests, and they rarely ever connected. It was just a little bit about everything, which I guess for one class, that's not really good because there's not really anything to build off of.

What is insightful in John's critical event narrative is the suggestion that he is a science major but sees that degree as more of a gateway or door to the field of law where he clearly identifies more strongly with. Next is Heather's narrative. She is the most unsure about the whole "science thing" out of all the participants. While

she does enjoy the factual side of science and sees herself doing something connected with nature. During her interviews, she avoided discussing her identity and instead chooses to focus on what she enjoyed more about education during her time in high school:

Heather For me, it's kind of a serious thing. A bit of a—I don't want to say down transition from high school, but I feel like there's a lot more pressure on me to figure out what to do. I guess I'm just a very cautious person. I want to know where I'm going to be going, and just given that's not really how college or life works, it's kind of a stress factor.

Interviewer What do you mean by a down transition from high school?

Heather Just that there's not as much interaction between professors and students, even given office hours and such. I feel like there's sort of an extra barrier between teachers and students.

Interviewer [Inaudible]. Oh, go ahead.

Heather Just I feel like there's a central motive to just sort of in a flurry, just get your students to pass, get through the class and move on, next group of kids. Almost just kind of a factory-like system, instead of a we need to really understand this in a passionate manner, and in a way that makes the learning enjoyable and fun.

Interviewer So, it sounds like your high school might have been very different than college?

Heather Yeah, I guess it was, mostly, I think, just because it was very lively in terms of getting students involved with the subjects that they were teaching.

Interviewer So, can you talk a little bit more about what you mean by lively, I guess?

Heather Well, more hands-on, like practice, physical demonstrations. You could see more rather than just quick textbook reading. Again, I might not be speaking enough from experience, just because I've just started college, and there's a lot more to see. So maybe those experiences that I'm looking forward to are still yet to come, and I'm just impatiently waiting here. But yeah, that's—I think that's mostly it.

Interviewer How was your transition from high school to college?

Heather It was really rough the first week, but that's mostly just because I'm a very big family person, and of course, college is a move away from family, and it was difficult finding friends or people to connect with or consult if you were having difficulties. There's a little bit of loneliness there, but I've gotten through that, so now it's better.

There is a distinct topical difference between Heather's narratives and the other participants. Heather is the only study participant that explicitly resisted associating herself with science in any way and did not share any early life experiences related to science. The next critical event narrative comes from Shay. She has a complex dialectic involving her identity as a FGC student and her academic identity. Shay has significant cultural and family responsibilities, and it is from those long-time cultural and familial ties that she has developed her interest and scientific identity. However, those same ties also exist at odds with her emerging individual identity as a university student and as a science person:

Interviewer You mentioned community. Is that important to you when picking a major?

Shay Yeah. I don't want to be—in the future if I'm working, I don't want to be locked up in a lab and just doing my own research by myself and not being able to communicate with other people. I want to mostly give back to people and just be able to be able to create my own things as well as communicate with people and help people.

Interviewer Is giving—how come giving back and helping people, why is that important to you?

Shay I guess because the way I was raised. My mom really helped—not helped, but she raised us, me and my brothers, all by herself basically. I just want to be able to do something that will make her happy and make her proud, as well as the people, my people back home in Somalia who are basically struggling. I have a lot of family members there that I don't really—I haven't talked to in a long-time, and I haven't seen. I want to be able to do something that gives me the opportunity to go back home as well as help other Somali people who are struggling, and just be able to do something for my community as well as my mom and my family.

Shay's narrative shares similarities with other narratives voicing the idea that she "has always wanted to do", and having her identity strongly rooted in family experiences. However, he unique cultural responsibilities makes her narrative distinct and

an excellent exemplar for the narratives of many FGC students who come from ethnically diverse backgrounds.

Follow-up interviews

Follow-up interviews were more structured than the initial interviews and focused more precisely on how students' university experiences over an academic year shaped their identities related to science and the critical event narratives used to share those identities. Analyses of the shifts—or lack of shift —from participants' critical event narratives revealed that early university experiences had little positive impacts on FGC students who had established identities related to science. For many of the participants who already had well-established identities their university experiences helped to reinforce those pre-existing identities. Newer university experiences were added onto their pre-existing critical narrative associated with their identities relating to science. However, for participants without early established identity narratives, early university experiences had little positive impact.

Early university experiences most often coded as a like event based on how the FGC students in this study talked about their science identities. From the initial to second round interviews there was almost never any mention of specific class activities, courses, or casual interactions with professors within in the narratives of students. Critical event narratives show almost no change from students' initial interviews. Even when explicitly asked to reflect on how their time at university shaped their initial identity narratives, every participant affirmed their initial critical event narrative. Students with well-established identities related to science often discussed how they would attend activities at the university to find other students like them that supports the way the "felt" about themselves. For example, Matt describes how he surrounded himself with like-minded people: "…I wanna [*sic*] earn it and get into biology. I wanna [*sic*] be surrounded by the peers that were competitive as me that went through all of this because if I do environmental studies, I'm the competitive one, and there's not a lot of peers that can relate with me, while in biology, I can relate with those peers because we all went through the steps to get into the course." Will also describes a similar circumstance meeting people whom he resonated with:

> Will All of the chemistry, as the pre-med guys, they would have just normal conversations about the class and what they were learning, and I never understood that. I was like, Guys, that shit sucks. What are you doing? But then I realized once I started doing study groups and making friends in the geology department, that's what my conversations were around, which was nice to understand.

Casey had a similar statement, "I guess…there were a lot of people that were really passionate about learning things and part of engineering is you are faced with a problem that you might not know how to solve but you can figure it out."

Discussion

Participants' critical event narratives suggest that many FGC students—notably, ones already interested in a STEM major—already have some form of pre-existing identity related to science. Prior work on FGC students consistently shows that they have less "insider information" about university life (Dika and D'Amico 2016; Orbe 2007) and less scientific capital (Archer et al. 2020) than traditional college students. This should lend them to be more responsive to early college experiences, however, this work suggests that some FGC students already have strong identities related to science well before entering a university. This result is paralleled by the conclusions of the ASIRES 2 study which found that many younger students who meet certain criteria already have strong aspirations toward STEM well before attending a post-secondary institution. This study revealed that while early university experiences did not create students' critical event narratives, these experiences did play a role in reinforcing strong narrative identities or breaking down less developed narrative identities. Without strong early narratives, challenges experienced during FGC students first year at a university resulted in them "re-writing" their earlier narratives to accommodate their perceived shortcomings. This result also parallels similar claims made in other studies. In their longitudinal analysis of science identities of URM students, Hernandez et al. (2013) found little change amongst students' science identities throughout their time at a university. Robinson et al. (2018) also made similar conclusions stating that FGC students with stable—early developed—science identities, which they labeled those students as "High with Transitory Incline", consistently identified with science during their university years. Conversely, Robinson et al. (2018) also found that students who did not have these well-developed identities tended to disidentify with science. Analysis of the critical event narratives reveal that informal experiences with science, teachers, nature, and most importantly family provided enough early exposure and recognition to foster their science identity in some way.

From the narratives in this study, I interpreted three broadly constrained categories—each of which warrant further investigation—of FGC students' science identities: (1) experiential, or identities rooted in scientific or natural experiences with people, (2) intrinsic, or identities that are so engrained that individuals have "always" identified as a scientist, and (3) provisional, identities that are newly engrained, not self-reflective or supported by numerous life experiences. Six of the participants in this study were interpreted to have experiential identities, four were interpreted to have intrinsic identities, and three were interpreted to have provisional identities. The interpretation that most of the participants in this study had identities established early in their lives or built around experiences with science before entering university reiterates the importance of early formative experiences with science (i.e., Archer et al. 2020) as well as the importance of parents' attitudes toward science and other informal learning opportunities (i.e., Shein et al. 2019).

Similarly, to non-FGC students and science professionals, recognition is a powerful component toward FGC students' developing science identities. Recognition can be self-reflective or it can come from a trusted individual (Carlone and Johnson

2007). Analysis of the critical narratives reveal that early life interactions—well before entering university—where their interests and passions were recognized by trusted individuals such as family members and teachers helped formulate their early science identities. Even after completing an academic year of impactful university experiences, recognition continued to be a crucial formative factor for FGC students' science identities. For many students, which includes FGC students, there are strong overlaps between recognition and competence. Many students develop strong associations with how they recognize themselves [i.e., identify]—or perceive how others recognize them—by their academic performance (Pelch 2018). Recognition is one of the dimensions of science identity describe by Carlone and Johnson (2007), and they suggest that recognition was one of the most crucial components for the development of science identity for the participants in their study. This theme is echoed in the analyses of the critical event narrative in this study. Taken collectively, this reinforces the impact recognition has on the development of students' science identities. It could also provide an avenue of focus for educators and researchers working to bring more FGC students into STEM. Designing interventions or activities that recognize—or even highlight—FGC students' interests and talents relating to science may be a powerful tool to help them overcome some of the barriers to their success at the university level.

Academic performance and science identity

Poor academic performance, a component of the performance domain proposed by Carlone and Johnson (2007), was interpreted to be more impactful on students who did not have well-developed identities before entering the university. Poor academic performance is related to identity because it has been shown to break down students' poorly established or fragile identities toward an academic discipline (Luyckx et al. 2011). Additionally, poor academic performance can lead students into self-deprecating cycles that foster strong negative emotions (Ciarrochi et al. 2002; Covington 1985; Pekrun et al. 2002; Pelch 2018). For example, Allison stated: "I don't know. I just feel like part of me is a bit not sure. I feel like I'm already set up for failure, because my first year was spent—my first year is gone. It doesn't really count…" That quote was initiated when I asked her about how her earlier critical event narrative changed over the school year. She had below average grades and that made her feel less competent and unsure about identifying with science. These results also connect with the model of STEM persistence proposed by Graham et al. (2013). In that model, academic performance and science identity are linked by students' academic performance. Poor academic performance caused her to alter or explain away her critical event narrative from the first interview. When asked about her initial narrative, Allison stated, "… if I was to be in any part of the medical field, I'd end up having to become a doctor. If I wanted to be a medical examiner, I'd had to serve a residency, and that made me really uncomfortable." Even when prompted to talk about how she wanted to help people and become a doctor, Allison only talked about her new experiences as contrary evidence to her pre-existing critical event narrative. In another example, Heather, who was interested in science and saw herself as a

"science person" started to consider switching out of a STEM major. In a similar narrative shift, Heather also used newer stories to "re-write" her earlier critical event narrative stating.

Heather Because I was reared with music and arts. My mind is more philosophical than it is technical. I have a very difficult time even just finding the motivation to look at the technical stuff. I mean Biology is still filled with it…

Building resilient science identities

Analyses of interview data in this study suggests that FGC students' early experiences with people act as a foundation—or scaffolding—allowing newer experiences to build upon and insulate their older identity narratives. If interactions with people in a significant way helps build positive changes to FGC students' science identities, then repeated life-time exposure to those experiences could work similar to the treatment effective of a psychological intervention. Science identity, like other latent psychological traits such as belonging, self-efficacy, and test anxiety all play a crucial role toward bolstering a students' academic persistence. Well-designed psychological interventions have been shown to promote positive changes for numerous psychological constructs related to academic success. Repeated implementations of these interventions have shown positive effects on the traits these interventions target (Yeager and Walton 2011). Analysis of the narratives in this study show that students who have had meaningful and significant interactions with people tend to insulate their pre-existing science identities, suggesting that repeated positive exposure can build resilient identities. Conversely, students who have identities not insulated with a variety of experiences with people may tend to be more susceptible to modification as they encounter struggles early during university life.

Traditional labels have conflicting meanings for FGC students

Openly asking students about their "science identities" or if they "identify as scientists" might be a confounding variable when seeking to investigate how FGC students, and more broadly undergraduates, begin to develop their own identities as scientists. In fact, the use of this label could be acting as an early barrier of science identity development for some FGC students. Within students' narrative segments, there was often a struggle to come to terms with the label of "scientist". This observation could have significant implications for researchers developing new instruments to measure science identity, or new psychological interventions seeking to affect the identities of undergraduates. Many of the interviews progressed to a point where I would directly ask students whether they identified as a scientist and what thinking of themselves as a scientist meant. This question typically confused many of the participants. While they often had strong identities with science, medicine, or nature participants were often hesitant to openly call themselves scientists. For example, Heather responded, "There are a lot of reasons why I'm constantly

conflicted with that emotion [speaking about her science identity]", and Abby said this when asked that question, "I don't picture myself as a scientist. I mean I would picture myself as a scientist once I become a scientist, like official." When she said "official" she was referring to her degree. Abby's response is interesting because she is hesitant to share her identity with the label of "scientist" because she is still working toward her degree. Abby's response is centered on some type of official recognition. This could be particularly important for researchers seeking to impact students' identities before they graduate. In addition to reservations with the label of "scientist", one participant shared a narrative conveying a powerful racial and ethnic barrier toward identifying herself as a scientist. Shay stated that she does not like using the term "scientist" to describe herself because she feels that she does not *look* like the scientists in her life. She states, "I can't think of myself as a scientist. It doesn't fit me. I don't know. When you see a scientist, you don't see me. In my head you wouldn't see me. You would see, I guess, the…". Her hesitation with accepting the label or associating with the term "scientist" lies in her mental image of a scientist. She is female and African American, most of the people she interacts with are white and male. This a common observation for female scientists and scientist from underrepresented minority groups (Carlone and Johnson 2007). This is another crucial consideration for researchers seeking to increase the numbers of FGC students in STEM degree programs, as many FGC students are also underrepresented minority students.

Data in this study suggests that students are more comfortable with other—more casual or less formal—labels to refer to their science identities. Labels like "science person", "science-y", or non-verbal terms where they are literally referring to themselves as quote, un-quote "scientists" while using their hands to denote quotations were far more common. For example, participants made statements such as, "I realize that I've really always been a science person…" or "I always thought of myself as science-y type…". It might be an effective strategy to test alternative labels to refer to scientists or science identities when developing new quantitative instruments.

Conclusions and implications

FGC students' critical event narratives suggest that early, pre-university experiences, provide the foundation for their identities relating to science. Those identities—if repeatedly reinforced through recognition—can be resistant to change. Due to their informal nature, experiences shared by FGC students to convey their identities can be overlooked in the literature. Participants' critical event narratives were interpreted to fit into three broad categories: experiential, intrinsic, or provisional. Rather than creating identities, early college experiences either reinforce or break down students' pre-existing narratives about their science identities. The propensity of a FGC student to interact with an individual(s) that they viewed as "significant" during university life seemed to have a strong positive impact that built on their pre-existing science identities. Students with more resistant science identities also tended to

share more experiences aligned with their critical events before entering university. Collectively, analysis of the critical event narratives presented in this study provide pathways for educators and researchers to help foster science identities during students' time at a university. It might be more prudent for faculty to assume that students already "see" themselves as scientists in some way, and to devote more effort towards reinforcing or affirming those beliefs.

While many of the FGC students in this study have well-establish science identities developed early in their lives, several participants clearly had early university experiences that eroded their science identities over time. This study only presents limited evidence about what those factors might be and how educators can address them. It has been suggest that identifying the barriers present at the university level is key to recruiting and retaining URM, and by association, FGC students in STEM programs (Estrada et al. 2018). This study reiterates that conclusion and further suggests that a better understanding of the narratives shared by FGC students to describe their identities could be crucial step toward identifying methods that can lead to the development of resilient science identities.

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Conflict of interest I declare that I have not conflicts/competing interests.

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References

Archer L, Moote J, MacLeod E, Francis B, DeWitt J (2020) ASPIRES 2: young people's science and career aspirations, age 10–19. UCL Institute of Education, London

Aschbacher PR, Li E, Roth EJ (2010) Is science me? High school students' identities, participation and aspirations in science, engineering, and medicine. J Res Sci Teach 47(5):564–582. https://doi.org/10.1002/tea.20353

Atkinson P, Delamont S (2006) Rescuing narrative from qualitative research. Narrat Inq. https://doi.org/10.1075/ni.16.1.21atk

Bamberg M, Georgakopoulou A (2008) Small stories as a new perspective in narrative and identity analysis. Text Talk 28(3):377–396. https://doi.org/10.1515/TEXT.2008.018
Bandura A (1977) Self-efficacy: toward a unifying theory of behavioral change. Psychol Rev 84:191–215. https://doi.org/10.1037/0033-295X.84.2.191
Bold C (2014) Designing research projects with a narrative approach. Using Narrat Res. https://doi.org/10.4135/9781446288160.n3
Carlone HB, Johnson A (2007) Understanding the science experiences of successful women of color: science identity as an analytic lens. J Res Sci Teach 44(8):1187–1218. https://doi.org/10.1002/tea.20237
Chemers MM, Zurbriggen EL, Syed M, Goza BK, Bearman S (2011) The role of efficacy and identity in science career commitment among underrepresented minority students. J Soc Issues. https://doi.org/10.1111/j.1540-4560.2011.01710.x
Chen X (2005) First-generation students in postsecondary education: a look at their college transcripts. Education 83
Ciarrochi J, Deane FP, Anderson S (2002) Emotional intelligence moderates the relationship between stress and mental health. Personality Individ Differ 32(2):197–209. https://doi.org/10.1016/S0191-8869(01)00012-5
Clandinin DJ (2016) Engaging in narrative inquiry. Engag Narrat Inq. https://doi.org/10.4324/9781315429618
Clandinin DJ, Connelly FM (1998) Stories to live by: narrative understandings of school reform. Curric Inq. https://doi.org/10.1111/0362-6784.00082
Clandinin DJ, Clandinin DJ (2019) Narrative and story in teacher education. Journeys Narrat Inq. https://doi.org/10.4324/9780429273896-6
Connelly FM, Clandinin DJ (1990) Stories of experience and narrative inquiry. Educ Res 19(5):2–14. https://doi.org/10.3102/0013189X019005002
Clandinin DJ, Connelly FM, Bradley JG (1999) Shaping a professional identity: stories of educational practice. McGill J Educ 34(2):189
Conrad S, Canetto SS, Macphee D, Farro S (2009) What attracts high-achieving socioeconomically disadvantaged students to the physical sciences and engineering? Coll Student J 43:1359
Covington M (1985) Test anxiety: causes and effects over time. Adv Test Anxiety Res 4:55–68
Craig CJ (2011) Narrative inquiry in teaching and teacher education. Adv Res Teach. https://doi.org/10.1108/S1479-3687(2011)00000130005
Cundiff JL, Vescio TK, Loken E, Lo L (2013) Do gender-science stereotypes predict science identification and science career aspirations among undergraduate science majors? Soc Psychol Educ 16(4):541–554. https://doi.org/10.1007/s11218-013-9232-8
Dika SL, D'Amico MM (2016) Early experiences and integration in the persistence of first-generation college students in STEM and non-STEM majors. J Res Sci Teach 53(3):368–383. https://doi.org/10.1002/tea.21301
Eddy SL, Brownell SE, Wenderoth MP (2014) Gender gaps in achievement and participation inmultiple introductory biology classrooms. CBE Life Sci Educ 13(3):478–492. https://doi.org/10.1187/cbe.13-10-0204
Engle J (2007) Postsecondary access and success for first-generation college students. Am Acad 3(1):25–48
Estrada M, Woodcock A, Hernandez PR, Schultz PW (2011) Toward a model of social influence that explains minority student integration into the scientific community. J Educ Psychol 103(1):206–222. https://doi.org/10.1037/a0020743
Estrada M, Burnett M, Campbell AG, Campbell PB, Denetclaw WF, Gutiérrez CG et al (2016) Improving underrepresented minority student persistence in stem. CBE Life Sci Educ 15(3):1–10. https://doi.org/10.1187/cbe.16-01-0038
Estrada M, Hernandez PR, Schultz PW (2018) A longitudinal study of how quality mentorship and research experience integrate underrepresented minorities into STEM careers. CBE Life Sci Educ. https://doi.org/10.1187/cbe.17-04-0066
Farrall S (1996) What is qualitative longitudinal research? Pap Soc Res Methods 11:1–25
Fernandez MJ, Trenor JM, Zerda KS, Cortes C (2008) First generation college students in engineering: a qualitative investigation of barriers to academic plans. In: Proceedings—Frontiers in Education Conference, FIE. https://doi.org/10.1109/FIE.2008.4720256
Gayles JG, Ampaw FD (2011) Gender matters: an examination of differential effects of the college experience on degree attainment in STEM. New Dir Inst Res. https://doi.org/10.1002/ir.405

Georgakopoulou A (2006) Thinking big with small stories in narrative and identity analysis. Narrat Inq 16(1):122–130. https://doi.org/10.1075/ni.16.1.16geo
Graham MJ, Frederick J, Byars-Winston A, Hunter A-B, Handelsman J (2013) Increasing persistence of college students in STEM. Science 341(6153):1455–1456. https://doi.org/10.1126/science.1240487
Hanauer DI, Dolan EL (2014) The project ownership survey: measuring differences in scientific inquiry experiences. CBE Life Sci Educ. https://doi.org/10.1187/cbe.13-06-0123
Hanauer DI, Graham MJ, Hatfull GF (2016) A measure of college student persistence in the sciences (PITS). Cell Biol Educ 15(4):ar54. https://doi.org/10.1187/cbe.15-09-0185
Hazari Z, Sonnert G, Sadler PM, Shanahan M-C (2010) Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: a gender study. J Res Sci Teach. https://doi.org/10.1002/tea.20363
Hazari Z, Sadler P, Sonnert G (2013) Research and teaching. The science identity of college students: exploring the intersection of gender, race, and ethnicity. J Coll Sci Teach 42:82
Hecht ML (1993) 2002—a research odyssey: toward the development of a communication theory of identity. Commun Monogr 60(1):76–82. https://doi.org/10.1080/03637759309376297
Hecht BML, Ii RLJ, Ribeau SA, Mahwah S, Erlbaum NJL (2003) African American communication: exploring identity and culture. Routledge, London, pp 438–442
Hernandez PR, Schultz PW, Estrada M, Woodcock A, Chance RC (2013) Sustaining optimal motivation: a longitudinal analysis of interventions to broaden participation of underrepresented students in STEM. J Educ Psychol. https://doi.org/10.1037/a0029691
Hoyer KM (2017) Stats in brief first-generation and continuing-generation college students: a comparison of high school and postsecondary experiences. U.S. Department of Education, Washington, DC
Ishitani TT (2006) Studying attrition and degree completion behavior among first-generation college students in the United States. J Higher Educ 77(5):861–885. https://doi.org/10.1353/jhe.2006.0042
Ives J, Castillo-Montoya M (2020) First-generation college students as academic learners: a systematic review. Rev Educ Res 90(2):139–178. https://doi.org/10.3102/0034654319899707
Kohler-Riessman C (2000) Analysis of personal narratives. Sage, London
Kost-Smith LE, Pollock SJ, Finkelstein ND (2010) Gender disparities in second-semester college physics: the incremental effects of a " smog of bias." Phys Rev Spec Top Phys Educ Res 6(2):1–17. https://doi.org/10.1103/PhysRevSTPER.6.020112
Labov W (1982) Objectivity and commitment in linguistic science: the case of the Black English trial in Ann Arbor. Lang Soc. https://doi.org/10.1017/S0047404500009192
Labov W, Waletzky, J (1997) Narrative analysis: oral versions of personal experience
Levine R, Gonzalez R, Cole S, Fuhrman M, Floch KCL (2008) The geoscience pipeline: a conceptual framework. J Geosci Educ 55:458–468
Luyckx K, Schwartz SJ, Goossens L, Beyers W, Missotten L (2011) Processes of personal identity formation and evaluation. In: Schwartz S, Luyckx K (eds) Handbook of identity theory and research. Springer, New York. https://doi.org/10.1007/978-1-4419-7988-9_4
Matz RL, Koester BP, Fiorini S, Grom G, Shepard L, Stangor CG et al (2017) Patterns of gendered performance differences in large introductory courses at five research Universities. AERA Open 3(4):1–12. https://doi.org/10.1177/2332858417743754
Mertova P, Webster L (2000) Critical event narrative inquiry in higher education quality quality in higher education. Qual Approaches Higher Educ Lomas Lomas Cartwright 3(2):15–22
Mertova P, Webster L (2019) Using narrative inquiry as a research method. Routledge, Milton Park. https://doi.org/10.4324/9780429424533
Orbe MP (2007) Negotiating multiple identities within multiple frames: an analysis of first-generation college students. Commun Edu 53(October 2013):37–41. https://doi.org/10.1080/03634520410001682401
Orbe MP (2008) Theorizing multidimensional identity negotiation: reflections on the lived experiences of first-generation college students. New Dir Child Adolesc Dev 2008(120):81–95. https://doi.org/10.1002/cd.217
Pascarella ET, Pierson CT, Wolniak GC, Terenzini PT (2004) First-generation college students. J Higher Educ 75(3):249–284. https://doi.org/10.1080/00221546.2004.11772256
Pekrun R, Goetz T, Titz W, Perry RP (2002) Academic emotions in students' self-regulated learning and achievement: a program of qualitative and quantitative research TT—Emotionen im Bereich

des selbstgesteuerten Lernens und der Leistung von Schülern und Studenten: Ein Programm für qualitative u. Educ Psychol 37(2):91–105. https://doi.org/10.1207/S15326985EP3702
Pelch M (2018) Gendered differences in academic emotions and their implications for student success in STEM. Int J STEM Educ. https://doi.org/10.1186/s40594-018-0130-7
Potvin G, Hazari Z (2014) The development and measurement of identity across the physical sciences. https://doi.org/10.1119/perc.2013.pr.058
President's Council of Advisors on Science and Technology (2012) Engage to excel: producing one million additional college graduates with degrees in science, technology, engineering, and mathematics. Science. https://doi.org/10.1080/10668921003609210
Raque-Bogdan TL, Lucas MS (2016) Career aspirations and the first generation student: unraveling the layers with social cognitive career theory. J Coll Stud Dev. https://doi.org/10.1353/csd.2016.0026
Riehl RJ (1994) The academic preparation, aspirations, and first-year performance of first-generation students. Coll Univ 70(1):14–19
Robinson KA, Perez T, Nuttall AK, Roseth CJ, Linnenbrink-Garcia L (2018) From science student to scientist: predictors and outcomes of heterogeneous science identity trajectories in college. Dev Psychol 54(10):1977–1992. https://doi.org/10.1037/dev0000567
Robnett RD, Chemers MM, Zurbriggen EL (2015) Longitudinal associations among undergraduates' research experience, self-efficacy, and identity. J Res Sci Teach 52(6):847–867. https://doi.org/10.1002/tea.21221
Saenz VB (2007) First in my family: A profile of first-generation college students at four-year institutions since 1971. Higher Education Research Institute
Shein PP, Falk JH, Li YY (2019) The role of science identity in science center visits and effects. Sci Educ 103(6):1478–1492. https://doi.org/10.1002/sce.21535
Smit B (2010) Using ATLAS.ti for qualitative data analysis. Soc Sci Data Softw 20(September):65–76
Smith JM, Lucena JC (2016) Invisible innovators: how low-income, first-generation students use their funds of knowledge to belong in engineering. Eng Stud. https://doi.org/10.1080/19378629.2016.1155593
Toven-Lindsey B, Levis-Fitzgerald M, Barber PH, Hasson T (2015) Increasing persistence in undergraduate science majors: a model for institutional support of underrepresented students. CBE Life Sci Educ 14(2):ar12. https://doi.org/10.1187/cbe.14-05-0082
Verdín D, Godwin A (2019) The relationship between engineering identity and belongingness on certainty of engineering major for first-generation college students. Am Educ Res Assoc. https://doi.org/10.302/1431660
Whalen DF, Shelley MC, Hdu I, Gdwd O, Ryhu I, Exw U, Dw QRW (2010) Academic success for STEM and non-STEM majors. J STEM Educ Innov Res 11:16
Wiles JL, Rosenberg MW, Kearns RA, Kearnst RA (2005) Narrative analysis as a strategy for understanding talk in geographic. Area 37(1):89–99
Yeager DS, Walton GM (2011) Social-psychological interventions in education: they're not magic. Rev Educ Res 81(2):267–301. https://doi.org/10.3102/0034654311405999