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Examining Transfer Student Experiences in STEM Using Science Identity and Trajectory

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Examining Transfer Student Experiences in STEM Using Science Identity and Trajectory

A Thesis submitted in partial satisfaction of the
requirements for the degree Master of Science

in

Biology

by

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The Thesis of Cheyenne N. Mercer is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

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ABSTRACT OF THE THESIS

Examining Transfer Student Experiences in STEM Using Science Identity and Trajectory

by

Cheyenne N. Mercer

Master of Science in Biology

University of California San Diego, 2020

Professor Stanley Lo, Chair
Professor Brenda Bloodgood, Co-Chair

Transfer students have shown to experience decreased academic success and persistence in science, technology, engineering, and math (STEM) compared to non-transfer students. Studies have suggested that student STEM experiences may reposition their science identity trajectory, the movement towards or away from science; science identity describes how STEM experiences might influence persistence in STEM over time. Our study explores science identity and trajectory through the experiences of 29 transfer students pursuing STEM in hopes of better understanding what possible STEM events promote positive science identity trajectory.

Interviews were conducted to explore students' STEM experiences and associated outcomes and were later transcribed and qualitatively coded using QDA Miner software. Our findings highlight that positive STEM events are linked to positive event outcomes, the events' impact on the student, and positive science identity trajectory. More specifically, positive STEM recognition events involving scientific meaningful others, such as professors, research advisors, and scholarship committees influence positive outcomes, positive science identity trajectory, and most likely a stronger science identity overall. Our results also show that students who experience negative STEM events interpret both positive and negative outcomes which suggests a neutral science identity trajectory without movement towards science. Overall, our study reveals the STEM events most associated with the formation of positive and negative science identity and trajectory. We hope that our findings will inform and guide policy makers, faculty, staff, and educational institutions on how to best support transfer students in forming positive science identities, trajectory, and increase transfer student STEM retention.

Keywords: transfer student, STEM, science identity trajectory, performance, recognition, interest

Introduction

United States policymakers emphasize that helping to increase Science, Technology, Engineering and Math (STEM) student retention while in college will be the easiest and most profitable way to produce a strong STEM workforce (Chen and Soldner, 2014). Although a third of all college degrees awarded in 2017 were in science and engineering (National Science Board, 2019), concerns regarding STEM retention still exist. Nearly half of baccalaureate and 70 percent associate degree students switch to non-STEM majors or leave STEM entirely (Chen and Soldner, 2014). Out of the two million bachelor's degrees awarded in 2016, close to 20 percent were in STEM (National Center for Education Statistics, 2019).

Underrepresented Minority and Transfer Students

Underrepresented minority (URM) students (i.e. Female, African American, Latinx, Pacific Islander, Alaskan Native/American Indian) have a disproportionately lower rate of STEM degree completion and successful transition into STEM fields compared to non-URM students (i.e. White, Asian). URM students received close to 40 percent of the 2017 STEM degrees awarded but individual minority identities fell below the national average for STEM degree attainment (i.e. African American- 12 percent, Latinx and Pacific Islander- 15 percent, Alaskan Native/American Indian- 14 percent), while non-URM students met or exceeded the national average (i.e. White- 18 percent, Asian- 33 percent); STEM degrees awarded to male students was almost double the number of STEM degrees awarded to female students (National Center for Education Statistics, 2019). Differences in STEM degree completion highlight the existence of possible education and learning inequities which may affect URM student populations' success in STEM fields. This information calls into question why URM STEM students struggle to persist in STEM.

URM students often identify with more than one minority identity. For example, Latinx students are commonly from socioeconomically disadvantaged backgrounds (along with African American students), they are often first generation immigrants and first generation college students in comparison to all other URM and non-URM students (Crisp & Nuñez, 2014). This information suggests that URM students may experience unique barriers which influence their STEM retention compared to non-URM students in STEM.

Transfer students are defined as students who have mobilized from one institution of higher learning to another, whether that be from a community college or another four-year university. Roughly half (43.6%) of all undergraduates begin their post-secondary education at a community college (Zhang, 2019; National Center for Education Statistics, 2018a). Transfer students are another underrepresented STEM group because the transfer student population is disproportionately URM (Hagedorn & Purnamasari, 2012; Ma & Baum, 2016; Provasnik & Planty, 2008). Transfer students have also shown to have a significant decrease in academic performance post-transfer; out of the 33 percent of transfer students who successfully transfer to a four-year college only 42 percent succeed in obtaining a bachelor's degree (Collins, 2018; Jenkins & Fink, 2016) compared to non-transfer students whose success rate is closer to 72 percent (Collins, 2018; Shapiro et al., 2016).

Research has highlighted significant characteristics tied to transfer students who obtained a baccalaureate in STEM. Transfer students who enrolled in full-time credit hours, took one or more college-level mathematics courses and received a high GPA during their first semester at their four-year college were more likely to obtain a bachelor's in STEM (Zhang, 2019). Enrollment in the lowest-level developmental mathematics courses in community college was found to be a significant predictor of STEM retention and degree attainment, gender was a predictor of switching out of STEM, ethnicity was a predictor for degree attainment, and socioeconomic status was found to be a predictor of transfer students' performance in science (Cohen & Kelly, 2020). A considerable amount of research has been done surrounding minority identities at the college level, but little research pays attention to and explores in detail the transfer student STEM experience contributing to transfer student science identity and trajectories, and the possible correlation to persistence in STEM despite representing a large and diverse population.

Science Identity Literature Review

Identity Types and Communities of Practice

The aim of our research was to explore transfer student experiences in STEM by using identity as an analytical tool (Gee, 2000) for understanding "who" students are in the context of STEM. Identity, described by Gee (2000), is "who you are" and can be defined in four ways: nature, institution, discourse, and affinity identity. These four identities overlap and are ways of understanding how identities are formed and sustained. Nature-identity (N-Identity) is the first identity type and describes the "biological" part of identity you have no control over. For example, being born before your youngest sibling would make you the older sibling, so your N-identity is being an older sibling. N-identities must be recognized by oneself or others outside of yourself to exist. For example, if you do not think of yourself as an older sibling and others around you do not recognize that you are an older sibling either, then you cannot identify as an older sibling.

Institutional-identity (I-Identity) is the second identity type and describes identity which is given or assigned to you by an authority. For example, being identified as a college student is due to a university authorizing you this identity because of your enrollment at the school. You are not born a college student and you cannot be a college student by yourself, it is an identity which must be assigned to you by a determining "power." I-identities can be seen as a "calling or an imposition," meaning, some individuals might feel that their I-identity is an identity which they want to fulfill actively while others feel their I-identity was forced upon them and they choose to reject the identity.

The third identity type is the discursive identity (D-identity). D-identity describes an identity which is assigned through other people's dialogue about you, and involves others interacting with you that makes you, for example, someone who is seen as kind or witty. A clever way to think about this idea is by asking, "Can I be considered a *kind* person if I were all alone, by myself on an island?" The answer is no. It takes interacting with others to be assigned a D-identity, you are not born with "it".

The final identity type is the affinity identity (A-Identity). A-identity is described as the identity you share with others while participating in specific group practices and norms. A-identities require participation and sharing with others, for example, being in a school student-run organization with other peers. Your A-Identity would be that of a 'member' participating in the student organization.

The formation and identification with different identity types in STEM involves the development of wanting to understand the world through science. Exposure to science which may contribute to the development of an interest in science can occur at a variety of ages and in many locations, for example, informal platforms like YouTube, talking with friends, or more formal platforms of learning like post-secondary educational institutions. The more formal term for the areas of exposure to learning are known as "communities of practice," these communities are developed by complex social processes practiced with others, not just individually, and have cultural-historical backgrounds (Farnsworth et al., 2016). Furthermore, an important component of communities of practice is that people can participate in as many as they want to develop and reinforce the identities and practices they desire to have and be a part of.

Identity is used by many researchers to understand how people are recognized as specific "kinds of people" and the way they act out their many identities in different contexts. Since there are different environments in which people may act out their identities differently, identity is considered fluid; with time it changes, and it is performed differently in different environments. Identity also differs from one's "core identity", core identity is a form of identity that remains relatively stable over time and across contexts (Gee, 2000).

Science Identity as a Concept

One research study conducted by Brickhouse, Lowery, and Schultz (2000) detailed in What Kind of a Girl Does Science? The Construction of School Science Identities introduced the concept of science identity. The aim of their study was to better understand how female students, who have an interest in science yet are viewed by society as non-scientific (i.e. race, gender, class) form their identity. They accepted the idea that students have many identities and they explore how identities overlap with the formation of students' science identity.

Their results showed that all students felt they were good at science and adopted different identities, outside of their science identity, which influenced the students' individual interaction with science. In addition to this finding, this study highlighted the importance of engaging classroom teaching practices and flexible curriculum structure to better support student interaction with science and promote positive science identity formation.

The Initial Science Identity Model

Understanding the Science Experiences of Successful Women of Color: Science Identity as an Analytic Lens by Heidi B. Carlone and Angela Johnson (2007), expanded identity research to the college level and further defined what "identity" counted as. Carlone and Johnson were interested in understanding "how women of color experience, negotiate, and persist in science" (Carlone & Johnson, 2007). A gap existed in science identity literature prior to this paper, research did not address how science identity might be influenced by other complex factors such as race, gender, and/or ethnicity, and did not provide a longitudinal approach when studying science identity. Carlone and Johnson wanted to explore how exactly science identity evolved with time, what scientific meanings were made, and how students positioned themselves in relation to science overtime.

Carlone and Johnson (2007) developed three parameters for "identity" in the initial science identity model. The first component is competence. **Competence** is when a student "demonstrates meaningful knowledge and understanding of science content and is motivated to understand the world scientifically." The second component is performance. **Performance** is defined to be when a student can "perform for others her competence with scientific practices," (e.g. performing a successful laboratory experiment, saying the right scientific words in conversation, acting in alignment with science culture, and more). The final component is recognition. **Recognition** is defined to be when a student recognizes themselves and is recognized by others as a "science person." Additionally, they loosely introduced the use of "science identity trajectory" as a way of labeling the different science identity groups they created as specific paths towards science.

According to Carlone and Johnson (2007), all three components overlap variably and this overlap largely depends on the student and with who they interact with. For example, a person can feel they are competent and perform well in science yet feel unrecognized by others and even themselves as a science person. Their study revealed that recognition was the most useful component of science identity for understanding students' unique experiences in science, meanings made in science, and how gender, race, ethnicity, and science identity interact with one another. These findings prompted for the expansion of Carlone and Johnson's (2007) initial science identity model to include a broadened recognition category.

Development of the Science Identity Model

In Connecting High School Physics Experiences, Outcome Expectations, Physics Identity, and Physics Career Choice: A Gender Study by Hazari et. al. (2010), the initial science identity model developed by Carlone and Johnson (2007) was further developed. Hazari et. al (2010) explored how high school physics student's physics identities were shaped by students' interactions with physics in the classroom and their expected physics career outcomes.

The competence and performance components of the initial science identity model, which were originally two separate components (Carlone & Johnson, 2007) were combined in the Hazari et al. (2010) study because students responded similarly or the same to question types which measured how students felt they could perform related physics tasks and how well they felt they understood physics content (Godwin et. al., 2016; Hazari et. al. 2010). In addition to combining competence and performance, the component "interest" was added to the science identity model. **Interest** describes students' want to participate in science (Godwin et. al. 2016) and is considered critically relevant in how students decide who they are and want to become in relation to science (Hazari et. al. 2010). Interest is emphasized as a predictor of science identity because past studies suggest that student career interests in science are an even stronger predictor of students obtaining a bachelor's degree in physical science in comparison to student's mathematic achievements (Tai et. al., 2006).

The Current Science Identity Model

Over time, the science identity model has developed from a three-component model including competence, performance, and recognition (Carlone and Johnson, 2007), to a newly formatted three-component model including competence/performance, recognition, and interest (Hazari et. al. 2010). Although the science identity model seems straightforward, it's successful implementation in research largely depends on the theoretical frameworks and the lenses that researchers choose to view theoretical frameworks through different angles, as well as the research questions they are asking.

The science identity model has become particularly useful for researchers interested in understanding the different experiences and interactions within communities of practice of underrepresented student populations. The development of the science identity model allows researchers to ask more specific research questions to expose key experiences and factors which may influence persistence of underrepresented students in science over time, as well as better understand why some students successfully persist in science education and obtain careers in science, in comparison to others who might deidentify with science entirely. This knowledge is important because science identity data can highlight areas of improvement to help institutions and faculty better support students, not just in the classroom through science classroom teaching practices and science learning, but long term so all students have an equitable opportunity to develop strong positive science identity formations and trajectory to persist in science education and obtain future careers in science.

Theoretical Framework

In our study, identity was applied through a mixed theoretical framework approach using both the science identity model and science identity trajectories. Science identity trajectories (Jackson & Seiler, 2013) track science experiences and resources STEM students access overtime and is useful for measuring the influence these two components may have on students' movement towards or away from science. This movement is characterized by three directions: inbound (towards science), outbound (away from science), and peripheral (static or no movement towards science). In our research, we use the term "positive trajectory" for inbound trajectory and "negative trajectory" for outbound trajectory (Jackson & Seiler, 2013).

The science identity trajectory framework is useful for understanding how students' science identities fluctuate over time, however, the framework itself is not founded on what science identity is defined to be based on the science identity model currently developed; the science identity trajectories explored by Jackson and Seiler (2013) did not track the science identity models' components: competence/performance, recognition, and interest experiences. By combining both theoretical frameworks, the science identity model and science identity trajectories, our research provides a more thorough approach to understanding transfer student experiences in STEM, students' science identity, and science identity trajectories so that we may better understand student persistence in STEM.

Our Study

The purpose of our research was to answer two questions: (1) What do transfer students in STEM experience regarding competence/performance, interest, and recognition? (2) How are students interpreting these experiences, and what meaning is being derived that ultimately influences science identity formation, science identity trajectory, and persistence in STEM?

To answer our research questions, we performed semi-structured interviews with 29 transfer students at UC San Diego, a West Coast four-year institution, we investigated student experiences by asking students to recall critical events involving the three components of science identity: competence and performance, recognition, and interest experiences. We found that students who experienced positive events interpreted positive impacts and students who experienced negative events interpreted both positive and negative impacts. When we applied the science identity trajectory framework to categorize the events and outcomes which propagated a more positive or negative science identity trajectory, we found that the positive events associated with positive outcomes suggested a positive science identity trajectory and support the formation of a strong science identity and greater likelihood of succeeding in STEM, while the negative events associated with both negative and positive outcomes suggested less clear science identity trajectories. We could not determine if negative events led to negative or positive trajectories because no obvious patterns pointed to one trajectory over others.

By understanding STEM transfer student experiences and identifying identity struggles and negotiations in STEM experiences, we hope to better understand what experiences might influence or contribute to STEM field persistence. By understanding students' science identity formations and science identity trajectories, we will better understand was experiences or factors might contribute to poor science retention of STEM transfer students. We hope that our results encourage staff, faculty, and institutions to support URM transfer students in STEM by providing resources or hosting experiences which foster the development of strong positive identity formations, trajectories, and ultimately successful retention in STEM fields.

Methods

Procedure

Experiences and interpretation of the three components of science identity were collected via interviews. Interview data was collected as part of a larger project with Austin Zuckerman, another BS/MS student who graduated in Winter 2020. The interviews were held with transfer students who were a part of the UC San Diego Summer Transfer Ahead Research Training (START) Program, a summer bridge program developed for transfer students to gain experience in research and laboratory work prior to beginning their first quarter on campus. We utilized the critical incident protocol (Dunn & Hamilton, 1986) to develop our interview technique and help students anchor and share specific STEM event memories of feeling (or not feeling) competent, that they performed well, recognized, and interested. The critical incident technique gives us the opportunity to engage with students during the interview to facilitate the sharing of specific events and any significance associated with the events they recall.

Our interview protocol involved two parts: START students were questioned about their experiences within the START program in the first half of the interview, and in the second half students were asked about their experiences at their previous colleges as well as their experiences at UC San Diego. Our interview questions will be of the epistemological variety, to “address theories of knowing and an understanding of the phenomenon of interest” (Saldana, 2016). In conjunction with the critical incident technique, our interview questions were formed with the intention to promote student reflection regarding the critical incidents in science they experienced, and we provided follow-up questions which functioned to probe for more description in order to bring forward any significance attached to events of interest.

Participants

There was a total of 32 START Program transfer student participants, and 29 START Program participants interviewed were included in our study. Out of the 29 students, 16 students identified as having a female gender identity and 13 students identified as having a male gender identity (one student identified as transgender male). Eight students participated in the START Program in 2015 (female=5, male=2, unknown=1), however, only 7 transcripts were available to code. Ten students participated in the 2016 START Program (female=3, male=9, unknown=1), however, only 9 transcripts were available to code. Fourteen students participated in the 2017 START Program (female=8, male=5, unknown=1), however, only 13 transcripts were available to code. Of the 29 transfer student START Program participants whose transcripts were included in the study, students' identified ethnicities were as follows: Middle Eastern (n=6), Latinx (n=9), Asian (n=5), Black (n=1), White (n=2), two or more ethnicities (n=6). All students were pursuing STEM. All names included in our study are assigned pseudonyms used to protect students' identities and privacy.

Data Analysis

Interview recordings from START students were transcribed, analyzed, and coded qualitatively using qualitative coding methods from The Coding Manual for Qualitative Researchers (Saldana, 2009) and QDA Miner software. Qualitative coding is defined as a word or short phrase developed by the researcher used to summarize a larger quantity of collected language-based data in a symbolic manner (Saldana, 2009). The code constructed is a method used by the researcher for translating data into a meaningful interpretation which can be used, for example, pattern interpreting. START interview transcriptions were "decoded" to find meaning. Once meaning was found within, for example, a sentence or even a whole paragraph, "encoding" followed which is the making of the codes to summarize the content in a concise way without the removal of any pertinent information.

Our research used various combinations of coding methods to code the student interview responses. We used a combination of Descriptive Coding which involves “applying descriptive nouns or noun phrases to data” and In Vivo Coding which uses derivations “from the actual language of the participant” (Saldana, 2009). Codes were further categorized to highlight notable STEM event, outcome, and science identity trajectory patterns and significances within and around students’ transfer college, START Program, and UC San Diego experiences to show how these experiences might contribute to student’s science identity formations and persistence in STEM.

Results

Table 1. Transfer Student Science Identity Events, Outcomes, and Trajectories. Science identity trajectories, movement towards (positive trajectory) or movement away from science (negative trajectory) based on lived experiences and reflected outcomes, were determined after analyzing student interpretations of the events and outcomes specified during interviews. Data analysis from seven student interviews were included in this table (out of a total of 29 interviews) and only codable responses were included. Students, when asked to share their most memorable events, answered with one or more events and one or more outcomes for each event recalled. Each ‘X’ represents a single individual’s response and documents the individual’s most memorable science identity event, accompanied outcome(s), and resulting trajectory.

		Most Memorable Science Identity Events (# of students who described specifc experience)									
		Performance			Recognition			Interest			
Science Identity Trajectories	Event Outcomes	High Academic Performance (4)	Low Academic Performance (6)	Improvement in Performance (3)	Professor Acknowledgement (4)	Academic Acknowledgement (2)	Lack of Acknowledgement (2)	Aligns/Applicable to Interests (4)	Exposure (4)	Doesn't Align/Not Applicable to Interests (1)	"When things get hard" (3)
Positive	Increased Self-Efficacy	XX		X	X	XXX		XX	X		
	Intrinsic Motivation	XX	X	X	X	XXX			X		
	Gain in Perspective	XX	X	XXX	XX	XX		X	XX		XX
	Growth Mindset	X	XXX	XX	XX				X		XXX
	Belonging and Feel Special	X		X	XXX	X			X		
	Stem Pathway							XXX	XXX	X	
Negative	Decreased Self-Efficacy		X								X
	Doubt		XXX				X				XX
	Fixed Mindset									X	XX
	Don't Belong						X				
	Defeat										XX

To determine which community college and four-year university events (related to performance, recognition, and interest) were most memorable for transfer students pursing STEM and how these events might have influenced students' science identity trajectory, we analyzed interview transcripts and qualitatively coded (Saldana, 2009) them to identify patterns emerging from the data; 10 prominent science identity event codes and 11 outcome codes emerged (Table 1).

<u>Science Identity Events</u>

Performance Event Codes

Performance events are defined as events when students are able to demonstrate scientific practices for others, like professors, showing that they are "science-like" and can actively "do", understand, are competent, and possess the knowledge of various science concepts and practices required to be considered a science person (Carlone & Johnson, 2007). We identified three prominent performance events. Our first code was **High Academic Performance** (n=4, the number of students who recalled this event; Table 1), when students described receiving a high course grade or exam score, passed a class, did well on an assignment or laboratory exercise, or in comparison to other peers. For example, when Kevin was asked about a time when felt he performed well, he spoke about his experience taking a college physics exam:

> I did well on a test…It was a physics test and yeah, I guess it was a little tricky and it turned out that the average was a 46 and I got a 100. So I thought, yeah, I felt good about that. (Interview, 14 June 2017)

In a different interview, Fatima described her experience as a student in a college biology laboratory course:

> … when I got into the lab, um, everyone, none of the students, none of my classmates, had uh, uh research experience, so they kind of started learning the techniques that we would use in the lab. But I had experience with almost all of the techniques we used in that lab and, um, every time the professor or the TA

> would explain something new, I would know about it and, um, I would answer their questions because I have experienced all of the, um, like the techniques before. So, yeah, that helped me be like feel um like a level kind of better than my classmates… for this lab, um, I was kind of ahead of everybody else. So, I was teaching my classmates rather than learning [with] them. (Interview, 14 June 2017)

Our second code in the performance event category created was **Low Academic Performance** (n=6, Table 1), when students received a low course grade, exam score, when they mentioned not passing a course, or struggled to demonstrate their scientific skills without mention of improvement. May shared with us her time in a college math course:

> I failed…It was the math courses were awful. I failed for the first time in a long time here at UCSD during my first quarter. And that was pretty memorable for me. I think that kind of made my entire year sort of not go as well as I hoped because of that failure. And I wasn't prepared for that. I didn't think that was going to happen for my first quarter and I just wasn't expecting it and I didn't deal with it as best as I could have or wished that I could have. (Interview, 14 June 2017)

Our third code in the performance event category developed was **Improved Academic Performance** (n=3, Table 1), when students mentioned struggling to demonstrate their scientific skills but eventually developed those same skills and successfully performed the task at hand. This could be when students fail to pass a class, but upon retaking the class they pass. Omar shared with us his experience struggling to conduct a Western Blot in his research laboratory:

> Probably performing my first Western Blot in my lab and kind of getting it to work. I remember everything that I tried wasn't working, it wasn't working and my advisor kind of really helped me. She pushed me and I finally got it to work and it was just so satisfying… I think the build-up to it was that it took two months for me to actually get it to work. So once I finally got it to work, it was like this relief that I could actually do it. It wasn't something only smarter people could do. Like I could achieve. (Interview, 13 June 2017)

Recognition Events Codes

Recognition events are defined as events when students acknowledge themselves or are acknowledged by others as a "science person" (Carlone & Johnson, 2007). We identified three prominent recognition events. Our first code created was **Professor Acknowledgement** (n=4, Table 1), when students received (or perceived) acknowledgement, praise, a letter of recommendation, were referred by or remembered by a professor whom they interacted with. Omar described a time he felt recognized by a professor:

> …I remember talking with Dr. 'X' about the classes I was taking and how I was doing the previous quarter. He kind of let me know that because some of the other students in the program aren't graduating this year…I was on track and he was kind of, I guess, proud of me. He didn't' say that, but it kind of felt like that… I guess because coming to UCSD was the first time that I was away from home. I've kind of been really connected with my family, so when I left I really couldn't talk to them because of like a 9-hour drive and they really couldn't come up…Dr. 'X' kind of acted, not as a parent, but more as like someone who could push me and like kind of recognize me as someone that did well. Kind of the admiration that I would get at home I felt like I was getting with Dr. 'X'. (Interview, 13 June 2017)

Our second code for the recognition event category developed was **Academic Acknowledgement** (n=2, Table 1), when students received (or perceived) acknowledgement, praise, an academic award or scholarship, or felt supported by a more generalized academic entity like the academic institution itself. This version of acknowledgement excludes interactions between students and other individuals, it is more of a systemic form of acknowledgement. Kevin's experience feeling recognized after winning a scholarship is a form of academic acknowledgement:

> …I got this scholarship that I applied for that was related to academic performance and stuff. And that kind of just surprised me. Yeah, it was in the middle of the school year…They give it to few people and they chose me. So, I felt that I was doing well… It was very surprising. I didn't expect it whatsoever. I woke up one morning and checked my email and there it was. (Interview, 14 June 2017)

Our third code for the recognition event category was **Lack of Acknowledgement** (n=2, Table 1), when students did not receive (or perceive) acknowledgement or praise, were not referred for an opportunity or remembered, did not obtain a recommendation letter, did not receive an academic award or scholarship, or did not feel supported by professors or a more generalized academic entity, or simply did not recognize themselves as science people. “Lack of Acknowledgement” refers to the absence of recognition during a moment which the student anticipated receiving recognition. For example, Fatima described a time when she was not recognized academically by her community college:

> Yeah, I think that was in my graduation from community college because, um, I think I had the the highest science GPA like in the science major at community college and, uh, they didn’t recognize the honors, so that was the only thing. (Interview, 14 June 2017)

Interest Event Codes

Interest events are defined as events when students feel interested or disinterested in science. When we analyzed transcripts to uncover events which might have influenced students’ interest or disinterest in STEM, we identified four prominent events. Our first code created was **Aligns/Applicable to Interests** (n=4, Table 1), when students liked what they were doing in science, for example, what they learned in STEM courses, volunteering, laboratory work, science research and more. These experiences strengthened students’ interest in science, they mirrored or paralleled current or developing interests they already had or possibly discovered because of the event itself. “Aligns/Applicable to Interests” code also refers to when students felt that what they were doing or learning about regarding STEM was applicable to their life, to other people they knew, current and future STEM interests and goals in science. Sadaf spoke of her experience taking a physiology course:

> Yes. The, the physiology classes that I took and am taking, uh they really make my interest stronger and stronger…the professor explaining something and go…this is why this happens and that happens…it kind of explains stuff that I have seen in my life and my family life…but I didn’t know why they happen…the professor explains that, it sticks in my mind, so…Because I’m going to learn about the human body, which is, uh, I think it’s beneficial for what I want in the future. Uh, so I would like in physiology, I would learn the right thing or the

> normal thing that's happening in the human body so now later on, when, if I get into medical school or in a PHD program, when I study the diseases, I would know the normal thing and then what's going on wrong to get that disease. (Interview, 16 June 2017)

The second code we developed was **Exposure** (n=4, Table 1), when students had theoretical exposure to STEM concepts, often in the form of gaining content knowledge in STEM courses, or hands-on-experience with specific science practices, like volunteering, research, and more, or had access participating in these events which developed their interest or disinterest in science. When Isabella studied abroad, she described having learned more about her interests because of the experience:

> …I studied abroad in Mexico in Oaxaca, um, because I thought I wanted to like get a MD/PHD and go to med school or whatever. Um, so, after I did research for a year, I went to Oaxaca, but it was through a UC Davis program, but it was still like UC classes um and we like shadowed doctors at clinics. And, um, I don't know, I just I realized I didn't like it…I realized it wasn't for me…that was like a real turning point…at first, I was a biochem major. So I think that, um, really shifted me and…it just really helped me reflect on like what am I really going to do and with my life, you know. So, um, I kind of switched gears and I changed my major to stuff that I'm more interested in because I did my research in, um, neuroscience so, um, I don't know. So I just kind of had like reflecting moments like when I was studying abroad. (Interview, 7 July 2017)

The third code we created was **Doesn't Align/Not Applicable to interests** (n=1, Table 1), when students felt that what they were doing or learning about science, for example, within their STEM courses, did not reflect their current or developing interests in science, or when the student could not apply the experience to their own life, current, or future goals and interests in STEM and therefore could not connect to the experience. Fatima gave us insight to this event when she described her experience taking organic chemistry:

> …the organic chemistry labs, all the organic chemistry sequence I had to take and the classes. Um, I couldn't like I I used to, uh, study hard for these classes, but I wasn't able to connect the material to to real life things like diseases and connect them to the human body. That made me not like the chemistry part of my major, but it went well. (Interview, 14 June 2017)

Finally, the fourth code within the interest event category we created was **"When things get hard"** (n=3, Table 1), when students attributed their struggles performing or succeeding in science to a force which influenced their decreased interest in STEM. For example, when Omar was asked to describe an experience when he felt less interested in science, he spoke of his experience struggling to perform the Western Blot in his research laboratory again:

> …during the process of getting the Western Blot to work… I just felt like nothing was working and at a certain point, I started thinking what's even the point of doing this? This is not going to work, it's not going to work again. And it just kind of felt like nothing was happening. (Interview, 13 June 2017)

<u>Science Identity Event Outcomes and Trajectories</u>

To determine the outcome of each event students recalled during interviews, we asked students to share with us what made the event memorable and how it impacted them. By analyzing transcripts and qualitatively coding (Saldana, 2009), we developed 11 outcome codes and separated them into two categories, the positive and negative science identity trajectory categories. The outcome codes assigned were placed in the appropriate box based on the event category the outcome associated (Table 1).

Positive Trajectory Outcome Codes

Outcome codes categorized under the positive science identity trajectory suggest that students who had positive event interpretations in STEM may have a strengthened science identity. We created 6 positive trajectory event outcome codes. The first positive event code made was **Increased Self-Efficacy** (total=10, Table 1), when students felt their experiences enhanced their self-confidence or belief in themselves as persons of science and their abilities to perform scientifically. The second code made was **Intrinsic Motivation** (total=9, Table 1), when students expressed that the events experienced inspired them, pushed them forward to improve and persist, and influenced them to put in the effort and work it would take to succeed in STEM in general. An example of "Increased Self-Efficacy" was Isabella's experience having her research published:

> …I think finding out that like my research is going to be published finally was like something that really boosted my confidence and really like helped me like, um, feel better about my, like feel accomplished here, like a little bit, you know, because like I didn't, I didn't even know that was possible, like [inaudible], so yeah that'll published in August or something. (Interview, July 2017)

In the same interview with Isabella, we asked how this moment of being published impacted her and her response exemplified the "Intrinsic Motivation" code:

> I think it's very motivating. Um, because UCSD is really difficult, so like I think like, the times when you do accomplish something, it's at least for me, like I, it means a lot to me, so like it kind of pushes me forward because I have a lot of things, like pushing against me. You know, like, with my life at home and just everything, you know, like um, everything going on right now. So it's just, um, having those accomplishments are really like, I don't know, motivating. (Interview, July 2017)

The third code created was **Gain in Perspective** (total=15, Table 1), when students felt they learned something new regarding science. The "Gain in Perspective" code does not account for times when students learned science content itself or understood theoretical information from their courses. Instead, it accounts for times when students learned *how* to approach learning important science concepts or when students learned what it means to be a person in science within their STEM classes, labs, when doing research, volunteering, and more. This code also encompasses when students made mistakes in STEM and learned something new, when they gained insight from their experiences, or any general realization in the form of a life lesson brought on by an event which they could choose to actively apply in the future to do better, persist, and succeed in science. For example, when Fatima excelled in comparison to her peers in a college biology laboratory course, she described what she learned from her experience:

> That made me learn it's always better to, um, know the stuff before you get into the class because, um, so, for example, when I was learning the the new material and the professor would explain it and, um, I would be studying it at the same time and I wouldn't be able to understand the details of the material. But, when for for this lab, because I knew like the the I would say the bullet points for all of the techniques, when the professor would explain something, I would understand it, I would understand the the better details of that technique because I would have the broad idea about the stuff he was talking about. (Interview, 14 June 2017)

The fourth code made was **Growth Mindset** (total=12, Table 1), when students thought positively and constructively about themselves and their abilities. We assigned "Growth Mindset" when students expressed believing they could achieve their STEM goals, showed resilience to persist during positive or negative STEM events, and when students maintained focus on what they could do to move forward and develop as a person in science. "Growth Mindset" was also assigned when students presented an internal locus of control, the students demonstrated a sense of personal responsibility for their dispositions and believed they could improve their circumstances. Omar exemplified "Growth Mindset" when he shared with us the impacts of failing a differential equations final exam had on him:

> I guess it taught me to work no matter what. Just, even if things are going well or if things are going not well. I should just keep on pushing my hardest. (Interview, 13 June 2017)

The fifth outcome code created was **Belonging and Feel Special** (total=7, Table 1), when students expressed superiority or uniqueness in comparison to others like peers and classmates, when they felt seen or heard by someone or the educational institution, and if they felt a sense of acceptance and belonging in the scientific community they interacted with (e.g. within class, in their major, research team, with classmates, colleagues, or with authority figures like professors and principle investigators, and more). "Belonging and Feel Special" was also assigned when students felt the experiences they had were special to them so they assigned meaning or importance to the event. We assigned the "Belonging and Feel Special" code when Fatima expressed her greater understanding of recombinant DNA course content compared to her peers. Fatima described:

> …every time the professor or the TA would explain something new, I would know about it and, um, I would answer their questions because I have experienced all of the, um, like the techniques before. So, yeah, that helped me be like feel um like a level kind of better than my classmates. (Interview, 14 June 2017)

The sixth, and final, event outcome code developed for the positive science identity trajectory category was **Stem Pathway** (total=7, Table 1), when events pushed students to establish STEM interests further. For example, lets discuss a student taking an organic chemistry course. The student may realize they are interested and like chemistry because they feel they are good at chemistry. They understand content, they perform well on exams, and they get above average scores. The student attributes and assigns importance to learning and doing well in organic chemistry, they view the course and associated experiences as vital components for getting into and succeeding in pharmacy school in the future, a STEM career path of interest. "STEM Pathway" also describes the opposite, when students expressed wanted to change their original STEM pathway to a different STEM pathway. This might resemble when students change STEM majors (e.g. biology major to physics major) or change STEM career goals (e.g. medical school to pharmacy school). If we go back to Sadaf's description of her time studying abroad in Oaxaca, Mexico shadowing doctors, Sadaf exemplified this change in STEM pathway:

> …I studied abroad in Mexico in Oaxaca, um, because I thought I wanted to like get a MD/PHD and go to med school…we like shadowed doctors at clinics. And, um, I don't know, I just I realized I didn't like it…I realized it wasn't for me. And that was like a real turning point…I was a biochem major. So I think that, um, really shifted me and especially I was just like I it just really helped me reflect on like what am I really going to do and with my life, you know. So, um, I kind of switched gears and I changed my major to stuff that I'm more interested in because I did my research in, um, neuroscience so, um, I don't know. So I just kind of had like reflecting moments like when I was studying abroad. (Interview, 14 June 2017)

Negative Trajectory Outcome Codes

Outcome codes categorized under the negative science identity trajectory theme suggest that negatively interpreted event outcomes may influence a negative science identity trajectory for students, and this influence might contribute to a weakened overall science identity. We developed five main negative trajectory event outcome codes. The first event outcome code made was **Decreased Self- Efficacy** (total=2, Table 1), when experiences decreased students' self-confidence or weakened their belief in themselves as persons of science and their abilities to perform scientifically. Kevin demonstrated "Decreased Self-Efficacy" when he reflected on his experience studying physics:

> I guess sometimes you read these physics textbooks and you just don't get it. And then you kind of question yourself, like can I really be a physics major? I have...sometimes you just have a problem where you just can't overcome it. (Interview, 14 June 2017)

The second code we developed was **Doubt** (total=6, Table 1), when students questioned themselves, their capabilities, belonging, interests, and goals in STEM. Araceli's experience in organic chemistry exemplified "Doubt":

> When I was taking my last course of O-Chem, which was 140, 140B, and I didn't pass it. I got an F and I think that extended my time here at UCSD. It really made me question like if if this is what I really want and if I really do want to do my major in microbiology and it really made me think about the future. (Interview, 8 June 2017)

The third code we made was **Fixed Mindset** (total=3, Table 1). Opposite of "Growth Mindset", "Fixed Mindset" was assigned when students thought negatively and unconstructively about themselves and their abilities. We also assigned "Fixed Mindset" when students expressed belief in not being capable of achieving their STEM goals and lacked the intent or motivation to improve their circumstances. These students viewed their dispositions as fixed, unchangeable, and powered by an external locus of control possibly preventing them from challenging their own circumstances to move forward and develop as a person in science. When Kevin spoke of his struggle staying interested in physics, his response was coded as “Fixed Mindset”:

> I guess sometimes you read these physics textbooks and you just don’t get it. And then you kind of question yourself, like can I really be a physics major? I have...sometimes you just have a problem where you just can’t overcome it. (Interview, 14 June 2017)

The fourth code created was **Don't Belong** (total=1, Table 1), when students felt they were not accepted into the scientific community they interacted in or feared they would not be accepted in current or future STEM environments. Isabella described struggling to establish a sense of belonging in science:

> …it's hard for me to feel like I belong here uh for many reasons. And I think like on top of that, to have like such a large focus on like the way that like like my grades are. I think that's really hard for me um just because it’s just like that's not like, I don't know, I feel like that doesn't define me. It's really hard for me to uh to come from such a nurturing environment from my community college and at SDSU because I took a semester there too. So, having those very nurturing environments and coming here and feeling so like outcasted I think it really like affects me and makes me especially since I'm a commuter. So, it makes me feel like I really don't belong here. (Interview, 7 July 2017)

The fifth, and final, event outcome code in the negative science identity trajectory category we made was **Defeat** (total=2, Table 1). The “Defeat” code is different from both “Fixed Mindset” and “Decreased Self-Efficacy” codes because “Defeat” was assigned when students demonstrated low self-efficacy resulting in students giving up on their STEM goals. Specifically, the students diverted from completing science related goals, big or small, possibly because they didn’t feel good enough, maybe they felt the task was too hard for them to accomplish because they believed they did not and could not possess the skills required to be successful. Rather than persevering and strategizing to develop a more favorable and successful outcome, these students abandoned the goal altogether and accepted defeat. If we go back to

Kevin's experience studying physics, Kevin exemplified "Defeat" when he described why studying for a frustrating test made him less interested in STEM:

> I guess sometimes you read these physics textbooks and you just don't get it. And then you kind of question yourself, like can I really be a physics major? I have...sometimes you just have a problem where you just can't overcome it. (Interview, 14 June 2017)

Our results suggested, when exploring the science identity events and outcomes of transfer students pursuing STEM in college, that students had more positive interpretations of event outcomes for positive events, resulting in a more obvious positive science identity trajectory and possible development of a stronger science identity. Whereas, students who experienced negative events reported both positive *and* negative outcomes which made the determination of science identity and trajectory for negative events less clear; individual students had conflicting interpretations of the same experiences. One student might have thought a negative event had both positive and negative outcomes, another student might have thought the same negative experience had just a positive outcome, while another student might have said the outcome was just negative. Therefore, we could not conclude that negative experiences might promote a negative science identity trajectory.

Discussion

In determining what experiences and interpretations transfer students have which may influence students' science identity formation and science identity trajectory, qualitative coding of 7 student transcripts (Saldana, 2009) highlighted common events and outcomes recalled among the students (Table 1). Science identity trajectories (Jackson & Seiler, 2013) describe students' movement towards or away from science based on student's science experiences and use of resources to propel them in specific directions. Although Jackson and Seiler's (2013) use of science identity trajectories is not founded in the science identity model developed currently

(Carlone & Johnson, 2007; Hazari et al., 2013), its application in combination with the science identity model is nevertheless useful for further understanding which common science identity events among transfer students in STEM are experienced, their outcomes, and subsequent science identity and trajectories are formed. Applying the science identity trajectory framework with the science identity model, we found that all events had one or more outcomes interpreted by individual students, and that each event across the performance, recognition, and interest categories produced similar and different outcome combinations despite being similar or different events.

Positive Science Identity Events, Outcomes, and Trajectories

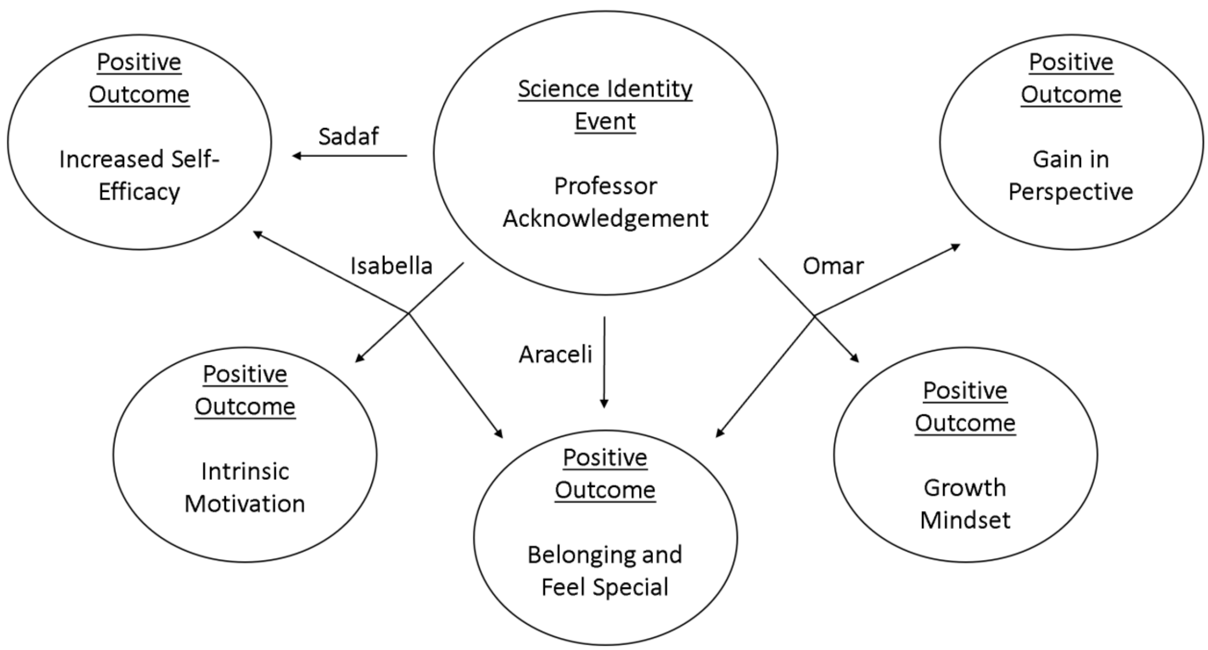

Figure 1. Positive Science Identity Event Outcomes. Data analysis from four (n=29) student interviews which explored transfer students' science identity experiences, outcomes, and trajectories revealed that students interpreted positive outcomes for positive science identity events, which suggests that the positive events produced positive science identity trajectories. Figure 1 includes one recognition event code we created, Professor Acknowledgement, and the various positive outcomes four students interpreted. Each arrow points from the event to the outcome and next to each arrow is the student's pseudonym.

We found that positive events were paired to students interpreting positive event outcomes. Our results showed that positive performance, recognition, and interest events (High

Academic Performance, Improved Academic Performance, Professor Acknowledgement, Academic Acknowledgement, Aligns/ Applicable to Interests, and Exposure) most likely promoted more positively associated event outcomes, most likely more movement towards science, and in turn the student may have developed a stronger science trajectory, identity, and possibly been more successful in STEM. Although our results are not surprising, it does deviate from our hypothesis. We hypothesized that students would interpret a variety of positive and negative event outcomes for positive events because students come from all different sociocultural and historical backgrounds and have most likely developed different mindsets from their unique experiences, but it seems that positive events fostered positive outcomes.

<u>Negative Science Identity Events, Outcomes, and Trajectories</u>

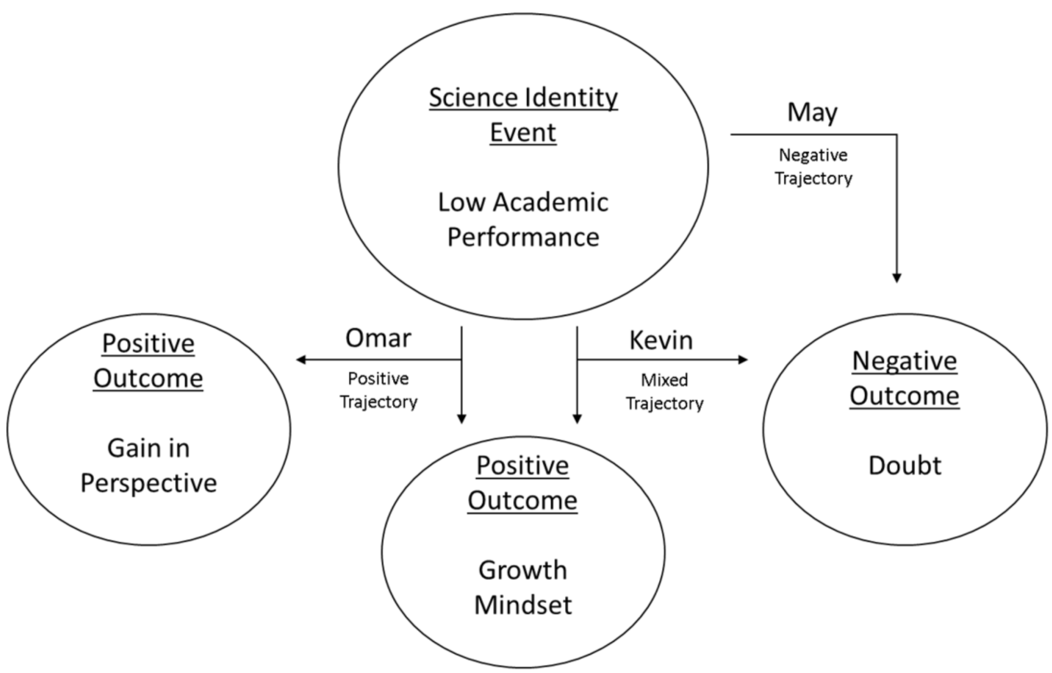

Figure 2. Variability of Negative Science Identity Event Outcomes and Trajectories. Data analysis from three student interviews (n=29) which explored students' science identity experiences and outcomes revealed that students interpreted both positive and negative outcomes for negative science identity events, which suggests that negative events produced variable science identity trajectories. Figure 2 includes one performance event code we created, Low Academic Performance, and the different outcomes three students interpreted. Each arrow points from the event to the outcome, atop each arrow is the student's pseudonym and below each arrow is the suggested science identity trajectory.

We found that negative events produced both positive and negative event outcomes. The pattern found from codes we created aligned with our original hypothesis that students would possess a variety of interpretations for negative event types. Our results showed that negative performance, recognition, and interest events (Low Academic Performance, Lack of Acknowledgement, Doesn't Align/ Not Applicable to Interests, and "When things get hard") were experiences which most likely promoted both positively associated event outcomes and negative, most likely more movement towards science, and in turn a stronger science identity, and possibly more success in STEM. Our interpretation of negative events producing both positive and negative outcomes points to a more ambiguous science identity trajectory and science identity formation. Interpreting both positive and negative outcomes for negative events suggests that students might not associate negative events with a clear enough outcome - only positive or only negative interpretations - that moves students along a specific trajectory.

According to Jackson and Seiler (2013), students who experience events which do not propel them towards or away from science have what is known as a "peripheral science identity trajectory", or no movement towards science possibly due to no events occurring or both positive and negative events occurring which cancel each other out and lead to a neutral trajectory (no movement, again). This lack of movement is thought to arise due to "mixed success" in science, an equivalent number of successes and failures occurred and equate to no overall movement. It might be that these specific negative events which produced variable outcomes, both positive and negative, might propagate this peripheral science identity trajectory.

Positive Recognition Events, Outcomes, and Trajectories

Students in science have been shown to experience various forms of positive recognition (Carlone & Johnson, 2007) and the results we found support this finding. Carlone and Johnson

(2007) identified specific "positive recognition events" as events involving recognition from "scientific meaningful others" (professors, research advisors, and scholarship or academic award committees). Students from Carlone and Johnson's (2007) study who possessed a strong science identity, what they called "Research Scientist Identity" were all students who experienced continuous, repeated positive recognition events, and emphasized the importance of recognition from scientific meaningful others.

Later, these same students went on to complete doctorates in science, which suggests some kind of relationship between positive recognition events involving scientific meaningful others that are continuous and repeated, positive science identity formation, science identity trajectory, and overall success and persistence in STEM. Similarly to the students who possessed the "Research Scientist Identity" (Carlone & Johnson, 2007), six out of the seven transfer student transcripts coded displayed "Research Scientist Identity" characteristics. When asked to recall moments where they felt more recognized, these six transfer students unanimously recalled positive recognition events involving meaningful scientific others linked to positive outcomes and a likely positive trajectory.

The results we found and codes we created for recognition experiences further supports Carlone and Johnson's (2007) recognition findings. Our codes for recognition events, "Professor Acknowledgement" and "Academic Acknowledgement", were linked to positive outcomes, positive trajectory, and all involved a scientific meaningful other. Although we cannot provide information as to whether these recognition events were continuous and repetitive, it is still valuable to note the similarity in the type of recognition valued. Our data, along with previous research (Carlone & Johnson, 2007), suggests that there is a likelihood that students, including transfer students, who experience positive recognition events involving recognition from scientific meaningful others, interpret positive outcomes and might have a greater likelihood of developing a positive science identity trajectory, stronger science identity, and have more success persisting in science.

Study Limitations and Future Directions

Our interview techniques were guided by the critical incident protocol (Dunn & Hamilton, 1986) which has its own limitation. One issue with this technique is that students were not provided the exact questions they would be asked prior to the interview so they had limited time to think and respond which may have led to trivial answers. To combat this, our interviewer was trained to probe with follow-up questions to encourage students to provide more detailed responses. Although use of the critical incident protocol assumes responses regarding lived experiences are the true interpretation for the individual, all conscious or unconscious attempts students made to alter their responses most likely biased our results in favor of the student.

It is possible that for positive events which produced positive outcomes, students might have overtly boasted about their experiences and dramatized the impact of events to come off as hard working, superior, and other positive synonyms which suggest success. For positive outcomes produced by negative events, students might have limited their response in front of the interviewer to control the interviewer's perception of them and to not look "bad" or come off as incapable. To avoid judgement, the interviewee might have added a positive outcome to a negative event to come off as stronger and more resilient; this could have biased the transcript results in favor of the student.

To control for this bias the best we could, we attempted to strengthen the interviewer-interviewee relationship by beginning each interview asking some basic questions: the student's major, past research, their community college, if their parents went to college, how they came to choose UC San Diego to continue their education, reasons for joining the START Program, the skills developed and benefits received from START in order to build rapport with students and make them feel more comfortable so they could provide honest and open answers about their positive and negative experiences during the interview. In the future, we recommend incorporating more grounded ways to control for interviewee response bias so that data is more reflective and accurate of students' true experiences and the impact of those experiences on them.

One suggestion to improve data collection would be to not only hold interviews with students but also hold interviews with student's network of close family, friends, peers, teachers, professors, and any scientific meaningful others they interact with to ask their interpretation of the student. Interviews conducted with people from students' social networks who were involved in specific experiences recalled by the student could provide first-hand account of the experiences and the student; hypothetically, one would have more than just the student's perspective to analyze. Following this interview protocol, one could triangulate the data to compare responses and look for similarities and differences in the interpretation of experiences from the students' perspective and those they interacted with, as well as get to know the student more from other's interpretation of them and the experiences they shared with the student. In addition to this, it might be useful to observe students in their courses longitudinally and take detailed field notes so that more information is available to contextualize experiences further.

Our study did not include inter-rater reliability and we did not finish coding for all 29 students; this should be adopted in future studies to improve the reliability of the codes produced and the results found. Coding for all 29 students may reveal novel event and outcome results which may suggest different conclusions. To improve our study overall, a longitudinal design should be adopted with a larger cohort of students to track student science experiences, outcomes, trajectories, and science identity formations from the beginning of community college to the end of their university years post transfer. This will allow one to gather valuable data and identify events we may have missed that occurred early on in community college and at the four-year university level as well, and help reveal how different or similar evets at both the community college and university level are most important and how these events and event interpretations might shape transfer students' paths and retention in science.

Conclusion

Previous studies involving identity formation have developed our understanding of identity as an analytical tool (Gee, 2000) and have provided valuable insight about the possible influential factors of science identity using the science identity model (Brickhouse et al., 2000; Carlone & Johnson, 2007; Hazari et al., 2010). In addition, the science identity trajectory framework (Jackson & Seiler, 2013) has developed our understanding of how students move towards or away from science as their science identity develops and changes. Although useful and undoubtedly a part of the foundation for identity research, gaps remain. Both the science identity and science identity trajectory frameworks have not, from our current understanding, been weaved together to develop a more comprehensive science identity model nor have both been used together and applied to better understand transfer student science identity formation. In our study, we have designed and exemplified a version of what this new model could look like.

Our version of the science identity model applies both the science identity and science identity trajectory frameworks by incorporating several key components from both models: (1) science identity events: competence/performance, recognition, and interest, (2) science identity outcomes, (3) science identity trajectory: positive and negative movement towards science, to explore transfer student science identity formation and trajectory in STEM. We were able to better understand what specific competence/performance, recognition, and interest experiences were most common, as well as the event outcomes interpreted by transfer students in STEM. Our findings suggested that transfer students interpret negative competence/performance, recognition, and interest events as having both positive and negative outcomes, whereas positive competence/performance, recognition, and interest events were associated with overwhelmingly positive interpretations. These results suggest to us that positive events might push students towards a positive science trajectory and possibly a stronger science identity, which may result in greater STEM retention; while negative events suggest a more ambiguous and foggy trajectory towards science, possible weakened science identity, and maybe a likelihood for leaving STEM. We also learned from our results that transfer student science identity formation and science identity trajectory is not so easily assumed nor tracked from a single experience and seems to be influenced by students' individualized mindset greatly; one student may view failing an exam as room for learning and growth while another student might view the same experience as a travesty and begins to doubt their STEM interests entirely.

In conclusion, we believe that the development of a more comprehensive science identity model which properly integrates core components of the science identity trajectory framework would result in a better understanding of how transfer students in STEM move through science, what experiences they have and the impact of those experiences on them, their science identity trajectory, science identity, and overall persistence in STEM. We hope that data gathered from this mixed methods approach will inspire future research and go on to inform educational institutions, faculty, staff, and policy makers on how they can best support transfer students in developing a positive science identity trajectory, stronger identification with science, and greater STEM retention so that these students may go on to create the next-generation STEM workforce.

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APPENDIX

START Interview Protocol

Thank you for participating in this interview. The interview will be confidential. We will remove any identifiers before sharing any information with the START faculty or publishing the results. If you feel uncomfortable at any time in the interview, please let me know, and we can stop. This interview consists of two parts. First, I will ask you about your experiences with START. In the second part, I will ask you about your experiences at your previous community college and here at UC San Diego in general. Do you have any questions before we begin?

1. Can you please tell us a little bit about yourself? For example, what is your major? Have you done research here on campus or elsewhere?
   a. Where did you go to community college before coming to UC San Diego?
   b. Did your parents or guardians attend college?
   c. How did you choose to come to UC San Diego to finish your undergraduate degree?
   d. What were your reasons for joining the START program?

A. START program

2. In your opinion, do you think that you have benefited from the START program?
   a. Why or why not?
   b. Academically, do you feel that you gained knowledge or skills from the START program?
   c. Do you feel more connected with faculty and researchers on campus because of the START program?
   d. Do you think the START program helped you learn how to navigate life as a student here on campus in terms of resources?
   e. Socially, do you feel more integrated within other students on campus as a result of the START program?
   f. Can you give a specific example?
   g. Looking back, are there any drawbacks to having done the START program?
   h. Are there any drawbacks to being in a program with mostly minority or first-generation college students?

3. Do you have any suggestions for how we can improve the START program to help future students to be more successful?

B. College student identity

Now I would like to ask you some more general questions about your experiences here at UC San Diego as a student.

4. Can you describe a memorable moment that made you feel like you are performing well or made you feel competent as a student in your major? The experience could be in a course, out of class, in the lab, etc.
   a. What made that moment memorable?

b. What would you say are the impacts of this memorable moment on you as a student?
c. What about a memorable moment that made you feel like you are not performing well as a student?

5. Can you describe a memorable moment that made you feel like you are recognized or not recognized as a successful student in your major? Again, this could be from in or out of class, for example, faculty, TAs, friends, or family.
   a. What made that moment memorable?
   b. What would you say are the impacts of this memorable moment on you as a student?
   c. What about a memorable moment that made you feel not recognized as a successful student?

6. Can you describe a memorable moment that made you become more interested or less interested in the subject matter of your major?
   a. What made that moment memorable?
   b. What would you say are the impacts of this memorable moment on you as a student?
   c. What about a memorable moment that made you feel less interested in the subject matter of your major?

<u>C. Figured worlds of college</u>

7. How would you define success as a student in your major here at UC San Diego?
   a. In your view, what makes a successful student?
   b. In your view, What does a successful student do?
   c. Can you give a specific example?
   d. Did your definition of success change in this regard over the last two years since you have been here?
   e. How? Why?

8. How do you think your family would define success for you at UC San Diego?
   a. What are their expectations for you at the university?
   b. What are their expectations for you after you graduate?

9. How do you think UCSD faculty would define success as a UCSD student?
   a. In your view, what do students do that gets recognized by faculty as being successful?

10. Thinking back to when you were at your community college or colleges that you attended, how would you define success as a student in your major there?
   a. In your view, what makes a successful student in that college?
   b. In your view, what does a successful student do in that college?
   c. Can you give a specific example?

11. Thinking back to when you were at your high school or high schools that you attended, how would you define success as a student there?
   a. In your view, what makes a successful student in that high school?
   b. In your view, what does a successful student do in that high school?

c. Can you give a specific example?

12. How would you define success as a researcher in your discipline of study?
    a. In your view, what makes a successful researcher?
    b. In your view, What does a successful researcher do?
    c. Can you give a specific example?
    d. Did your definition of success in this regard change over the last two years since you have been here?
    e. How? Why?

D. Survey

Finally, I would like to ask you to fill out a very short survey, so we have some information for our record. Again, this information is confidential. We will remove any identifiers before sharing any information with the START faculty or publishing the results.