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Zuckerman, Austin

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UNIVERSITY OF CALIFORNIA SAN DIEGO

Examining Undergraduate Experiences and Identity Navigation in STEM

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

in

Biology

by

Austin Lee Zuckerman

Committee in charge:

      Stanley Lo, Chair
      Eduardo Macagno, Co-Chair
      Frances Contreras

2019

The Thesis of Austin Lee Zuckerman is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

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Co-Chair

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Chair

University of California San Diego

2019

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Chapters II and III, in part, are currently being prepared for submission for publication of the material. Zuckerman, Austin L.; Lo, Stanley M. The thesis author was the primary investigator and author of this material.

ABSTRACT OF THE THESIS

Examining Undergraduate Experiences and Identity Navigation in STEM

by

Austin Lee Zuckerman

Master of Science in Biology

University of California San Diego, 2019

Stanley Lo, Chair
Eduardo Macagno, Co-Chair

Undergraduate education represents an important transitional stage where students decide upon and pursue their respective career pathways. Although an increased demand for professionals in the science, technology, engineering, and mathematics (STEM) workforce supports the recruitment of larger student populations into higher education, the number of trained professionals is expected to be insufficient due to the low retention of students in STEM degree programs and research, especially under-represented minority and first-generation students. Understanding the challenges that students broadly face during their university experiences is essential for informing institutional practices that foster the retention of students

in STEM. Because a large proportion and diverse group of undergraduate students begin their post-secondary education at community college, this study examined the experiences and identity navigation of transfer students (n=29) majoring in STEM as they transitioned into a university-level education and pursued professional opportunities. The first analysis used Holland's (1998) figured worlds as a theoretical perspective to examine multiple points of misalignment between the expectations that transfer students possessed prior to entering the university and their understanding of success that was reconfigured by their university experiences. The second analysis used phenomenography to define an outcome space that describes variations in these students' conceptions of the research profession. A comparison between the participants' current and retrospective conceptions revealed a more nuanced understanding of the nature of research after developing their own research and professional experiences in STEM.

Chapter I

Introduction

Although the expansion in the demographic diversity of undergraduate students in the United States is reflective of the increased number of students enrolling in post-secondary education, there is projected to be a deficiency of students studying STEM (PCAST, 2012; NSF, 2014). Part of this underrepresentation can be attributed to a high number of under-represented minority and first-generation students transferring out of their STEM degree programs (PCAST, 2012; Terenzini, Springer, Yaeger, Pascarella, & Nora, 1996; Hurtado, Cabrera, Lin, Arrellano, & Espinosa, 2009; Chen 2013, Dika & D'Amico, 2016; Graham, Frederick, Byars-Winston, Hunter, & Handelsman, 2013). Previous research has indicated that these students are at a clear disadvantage in regard to financial support, academic preparation, and social and professional integration into the university environment (Tinto, 2010; Engle, 2007). Although models of student retention maintain that effective social and academic integration are essential, there is less understanding on the appropriate intervention practices that can facilitate a university culture that fosters student retention in STEM (Tinto 2010; Seymour & Hewitt, 1997; Ulriksen, Madsen, & Holmegaard, 2010; Anderson & Kim, 2006).

Because entry into the university represents an important transitional stage where students are recruited and ultimately enculturated into their respective fields of study, participation in STEM depends on student perceptions of their preparation for university-level coursework and the experiences that shape their motivation and aspirations (Wang, 2013). Broadening and diversifying participation in STEM is contingent upon the ability of faculty and administrators to cultivate campus environments and educational experiences that foster success for students from a variety of educational and cultural backgrounds (Tinto, 2010; Museus & Liverman, 2010; Toven-Lindsey, Levis-Fitzgerald, Barber, & Hasson, 2015). Given the low rates of retention in STEM, additional studies on the specific academic and social challenges that

students experience during their transition into a university-level education must be conducted to inform these institutional practices (Museus & Quaye, 2009; Toven-Lindsey et al., 2015).

A comprehensive understanding of the experiences that can positively or negatively reinforce student retention in STEM warrants an examination of student identity navigation across time and context. Identity is a complex construct that is constantly positioned and negotiated as students engage in various discourses and practices at the university (Gee, 2000; Wenger, 1998). The initial transition to the university can be particularly difficult if students experience discontinuities between their sense of personal identity and the identity that is reconfigured by the norms and expectations of the university (Urietta, 2007). Examining the various individual challenges that students face in their transition to the university provides a more holistic understanding of the institutional practices that facilitate a more stabilized academic transition into a university level STEM education.

In order to expand upon growing research on undergraduate students' identity navigation and experiences in STEM, two studies are presented. The first study analyzes how transfer students configure their identities during their transition from community colleges into the university setting. Transfer students were selected as a study population because community colleges act as a pathway to higher education for many students, especially for students that come from socioeconomically underserved and culturally minoritized backgrounds. The transfer students in this study articulated areas of incompatible expectations across the university, community college, and high school learning environments, as well as those among themselves, their families, and the faculty.

Because all the transfer students in this study population were majoring in STEM, the second study describes how these students understand research as a profession. Through

articulation of their retrospective conceptions of the research profession prior to engaging in

university level coursework and research experiences, most students described a fundamental

difference between their current and retrospective conceptions. This difference is indicative of

the conflicting expectations that students with limited exposure to the research community may

have prior to building and developing their own research and professional experiences. These

incompatible expectations may limit the retention of students in STEM if they perceive that they

are not provided with a space to configure their identities toward a career pathway in STEM.

These analyses provide insights that university faculty and administrators could ultimately utilize

to develop institutional interventions and practices that foster a stabilized academic transition for

students into university-level STEM degree programs and research experiences.

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Chapter II

Transfer student experiences in STEM: Examining the community college to university transition using figured worlds

Abstract

Community colleges act as a pathway to higher education for many students, including students that are pursuing science, technology, engineering, and mathematics (STEM) disciplines. Because of the increased demand for professionals in the STEM workforce, a successful transition to a university level STEM education is essential for increasing the number of transfer students that complete STEM degree programs. Fostering a stabilized academic transition for transfer students is contingent upon an understanding of the academic and social experiences that can affect their retention in STEM. In this study, Holland's (1998) figured worlds was used as a theoretical framework to examine how transfer students perceive their experiences and identity negotiation during their transition from community college to university. This analysis examined areas of incompatible expectations across the university, community college, and high school learning environments, as well as those among students, families, and faculty. Incompatible expectations across different figured worlds provide insight into potential intervention that can be implemented to mitigate the challenges associated with the community-college-to-university transition and to foster the retention and success of transfer students in STEM.

Introduction

More than 40% of undergraduates begin their post-secondary education at community colleges, and these students are disproportionately first-generation (FG) college students or under-represented minorities (URM) (Ma & Baum, 2016; Townsend, 2008; Seymour & Hewitt, 1997; Hagedorn & Purnamasari, 2012; Bahr, Toth, Thirlof, & Masse, 2013). Although community colleges play a critical role in the pathway to achieving a post-secondary degree, the

challenges and experiences of transfer students have been surprisingly understudied (Laanan, Starobin, & Eggleston, 2010; Townsend, 2008). Because transfer students represent a diverse, yet neglected group of undergraduate students, it is particularly important to understand how the experiences and challenges of these students impact their representation and retention in STEM (Laanan, 2007; Flaga, 2006; Zamani, 2001; R. Mooring & S. Mooring, 2016; Dika & D'Amico 2016; Jackson, Stebleton, & Lannan, 2013; Mooney & Foley, 2011).

An increased demand for professionals in the STEM workforce over the next few decades (PCAST, 2012; NASEM, 2016) supports the recruitment of larger student populations into STEM majors, but the number of trained professionals in the STEM field is expected to be insufficient. This deficiency can be attributed to the low retention of undergraduates in STEM majors and research, especially students that are under-represented minority (URM) and/or first-generation (FG) (NSF, 2019). Students in community college leave STEM majors at a higher rate than students who begin their post-secondary degree directly at a 4-year university (NASEM, 2016). Previous research suggests that this lack of retention is due to the culture of STEM classrooms and institutional models that many minoritized[1] students find unwelcoming (NASEM, 2016; Beasley & Fischer, 2012; Ramsey, Betz, & Sekaquaptwea, 2013; Seymour & Hewitt, 1997). Students that are accustomed to the institutional culture present in community college may not necessarily be aware of the differences in culture between their college and a 4-year university (Townsend & Wilson, 2006; Flaga 2006; Chrystal, Gansemer-Topf, & Laanan, 2013). A change in academic environment and student perceptions of their interpersonal interactions are factors outside of socioeconomic status that can determine persistence and

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[1] We acknowledge that the term "minoritized" encompasses multiple dimensions of student identity and background (e.g. gender, sexual orientation, financial status). This study will use the term to refer to students that are first-generation college students and/or under-represented racial/ethnic minorities.

performance (Chang, Eagan, Lin, & Hurtado, 2011). Overall, the tendency for students to withdraw from their science education is primarily due to the various challenges they face in their academic and social experiences (Tinto, 2010), the inability to achieve a sense of meaning and belonging within their academic world (Holland, Lachiotte, Skinner, & Cain, 1998) and a difficulty in aligning their sense of identity and self with the norms and practices of the scientific community (Carlone & Johnson, 2007).

The formation of identities in STEM can be affected by one's gender, racial, or ethnic identities (Carlone & Johnson 2007; Graham, Frederick, Byars-Winston, Hunter, & Handelsman, 2013). Because community colleges serve as a gateway to higher education for traditionally under-represented groups (Crisp & Nunez, 2014; Rendon & Mathews, 1989; Hagedorn, 2008) and because transfer students are disproportionately URM and FG, similar experiences and challenges that under-represented groups face are, on average, likely to be as pronounced for transfer students. URM and FG students are more vulnerable to negative stereotypes or racialized experiences that cause them to be more "stigma-conscious" and to lower their educational prospects (Chang et al., 2011). Additionally, many transfer students are stigmatized as "latecomers to science" because they initially embark on alternative pathways following high school due to poor academic performance or lack of interest in a scientific career (Jackson & Seiler, 2013). When these students eventually enter the university, they may not be provided with access to sufficient resources or opportunities to reconfigure their identity in a way that allows them to align their sense of self with the norms and practices of the STEM education community. It can also be argued that transfer students should not be required to reconfigure their identities in order to conform to the norms and values of the university, especially if traditional institutional and teaching practices are marginalized and do not welcome a broad

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range of student identities into the university community (Scanlon, Rowling, & Weber, 2007).

However, because identity is a complex and dynamic construct, it may not be feasible for institutions to implement practices that can universally accommodate a broad range of student identities. In lieu of this restriction, and to effectively promote diversity, equity, inclusion, and retention of these students in STEM, it is essential to develop institutional practices that, at minimum, guide transfer students through their transition from community college into a STEM research university. These institutional practices should introduce transfer students to resources that cultivate academic and mentorship experiences that help them individually construct a sense of identity and belonging within their STEM education community (Jackson & Seiler, 2013; Graham et al., 2013).

Because identity is a construct that can significantly impact the experiences of students in their educational pursuits and because transfer students represent an understudied student population, this study intends to examine the experiences and challenges that transfer students face as they author and reconfigure their identity after their transition into a STEM research university. This identity transformation was studied by analyzing the differences between how these students understood success at the university in comparison to their previous experiences in community college and high school. Using Holland et al.'s (1998) *figured worlds* as a theoretical model, this study addressed the following research questions:

1. How do transfer students define and contrast their understanding of success across three different educational contexts: university, community college, and high school?

2. Because family and faculty are sources of social capital that influence student navigation through the university, what is the perceived influence of family and faculty expectations on student identity configuration within the university space?

These research questions provided insight into the potential challenges that transfer students face in their transition from community college to a STEM research university. Elucidating the potential challenges associated with the community college to university transition is informative for the development of institutional practices that faculty and administrators can implement to provide support and guidance to transfer students as they navigate a new academic space and reconfigure their identity to meet the rigorous demands of the university.

Theoretical Framework: Figured Worlds

Figured worlds are abstract realms that describe personal development in a specific context, and this framework has previously been used in research on student engagement and identity (Holland et al., 1998; Urietta, 2007). Identities are configured according to the specific practices that are valued within a particular world. Through extensive experiences and interpretation of these experiences in these spaces, students begin to embody and position themselves according to the norms and values within these worlds (Holland et al., 1998; Jurow, 2005). However, initial entry into these worlds involve students crossing boundaries in which multiple figured worlds may intersect in one space (Price & McNeill, 2013; Langer-Osuna, 2015; Calabrese Barton, Kang, Tan, O'Neill, Bautista-Guerra, & Brecklin, 2013). Because students shape their present and future goals by drawing upon previous life and academic experiences, there are often points of continuity and discontinuity between the meanings and

expectations across figured worlds (Price & McNeill, 2013). For example, Calabrese Barton and Tan (2010) investigated the developing agency of youth that participated in an urban community science club by examining this club as space where youth were able to identify themselves as knowledgeable "community science experts." Identifying as community science experts allowed these youth to engage in scientific ideas and discourses. Students were ultimately able to align their sense of self within this space by connecting their home community experiences, resources, and relationships to the practices and discourses within their figured worlds of the scientific community. Analyzing how students engage in figured worlds provides a more comprehensive insight into how students construct understanding and interpretation of their academic and social experiences across time and context (Jurow, 2005).

Several other theoretical frameworks have been used to examine the positioning of student identity within different educational contexts (e.g. Gee, 2000; Wenger, 1998; Carlone & Johnson, 2007). The figured worlds construct has previously allowed for the examination of the connection between personal and academic identities in relation to classroom learning and engagement (Langer-Osuna, 2015; Tonso, 2006). This construct relies on a fundamental understanding of how individuals' author or position their identities to navigate through different contexts across time (Holland et al., 1998; Urietta, 2007; Chang, 2014). Identities are often negotiated when navigating through cultural spaces and students majoring in STEM fields may need to reconfigure who they understand themselves to be if traditional science teaching and practices are perceived to be marginalized by promoting a narrow range of science identities (Rubin, 2007; Holland et al., 1998, Carlone & Johnson, 2007, Costa, 1995). The positions of students within these worlds can either confer a positive or negative experience depending on the

ability of the students to effectively align their sense of identity and self with the norms and practices of the academic figured world.

Importantly, the concept of figured worlds is similar, but not identical, to the concept of "community of practice." A community of practice is the foundation of a social learning system that is defined by norms and values that result from a mutual understanding of competence shared by a community (Wenger, 2000; Lave & Wenger, 1991). A community of practice implies that positioning of one's identity is a collaborative process that depends on mutual engagement between members of the community. Individuals that are newcomers to the community embody practices and identities that can either complement or conflict with the practices previously upheld within the community (Lave & Wenger, 1991; Handley, Sturdy, Fincham, & Clark, 2006; Wenger, 1998). Participation in the community depends on the ability to negotiate meaning within a shared domain through a shared repertoire of resources and practices (Wenger, 1998). The community of practice can therefore be construed as a shared social world in which participants collectively determine the standard practices and behaviors that are to be upheld in the learning community (Wenger, 1998). The concept of figured worlds is more focused on how *individuals'* author themselves in a social space and the ways that individual identities are negotiated by the social norms and expectations within that space. The figured world is a lens into the community of practice and the positioning of one's identity to discover meaning within this space is dependent on expectations drawn from previous life and community experiences (Holland et al., 1998; Price & McNeill, 2013). For example, a university can be interpreted as a community of practice that is defined by a historical, yet evolving repertoire of academic expectations. However, the university is also an individually defined figured world for students. The *individual* identity negotiation and figuring within this space is

based on the ability of these students to leverage and bridge their cultural and academic backgrounds and experiences to develop a sense of individual agency needed to engage in the shared practices of the community.

Identity formation during an academic transition relies on students discovering meaning and understanding of the social and cultural norms within a new academic space (Holmegaard, Madsen, & Ulriksen, 2014). There may be an initial gap between the expectations and actual experiences of these students when transitioning to a 4-year university and students may therefore need to implement identity negotiation strategies in order to develop a sense of belonging within this new space (Holmegaard et al., 2014; Berzonsky & Kuk, 2000; Ethier & Deaux, 1994; Azmitia, Syed, & Radmachel, 2013; Carlone & Johnson, 2007; Holland et al., 1998). These negotiation strategies are often dependent on capitalizing on support networks from family, peers, and faculty that can validate students' sense of belonging in the university community (Azmitia et al., 2013). The ways that students recognize their positions within differing figured worlds can vary as the perceived norms and expectations within a figured world can alter across time (Calabrese Barton et al., 2013; Holland et al., 1998). However, the outcomes within these worlds can be uncertain due to the dynamic nature of student identity and how identity is reconfigured when students enter a new figured world. The figured worlds theoretical model provides a useful framework for studying student experiences and identity formation across different academic transitions. In order to broadly promote student retention, it is especially important to understand the challenges that minoritized students face in these transitions, as these students often do not have access to the social capital and resources needed to properly configure their sense of identity within the university community (Tinto, 2010; Saunders & Serna, 2004; Azmitia et al., 2013; Moschetti & Hudley, 2015).

<div align="center">**Methods**</div>

Study Participants

     This study was focused on examining how transfer students position multiple figured worlds in relation to their experiences and understanding of success at the university. Participants for this study were selected from a bridge program that was intended to provide transfer students with an intensive six-week introduction to biological research in the summer prior to their first quarter at the university. The program also provided opportunities for participants to network with faculty and to explore campus resources that would introduce them to other research and professional opportunities in STEM. To capture a wide range of experiences, a total of 29 (out of a possible 31) transfer students (~75% FG and ~66% URM) that had participated in this program were interviewed. These students were interviewed approximately 1.5-2 years after the conclusion of the program, near their target graduation dates. Therefore, the participants had culminated a majority of their university experiences that could be compared to their previous experiences in community college and high school.

Data Collection

     A semi-structured interview protocol was implemented as part of a larger study that examined various aspects of the participants' university and community college experiences. The interview questions for this study prompted participants to define their perceptions of success across three potentially overlapping figured worlds: university, community college, and high school. These educational contexts represent three different figured worlds in three different academic spaces. For each of these educational contexts, the participants were prompted to 1) define success as a student within this context, 2) specify what makes a student successful and/or

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what a student does to be successful, and 3) provide specific example(s) of what a student does

to achieve success. To further identify differences in academic expectations of success across

these three contexts, the participants were also prompted to indicate if their definition of a

successful university student had changed over the course of their university academic career.

Because the university figured world was the central focus, we also triangulated how each

participant perceived that their family and university faculty would define success to elucidate

potential points of overlap and misalignment in relation to their personal figured world of a

successful university student. For the figured world of the family, the participants were prompted

to 1) define how they thought that their family would define success at the university, 2) specify

the expectations that their family had for them at the university, and 3) specify what their

expectations were for them after they graduated. For the figured world of faculty[2], the

participants were asked to articulate 1) their perception of how faculty would define success and

2) what students specifically do that gets recognized by faculty as being successful. The figured

worlds of family, faculty, and the student represent three figured worlds intersecting in one

academic space: the university.

Data Analysis

The interviews ranged from 20 minutes to 59 minutes in length (average: ~34 minutes)

and served as the primary source for an interpretative qualitative analysis. The interviews were

transcribed semi-verbatim either manually or by a professional transcription service. For the

preliminary analysis, patterns were noted within responses after an iterative close reading of the

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[2] The 29 interviews were conducted across three cohorts of program participants. The question prompting participants to articulate their figured world of faculty was not asked to the first cohort. Therefore, only 22 out of the 29 participants provided responses to this section of the interview protocol.

interview transcripts. From these preliminary notes, in vivo codes and memos were generated using participants' own phrases to succinctly summarize the parameters of success defined within each figured world. Codes were applied to participant responses for each individual figured world. Broader categories were then developed inductively by grouping the codes together, and the linkage between these categories were summarized in three interpretive themes.

The commonalities and variations within each theme are illustrated through generative case studies that situate individual student experiences in their unique contexts. Generative case studies generate descriptions of a subject's mental structures that reflect more complex ideas and meanings (Clement, 2000). In contrast to a strictly convergent, coded analysis, observation categories in a generative analysis are not fixed and the inferences drawn from this analysis provide the basis for a theoretical framework that can explain the complex mental processes observed. In the context of this study, each interview participant served as a case study by describing and contrasting the meaning of success across their university, community college, and high school figured worlds and by triangulating their figured worlds of family and university faculty into their figured world of a university student. These descriptions provided insight into how students individually author and reconfigure their identities during their academic transition into the university and the areas of incompatible expectations across the university, community college, and high school learning environments, as well as those among students, families, and faculty. The case studies presented illustrate commonalities and variations among student perceptions of their experiences and understanding of success within each figured world in this theoretical model.

Reliability

One researcher independently coded and interpreted all 29 interview responses. Excerpts were discussed with a second researcher to verify that the codes succinctly and accurately summarized the connotations of the interview responses. The second researcher also reviewed the six case studies that were selected for this analysis. An open discussion between the two researchers corroborated that the interpretations of the interview responses were consistent and that the case study excerpts aptly represented the themes that emerged from the analysis.

Findings: Case Studies

A total of six case studies from the interview samples are presented as narratives. The narratives were constructed by selecting participants that provided responses that were broadly representative of the commonalities and variations within each theme. The narratives were constructed by selecting interview excerpts that described the participants' perceptions of success in each figured world within our theoretical model. These participants also represented a broad range of demographics (e.g. race/ethnicity, gender, first-generation status) within the study population (Table 1). All names in these case studies have been replaced by pseudonyms in order to maintain participant confidentiality.

Table 1: Descriptions of participants that were selected for case studies. All names have been replaced by pseudonyms. Participants were designated as "first-generation" if neither parent/guardian had received a four-year degree in the United States.

Name	FG/CG Status	Race/Ethnicity	Gender	Discipline of study
Yosef	First Generation	Middle Eastern	Male	Engineering/Computer Science
Cameron	Continuing Generation	White & Asian	Male	Biological Sciences
Isabella	First Generation	Hispanic, Latino, or Spanish	Female	Biological Sciences
Terrance	Continuing Generation	African American, Black	Male	Cognitive Science
Maria	First Generation	Hispanic, Latino, Spanish	Female	Biological Sciences
Mona	First Generation	Middle Eastern	Female	Health Sciences

Yosef

Yosef is a first-generation college student that entered the university as a biology major. However, throughout his exploration of different scientific fields during the summer bridge program, he decided to switch to an alternate STEM major after completing the program.

In his figured world of a successful university student, Yosef emphasizes the importance of developing an interest in the subject matter of one's major by building experiences and connections.

> (…) realize that the numbers aren't everything. Make connections with everyone possible and also just have a passion for what you do. [One] of the examples that I would give is the fact that I personally always sit at the front of the classroom, but I always talk to a professor who is teaching either before or after the class is taught. And that has made me, you know, more familiar with the faculty and I think that opens up opportunities...And, so it just, you expanding who you know affects what you're going to be able to do so much. Because even if you, even if you know you're shit, even if you know what you're doing, not knowing people is not going to take you that far.

Yosef's metrics of success within the university figured world contrast to his perception of success during his initial transition into the university. He originally measured success strictly by grades. Although Yosef's current definition of success undermines the importance of grades as a metric, he states that his passion for his major and his desire to build connections and experiences has enhanced his academic performance.

> (...) after realizing that there are a lot of people at the school that get A's in everything, that is not my definition of success anymore. Because, for me, the definition of success is what is it that makes you unique. What is it that makes you, you know, stand out. When, like people say, "this person is successful," they can't say that everyone with a 4.0 is successful because that isn't necessarily, that isn't necessarily a good criterion when you have so many people. I feel like success is something that's more specific. More "this person is successful over others because they have done this and not just that." And I feel like, I've stopped caring that much about. It's weird, because I still have a 4.0, but I don't care about it. It's more like. It's kind of like a side effect to caring about everything else and succeeding at everything else that that just happens versus focusing more on that.

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Conversely, because he perceives that there were limited professional and research

opportunities in STEM at his community college and that there is a decreased tendency for

students to seek faculty connections due to the lack of opportunities, Yosef perceives that high

grades are the primary metric of success within his figured world of community college.

> Um, there weren't a lot of research positions at [my community college]. So, I'm
> pretty sure that success was very strictly about the number. It was very strictly
> about what grade you get in that class and that's it. And especially at [my
> community college], connections that you make with the professors aren't as deep
> as they... aren't as meaningful. And I feel like, even if you do have a connection,
> they're not going to give you a research position because they don't, they're not
> doing research, because it's not a research school. They're not going to refer you
> to places with internships because they don't have connections with people in the
> industry. And so, they just care about the grade and students just care about the
> grade. And that's probably their success metric.

Like in his community college figured world, Yosef recognizes that success in high school is

more dependent on grades, but he also mentions the tendency for high school to measure

popularity as a parameter of success.

> At high school, I feel like success was also strictly related to the grade. Um, I was
> in the Middle East back then, and it was the IB system, so I'm pretty sure it's an
> entirely different perspective from the people who are here. Yeah, its success was
> more about being social than it was about, it was about the grade, but it was also
> about, you know, who was, as all high schools are, who was more popular, who
> was more social. I feel like that is an indicator for who's successful in high
> school...But then, that doesn't apply anywhere after because, who cares if you're
> popular or not in college.

Because he argues that the popularity metric of success "doesn't apply anywhere after" high

school, these is a partial lack of overlap between his high school and community college figured

worlds. However, the community college and high school figured worlds demonstrate overlap in

the high emphasis on academic performance. Both of these figured worlds ultimately contrast to

his figured world of the university due to the decreased emphasis on building connections and

academic experiences outside of the classroom setting.

Furthermore, when configuring his perception of how university faculty would define success as a university student, Yosef notes that these metrics of success may vary from faculty member to faculty member. However, he recognizes that faculty would similarly emphasize the importance of building connections and experiences outside of the classroom. Because he believes that these overlapping metrics of success can vary among faculty, the figured world of faculty aligns well, but is not completely cohesive with Yosef's university figured world.

> That's also very dependent on the professor. But, um, I think they definitely care more about the connections. They definitely care more about, you know, what you get from the teaching experience rather than the grade because I've had so many times where I've taken classes and I didn't necessarily outperform others, but I ended up getting an A+ in the class because I feel like they knew that I got the most out of the class as I could possibly get. And so, they would probably think that, you know, making the connections, exploring, doing internships. All the professors would say like "do your internships. Don't take summer classes." And, I'm pretty sure people in [biology] are like "get yourself a research position." Don't like just sit there and study classes. And so that is the norm at [the university] to like focus on what's outside the classroom. And I think, the more you do in that sense or the better you do outside of class, the more successful you are in terms of [university] faculty.

Conversely, when configuring the figured world of his family into the university space, Yosef believes that his family would define success primarily by his achievement of a 4.0 GPA. However, he claims that they disapprove of his alternate STEM major because they feel that it does not give him as much status. Although he believes that this perception of success can vary from individual to individual, his own family's metric of success does not appear to overlap at all within the university figured world. This misalignment may be due to differences in educational standards that his family had experienced when they briefly attended (but did not complete) college in a foreign country.

> Um, they would define it as a 4.0 for sure. But I feel like, I don't, I honestly don't know because it's, it's very dependent on the family. It's very dependent on what your family expects of you. There's, you know, families that, even when I told my parents that I was going to switch to [alternate STEM major] from being pre-med,

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they were extremely shocked and they didn't like my decision, but they also didn't realize how successful the [alternate STEM major] field is and how how…They care about the name that I'm going to make for myself. And, I feel like if they were doctored, like if they wanted a doctor, they think that, oh, only doctors and lawyers are going to get the high name or engineers and people who do anything else are not going to have as much of it as much of a status.

Cameron

Cameron is a continuing-generation student that had conducted research in the same lab since his first quarter at the university.

Cameron's figured world of a successful university student is focused on an in-depth understanding of course material that is achieved primarily through one's ability to teach the material to his or her peers. Although Cameron believes that a critical understanding of course material and providing mentorship to one's peers is an ideal metric of success, he simultaneously acknowledges that a high grade point average (GPA) is a more tangible, recognized metric within this figured world. Therefore, in order to fulfill this parameter of success, he argues that a successful student attends class regularly, uses supplemental study materials, and seeks instructional assistance when needed. He perceives that this in-depth understanding can also be assessed by one's ability to teach the material to others.

> Well. I think you're successful in learning the material if you can teach the material to someone else. Um, but obviously success is if you can get an A. Um, personally, I don't settle for anything less than an A. Even an A-, I'm not happy with. Um, A or A+, that's what I aim for. But that's the real bummer, right, of the education system is that like everything is so grade based. So, when I teach a [discussion section as an instructional assistant], right? No one, not very many people, I'm not going to say no one, not very many people care about the actual learning part. They just want to know what they have to memorize for the test, and then can they forget it and then get away with that for the rest of their life. Right? Everything is just grade based. But I think you're successful if you can learn it and teach someone else. Um, that is, that would be the ideal system. Right? But obviously it's measured by GPA.

There is a strong overlap between Cameron's community college and university figured worlds in this emphasis on academic performance, but the emphasis on high grades in community college was more reinforced by the importance of high grades in the transfer process. Cameron believes that his focus on conceptual understanding evolved more during his experiences at the university, and his definition of success at the university is not as restricted by the focus on grades that he believes strictly defined success within his community college figured world.

> I think, maybe if anything, because in community college, my focus was to transfer, right? You need to do that you need good good good grades. So, my only goal in community college was to get good grades. Um, I wasn't really focused on necessarily remembering too much the material. But is that the point of, I studied so much that I definitely remember everything in community college. Even now, like, I have my friends from community college. We are in class and we learned this in so-and-so's class, you know? And then we'll recollect the old days, right? But, uh, here [the university] I think I probably definitely focused more on conceptual concepts and not memorization.

The emphasis on high academic performance is pronounced in both Cameron's high school and community college figured worlds. However, in community college, he sees the mechanism of achieving high grades to be similar to the university figured world through regular attendance, proactive studying, and participation.

> Well in community college, the goal is to transfer. Not very many people are there just to get an AA. Um, there are some, which is great. Um, but what makes a successful student in community college is the same thing that makes you a successful student anywhere, really. Um which I already said, which was you got to go to class, definitely do all the homework. They definitely give you a lot of homework in community college. Go to office hours if you need it. But, uh, spend time outside of studying for sure.

However, because there is less opportunity for office hours in high school and because high school students are often given templates and straightforward guidelines that leads to high performance, Cameron recognizes less complexity and rigor in the mechanisms for achieving success within the high school figured world.

Um. In high school, professors don't really have, or teachers I guess, don't really have office hours, so you don't really do that. But high school is pretty easy right? Because they give you a template. They tell you need to do X, Y, and Z for these assignments. And if you follow those guidelines you get the A, right? You don't really need to do, uh, too much other than that. So, in that regard, uh, we successfully used honestly need to follow directions. If you can follow directions and you get the A. You know, I have. I had so many classes where especially in like English class or something like that, um, if you just follow the outline of what you need to write in the essay, right? Then you get a good grade on the essay. And people would do terribly because they just didn't follow directions. So, um, yeah. Getting a good grade makes you successful in, uh, high school. Maybe being involved in athletics or the clubs, you know, a national honor society or something.

Conversely, a point of overlap between the community college and high school figured worlds is Cameron's emphasis on being proactive outside of the classroom in order to prepare for his future endeavors. This is achieved primarily through learning the steps needed to successfully transfer in community college and increasing one's participation in high school extracurricular activities, as he states that "getting a good grade makes you successful in high school [and] maybe being involved in athletics or the clubs, you know, a national honor society or something."

Cameron's emphasis on high academic performance in each of his academic figured worlds seems to be strongly influenced by familial expectations. He claims that he had grown up in a strict family that believed that high grades translated to success in the "outside world." Therefore, his figured world of his family appears to be overlapping strongly and serving as a bridge to all of his academic figured worlds. Both of his parents had received bachelor's degrees. Their familiarity with the college experience may be the fundamental reason for why their basic metrics of success overlaps with all of Cameron's other figured worlds. This overlap did not appear as strongly (or exist at all) in other program participants who were first-generation college students.

Um, well, I've always grown up in like a really strict family where you always need to be at the top of your class, always very high grades. Um, so definitely if I ever go home and tell them I got like a B, that's not going to go down very well. So definitely, uh, success is doing well. Getting an A, you know, even if you get an A though, say like a 95 percent in the class, that's great. But could you have done better? If you could have done better, then you should have. That's the way they look at it. Um, and it's a good way to look at it, but it can be like stressful sometimes for sure. Um, yeah, I mean, to them, really, as long as you're doing well, in school, grade wise because that is what translates to the outside world in the end. How you get a job. How you go on to higher education. Right?

Finally, through triangulation of how he perceives university faculty defines success, Cameron believes that there is not a cohesive definition of success among all faculty. He believes that professors could either highly emphasize the importance of grades or focus on understanding course material in a manner that allows one to teach others or apply knowledge to new scenarios.

Um, I think it depends on the professor. Um, I think a lot of professors are very grade based also. Um, and if you can do well on their exam, then they think you're a successful student, but everyone has very different exams, right? So, taking classes where there are just three problems on the exam, and you have to know the concepts. Um, I'm also taking exams and classes where it's just straight up just "did you memorize like the lecture?" Right? You don't really have to do any application critical thinking, it's just straight up like "did you listen? did you come to class?" Um, so it's kind of hard to say what exactly they define success because I think their ideas are so so different. Um, so yeah. It's, it's tough to say. But I would I would hope we kind of shift more toward what I said earlier, which is if you understand the material well enough to teach it and if you can apply it to different to different scenarios, right? Not just, like, oh like draw an amino acid structure. Like anyone can do that.

There is strong overlap between his perception of faculty's figured world of success in the university and his personal figured world. However, Cameron's difficulty in recognizing a comprehensive definition of success among faculty demonstrates that the metrics of success defined in the figured world of the faculty are not as rigidly defined as in his personal figured world of a successful student.
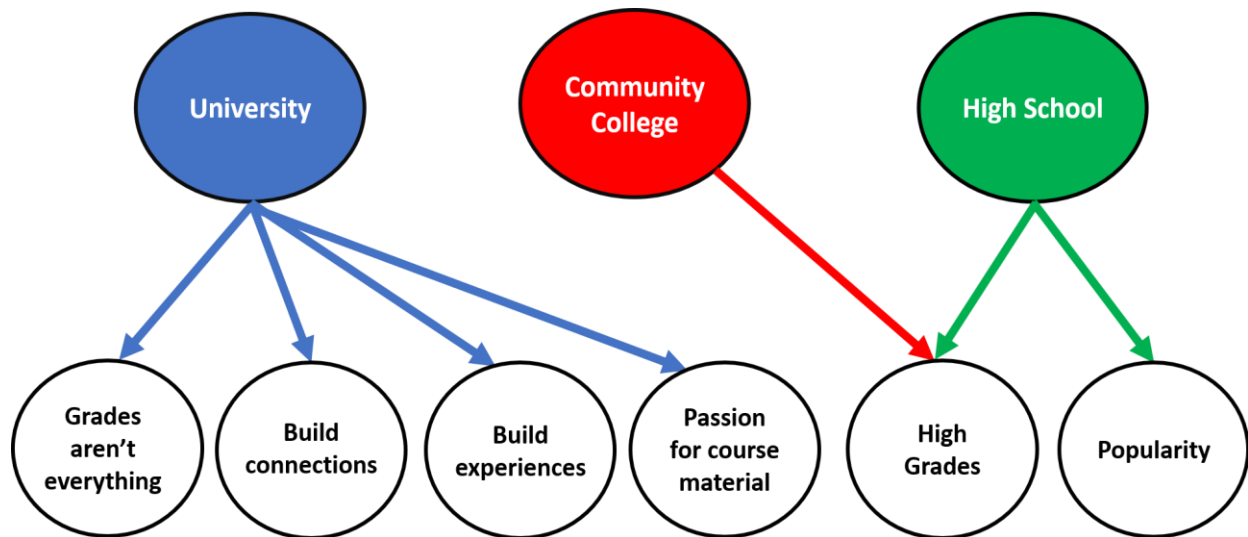
Figure 1A: Configuration of the university, community college, and high school figured worlds for Yosef, a first-generation student. Metrics of success coded within each figured world are indicated in the circles below the three figured worlds.
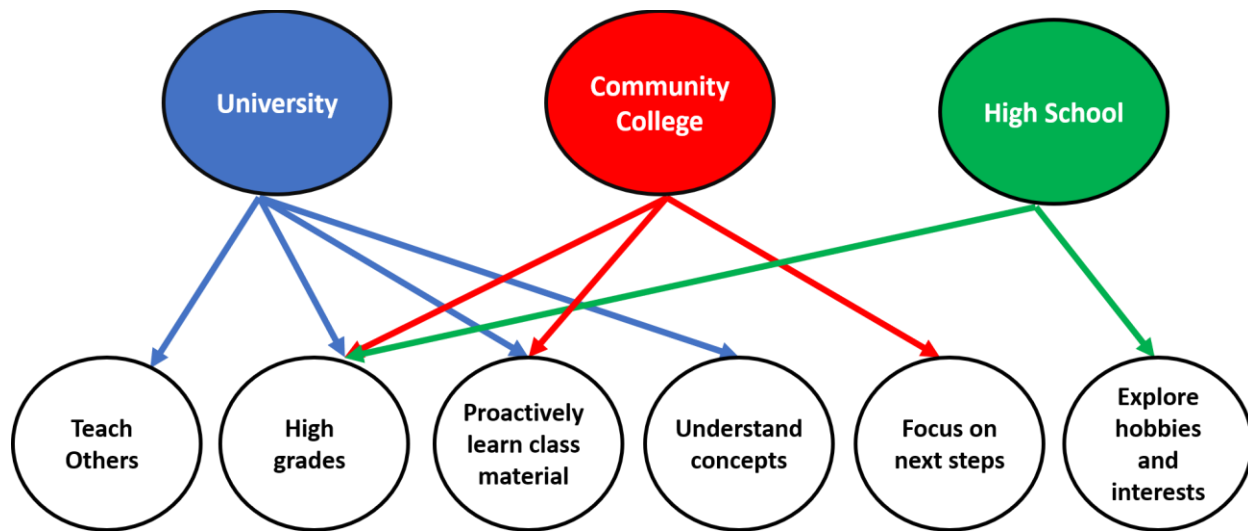
Figure 1B: Configuration of the university, community college, and high school figured worlds for Cameron, a continuing generation student.
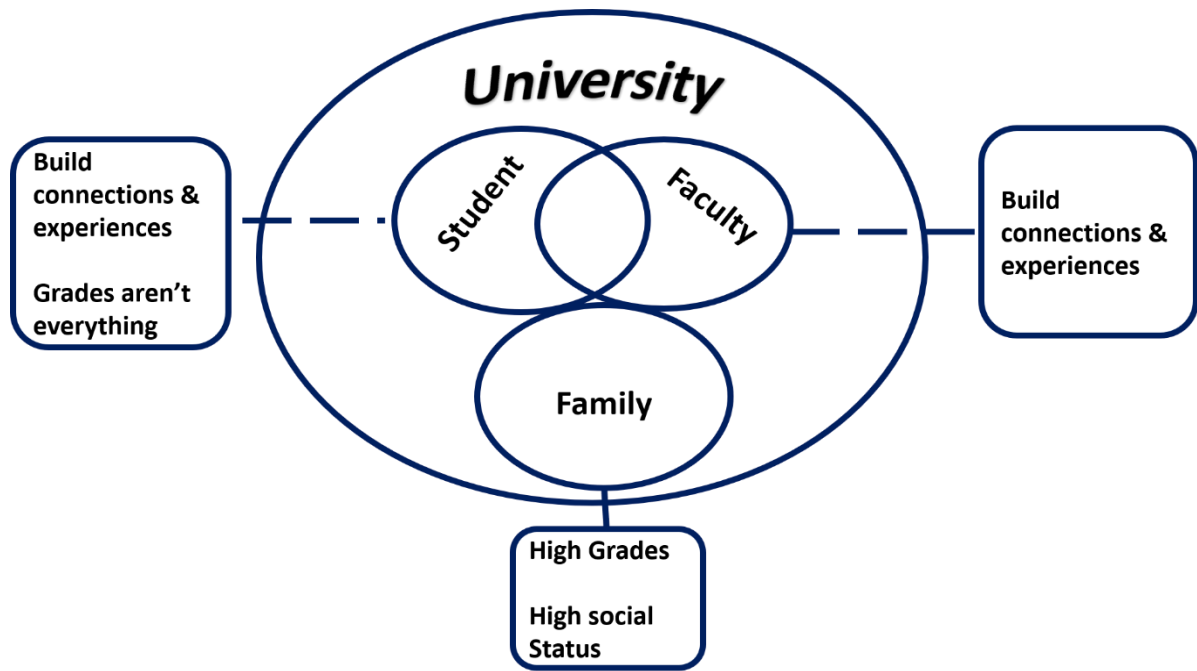
Figure 2A: Configuration of student, family, and faculty figured worlds within the university space for Yosef, a first-generation student. The figured worlds of family and faculty are positioned in relation to his personal definition of a successful student. Overlap between figured worlds represents similarity in the metrics of success described by the participant.
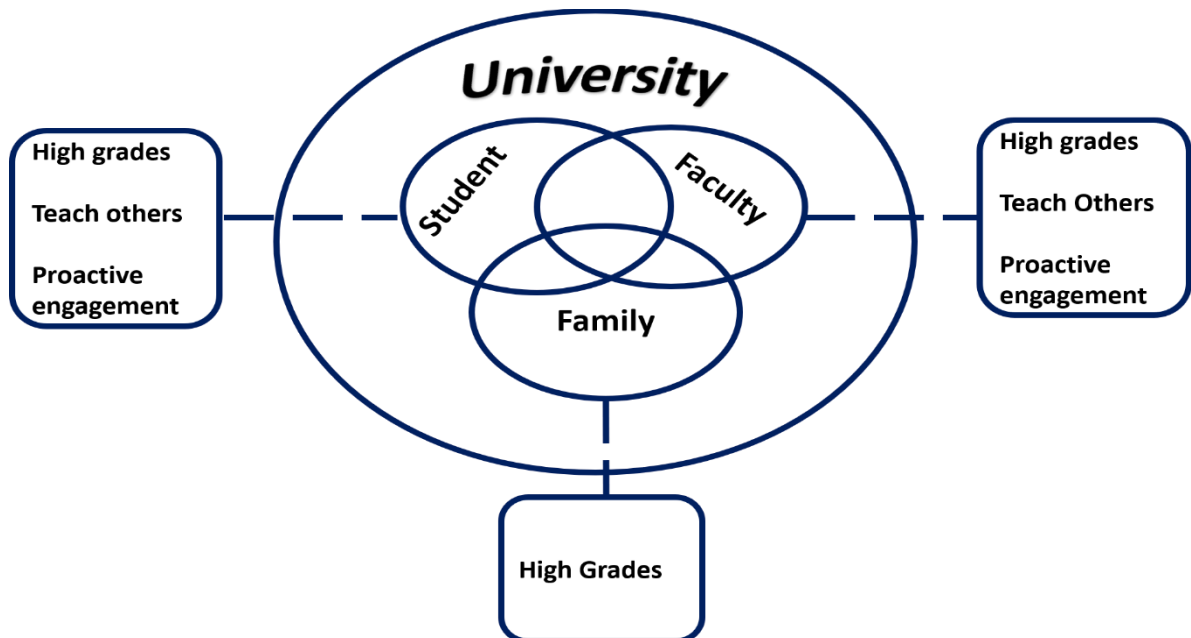
Figure 2B: Configuration of the figured worlds of the student, family, and faculty within the university space for Cameron, a continuing-generation student.

Isabella [3]

Isabella is a first-generation student who began her research experiences immediately preceding her participation in the summer bridge program.

Isabella defines success in the university figured world primarily by a student's resilience in the face of challenges or failures. She views successful students as individuals who use supplemental learning resources on campus and build connections with faculty in order to understand different perspectives and to explore alternative paths and options. However, before she entered the university, she defined success primarily by high grades. The challenges that she has faced at the university and the inspiration she has received from seeing others persist in the face of adversity are the primary factors that influenced her new definition of success within this figured world.

> (...)I think before I thought success was just like grades. And I think I grew a lot from then because like, I don't know. It's like, yeah, so I think for sure...I think just like all the challenges I've faced here. Um, I think seeing people that I admire and like, um, that I define as like being successful, um, is different from what I thought was so like, just in, um, I just think I have a, um, higher appreciation for students who are resilient as opposed to students who just do well academically.

Isabella identified herself as being a "good student" in community college and believed that she had a strong sense of community due to her ability to work efficiently with other students and build connections with faculty. Her metric of success in this figured world is more defined by grades, as she perceives that high grades are a primary measure of one's ability to successfully transfer. However, she also articulates that building connections and being involved in different opportunities are a source of confidence that is instrumental in the transition from community college to university.

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[3] Isabella was a participant in a cohort that was not prompted to articulate the figured world of faculty. This question was later introduced in an updated protocol that was administered to the second and third cohorts. Therefore, the figured world of faculty is not configured within Isabella's narrative.

> Um, I think there, I always thought like success was like getting good grades and transferring into a good university. I think that like I felt like that defined my success. Also, being involved with different opportunities and, um, I think just doing well in your classes. It was, I don't know, I think that's what I defined success as. I was very, I guess like a lot of people, they really looked up to me at community college. So, I had like, everyone knew me for being a "good student", like everyone. So, I think it was just different my very different my experience there.

Isabella's perception of a successful community college student is primarily influenced by her belief in the strong sense of community in her community college that was not present in her high school. Conversely, she did not perceive that anyone in her high school was interested in her future success and the only accomplishment she could identify was a timely graduation.

> (...)I went to high school that really didn't prepare me at all for college. Like at all. Um, when I transferred, like I was on the lower math, lower English, lower everything. So, like I had to start from the bottom. So, um success for me, was just, I guess graduating because, um, I was like very forgotten at my high school. Like, nobody like cared about, you know, my success. I remember like my senior year, like having no plan and I had to reach out to my teacher and like it was really difficult to even do that. And so, um, I think success for me in high school is actually just like graduating, and just continuing from there.

Therefore, in her configuration of her university, community college, and high school figured worlds, high school does not overlap with the other two worlds. The community college world is perceived to be an effective bridge into the university environment due to the similar emphasis on building connections and exploring opportunities. The primary point of misalignment between the university and community college figured worlds is her enhanced emphasis on grades in community college that does not appear to be as prevalent in her figured world of the university.

Moreover, when configuring her family into the figured world of the university, Isabella does not perceive that her family would understand the specific actions needed to achieve success within the university space due to their lack of college experience.

Um. Well I, they don't understand that like, you know, like, what like master's school is or like you know like go to a Ph. D program. They don't understand any of that because they've never come to like college. Um, so it's hard to explain it to them, but they kind of just want me to right away like get a good paying job and just doing all that stuff.

She articulates that her family appears to be more focused on long-term goals such as obtaining her degree and establishing a plan following her graduation. Because she perceives that her family has a limited understanding of how a student achieves success in the university, Isabella's figured world of the family appears to be mostly configured outside of her personal figured world of a successful university student.

Terrance

Terrance is a continuing-generation student that has been continuously involved in multiple research labs following his participation in the summer bridge program.

The integral components in Terrance's personal definition of a successful university student includes high grades and the ability to critically recall or utilize one's knowledge beyond studying for an exam. He perceives that these parameters of success are achievable through an appropriate amount of effective studying that allows the material to be better internalized and eventually applied.

I think in general, for me, um, it is getting A's and being able to recall or utilize in a critical way the material that you've learned in the past. So, not just learning for a test, but really ingesting the material. Because my major is, I don't know, intentionally or otherwise, is geared towards getting into research. There's not a lot of practical and general knowledge that we get from here. It's very finite and specific, um, research based "question and answer" knowledge.

Although his specific criteria for defining a successful student in the university environment did not change, he recognizes a difference in the mechanism of achieving this success. In

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comparison to community college, he recognizes that study methods and time commitment are very dependent on the individual due to the increased pace and rigor of university.

> Uh, I think that I had a pretty good idea of what it takes to be successful in school before I came here (...) well I guess maybe it changed. Before I said, "oh, you need to put in like, um, if you're in class for three hours a week and you put in, um, an extra two hours for every hour you're in there studying." And I think part modify that to just be appropriate for people, um, as an individual. And that's because, um, [the university] is much faster and harder than it is in, um, community college.

Moreover, Terrance perceives that the expectations for a community college student are far lower than a university student. He believes that simply passing and transferring to a university would be the primary metric of success in his community college figured world. This perception of a successful community college student was influenced by his observation that a majority of community college students in his hometown were unable to complete these minimum expectations.

> Um, the expectations are far lower there, so I think that passing is the X for, you know, success. I think that not dropping out is success. I think getting an AA or transferring to a four-year university and completing that is like the gold standard of success because I don't think that the majority of people that go into community college...do that.

When prompted to elaborate on what he perceives successful community college students specifically do to achieve success, Terrance reflected that those who demonstrated high achievement were usually more responsible, as demonstrated by their ability to balance academics and part-time employment. However, he perceives that these successful students were focused primarily on high grades rather than gaining a deep conceptual and applicable understanding of their course material.

> Most of the time, they have a job. I think that that would give them responsibility outside of school and constrain the amount of time that they would have to study and whether or not there's a causal relationship or it's bidirectional, I noticed that

a lot of the successful students had jobs, um, as well as putting the time in necessary to study and know the material. Uh, in community college, a lot of people were, more so than here, but it happens here, were more worried about the test and getting the grade based on a test and not really worried about actually internalizing the knowledge. They worried about learning the material that would be on the test so that they could pass and move on to the next thing.

The distinguishing metrics of success in Terrance's university figured world continues to be pronounced when compared to his perception of a successful high school student. Like his community college figured world, he perceives that the primary goal is to transfer, and this achievement is based on high academic performance as measured by grades. Although he desires to see a focus on the "cultural and creative growth" of the individual, he feels that the secondary education system embodies quantitative metrics of success that undermine the cultivation of critical thinking skills that he perceives are essential for success in the university figured world.

> I don't agree with [high school's] version of success. I think it's very quantitative and misses a lot of the important aspects of what makes a successful student. Um, for me, a successful student is someone who is able to be above average on all of those things that they, on tests, standardized tests, and SATs. You know, if you're above average, that is success. If you get in a four-year university, that is success. But I think that they failed to take into account things like cultural growth and creative growth. And so, they would not really care what sort of grades you got in a Spanish class or in an Art class or in a Music class, and that was disappointing that they didn't worry or weren't concerned with the holistic growth of an individual.

In configuring his perception of faculty's understanding of success in the university space, Terrance sees high variation in these conceptions due to his belief that there is not a comprehensive conception of success among all the faculty departments within the university. Because of this variation, his figured world of university faculty fails to completely overlap with his personal metrics of success within the university figured world.

> I think that's going to vary pretty widely, wildly. I think that the [university] departments are so large that there is not a cohesive vision as to what makes success. And if there is a cohesive vision, I don't think that most professors know it or follow it when evaluating students... Get A's. Basically. I think that's

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probably it. I mean there were some professors that appreciate different things, um, like inquisitive students and people that are engaged and come to office hours. I think every professor appreciates people that come to office hours and ask, um, engaging and non- redundant questions, um, or novel questions like I said, I don't mean anything negative by that, but yeah, I think that answers that.

Furthermore, Terrance emphasizes the lack of influence that his family exerts on his specific definitions of success within his university figured world. He claims that they have minimal expectations beyond him graduating in a timely manner and are focused on larger scale goals such as achieving a stable job and having him accomplish any personal goals that he sets.

> I think that they're kind of laid back and they would just want me to accomplish the goals that I had set. And so, I mean they're incredible. They're very, very proud of the success that I've made and the progress that I have made. But I don't think they have anything specific in mind other than wanting me to accomplish the goals that I want to accomplish.

In contrast to participants that were first-generation college students (e.g. Figure 2A), the partial lack of overlap between Terrance's figured world of the family and the university space is not attributed to his family's inexperience or misunderstanding of the university domain. Because both of his parents received a complete college education, their lack of influence on his university figured world is instead due to their desire to see him independently explore his interests and progress toward achieving his goals.

Maria

Maria is a first-generation student that has volunteered extensively in a research lab since her participation in the summer bridge program.

In her university figured world, Maria defines a successful student as someone who seeks mentorship and knowledge in their field while simultaneously exploring and learning about other

fields. She believes that while it is important to focus on doing well in class, volunteering or

interning in labs and preparing for graduate studies is equally important.

> I would define it as someone who comes out of [the university] not just with good
> grades, but also with experience and with, um, you know, mentorship and
> knowledge. Yeah, maybe also someone who isn't just or isn't just knowledgeable
> in their major, but also in other fields (...) they volunteer or intern in labs. You
> know, they could put school as a priority, but also not let it take over their lives.
> And they just go out to work or do their masters or Ph.D.

She articulates that her current definition of success conflicts with her previous conception of a

successful student in community college. In community college, she was more focused on

achieving high performance in her coursework.

> Because at [community college], I was I was focused on, you know, just being at
> the top of the class and didn't really much pay attention to stuff that was going on
> outside. Uh, you know, social issues and stuff like that. And being here at [the
> university], I realized that, you know, you don't have to be top of the class to be a
> good student or a successful student.

However, her conception of a successful community college also focuses on building mentorship

with her professors and other students, and thus shows partial overlap with the parameters of

success in the university figured world.

> Um, well, when I would see my friends and like, for example (...) with my
> friends, we would always stick together, you know, when we had midterms or
> even when there was no midterm they would always, you know, be studying. And
> we would meet with professors. We would actually get along with our professors.
> Um, we would have mentors for sure. To me, mentors are a big thing. Um, and
> we would just, I guess, hang around the people that we wanted to be like, or that
> we knew were going to help us move forward beyond community college. Uh,
> yeah so mostly it was having that connection with faculty.

> Much like her university figured world, Maria perceives that university faculty's

definition of success would include well-roundedness in other social issues beyond one's major.

She also articulates that students who are proactive and cultivate meaningful connections outside

of the university figured world are recognized by faculty as being successful. When asked to

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explain how she perceived faculty would define success as a university student, Maria articulated:

> It's so hard, so many things. Um, so would be disciplined for sure. And like I said, they would be aware of other issues going on, not just, you know, what you're studying. Someone who is willing to just go outside their comfort zone and, you know, go talk to people whenever you have a question, like not be afraid to get it answered. And someone who sees just beyond [the university].

In contrast to her university and community college figured worlds, Maria did not feel like she achieved success in her high school. She therefore had more basic metrics of success, such as performing well in class. Although a point of overlap between the university and high school figured worlds is manifested in active involvement in extracurricular activities, she sees high school involvement more geared toward non-academic interests. Maria's figured world of a successful high school student is more focused on achieving basic academic competence in order to move beyond the high school figured world and focus on long-term academic and career goals.

> Um, honestly that's going to be hard for me to answer because high school wasn't that great, and that's why I went to community college. But I guess as a high school student, when you're successful, it means that you're not just, um, influenced by your peers. You know. Doing bad stuff. You're focused. Um, you're taking your classes seriously because you know that maybe it doesn't mean anything to you right now, but in the future, it's going to mean a lot. I mean graduating from university and going and having your career that you love. So just, I guess thinking beyond just high school is what makes high school students successful.

Additionally, there appears to be a misalignment between her figured world of family in relation to her personal figured world of a successful student in the university space. Maria perceives that her family does not understand what success is at the university and are more focused on larger-scale accomplishments such as graduation, graduate school, and achieving a stable job. The perception that there is a lack of specific expectations within from her family is

likely related to Maria's identification as a first-generation college student that had little

structured guidance from her parents throughout her university experience.

> (...)I feel like they don't understand what it means to be at [the university] (…)
> Like, they just think it's another university. Uh, so. They don't really have high
> expectations. You know, they just are proud that I'm here studying, um, and
> graduating.

Mona

Mona is a first-generation American college student whose research experiences did not

begin until her participation in the summer bridge program. However, she claims that her

participation in the summer program was the first step in getting her "foot in the door" to the

various research opportunities available at the university.

In her figured world of the university, Mona defines success by the ability to apply one's

academic knowledge outside of the classroom setting. This provides a "clear vision" of what one

wants to accomplish with his or her major. She also notes the importance of effectively

managing one's time and achieving a balance between academic and non-academic interests.

> Yeah. I would definitely say that first is having a clear vision of what you want at
> the end is extremely important. So, if I still didn't know what I wanted to do, then
> I don't think that I would've been very successful because I would've found a hard
> time being passionate about the subject I'm learning, because it's all random. No
> clear vision of what I want from my life. So that, and then also time management.
> (...) There's not a minute to waste. But also, having-- and this I learned very
> recently, is having a good balance. Having a good life balance. You can't study
> 24/7, it's not effective. So, having other hobbies like, for me recently, it's going to
> the gym. So, I make it a point to go to the gym every day (...) But doing
> something that's not school related was so important and I wasn't doing that in my
> community college, which is why I struggled so much. But who's studying so
> much? Yeah. So, time management, balance, really immersing yourself into the
> material.

These metrics of success greatly contrast to those present in her community college figured

world. In community college, she did not recognize the importance of developing a passion for

what she was learning. She heavily emphasized the importance of high grades, but this emphasis

on academic performance did not necessarily correlate with developing a connection to the

course material and discovering purpose in her major.

> [Success was] just grades. Yeah. I mean, I don't really think that-- yeah, it was a
> very dispassionate environment to be in [laughter]. I don't know. Everyone has a
> different experience at community college, but I felt like I wasted a lot of time.
> You're not really surrounded by the same people, so community college, a lot of
> people tend to want the easy way out or they tend to want less difficult exams or
> they always complain about the professor. But the environment [at the university]
> is really different. Students are more driven and motivated to learn the materials.
> (...) [In community college], I just remember going to the library, doing textbook
> problems, doing the homework problems. There's a lot of busy work at
> community college. And busy work is great, but it's not connecting material and
> that wasn't really emphasized a lot at community college. It was more just like,
> memorize how to solve the problems, and it's not the greatest way to learn.

Mona also articulates that there is little alignment between her figured world of the

university and her figured world of high school. She defined success in high school primarily by

one's personal monetary wealth and involvement in advanced level classes. Her definition of

success in this figured world did not expand significantly beyond these basic metrics.

> My definition of success back in high school was very, very different than
> anything now. I mean, back in high school it was about if you're happy and rich,
> which was a horrible measure (...) taking AP classes, honors classes, being
> involved extracurricularly at the high school, and then going to college. That was
> it.

Moreover, when configuring her figured world of the family in relation to her figured

world of a successful student, Mona notes a disparity between these two worlds due to her

parents' limited understanding of the United States university system. She recognizes that there

may be a cultural barrier that prevents them from being able to define any specific expectations

for her at the university, as she states, "my parents were born in Egypt, so there's a lot of cultural

differences, if I could say that. So, they're not really familiar with the U.S. cultural system as

much, but they just keep telling me to work hard and not give up."

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Finally, when triangulating her perception of university faculty's understanding of success in relation to the university, Mona found difficulty in identifying rigid metrics of success. However, she did assume that faculty expectations are likely to show at least some overlap with those present in her figured world of the university. She claims that developing passion and a genuine interest in the subject matter of one's major is a metric of success that is likely to be recognized and respected by university faculty.

> In all honesty, I mean, I really haven't asked faculty yet (...) So I'm not really sure, but if I had to guess, it's definitely a student who goes to office hours all the time, gets As on exams, is genuinely interested in the subject matter. That kind of student definitely gets recognized by the professor. (...) So the success measured by a professor, I would probably say is the ability to connect and convey the same ideas is that the class can go a little bit beyond that.

Discussion

The case studies presented represent the various ways that the participants in this study individually configured their identities within the figured worlds analyzed in this theoretical framework. The relationship between different figured worlds in different academic spaces (university, community college, and high school) or between different figured worlds in the same space (the perception of how family and faculty would define success in relation to the student's personal definition) is based on overlap or misalignment between the defined metrics of success within each of these figured worlds (Figure 3A & Figure 3B). The commonalities and variations in the conceptions of success across these different figured worlds were consolidated into three main themes: 1) Grades aren't everything, 2) Limited role of the family, and 3) Variable metrics of success among faculty. Descriptions of these themes are supplemented with excerpts from other interview participants in the study population. The implications for the challenges that

transfer students face as they configure their identities during their transition into the university are also discussed.
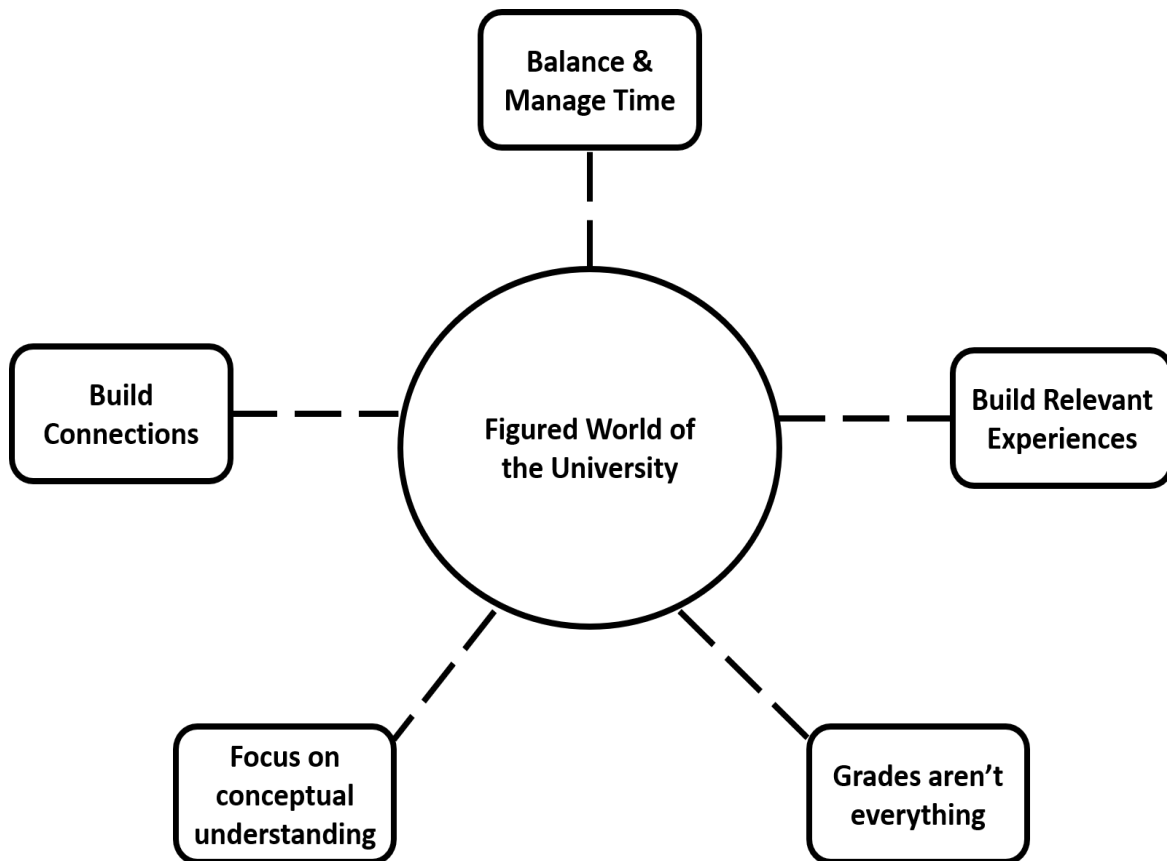
Figure 3A: Figured world of success in the university defined by numerous metrics of success that expand beyond academic performance.
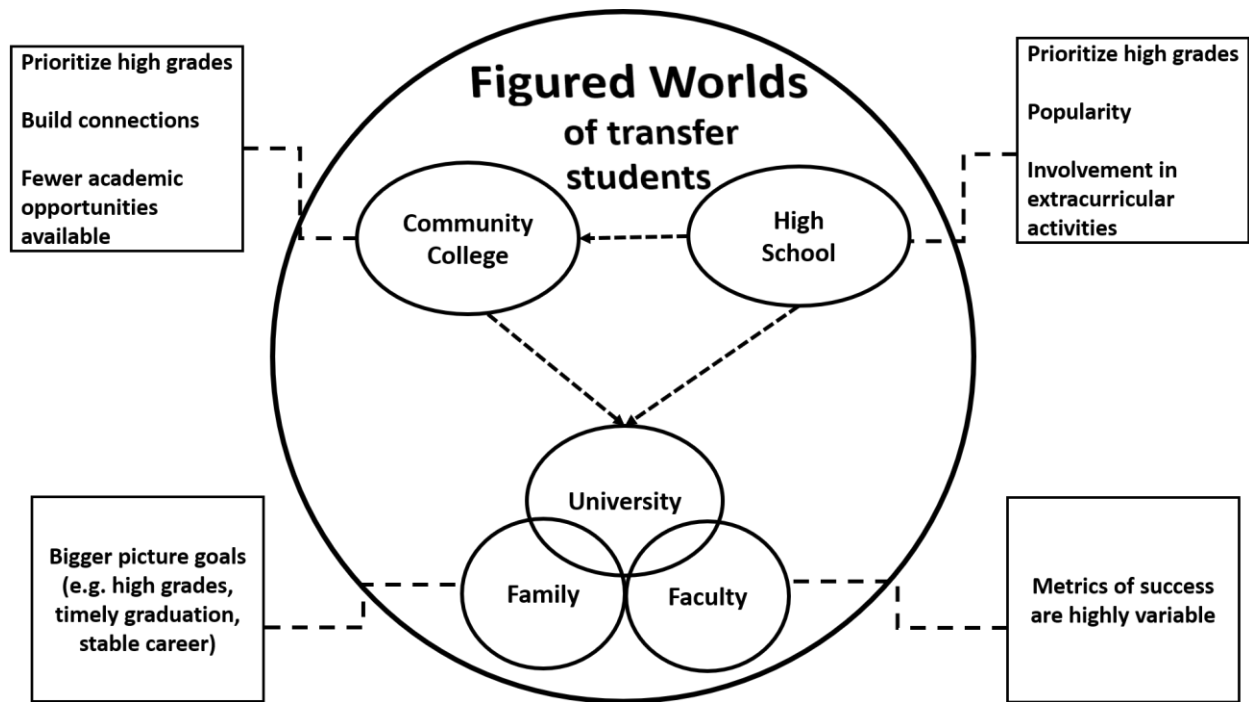
Figure 3B: Transfer students' figured worlds of three different academic spaces (university, community college, and high school). Figured worlds of family and faculty are configured within the figured world of the university. Metrics of success for each figured world are summarized based on commonalities in the case studies presented.

Theme I: Grades aren't everything

When the participants were prompted to define success as a student, the focus on high grades was perceived as a higher priority in community college. The initial focus on these high quantitative metrics of success in community college likely relates to the perceived importance of high grades in the transfer process. Because high grades are perceived as the primary metric that determines university admission, some transfer students may feel constrained to adhering to this single parameter throughout their community college experiences. For example:

> (…) I mean success in community college is getting a 4.0. Because your entire purpose in life at that point is to transfer somewhere. That's that should be the entire goal. To get straight As. Uh, for defining like success as a community college student, that's what I would say.

However, following their experiences at the university, the participants expanded their conceptions of success to include other metrics, such as a stronger emphasis on conceptual understanding and the ability to apply academic knowledge to research opportunities. Several participants claimed that their overall definition of success as a student had at least partially changed over the course of their university experiences. This change primarily derived from the realization that high grades are an incomplete metric of success that undermine the importance of building applicable research and professional experiences. Even in cases where high grades were emphasized in the university figured world, this metric of success was supplemented by a stronger focus on developing a fundamental and applicable understanding of the course material (Case studies: Cameron & Terrance). Through reflection of their community college experiences, some participants claimed that there were limited opportunities to explore their academic interests and build relevant academic experiences within this figured world. For example, one participant stated:

Um, I mean at community college, it's harder because there's not as um, to, there's not as many opportunities outside of the classroom to develop your interests. Um, for me, if I wanted to work at a lab, I had to go over to [another university]. There was nothing at my community college for me to do. And luckily it was, you know, virtually across the street, so that wasn't a big like sacrifice. Um, but there are, like, lots of clubs at community college. Um, the most valuable volunteer experience I ever had was at community college. And, um, so there are ways to get involved. Um, but it does take a little bit I think more effort than it does here at [the university].

Because the opportunities to build relevant academic experiences in community college are perceived to be limited, the emphasis on achieving high grades becomes even more pronounced. Based on participant testimonies, research and mentorship experiences seem to be more naturally integrated in the university figured world in comparison to community college (Case studies: Yosef, Isabella, Maria). Although alternate extracurricular and volunteer opportunities are present in community college, community college students pursuing STEM may perceive that they are not able to construct experiences that are directly relevant to their field of study. Because the university world is perceived to have a greater variability in the metrics of achieving success, transfer students that are not provided with opportunities to explore their academic aptitudes beyond the classroom in community college may configure high grades as the primary determinant of academic competence in their figured world of the university. This misalignment between the university and community college figured worlds indicates that the transition to the university can be particularly difficult for transfer students with little exposure or access to mentorship and practical experiences that introduce them to the dynamic and rigorous expectations of a STEM research university.

Furthermore, although this study was primarily focused on examining the community college to university transition, the participants were also asked to define success as a student in high school in order to infer points of overlap and misalignment between the high school,

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community college, and university figured worlds. Overall, the responses indicate that there were

lower expectations of success in high school in comparison to community college and the

university. However, there appears to be a stronger overlap between the community college and

high school figured worlds in the focus of high grades as a quantitative metric that primarily

determines a successful admission and transition into the next stage of their academic careers.

For example:

> I don't really think you need to, you know, kill yourself to get above that 4.0. I
> mean, nowadays, you kind of have to. But, uh, I mean I think at end of the day
> you you'll get, you know, you'll get where you want to go in life if you've got like
> a 3.9 or whatever. So at least to me, but I mean the people in general that at my
> high school though, everyone was pretty um, competitive, because they were
> pretty cut-throat over there. So they were, they were all gunning for, you know,
> like everyone was taking, like, you know, 5 or whatever AP classes and
> everybody's got like a 4.0. Like a lot of kids at my school got into a UC straight
> out of high school, which is pretty hard honestly now. So, my high school was
> pretty competitive like that.

Like in community college, the available extracurricular opportunities are not perceived

to be necessarily related to the development of academic interests that are directly relevant to the

student's field of study at the university. However, participation in high school extracurricular

activities is more motivated by a desire to achieve popularity, which is a perceived metric of

success that is unique to the high school figured world. As one participant stated:

> You need to do academics. You need to study all the time. And I think in high
> school, if you have a bad social environment, you're going to have a bad time,
> and that's going to affect your grades. So being able to have a solid social group
> and be involved in different aspects, like sports or theater, all will inherently get
> your grades higher in high school because sociology is so important.

Because popularity is not as emphasized in the university figured world, students that

directly transition from high school to a 4-year university may have an immature conception of a

successful student that is more focused on sustaining a social image and achieving academic

prominence through high grades. Because these metrics of success are not perceived to be

emphasized as highly within the university figured world, high school students that transition directly to the university may also face a discontinuity between their identity in high school and the identity that conforms to the rigorous and expanded metrics of success that are perceived to be present at the university.

Theme II: Limited Role of the Family

Previous studies have indicated that first-generation college students face greater challenges in their transition to the university because they experience discontinuities between the expectations of their family and those present within the university (Engle, 2007; McCarron & Ineklas, 2006; Terenzini, Springer, Yaeger, Pascarella, & Nora, 1996; McConnell, 2000). In particular, these students feel that their families lack a fundamental understanding of their daily school environment and do not provide the same levels of support in the college experience as the families of continuing-generation students (Bryan & Simmons, 2009; York-Anderson & Bowman, 1991). In the case studies presented, the disparity in the roles of the family between first-generation and continuing-generation students continues to be reinforced. When configuring the figured world of the family in relation to the university, the family was mostly positioned as an independent world for the first-generation students (Case studies: Yosef, Isabella, Maria, Mona; Figure 2A). When asked to define what specific expectations that their families had for them while at the university, these students were not able to easily identify these metrics due to their belief that their families had little understanding of the university experience (Case studies: Maria, Mona) or little understanding of how success was achievable in their STEM major (Case study: Yosef).

In contrast, the continuing generation participants perceived greater overlap between their university and family figured worlds. This could be due to their families being able to empathize and understand the metrics of success at the university due to their own college and career experiences (Case study: Cameron). Even in a case study where a participant did not perceive any specific expectations from his family (Case study: Terrance), this was due to the participant's perception that his family desired him to build his own experiences and accomplish his personal goals. Because they supported these goals and trusted his metrics of success to achieve these goals, this figured world of the family partially overlapped with the participant's personal figured world of a successful university student. Unlike first-generation students in the study site, the non-overlapping portions of the figured world configuration were due to the participant's perception that his family desired for him to build his own experiences at the university with minimal bias or influence from their own university experiences.

However, the lack of overlap between the figured world of the family and the figured world of the university may also be due to a broad conception of what the family perceives as being successful. For example, one participant stated that, "family looks at the bigger picture. What are your grades? How well are you doing? Are you going to get accepted to graduate school? Those things." These conceptions do not rigidly fit into the specific metrics of success present in the student's figured world of the university. Because several of the first-generation participants had parents that did not attend schools in the United States, there is an additional perceived cultural barrier that limits the crossing of the family figured world into the university student figured world. For example:

> They're not very familiar with the U.S., uh, university system. And, um, for them, they don't know when I'm going to have a midterm or not or how how long is a quarter and I've been trying to explain to them how the system works. But they always forget, right? It's not their priority.

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This figured worlds analysis is therefore consistent with previous literature claiming that there is contrasting levels of familial support between first-generation students and continuing-generation college students (Pascarella, Pierson, Wolniak, & Terenzini, 2004; Collier & Morgan, 2008; Mehta, Newbold, & O'Rourke, 2011). In particular, the first-generation students perceive little or less overlap between their figured world of their family in relation to their personal figured world of success at the university. This lack of overlap indicates that first-generation students perceive that their families may lack a fundamental understanding of the rigorous demands and expectations at the university. Because they perceive that their families are unable to provide guidance through their transition into the university, first-generation students may not have access to a fundamental source of social capital that would help them explore the opportunities and social networks needed to effectively reconfigure their identities within an unfamiliar academic environment.

Theme III: Variable metrics of success among faculty

Because positive interactions between students and faculty are a foundation for positive educational and personal outcomes for the student (Lau, 2003; Kim & Sax, 2009), it is important to configure the figured world of university faculty into the figured world of the student in order to elucidate commonalities and differences between the perceived conceptions of success. Especially for FG and URM students, academic motivation can be negatively affected if students perceive that they are interacting with faculty that do not take an interest in their learning and development (Roska & Whitley, 2017). In a STEM research university, students need to take the initiative to reach out to faculty in order to participate in mentored research experiences. However, if students lack familial guidance and resources that would otherwise help them

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recognize research as an option when they enter the university, these students may lack the

confidence and navigational capital needed to interact with faculty (Bangera & Brownell, 2014).

This lack of confidence can be further exacerbated if there is a disparity between university

faculty expectations and what students perceive those expectations to be (Collier & Morgan,

2008).

 All participants in this study were provided with extensive opportunities to interact and

network with faculty in STEM research settings. When prompted to elaborate on what they

perceived students specifically do that is recognized by faculty as being successful, many

participants indicated at least some overlapping metrics between the student and faculty figured

worlds. This included, but was not limited to, building connections and experiences (Case study:

Yosef; Figure 2A), proactive engagement in class interactions (Case studies: Terrance, Maria;

Figure 2B), and focusing on long-term contributions to the STEM research community (Case

study: Maria). Although the participants were able to identify overlap between these worlds,

students also recognized a challenge in rigidly defining these parameters of success due to their

belief in the variability in the overall conceptions of success across individual faculty members

and different departments. As noted by Terrance, the university departments are so large that it is

difficult to define "a cohesive vision to what makes success." This is evident in the recognition

of different "extremes" within the metrics of success that could either be measured solely by

academic performance or can extend to involvement and contribution in research or other

professional settings. For example:

> I think the minimum for students is for professor's expectations of the student is
> to do well in class. The other one is to contribute with the class, bring in other
> subjects that could relate to a class. Um, probably, do some of their research in
> their lab and if they find something interesting, as a student will be "oh nice". Not
> only you're doing well in my class, but you're actually writing something to my
> lab. Probably that will be the extreme side of professors of success, but in general

I think professors think that a good student doing well in their classes is the success that they expect.

Overall, when configuring university faculty's figured worlds of successful students, many participants struggled to articulate well-defined metrics, as they did not recognize a comprehensive understanding of success among faculty. This is particularly alarming for FG and/or URM students that may not have access to sufficient resources or guidance in their transition from community college to a research university. If these students do not receive guidance through this transition and are not provided with the resources to initiate these faculty interactions, there may be a disparity between faculty expectations and what these students understand these expectations to be. In a research university where interaction with faculty is essential for cultivating STEM experiences and opportunities, a lack of overlap between the faculty and student figured worlds is potentially detrimental to the retention of minoritized students in STEM majors and for promoting diversity in the STEM research community.

Limitations & Future Directions

Several limitations in the methodology and structure of this study should be noted. First, the participants in this study represent a small population of transfer students that had received guidance in their transition into a STEM research university. Because these students were provided with mentorship experiences and resources through participation in a summer bridge program, the experiences that these students articulated in each figured world may not be broadly representative of transfer student experiences in STEM majors. A future study could examine the figured world configurations of transfer students that did not participate in mentored research experiences. This would provide additional insight on how transfer students from a variety of

backgrounds configure and reconfigure their identity in their figured world of the university based on their previous academic experiences in community college and high school.

Secondly, although the figured worlds of the family and faculty were triangulated within the university space, faculty and family were not interviewed. The conceptions of success within these figured worlds do not necessarily reflect the actual conceptions of a successful student held by the university faculty or the participants' families. The conceptions of success within these figured worlds are based on how the participants *perceived* their family or faculty would define success. Although it cannot be clearly determined if these perceived conceptions are reflective of the actual conceptions that these influential individuals possess, using the perceived understanding of success remains advantageous for examining the sense of support and social capital that transfer students perceive is available to them in their academic transitions and enterprises. Future iterations of this study could directly interview family and/or faculty to examine how these individuals configure their figured world of a successful student in the university space. This would provide insight into potential disparities between how students perceive their family and/or faculty would define success and how these influential individuals would actually position themselves in relation to the students' figured worlds of the university.

Finally, each participant's articulation of success in community college and high school relied on a retrospective reflection. It would have been advantageous to perform a long-term study in which students were interviewed prior to their matriculation into the university. This would provide a clear articulation of these participants' understanding of success in community college during their lived experiences at community college. This in-vivo articulation of the community college figured world would serve as a more structured basis for examining the

identity reconfiguration that students experience as they redefine their metrics of success after transitioning into the university.

Implications

The exploratory nature of this study provides fundamental implications for institutional practices that are intended to foster the recruitment and retention of transfer students in the STEM field during their academic transition into the university. Although transfer students represent a broad range of demographics, the disproportionate representation of FG and URM students within this population indicates that many of these students come from underserved backgrounds that may not privilege them with sufficient resources and guidance during their matriculation into the university (Anderson & Kim, 2006; Hurtado, Han, Saenz, Espinosa, Cabrera, & Cerna, 2007). This study was intended to explore transfer students' understanding of what makes a successful student in their STEM major at the university and how this contrasts to their previous conception of a successful student in their community college. The themes in this research study confer an enhanced understanding of the potential challenges that transfer students face when reconfiguring their identity in the university. The figured worlds theoretical model contributes to an understanding of the potential misalignment between the expectations that transfer students originally possess prior to entering the university and their evolved understanding of success that is ultimately defined by the rigorous demands of this new academic space (Laanan, 2007).

The increased emphasis on high grades and the perceived lack of meaningful academic and research experiences in community college indicates that transfer students may be less inclined to seek out and participate in research and professional development opportunities in

STEM after transitioning to the university. Without sufficient access to opportunities that allow them to explore practical experiences in their major, these students may be deprived of a foundational lens into what a career in their discipline of study would entail. The achievement of high grades represents a tangible extrinsic academic reward that students perceive is a fulfillment of academic expectations and a demonstration of academic competence (Hurtado et al., 2007; Spady, 1970). The participants in this study had articulated that this over-prioritization of high grades had been undermined after participating in one or more mentored research or practical experiences in STEM. The shifted focus on cultivating meaningful mentorship and research experiences illustrates a new understanding of the intrinsic reward and motivation that results from proactive intellectual engagement within the STEM university community. Integration into the university community through practical experiences in one's major therefore requires more proactive engagement in the community through effective negotiation and alignment of one's identity and sense of agency in a professional academic environment (Reyes, 2011; Hurtado et al., 2007).

Because the pursuit of a degree in STEM involves the transition into a professional learning community with potentially unfamiliar norms and values, transfer students that do not recognize the importance of participating in extracurricular academic and practical experiences in their major may lack the intrinsic motivation and self-efficacy that is needed to persist in a STEM career pathway (Hirst, Bolduc, Liotta, & Packard, 2014; Wenger, 1998). To provide transfer students with an opportunity to develop personal agency in the STEM university community and to cultivate professional skills through participation in research and professional development experiences, it is necessary for universities to partner with community colleges to recruit transfer students into programs that promote early inclusion in the STEM community

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(Hirst et al., 2014). These professional experiences require the time and mentorship of faculty supervisors that would work extensively with these students. However, a common theme that was observed in this study was variation between the participants' personal conception of a successful university student and how they perceived faculty understood success. A disconnection between these figured worlds could potentially dissuade students from seeking the faculty interactions that are essential for cultivating mentored experiences in STEM.

Positive interactions between students and faculty have been associated with increased engagement, motivation, and persistence of students (Volkwein, King, & Terenzini, 1986; Pascarella & Terenzini, 2005; Hurtado, Eaga, Tran, Newman, Chang, & Velaso, 2011; Hoffman, 2014). Students that perceive faculty as being approachable and readily accessible are more likely to utilize them as a resource to ensure a smoother academic transition and to seek guidance in their long-term academic and career goals (Lannan, 2007; Volkwein et al., 1986). Because faculty interactions are a source of social capital in the community college to university transition, bridge programs that initiate faculty interactions with transfers students are warranted to facilitate positive and guided mentorship experiences for these students. Initiating faculty interactions early in the university experience is essential as students majoring in STEM will need to approach and interact with faculty to gain access to research and professional opportunities in STEM. By introducing these students to faculty that are interested in their long-term academic goals and are willing to invest time to guiding them in their transition to the university, transfer students may be better able to develop a sense of community and belonging that helps them feel welcomed and supported in the university environment (Townley, Katz, Wandersman, Skiles, Schillaci, Timmerman, & Mousseau, 2013; Johnson, Soldner, Leonard, & Patty, 2007).

Although participants in this study articulated variation in how they perceived faculty would define success as a university student, there was also recognition of at least partial alignment within their own figured world of a successful student. Interacting with a variety of faculty mentors in their initial transition to the university may provide transfer students with multiple perspectives of the dynamic and expanded metrics of success present in the university. For students that are accustomed to defining success primarily by high grades in community college, faculty guidance in the initial transition to the university may result in an earlier recognition of the importance of practical and proactive experiences in their STEM majors. Institutional support programs that facilitate these faculty interactions and transitional resources are especially important for students that are first-generation. As presented in this study, several first-generation students perceived that their families were unable to provide effective guidance into the university due to their lack of familiarity with the university system. This lack of navigational capital in the transition to the university further supports the additional guidance that transfer students need to be enculturated into the STEM university and to combat the potential "transfer shock" that results from contrasting conceptions of success between the community college and university figured worlds (Hills, 1965; Townsend & Wilson, 2006; Townsend, 2008).

Additionally, easing the community college to university transition may be achieved prior to matriculation into the university through increased access to purposeful and constructive advising in community college. Advisors in community college can serve as a fundamental source of social capital that introduces resources to students during their prospective transition into the university. These advisors can be official advising staff or trusted faculty members that informally provide advice on the transition into a university-level STEM education. However,

encouraging student progression in STEM majors requires that advisors be knowledgeable about disciplinary STEM major requirements and resources that offer professional development and research opportunities (Packard & Jeffers, 2013). An improved collaborative network of support between STEM faculty and professional advising could provide multiple perspectives and resources that facilitate increased accessibility to meaningful advising and mentorship experiences for prospective transfer students.

In summary, although community colleges represent a large and diverse population of students pursuing a post-secondary education in STEM, an in-depth examination of the identity negotiation that transfer students experience in their transition to the university has been surprisingly understudied. In order to add to the limited knowledge on this topic, this study examined the challenges that transfer students articulated when reconfiguring their identity to conform to the rigorous demands of a STEM research university. Generative case studies highlighted the variation in which these students individually assigned meaning to their social and academic experiences at the university based on the perceived influence of their families, university faculty, and community college experiences. This analysis offers a preliminary insight that university faculty and administrators can utilize to partner with community colleges and to develop practices that foster a stabilized academic transition for transfer students. Increasing access to mentorship and professional opportunities during the community college to university transition can provide transfer students with the space and resources needed to properly configure their identity and achieve a sense of meaning and belonging in their STEM educational pursuits.

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Chapter III

Examining the variations in undergraduates' conceptions of researchers: A phenomenographic study

Abstract

Undergraduate research experiences play a critical role in training the next generation of scientists. However, participation in research requires awareness of existing opportunities and an understanding of the cultural norms within the research community. While some studies have identified the different ways in which researchers understand their work and profession, few studies have directly examined student conceptions of researchers, especially at the undergraduate level. Given that the norms and values of research may be unfamiliar to students with limited exposure to the research community, this study examined how undergraduates experience or conceptualize research as a profession. Data were collected from a summer-bridge program aimed at introducing incoming transfer students to research. Participants were prompted to articulate their perception of what a successful researcher is, what a researcher specifically does to be successful, and whether their conception of researchers had changed following their university experiences. Data were analyzed using phenomenography as a theoretical perspective. Three conceptions of researchers were identified based on variations within the following aspects: process of research, scope of contribution, and interactions with other researchers and broader communities. Most participants retrospectively described their initial conceptions of a researcher as simplistic, with little appreciation for the complex methodological processes and extensive collaboration that are needed to meaningfully contribute to the research community. However, extensive research experiences had shifted these conceptions to a more nuanced understanding that research requires proactive engagement and collaboration. The disconnection between the initially simplistic conception of researchers (Conception I) and more mature conceptions (Conceptions II and III) is indicative of the conflicting expectations that students with limited exposure to research may have prior to engaging in research. Overall, these findings

support the need for institutional interventions that engage and provide guidance for students in their transition into research.

Introduction

Economic projections in the United States indicate an increasing demand in the scientifically educated workforce over the next few decades, but the number of trained professionals in science is expected to be insufficient (PCAST, 2012; NASEM, 2016; Wilson et al., 2012). This workforce gap can be partially attributed to the low retention and persistence of students at the undergraduate level, especially for minoritized[4] students such as first-generation (FG) college students and under-represented minorities (URMs) (NSF, 2019). Promoting a diverse workforce is critical when addressing complex societal problems, as individuals with different experiences can provide multiple perspectives (Intemann, 2009). The decreased participation of students in science, especially FG and URM students, is due to a combination of factors, including inequitable guidance in their transition into higher education, a misalignment with scientific cultural norms, and the lack of access to existing research opportunities (Bangera & Brownell, 2014; Spronken-Smith, Mirosa, & Darrou, 2013).

The expansion of a scientifically educated workforce is dependent on recruiting students into science majors that facilitate engaging and meaningful experiences, particularly in research experiences that support professional development and proactive learning (Lopatto, 2007; Graham, Frederick, Byars-Winston, Hunter, & Handelsman, 2013). Undergraduate research experiences under the guidance of faculty mentors enculturate students into the scientific

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[4] We acknowledge that the term "minoritized" encompasses multiple dimensions of student identity and background (e.g. gender, sexual orientation, financial status). This study will use the term to refer to students that are first-generation college students and/or under-represented racial/ethnic minorities.

community by providing the social support network and resources needed to explore more advanced professional opportunities (Jones, Barlow, & Villarejo, 2010; Thiry & Laursen, 2011; Bangera & Brownell, 2014; Linn, Palmer, Baranger, Gerard, & Stone, 2015) and by acting as a potential career pathway for the next generation of scientists (Seymour, Hunter, Laursen, & DeAntoni, 2004; Russell, Hancock, & McCullough, 2007; Hunter, Laursen, & Seymour, 2007; Linn et al., 2015; Graham et al., 2013). These research experiences also provide opportunities for students to develop their critical-thinking and problem-solving skills and to contribute to novel research in science (Hunter et al., 2007; Eagan, Hurtado, Chang, Garcia, Herrera, & Garibay, 2013; Baiduc, Drane, Beitel, & Flores, 2017). During their initial research experiences, students typically struggle in their transition from the classroom setting to the different social structure and more challenging learning environment within research (Balster, Pfund, Rediske, & Branchaw, 2010). This struggle is more pronounced for FG and URM students who are less likely to be privileged with the cultural knowledge of the behavioral norms and values within the research community (Balster et al., 2010; Villarejo, Barlow, Kogan, Veazey, & Sweeney, 2008). FG and URM students may also receive inequitable guidance or lack the social capital needed to access research opportunities and initiate faculty interactions that introduce them to the research community (Bangera & Brownell, 2014; Hurtado, Eagan, Tran, Newman, Chang, & Velaso, 2011; Prunuske, Wilson, Walls, & Clarke, 2013).

In addition to the issue of access, student conceptions of a scientific profession need to be aligned with their personal identity in order to develop a sense of agency in their pursuit of a scientific career (Brickhouse & Potter, 2001; Carlone & Johnson, 2007; Hunter et al., 2007; Chemers, Zurbriggen, Syed, Goza, & Bearman, 2011). Understanding this alignment is first contingent upon identifying the different ways in which students understand what it means to be

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a scientist. Existing literature on student conceptions of scientists has primarily focused on the K-12 educational contexts. Students in these contexts often conceptualize science as a set of rigidly defined tasks that are performed by scientists with a narrow range of identities (Calabrese Barton & Yang, 2000; Calabrese Barton, Tan, & Rivet, 2008; Tan & Calabrese Barton, 2008; Hodson, 1993; Brickhouse, Lowery, & Schultz, 2000; Gilbert & Yerrick, 2001). These conceptions are often depicted as an embodiment of masculinized, western, white values that do not properly reflect the work and diversity of the science profession (Chambers, 1983; Barman, 1999; Finson, 2002; Mead & Metraux, 1957). Conceptions of the science profession as rigidly defined and culturally marginalized are not consistent with an informed view of the nature of science. The nature of science promotes the development of scientific knowledge through creative and imaginative processes that are conducted by a culturally and socially diverse body of scientists (Lederman, 1992; Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002). However, the stereotypical depictions of a scientist indicate that many students lack knowledge of what actual scientists are and possess few real-world references to counter these potentially negative and marginalized conceptions (Finson, 2002; Barman, 1999; Aschbacher, Li, & Roth, 2010).

Marginalized conceptions of scientists can ultimately undermine the motivation and self-efficacy that students need to continue pursuing science as a career pathway (Hurtado, Cabrera, Lin, Arellano, & Espinosa, 2007; Calabrese Barton & Yang, 2000; Chemers et al., 2011). The emerging identities of students in science is dependent on their evolving sense of who they are and how they envision themselves in the future (Calabrese Barton, 1998; Calabrese Barton & Tan, 2010). The recruitment and retention of minoritized students in science coursework can ultimately be threatened if students are unable to recognize overlap between their sense of identity and their conception of a scientist (Brush, 1979; Beasley & Fischer, 2012; Steele, 1997).

In higher education, we know this to be true from studies that have examined undergraduates' negotiation of their science identities in the face of marginalizing racial and gender stereotypes (e.g. Carlone & Johnson, 2007; Chang, Eagan, Lin, & Hurtado, 2011; Hazari, Sadler, & Sonnert, 2013).

Few studies have directly examined student conceptions of research and researchers and even fewer of these studies have been completed using an undergraduate level student population (Chambers, 1983; Finson, 2002). The existing literature on K-12 student populations provide a fundamental basis for examining conceptions of the research profession at more advanced academic levels. The evolution of higher education and the increased demand for science professionals in the workforce warrants an enhanced understanding of the nature of research as it is experienced by students majoring in science, technology, engineering, and/or mathematics (STEM). There is also a need to study the variation in conceptions of research over time and if research is experienced differently based on incompatibilities between student conceptions of the research profession and the actual norms established in the research community (Brew, 2001). Given that the cultural norms and values of the research community may be unfamiliar to students (especially students that are URM or FG), this study is aimed at examining the contrasting student conceptions of the research profession before and after their undergraduate research and academic experiences at a public research university. The investigation of these conceptions addressed the following research questions:

1. How do undergraduate students majoring in STEM conceptualize research as a profession?

2. How do student conceptions of the research profession change following participation in undergraduate research experiences?

Theoretical Framework and Literature Review

This study uses phenomenography as the theoretical framework to examine how undergraduate students conceptualize research as a profession. Phenomenography investigates the qualitatively different ways that individuals experience, understand, or think about a phenomenon (Marton, 1981; Marton, 1986). The different awareness is organized into an outcome space, which represents a set of descriptions that are logically related to one another and reveal the distinctive ways in which individuals interpret the phenomenon (Marton & Booth, 1997). Variation theory within phenomenography further formalizes this outcome space into specific features (called "aspects") that individuals attend to when describing the phenomenon, as well as the differences (called "variations") within each aspect that articulate how different individuals conceptualize the same phenomenon (Marton & Tsui, 2004).

Phenomenography has been used to investigate many aspects of higher education (Entwistle, 1997; Richardson, 1999; Akerlind, 2005). Specifically, a few studies have examined how researchers perceive and understand the nature of research. Akerlind (2008a) identified a total of five aspects in which university faculty in Australia attend to as they experience their research and academic work: researcher intentions, research process, anticipated outcomes, attitudes toward research, and the relationship among research questions, the field of study, and personal and societal issues. Variations within each of these aspects are based on an inclusive hierarchy in which each progressive categorical conception expands upon the previous conception, suggesting an increasing sophistication in the overall understanding of the nature of research. These researchers' conceptions of their profession ranged from a product-driven focus to recognizing research as a personal journey that enables broader change and contributions to larger communities. Akerlind (2008a) also found that a higher level of experience in research did

not necessarily correlate with the more sophisticated conceptions and researchers of similar disciplines and levels of experience are not uniform in their conceptions.

Brew (2001) observed multiple qualitatively different ways by which senior researchers in Australia, defined as university faculty with extramural funding, understood research. These conceptions are defined by aspects related to researcher intentions and research process that are differentiated by the degree to which a researcher views their work as an internal process versus a pathway to an external product (Brew, 2001). The variations within this internal-external continuum emerge from a negotiated space in which a researcher may recognize their research interests as being influenced or even dictated externally by competitive funding or university policies (Luukkonen & Thomas, 2016). Researchers who perceive this lack of internal control may sacrifice their own interests in favor of research topics that are more likely to meet the competitive demands of external funding (Brew, 2001). Similarly, two additional studies have examined how university faculty who mentor graduate students in Australia, New Zealand, South Africa, and United Kingdom conceptualize research (Bills, 2004; Kiley & Mullins, 2005) in relation to the research process and anticipated outcomes. Akerlind (2008a) summarized the variation in these conceptions by the extent to which a researcher recognizes the research process as 1) methodological and systematic 2) a platform to innovate new knowledge, and 3) an opportunity to achieve a more nuanced conceptual insight or understanding of their work.

Examining a researcher's understanding of their growth and development in their profession has also emerged from an analysis of the variations in a researcher's internal sense of competence, sense of external recognition as a researcher, quantitative increase in productivity, and a greater breadth of knowledge and understanding of the profession (Akerlind 2008b). Other studies have also identified variations in how researchers evaluated success based on their scope

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of impact to themselves individually, to the research community, and to a broader world (Akerlind, 2008a). For example, Bruce, Pham, and Stoodley (2004) identified variation in which academic and industry researchers in the Information Technology (IT) community attributed significance and value of their research projects to the contribution to 1) personal goals that foster professional interest and gain, 2) broader academic research and industry goals, and 3) research outcomes that solve real-world problems and service everyday technology users.

Additional studies on academic researchers have also related experiences in research to experiences in university teaching. Prosser, Martin, Trigwell, and Middleton (2008) observed variation in the extent that university faculty with substantial research experiences had conceptualized teaching as a student-focused experience. The extent to which teaching is student-focused relates to academic researchers' awareness of the importance of fostering perspectives external to the research community and to help students develop views and understanding of the field of study. Similarly, Light and Calkins (2015) observed that university faculty with research experiences vary in the extent that they recognize a meaningful connection between teaching, learning, and research practices. Faculty with a conception that connects these practices are cognizant of the value of engaging and challenging students to think and learn like researchers. Faculty awareness and reflection on the connection between these practices is critical for introducing teaching skills and practices that disseminates knowledge and fosters student development (Light & Calkins, 2015).

Taken together, these studies provide a fundamental understanding of how university faculty across many disciplines conceptualize their research and academic work. Other phenomenographic investigations have identified similar aspects for how graduate student conceptualize research as a profession. Graduate education represents a critical developmental

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stage where students are actively involved in research and are exposed to professional and social

experiences that further develop their understanding of the research profession. The variations to

which graduate students conceptualize research have been hypothesized to be contingent upon

these students' prior understanding and beliefs regarding how and why research is conducted

(Meyer, Shanahan, & Laugksch, 2005). Similar to phenomenographic studies that examined

researchers' understanding of the nature of research, Stubb, Pyhältö, and Lonka (2014) observed

variation in the degree to which doctoral students at a Finnish university viewed the research

process as a personal journey rather than a pathway to achieving an external product. Although

students at earlier stages of their graduate education tended to describe research as a personal

journey, there continued to be variation in these conceptions at different academic stages of the

doctoral process and across disciplines (Stubb et al., 2014).

In addition to examining professionals that have passed the educational threshold to being

grounded in the research profession, it would be beneficial to conduct additional studies that

integrate the journey that is involved in becoming a scientist and the transitional educational

stages that are essential for committing to a career in research. Preliminary studies of graduate

student conceptions have provided the foundation for modeling post-secondary student

conceptions of research at the individual level. However, an examination of student conceptions

of research at earlier stages in their academic careers, such as at the undergraduate level, must be

conducted to examine if there is an association between research conception and research

completion (Meyers et al., 2005). Undergraduate education represents a critical transitional stage

where students decide to pursue their respective career pathways. Institutional practices that

foster the retention of students in scientific career pathways are critical during this academic

period, especially as many students may come from underserved backgrounds that may limit

their access to a fundamental understanding of the nature of science. To expand upon the growing interest in examining this understudied population, this study focuses on examining the outcome spaces of undergraduate student conceptions of a successful researcher both prior to and following their research experiences at a public research university.

Methods

Study Participants

Participants were selected from a summer bridge program designed to introduce transfer students to research in the biological sciences and other professional opportunities in STEM. Transfer students were selected for this study because they represent an understudied student population that represents a broader range of demographics (e.g. first-generation, under-represented minority, broader age span) of a typical undergraduate student population. A total of 29 (out of a possible 31) participants were interviewed, and a majority of the participants in this program were either first-generation (75%) or under-represented minorities (66%) (Table 2). The participants were interviewed about two years after their participation in the summer program and near their target graduation date. Therefore, most of these students had culminated a majority of their university and undergraduate research experiences at the time of the interview.

Table 2: Interview Participant Characteristics (n=29)**.**

Participant Characteristics	n	%
Gender		
Male	12	41.4
Female	16	55.2
Transgender Male	1	3.4
Race/Ethnicity		
African American, Black	1	3.4
Asian	8	27.6
Hispanic, Latino, Spanish	12	41.4
Middle Eastern	6	20.7
White	8	27.6
First-Generation Status		
First-Generation[5]	22	75.9
Continuing-Generation	7	24.1
Discipline of Study		
Biological Sciences	13	44.8
Physical Sciences	1	3.4
Health Sciences	1	3.4
Cognitive Science	7	24.1
Engineering/Computer Science	4	13.8
Mathematics	1	3.4
Social Sciences	2	6.9

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[5] Participants were designated as "first-generation" if neither parent/guardian had received a four-year degree in the United States.

Data Collection

The interview questions that were administered in this study were a part of a larger interview protocol that prompted participants to discuss various aspects of their university and community college experiences. To examine these students' conceptualization of research as a profession, the participants were prompted with the following interview questions:

1) How would you define success as a researcher in your discipline of study?

2) In your view, what makes a successful researcher or what does a researcher do to be successful?

3) Did your definition of success in this regard change over the last two years since you have been at [the university]?

The third interview question prompted participants to indicate whether their conception of a successful researcher had changed over the course of their university experiences. Therefore, articulation of this change relied on a retrospective account of their previous conceptions prior to their undergraduate research experiences. This additional retrospective prompt was utilized to capture as much of the outcome space as possible. Although some participants had switched out of their biology major after the conclusion of the program, all had remained in the STEM field at the time of interview correspondence. Because not all participants were majoring in specialized scientific disciplines at the time of the interview, the term "researcher" was purposefully used instead of "scientist" in order to be inclusive to a broader range of STEM disciplines.

Data Analysis

Interviews were audio recorded and transcribed semi-verbatim by a professional transcription service. The transcripts were spot-checked and edited manually to correct for discrepancies with the audio recordings. A grounded theory methodology was primarily used to analyze the interview responses. Grounded theory is intended to provide a thorough theoretical explanation for social phenomena (Corbin & Strauss, 1990). This theoretical conceptualization relies on deducing patterns of behavior or responses among qualitative data samples (Strauss & Corbin, 1994). Preliminary analytic codes were developed through an *open coding* scheme in which interview samples were given conceptual labels (Corbin & Strauss, 1990). After an iterative reading of the interview transcripts, memos and in vivo codes were generated using participants' own phrases that captured critical yet broad meanings of the research profession. These codes and memos provided a common meaning to the raw data and were modified and expanded upon as more interview transcripts were analyzed. After applying the preliminary codes to individual responses, broader code categories were developed inductively. Grouping similar codes gave rise to these categories and the interviews were further scrutinized to identify the range of variation within each category (Saldana, 2015; Corbin & Strauss, 1990; Corbin & Strauss, 2015). Through a process referred to as *axial coding*, specific aspects and variations were identified and ultimately organized into an outcome space that described different conceptions of researchers (Corbin & Strauss, 1990; Corbin & Strauss, 2015; Marton & Pong, 2005).

The final stage of grounded theory that occurred in the later phases of the data analysis was *selective coding.* In this stage, the data for each aspect and variation were revisited to further refine the definitions in the outcome space (Corbin & Strauss, 1990). Theoretical saturation was

achieved due to a relatively large number of interview samples that provided additional insights

and more comprehensively defined the variation within each aspect. This developed three final

categorical conceptions (Conception I, Conception II, and Conception III) that were applicable to

a broader range of interview responses. Each interview response was coded as representing

Conception I, Conception II, or Conception III if the response described at least one aspect that

was represented within that categorical description. Multiple conceptions could be applied to one

interview response if variations of aspects from different conception categories were described.

Reliability

One researcher coded the conceptions in the outcome space to all 29 interview responses.

The outcome space was applied to 12/29 (41.3%) interview responses by a second independent

coder, yielding an inter-coder agreement of 87.5%. A Cohen's kappa of .8208 confirmed that this

agreement was not due to chance alone. This corroborated that the conception categories were

applicable to a broad range of the interview responses, thereby validating that this outcome space

could be used to establish our framework that articulates the variation in undergraduates'

conceptions of researchers.

Findings and Analysis

Three aspects were identified that distinguish the contrasting conceptions of a researcher based on interview results from this study:

1. Process (or how a researcher approaches their work): The complexity of a researcher's methodological approach and how the final research product is perceived to be attained;

2. Contribution (or to whom a researcher considers their work important): The scope to which the researcher uses their research to advance the research field and serve societal needs;

3. Interactions (or how a researcher collaborates with other researchers): The extent to which a researcher collaborates with other researchers and provides mentorship to junior colleagues.

Variations within each of these aspects revealed three types of conceptions (Conception I, Conception II, and Conception III) that defined how undergraduates in our study perceived research as a profession. Table 3 summarizes the comparisons across these conceptions based on the defined variations within each of the three aspects.

Table 3: Outcome space for three differing conceptions of researchers. Relationship of conceptions is illustrated by variation across three aspects within the outcome space. Adapted from Light & Calkins (2015).

	Conception I	Conception II	Conception III
Process: How a researcher approaches their work	The research process is simplified. Success of research is defined more by the tangible end product, not a structured methodology.	The process of research is defined by a structured methodology that relies on critical thinking and creativity.	The research process is iterative. Researchers must frequently refine and adapt their overall experimental approaches.
Aspects of Variation **Awareness that:**	*Research is a defined process that relies on a structured methodology*		*The research process is a personal journey with multiple possible approaches and outcomes.*
Contribution: To whom a researcher considers their work important	Research is primarily used to enhance one's status and self-interests.	Research is primarily performed to advance the knowledge of the research community.	Research is performed to contribute significantly to knowledge in the research community and to address broader social issues.
Aspects of variation **Awareness that:**	*Research projects should primarily be conducted to advance the research field and community.*		*The impact of research should extend beyond the research community to address a common societal problem.*
Interactions: How a researcher collaborates with other researchers	Researchers work alone and limit their interaction with other researchers in their field.	Researchers collaborate extensively on projects with other researchers in their lab and the scientific community.	Researchers strive to expand access to the scientific community by teaching and offering mentorship experiences to aspiring scientists.
Aspects of Variation: **Awareness that:**	*Interaction with other researchers is essential to achieve feedback and to contribute knowledge to the research community.*		*Interacting with individuals beyond the professional community expands and diversifies the research community.*

Process: How Researchers Approach Their Work

Conception I. Researchers described in this conception are defined by the tangible end products or accomplishments in research rather than the research process or personal journey in academic work. Research is not viewed as a methodological process, and the overall process is simplified. The outcomes and successes of research are believed to be obtained immediately with few complications during the process. After publishing their work, a researcher is perceived to accept the results as final and does not attempt to expand upon their findings. For example, one participant described success in research: "I guess I always thought of success as just getting that one result and saying 'Hey, this is it.'" Similarly, another participant said: "I also was one of those people that thought, well, it means having your research be successful. The project works. You're done. You publish a paper, and that's good, you know?"

Conception II. Researchers described in this conception are characterized by their focus on the overall process of research instead of the end products. Conception II also recognizes the importance of a structured methodology based on a defined research process. For example, one participant described a successful researcher as: "You got to know everything that's happening, know all the tools and instruments and any procedures people have been doing in your field of study, and what they have been discovering, and how you can piggyback off that." In this conception, researchers are further perceived to understand that success is not immediate and being proactive in the scientific community to receive feedback and collaborate on research projects is an essential part of the research process. Staying updated with new research by exploring primary literature and attending scientific talks are described as actions that can propel the process of one's own research.

> Put in the hours. I remember this one graduate student in my lab that I was in, she was always working. She was always on the computer putting the hours in.

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Always talking a lot to other researchers. She was always going to other labs and ask questions. She wasn't shy about going to other labs. I liked her research, and she got a paper published and everything. I think just talking to people, asking for help, and just putting in the hours make you successful.

Unlike in Conception I, this excerpt illustrates that the final products of a researcher's work are perceived to be obtained through a systematic process that depends on an efficient use of defined methodologies and social capital. Progression through the research process is dependent on the foundational tools and methods established by other researchers in the field. A researcher can utilize these methodologies and input from other researchers in order to establish their own defined methodological approach. The final end product of research (e.g. a publishable paper) is perceived to require a significant amount of time to be obtained, and more emphasis is placed on the methodologies that are central to the research process rather than the final product or award that is expected at the end of the process.

Conception III. Researchers described in this conception are perceived to recognize research as an iterative process rather than a simplified linear procedure that yields successful results immediately. Conception III also has a focus on achieving personal growth as a scholar by embodying perseverance and resilience in cases of adversity. Failure is used as a building block to augment the research approach and to further develop professional skills. Learning from failures allows a researcher to be adaptable in the ongoing changes in their field and to develop new methodological approaches to their projects. Even in cases of success, a researcher is perceived to expand upon their findings to further advance their field and attempts to be open-minded to the feedback and criticism from other researchers.

Excerpt 1:

You really have to be proactive about thinking about what you're doing and what it means to run this kind of experiment versus just following a protocol. I think that's really important as a researcher, and then also, resilience is really important

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because the experiments fail so many times, and it can get frustrating if you're
trying to get results quickly.

Excerpt 2:

> They work a lot and hard. They are very focused, and they make sure that they
> approach a question from as many angles as they can think of. So, they don't just
> ask a question and say, "this will be a right way," and they ask the question and
> say "this will be a right way" but, "what would make this way confounded? What
> would make it wrong? What else could be contributing?"

In Excerpt 1, research is described as an iterative process that requires

perseverance to recover from failures and to reexamine one's approaches. The tangible

end product of research is not perceived to be obtained immediately, as complexities and

obstacles are expected in the research process. Excerpt 2 illustrates that even when few

complications are present, a researcher continues to critically analyze alternatives. In

contrast, in Conception II, the research process is perceived to be firmly established, and

little deviation is necessary to achieve success. In Conception III, a researcher explores

potential deviations from the defined process and recognizes multiple possible outcomes

to one's methodological approach. Researchers in this conception are perceived to be

open to different possible approaches to their work and recognize the process as a

personal journey that requires engagement and collaboration, ultimately contributing

knowledge to the field and growing personally as a scholar (Stubbs, 2012). The research

process is defined yet adaptable, as the researcher is perceived to address their research

question from multiple perspectives and approaches.

Contribution: To Whom a Researcher Considers Their Work Important

Conception I. Researchers in this conception are described as using research to pursue their self-interests rather than to advance their field or contribute to society. For example, one participant described successful researchers as:

> I always felt that researchers work on their projects, and they don't care about everyone else. Like, they just do their work, and that's it. (...) I always heard that researchers don't talk to others. Like for example, the postdocs or the professors, they don't care about their students. They don't care about what other people are doing.

Conception II. A researcher is perceived to use their research to advance their field. These researchers strive to expand upon previous research by working toward noteworthy findings that add to existing knowledge. The researcher is perceived to be enthusiastic about communicating their research to the scientific community and to explore other research fields to further build their own projects and contribute to the research world.

Excerpt 1:

> You need to, I feel like I need to read or know what others are doing in whatever project I'm working on. So, it's not just me because, what they, whatever other researchers or scientists are working on, it's very beneficial to have, like, because they already have found things that I need to kind of grasp on there and continue on. Kind of develop that research from there. It's not just repeat whatever that they did but taking that information and kind of build it on to go to the next step.

Excerpt 2:

> But just contributing really, just contributing to the body of knowledge that we're creating in [my field]. It's such an incredible field of work. I really love it. But as far as, I mean, that would be my definition of success. I know that other people have different definitions of success like publishing in prestigious journals et cetera, getting a faculty position, or something like that. But for me, just to be able to contribute to the research feels like success.

Excerpt 1 illustrates that a researcher's own work builds on the established knowledge and methodologies from other researchers in the field. Excerpt 2 describes a researcher who finds intrinsic values in contribution to their field, thereby contrasting to Conception I, which is largely defined by the researcher's own prestige and professional success.

Conception III. Similar to Conception II, a researcher described in Conception III is genuinely interested in using their research projects to contribute to the research community and does not attempt to strategically use research to enhance their ego and personal status. In expansion upon Conception II, a researcher in Conception III is perceived to use their research to serve people outside of the immediate research community. By intending to serve society at large, a researcher is perceived to broaden the impact of their research by simultaneously contributing new knowledge to the scientific community and using this knowledge to address a common societal problem.

Excerpt 1:

> I think good research isn't just done for the sake of research. I think there should
> be some sort of, you know, goal, whether it's to, you know help elucidate the
> answer to a problem or address some sort of social issue, medical issue,
> something like that.

Excerpt 2:

> I think having your research be meaningful and important to you and also to other
> people in the world so that it's benefitting the world in some aspects, I think that's
> the most important thing and I think that's what defines success in research.

As noted in Excerpt 1, a researcher described in Conception III recognizes that a research project should be initiated based on a desire to serve a broader social or societal purpose. The scope of contribution that research transmits beyond the scientific community is perceived to confer a greater purpose and meaning to a researcher's endeavors. Although Excerpt 2

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emphasizes that research should be meaningful to the researcher, this connotation of self-fulfillment contrasts with that observed in Conception I. A researcher in conception I is perceived to focus on participating in the research field solely for an opportunity to gain personal status and prestige. The second excerpt illustrates that a researcher's desire to explore his or her interests is instead rooted in a genuine ambition to serve public communities and address unsolved social or medical issues in society.

Interaction: How a Researcher Collaborates with Others

Conception I. Researchers are perceived to work independently and rarely interact with other researchers in their field. They do not seek feedback or collaboration with other researchers, and they show little regard for the work of other researchers.

> I honestly thought a researcher was just a guy that was in the lab all the time just like working with test tubes and stuff like that. I honestly didn't like, in the beginning, before I was even involved with a lot of research, I didn't know that they made presentations and posters. I didn't really, like, think about all that. I've kind of just thought it was a guy that was in the lab all the time and didn't really go out.

Conception II. A researcher is described as building connections within the scientific community to broaden their scope of knowledge within their field. A researcher is perceived to be eager to collaborate on projects with other researchers and values constructive feedback as they refine their methodological approach. It is recognized that a researcher regularly presents their findings to the research community and seeks to learn more from other researchers in order to better understand their own projects. By networking with other researchers, a researcher is able to build the essential connections that are needed to be proactive and make significant contributions to the research community. As one participant stated: "Even the most brilliant people crowd source information, and they ask other people for advice and feedback, and they

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incorporate that feedback." This emphasizes that active collaboration within the scientific community is required to develop a defined methodological approach based on the feedback and findings of other researchers. Science is conceptualized as a cooperative endeavor that requires extensive collaboration among researchers in order to discuss common research interests and to meaningfully contribute to the research field. This conception of the research profession directly contrasts to the assumption that researchers work in isolation and use research solely to pursue their self-interest in Conception I.

Conception III. In addition to building connections within the scientific community, a researcher in Conception III is perceived to extend beyond networking with professional scientists and offer mentorship opportunities to aspiring researchers. A researcher is recognized as being eager to teach others about the process and practices of the scientific community and is willing to devote their time to training the next generation of scientists.

> Professor [Name] has been doing research for years. And I think one thing that makes him different from a lot of other people is he actually wants to teach the kids science. He works with a lot of undergrad students. And I think that's just helpful for a lot of people. And he actually enjoys it. And you can tell he enjoys it. So, I think that's good for a researcher to have that quality.

This excerpt illustrates that a researcher in Conception III is perceived to not constrain their sharing of scientific knowledge to experts within the scientific community. Aligning with a desire to serve a broader society, researchers within this conception understand that it is essential to expand access to the scientific community and provide mentorship on the pathway to careers in science. By expanding the network of scientists from a variety of backgrounds and experiences, these researchers are perceived to view these mentorship opportunities as a means of addressing complex problems from multiple perspectives and to refine existing methodologies in the pursuit of advancing the research field.

Additional trends in the outcome space:

      Hybrid conception II/III. Several case studies analyzed within the outcome space were not rigidly defined by a single conception due to responses that featured a hybrid of Conception II and Conception III aspects. This hybrid conception resulted from participant responses that were coded as Conception II in one aspect and Conception III in another aspect. For example:

> I'd say, having a good grasp of the background of your field is absolutely fundamental. On top of that, what's the word for it? Commitment? Perseverance? Research is very difficult at times. Things never go the way you want them to go. Just being able to continue with an idea that you have. I'd say collaboration as well. Research isn't done in a vacuum. You kind of need to focus on not just what other researchers are doing but what other people in your lab are talking about and what they're doing as well.

This emphasis on a researcher's flexibility in their methodological approach is aligned with Conception III of research as an iterative process. The ability of a researcher to persevere and adapt is perceived to be attainable through a Conception II level of interaction in which a researcher interacts extensively with professional colleagues to gain feedback and resources that can be used to refine his or her methodologies. Although this response was coded as describing a Conception II level of interaction, it is possible that the Conception III features of this aspect (community mentorship and teaching experiences) were also present in this participant's conception, but these features were not explicitly described. However, this could also be indicative that participants with this hybrid conception of research demonstrate a developing, yet incomplete expertise of the nature of science. Although these participants may lack some of the expert pieces that are present in conceptions that include only Conception III aspects, responses that include an overlap of Conception II/Conception III aspects are more developed than a conception that is defined exclusively by Conception II characteristics.

No conception. Because the interview protocol prompted the participants to retrospectively define their conception of a researcher prior to their undergraduate research experiences, some participants were not able to clearly articulate any of the key features within the outcome space due to a lack of prior exposure to the research community. Due to a lack of real-world references to describe their understanding of the practices and values of the research community, these participants claimed that their previous conception of research was groundless or nonexistent. For example:

> To be honest, I had never been exposed to research before I got here. I had never been exposed to research before the [summer-bridge] program. So, I didn't really have any idea of what success for researchers looked like before that. So, I can't say that it changed, but now it actually exists.

Because none of the variations within the aspects of the categorical conceptions are clearly described, responses with no identifiable alignment within the outcome space were coded as "no conception."

Current vs. retrospective conceptions

Participants were asked if their conception of a successful researcher had changed over the course of their research experiences at the university. The retrospective and current conceptions were coded individually for each participant. Coding each participant as possessing Conception I, II, II/III, or III prior to ("retrospective conception") and following ("current conception") their undergraduate research experiences revealed an initial conception of a success that was defined primarily by Conception I characteristics (Table 4). The descriptions of the participants' current conceptions were coded primarily as aligning with Conception II and Conception III aspects, indicating an overall shift in the participants' understanding of the

research profession following their participation in mentored research experiences during their

undergraduate education.

Table 4: Frequencies (n=29) of conceptions that participants retroactively described as possessing prior to (original conception) and following (current conception) their research experiences. Ambiguous responses that could not be coded were marked as "un-codable."

Conception	Original Conception	Current Conception
Conception I	18	1
Conception II	2	4
Conception II/III	3	14
Conception III	0	10
No Conception	3	0
Un-codable	3	0

Discussion

The interview data have established an outcome space with three conceptions of the research profession that are characterized by three defining aspects: how a researcher approaches their work (process), to whom a researcher considers their work important (contribution), and how a researcher collaborates with other researchers (interaction).

From a retrospective account of their conceptions of researchers prior to their academic and research experiences at the university, many interview participants described their initial conceptions as aligned primarily with Conception I characteristics (Table 4). Conception I is defined by a simplified research process that is focused on promoting a researcher's self-interest. These researchers are perceived to have little regard for contributing to and interacting with a broader research community outside of their own laboratory. The researcher described in Conception I is overall disconnected from the research process and broader community. This conception aligns with a negative and stereotypical view of researchers, specifically in science, as socially inept and isolated workaholics that are not relatable to the general public (Losh, 2010).

In contrast, characteristics of Conceptions II and Conception III reflect an understanding that research is not conducted in isolation and is defined by a structured methodology. In comparison to Conception III, Conception II regards the research profession as more simplified and established, yet the researcher is still recognized as being proactively involved in the research process and community. The distinction between Conception II and Conception III are aspects that are more comprehensively aligned with an informed view of the nature of science in Conception III, as demonstrated by the recognition of research as an iterative and adaptable personal journey with multiple possible outcomes (McComas, 1998; Lederman, 1992; Lederman

& Zeidler, 1987). A researcher in Conception III is recognized by a willingness to use their research to contribute to a broader society and expand access to the research community through mentorship and teaching experiences. Therefore, Conception III of a researcher includes all characteristics defined by Conception II, but there is recognition of a greater complexity in the researcher's process and a broader scope of social influence. The research community in Conception III is viewed as a *community of practice* in which the researcher shares knowledge and learning experiences to develop an inclusive and diverse research community driven by mutual engagement and a shared mission (Lave & Wegner, 1991; Wenger, 1998; Akerson, Cullen, & Hanson, 2009). This community of practice is conceived as a scaffold where researchers collectively provide support and mentorship to aspiring researchers. This distribution of knowledge and social capital is intended to expand access to this community and to share a more nuanced understanding of the nature of science with individuals of varying experiences and backgrounds in research (Olitsky, 2007; Akerson et al., 2009).

Moreover, participants overall described their initial conception of a researcher as immature and simplistic, with little appreciation for the complex methodological processes and extensive collaboration that are needed to meaningfully contribute to the research community. However, the extensive opportunities that the students were provided with to participate in STEM research settings had shifted their conceptions to fit more with the Conception II and Conception III characteristics (Table 4). Akerlind's (2008a) synthesis of phenomenographic studies on conceptions of researchers implies that categorical conceptions are part of an inclusive hierarchy in which each conception includes and expands upon the defining features in the previous conception (Figure 4A). Although Conception II and Conception III featured overlap in their defining characteristics, Conception I characteristics did not appear to align within these

conceptions (Figure 4B). We hypothesize that the defining aspects of Conception I may be distinct from Conception II and Conception III. However, a revised interview protocol that prompts participants to clearly distinguish how their previous and current conceptions of research differ across the three defined aspects will be required in order to clearly identify this distinction.

Because the participants' initial conceptions of a successful researcher were defined more by Conception I characteristics, students majoring in STEM may have an initial perception of the research world that demonstrates an incomplete understanding of the nature of research and what a career in the research profession would entail. The disconnection between the initial perception of a successful researcher and the matured conception is overall indicative of the conflicting expectations that students with limited exposure to the research community may have prior to building and developing their own research experiences. Project work in which students participate in a practical application of the scientific method is also a common mechanism of socialization into the scientific research communities at the university level (Brown, Collins, & Duguid, 1989; Ryder & Leach, 1999). This indicates that student images of the nature of science are dependent on their concrete experiences in science and the building of mentorship experiences with faculty and professional researchers (Ryder & Leach. 1999). However, students from socioeconomically disadvantaged backgrounds may not have access to the resources that are essential to initiating these mentorship and practical research training experiences (Hurtado, Cabrera, Lin, Park, & Lopez, 2008; Bangera & Brownell, 2014). Without these experiences and opportunities, students from minoritized backgrounds are not provided with the space to envision themselves as scientists and to orient themselves toward a scientific career pathway (Carlone & Johnson, 2007; Eagan, Hurtado, Chang, Garcia, Herrera, & Garibay, 2013).
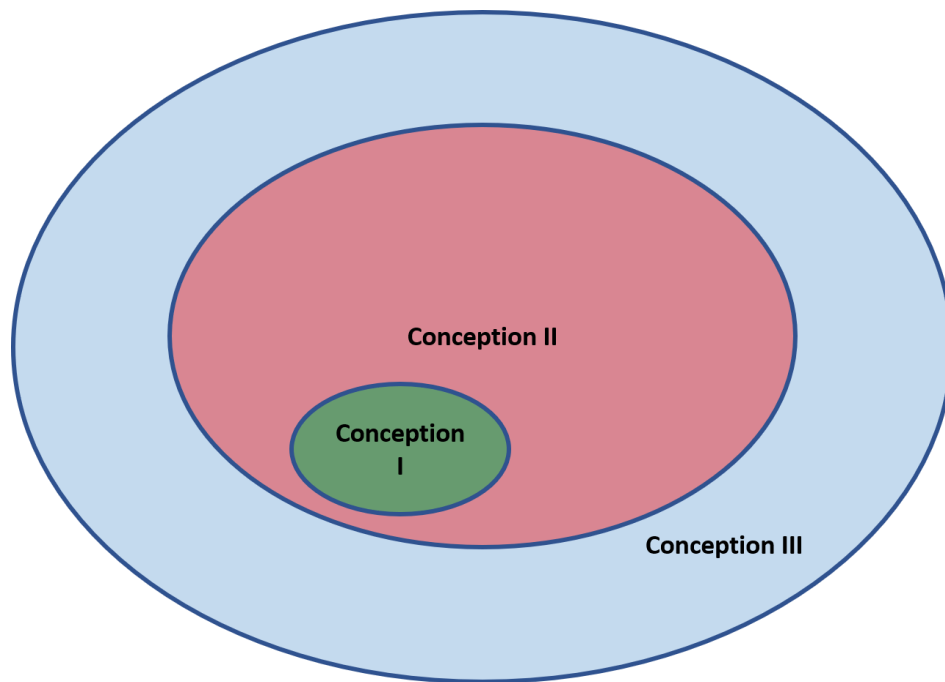
Figure 4A: Relationship between the three conceptions of a researcher represented as an inclusive hierarchy, in which each conception progressively increases in complexity by including and expanding upon the characteristics of the previous conception. This representation is supported by Akerlind's (2008a) synthesis of phenomenographic studies on researchers' conceptions of the research profession.
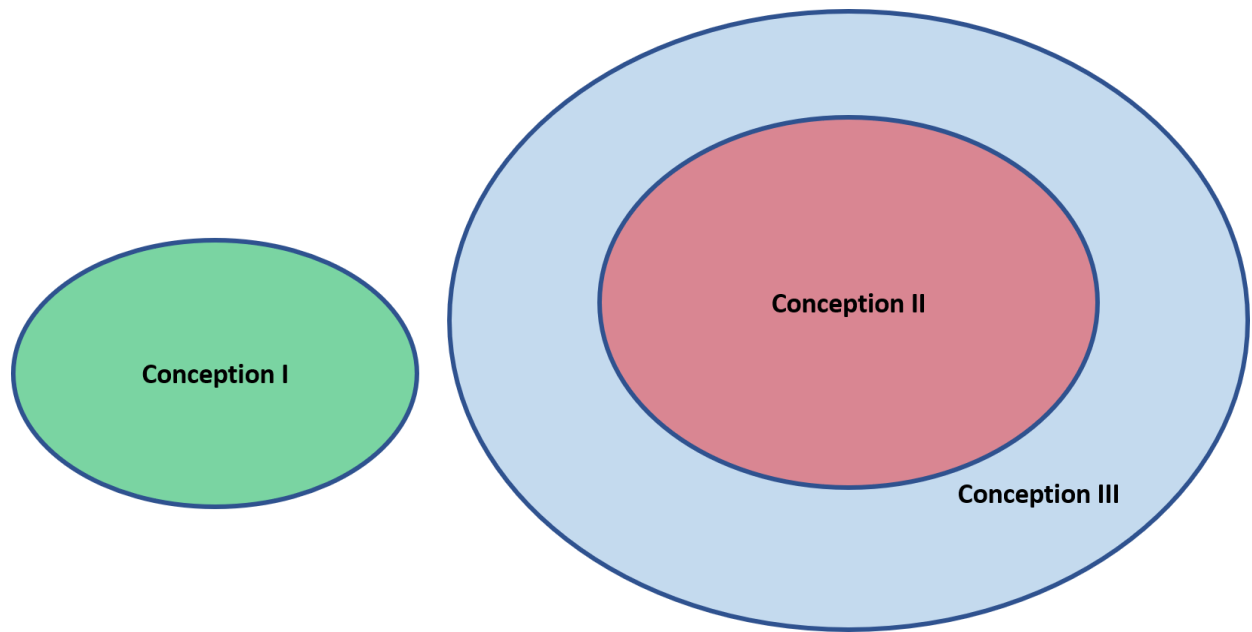
Figure 4B: Hypothesized relationship between based on the comparison between the coded aspects of participants' original and current conceptions. Conception III includes and expands upon Conception II characteristics, while Conception I characteristics are isolated and featuring no overlap between these two conceptions.

The scientific research community can also be construed as a *figured world* where identities are formed in practice and participants are positioned according to the norms and values within that space (Holland, Lachiotte, Skinner, & Cain, 1998). Students that have a preconception of the science community as a world that promotes a narrow range of identities will not perceive themselves as "science people" if they feel that they are not able to configure their identities within this space. Scientific research can potentially be conceived as monotonous and uninviting to students that have few real-world reference points to construct their views and understanding of the profession (Schinske, Cardenas, & Kaliangara, 2015). Students that adopt negative and marginalized conceptions of researchers and the conditions that they work in are not likely to possess the inspiration and motivation needed to continue down a scientific career pathway. One of the main objectives of science education has and continues to be the maturation of the student conception of the nature of science by showing students that science is a social and creative process that can be performed by a culturally diverse body of researchers (N. Lederman, J. Lederman, & Antink, 2013). The increased recognition of science as a social and dynamic process is reinforced by the shift from Conception I to Conceptions II and III after the participants in our study site had the opportunity to build their own research experiences and interact extensively with research faculty.

Limitations

While this study provides a fundamental insight into undergraduates' evolving conceptions of research following extensive participation in mentored research experiences, there are several limitations to our overall methodological approach. First, the interview questions were not structured to prompt participants to address each of the three individual

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aspects that varied across the conceptions. Participants were simply asked to define success as a researcher and to indicate whether or not their conception had changed following their university and research experiences. The three aspects were identified from broader categories that were generated after applying an in vivo coding scheme to the responses. Because all aspects were not necessarily addressed by each participant and were not clearly defined prior to conducting the interviews, it was not feasible to identify the conception that each individual participant held for each individual aspect. We therefore cannot definitively conclude whether the three conceptions are distinct or are simply expansions upon the previous conception in an inclusive hierarchy. However, the open-ended nature of the interview questions was advantageous for examining the aspects of the research profession that the participants most often attended to.

Secondly, the responses to the interview questions required the participants to provide responses that were retrospective. It would have been more beneficial to conduct a long-term study in which students were interviewed both prior to and following their experiences in undergraduate research. This would have provided a more structured comparison to examine if and how their conceptions of a researcher had shifted across the three aspects following their participation in research. Future iterations of this study could also feature comparative interviews with students majoring in STEM that have no research experience, non-transfer students, and/or students with non-STEM majors to further examine the variation in conceptions of a researcher across a more diverse population of students without scientific research experience.

Conclusion

This study constructed an outcome space that describes the variations in how undergraduates conceptualize the research profession. Assigning conceptions within this

outcome space to individual interview responses revealed a fundamental difference in students'

retrospective conceptions of the research profession prior to participation in undergraduate

research experiences. This finding warrants future studies that examine the specific experiences

that facilitate the change and maturation of these conceptions. These findings would inform and

support the development of broad-scale institutional intervention practices and programs that

provide guidance to undergraduate students in their transition into a STEM-research university.

Because undergraduate research experiences have been shown to increase student intrinsic

motivation to learn, the ability to work independently, and their overall understanding of what a

scientific career would entail (Lopatto, 2007; Hurtado, Cabrera, Lin, Arellano, Espinosa, 2009),

these institutional practices are expected to encourage and facilitate student involvement in

mentored research experiences. These experiences will provide students with opportunities to

network with faculty and researchers in STEM research settings, and introduce them to

challenging methodologies and practices that help them recognize research as a collaborative

journey with multiple potential outcomes and opportunities for growth as a professional (Baiduc

et al., 2017; Seymour et al, 2004).

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Chapter IV

Conclusion

In the studies presented, the perspectives of transfer students who had participated in a summer-bridge research training program provided broad insight into the experiences and identity negotiation that students may face when transitioning into a university-level STEM education. These studies highlighted the incompatible expectations within the university and research learning environments that can potentially limit persistence in STEM, especially if students are not provided with equitable access to the resources and guidance needed to reconfigure and negotiate their identities to meet the rigorous demands of the university and research communities. These findings support the development of a more comprehensive model of institutional intervention that stabilizes the academic transition into the university and fosters student persistence in STEM degree programs and research. As an example, future studies can assess the outcome measures of the summer-bridge program that supported the participants in this study. Because this program was intended to support participants' enculturation into research and other professional opportunities in STEM prior to matriculation into the university, the outcome measures will determine the efficacy of this summer-bridge program as a model of institutional action that prepares prospective undergraduate students for an academic and career pathway in STEM.