FACILITATING INCLUSION AND ACCESS OF UNDERGRADUATE STUDENTS IN LARGE-ENROLLMENT SCIENCE CLASSROOMS

by

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Facilitating Inclusion and Access of Undergraduate Students in Large-Enrollment Science Classrooms

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ABSTRACT

There has been a significant amount of money invested and work conducted in the United States to facilitate the inclusion of underrepresented students (e.g., females, students of Color) in science fields. However, change has been frustratingly slow. One reason for the slow change is that initiatives have largely focused on symptoms, such as learning gains or retention, and failed to address the disease, underlying systemic barriers that deter students from entering and persisting in STEM fields. These systemic barriers influence cultural values and norms that permeate science education and may make it unwelcoming to underrepresented students. My dissertation work looked at the Learning Assistant (LA) model, which offers a context in which transformation can happen, and described (1) how the LA model has helped facilitate inclusive practices that foster a positive culture and (2) where educators can modify the practices of the model to promote the removal of barriers that may hinder students. Chapter 2 provides an overview of how instructors can provide students access to capital and renegotiate power differentials in order to create more transformed classroom spaces. Chapter 3 focuses on students’ identity production and describes how socially constructed identities, such as gender and race, and lived experiences impact how students created a science identity. Chapter 4 describes one LA-supported biology classroom and how the instructor and LAs helped facilitate a sense of belonging for students. Overall, my research supports that the LA model provides a context for transformation and that LA-supported classrooms are establishing some inclusive
norms and values, though this varies by instructor. It is important to continue work in diversity and inclusion because science education can unintentionally dehumanize students when traditional norms are allowed to persist.

The form and content of this abstract are approved. I recommend its publication.

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CHAPTER I

INTRODUCTION

I think people of various identities know that diversity is always something that's going to be happening. It's something that is huge now, so it's great to see people of different ethnicities being more represented in the community. Science and society - I think it's still kind of biased [in regards to] race and gender. You know it's kind of hard when you're a girl, and you're in the science field because it's something that's kind of still taboo at this point. And I think it's just society is still having a hard time getting past [it] … They tell you, ‘You can't do it.’ Things like that. It just kind of motivates me to work harder, so I can prove them wrong.

- Interview with Amy, General Biology I Student, 25 Oct 2017

“Why aren’t we there yet?” Problem and Significance

Science in the United States has long faced a diversity problem as evidenced by the fact that our academic and industrial work force is comprised predominantly of White males (National Science Foundation, 2015). There has been significant work at the undergraduate level to increase enrollment and retention of underrepresented students, particularly students of Color (I define students of Color as Black, Latinx, Native American, Pacific Islander, and Southeast Asian students) and female students. We are increasingly seeing literature that acknowledges that science greatly benefits from the incorporation of many voices from many lived experiences and perspectives (Brayboy & Castagno, 2008; Malcom & Feder, 2016; Ryan, 2008). There has also been an increase in funded programmatic initiatives and services to help traditionally underrepresented students. Some examples include the Howard Hughes Medical Institute’s Inclusive Excellence Grants and the National Science Foundation’s Louis Stokes B2B Alliance
for Minority Participation Grants. Despite a great deal of effort and both government and private funding, change has been slow.

Issues of equity in science education are not a new phenomenon; researchers have been working on creating spaces where underrepresented students can thrive and be successful. For those of us educators who seek to create science classrooms in which all students can thrive, we readily converse about changes in pedagogical techniques that can better facilitate classroom equity (Tanner, 2013). Some pedagogical innovations include using more inclusive language that does not assume a particular gender identity, family structure, or upbringing (Allen & Tanner, 2007) or assigning regular homework about scientists of Color and their research to showcase diverse representations in our classrooms (Schinske, Perkins, Snyder, & Wyer, 2016). These interventions are being implemented at institutions across the U.S., in the hopes that the persistence gap in the science field narrows for underrepresented students, predominantly students of Color and female students. However, even with our current efforts and greatest intentions, we see that our successes vary depending on the institution and the context. As such, those of us who study equity and inclusion in science education regularly ask, “Why aren’t we there yet?”

Arminio, Torres, and Pope (2012) argue that many efforts do not work because they are focused on the wrong issue. Matias (2016, p. 194) corroborates this by stating that within the field of teacher education, “rarely interrogated is the question of why an achievement gap exists in the first place”. Matias (2016) shares the sentiment posed by Arminio et al. (2012) and used an analogy to illustrate this phenomenon. Many times, institutions “treat” issues such as retention, dropout rates, unsatisfactory learning gains, and low student satisfaction, which are the symptoms that emerge from underlying root causes. The disease that causes those symptoms is
institutionalized systems of oppression in the forms of “-isms” (e.g., sexism, racism, ableism). Matias argues that many of the times, we focus on treating the symptoms without thinking about the disease that causes those symptoms to manifest. Admittedly, the science education community has narrowly fixated on providing remedies for the symptoms (e.g., retaining or recruiting students of Color, maximizing quantifiable outcomes such as learning gains) that we often forget to consider the underlying causes of those symptoms. Therefore, part of the solution needs to consider why we see what we see in higher education. Unfortunately, many of the initiatives and programs that are implemented do not address the diseases that undergird science education.

The mission of my dissertation work, which is founded on the work of countless other scholars before me, is to facilitate inclusion and access in science education in ways that honor and value the experiences and narratives of individuals who choose to enter science fields. If, as a field, we truly want underrepresented peoples to be part of the community, to succeed, and to thrive, the conversation needs to (1) be intentional, (2) acknowledge histories and systems of oppression, and (3) re-imagine what science education can look like at colleges and universities.

Diversity and Inclusion Initiatives in Science Education

In the United States, we have seen a variety of programmatic initiatives at different institutions that aim to increase participation and retention of underrepresented groups. These initiatives have their merits and have led to successes, but using a few examples below, I problematize some of the logic behind these programmatic initiatives and discuss how we could leverage programmatic initiatives in ways that do facilitate inclusion and access.
Some programmatic initiatives, though well-meaning and encouraging, still approach underrepresented students from a deficit-thinking lens (Solorzano, Ceja, & Yosso, 2000; Solorzano & Yosso, 2001; Valenzuela, 1999). For example, there are permeating assumptions that underrepresented students do not academically perform well in higher education and need extra help because of (1) their secondary education curriculum or (2) internalized stereotypes (Rath, Peterfreund, Xenos, Bayliss, & Carnal, 2007; Solorzano et al., 2000; Solorzano & Yosso, 2001). Additionally, underrepresented students are commonly “othered” for their differences and may be expected to assimilate to localized and globalized cultures in order to be “successful” (Bang, Warren, Rosebery, & Medin, 2012; Brickhouse, 1994). Considering this, programs such as supplemental instruction (SI) (Arendale, 1994) or PEERS (Toven-Lindsey, Levis-Fitzgerald, Barber, & Hasson, 2015) may be problematic because of the tendencies to make sure students conform to traditional expectations in order to be able to succeed, thus addressing the symptoms but not the disease.

Addressing the disease requires a re-imagining of what science education could look like and a transformation that changes the structure and culture. By changing the structure and culture, there are opportunities to establish new norms and values that centers students’ experiences and histories and diminish “-isms” that are embedded in society. There are some examples of transformation-based initiatives that break away from the traditional science education paradigm. For example, Course-based Undergraduate Research Experiences (CUREs) have been popularized in science education as a means of giving undergraduates a means to participate in a true inquiry-based research project in lieu of traditional confirmation-based lab exercises (Corwin, Graham, & Dolan, 2015). CUREs differ by institution but traditionally offer a context in which students are allowed to ask novel research questions that are interesting to them,
develop methods, and collect and analyze data to answer their question. Long-term research looked at the effectiveness of CUREs and showed that a transformation of the laboratory curriculum into an inquiry-based experience helped retain more students in STEM and increased graduation rates within 6 years (Rodenbusch, Hernandez, Simmons, & Dolan, 2016). CURE students are able to decide how to learn and are able to create a space where they can authentically contribute to science and be part of the community. This, in turn, may create a sense of belonging for students. If, as science educators, we want to create an education that is equitable and accessible to all those who want to participate, this type of transformation is necessary in order to remove problematic ideologies that perpetuate “-isms”.

Course Transformations and the Learning Assistant Model

Course transformations provide faculty members with opportunities to institutionalize new norms that will foster learning and respect. I believe that transformations are necessary in facilitating inclusion and access in science education because they already deconstruct many problematic institutional norms and require new norms and ways of thinking to be successful. The course transformation context at the heart of this dissertation is the Learning Assistant (LA) model.

The LA model was originally conceived at the University of Colorado Boulder and is in use at over 80 higher education institutions. It is being increasingly adopted by colleges and universities worldwide (http://www.learningassistantalliance.org/). LAs are undergraduates who have previously excelled in a particular science course and have expressed interest in helping their peers learn. Though specific elements of the model may differ based on the institution’s needs, LAs are meant to help faculty incorporate student-centered instruction in the course for
which they are an LA and help increase interactions among students. Effort is made to recruit LAs that reflect the diversity of students in the courses for which they LA.

LAs have several responsibilities. LAs attend all class sessions and meet weekly with the faculty who teaches the course. LAs also serve as a bridge to and from students in ways that could promote greater understanding of student learning and diversity. Further, LAs all take a pedagogy course to discuss learning theory, diversity, promoting discourse, and student conceptions. The tools that they learn are expected to help them aid faculty in transforming science courses from traditional lecture to a student-centered active learning environment that is inclusive of a diversity of learners. LA supported classrooms have increased student learning gains and more instances of curricular change (Otero, Pollock, McCray, & Finkelstein, 2006; Pollock & Finkelstein, 2013; Talbot, Hartley, Marzetta, & Wee, 2015). However, little work has been done to characterize how the LA model has and can be used to create a more inclusive space for underrepresented students (Van Dusen, White, & Roualdes, 2016).

Dissertation Problem Statement

Programs based on the LA model are increasingly being implemented at institutions worldwide because of previous research that concluded that their inclusion has helped student learning and retention. However, there is little research on how LA models may transform classroom culture to facilitate inclusion and access for students, particularly underrepresented students. Throughout my dissertation, I am focused on how LAs institutionalize inclusion and a sense of belonging. I do this by understanding faculty members’ perceptions of inclusion, students’ science learner identity production, and the day-to-day phenomena that occur in an LA-supported classroom. This dissertation will inform institutions and faculty members of elements of the LA model that
allow students to feel like they belong in the science classroom and in science generally. It will help create a more supportive environment for students in courses with LAs.

Theoretical Framework

I chose figured worlds as the theoretical framework of my dissertation. Holland, Lachicotte, Skinner, and Cain (1998) defined *figured worlds* as “socially and culturally constructed realm[s] of interpretation in which particular characters and actors are recognized, significance is assigned to certain acts, and particular outcomes are valued over others” (p. 52). In general, *figured worlds* describes concrete (e.g., home, neighborhood) and abstract (e.g., science, education) communities which all possess certain norms that establish values and ways of knowing. People exist in multiple *figured worlds* and construct a “self” based on these worlds. This “self” is influenced by how individuals participate in their *figured worlds* and by how they make meaning of their experiences. I describe *figured worlds* in greater depth in Chapters 3 and 4.

Despite the overwhelming historical and cultural barriers and discourses that undergird science education, *figured worlds* recognizes the agency that individuals have within that *figured world* (Chaffee & Gupta, 2018; Holland et al., 1998; Urrieta, 2007a). This agency is particularly important because current science culture can be problematic for underrepresented students, and individuals in the community can use their agency to combat the status quo to create a space that is more meaningful (Buxton, 2001; Holland et al., 1998; Price & McNeill, 2013). The new day-to-day phenomena that occur will help students renegotiate and rethink who they are and potentially make them feel as though they belong (Strayhorn, 2012; Trujillo & Tanner, 2014).
I believed that *figured worlds* appropriately frames my dissertation work because of several factors. *Figured worlds* recognizes the sociocultural and sociohistorical nature of human communities and understands that there are norms present that may negatively impact some individuals within a community. Holland et al. (1998) cited the work of Bourdieu and Passeron (1990), which focused on social and cultural reproduction of education and society and how norms and values get passed through generations, providing dominant classes more access to capital and power. This helps disenfranchise non-dominant groups and is still apparent in education today, though presently, there are science education contexts in which faculty members are working to provide all students with access to capital and are willing to renegotiate power differentials (see Chapter 2). *Figured worlds* also considers that people can “author” their own experiences, based on socially constructed identities (e.g., race, gender), and produce new identities, such as science identities, in relation to how they perceived past and current experiences (see Chapter 3). Finally, *figured worlds* acknowledges the agency that people have. It recognizes that people in subsequent generations have the ability to change the culture of their figured worlds by upholding new norms and values. In science education, this could manifest via creating a science classroom that institutionalizes a sense of belonging to help students feel more intertwined in the science community (see Chapter 4).

**Study Context**

This study primarily took place in several introductory biology classes at the University of Colorado Denver, although one chapter includes data from two additional institutions. Chapter 1 included participants from North Dakota State University and Florida International University. Chapter 2 focused on five introductory biology courses at the University of Colorado Denver. Chapter 3 focused on one introductory biology course at the University of Colorado Denver.
All courses referenced in this dissertation implemented active learning in their classrooms, and all but one of the courses referenced in this dissertation included LAs in class. The learning environments differed depending on the institution. LAs at the University of Colorado Denver worked in traditional classrooms where rows of seats faced a lecture podium at the front of the class. LAs at North Dakota State University and Florida International University worked in SCALE-UP classrooms where students sat in tables of 8-10 students to facilitate group work. All of this work was a part of a larger National Science Foundation grant studying active learning (NSF #1525115), and I was given permission to collect and utilize the data under IRB #14-0028.

Overview of Dissertation

My general focus of my dissertation is inclusion in science education with a goal to understand what classrooms look and feel like for students. This is because their perceptions of the classroom are fundamental to them deciding whether or not they will stay in a science major. In my dissertation, this goal is understood through faculty interviews, student interviews, and course observations (Figure 1.1). I believe that this work can contribute to the growing knowledge base about the LA program and can help faculty members and institutions who use LAs think more intentionally about what they do in courses and the types of norms and values that would want to establish for their students.

Chapter 2 of this dissertation focuses on biology, chemistry, and physics faculty members and how they provide students with access to capital and renegotiate power differentials in their courses. I used faculty interviews for this study. The purpose was to understand how their practices and perceptions may have facilitated inclusion for students in these classrooms.
Chapter 3 of this dissertation focuses on how introductory biology students produced science identities. I describe how socially constructed identities and procedural elements of the classroom impact the science learner identities that students form. I used student interviews for this study. I pursued the following research question: How does Conceptual Identity Production and Procedural Identity Production inform the manner in which students’ science learner identities are created and shaped?

Chapter 4 of this dissertation is a deep case study that focuses on one introductory biology classroom. The case study describes how one LA-supported class worked to institutionalize a sense of belonging for students in the course. I discuss how authentic carrying from the instructional team, discourses of opportunity, and authoring experiences allowed students to feel as though they were a part of the community.
Chapter 5 of this dissertation is a conclusion and synthesis of chapters 2 to 4 and returns to the overall goal of describing how the LA model can facilitate inclusion and access for students. I end by providing conclusions and discussing future directions for research.
CHAPTER II
INSTRUCTOR PRACTICES AND PERCEPTIONS IN LEARNING ASSISTANT
SUPPORTED CLASSROOMS: A CAPITAL AND POWER PERSPECTIVE

Abstract

Background

Studying instructor actions and their perceptions of the classroom is especially important given the lack of participation of traditionally underrepresented students in science and the need to increase science expertise. Instructors are important actors in the classroom because they significantly impact undergraduate science classroom structure and norms. This paper explores how undergraduate science instructors perceive both their students and how their own classroom practices can facilitate student access and inclusion. We interviewed seventeen science instructors from three different institutions and interpreted those interviews using the framework of capital and power. All of the instructors employed the Learning Assistant model, which uses near peers to support active learning instruction. We were interested in inclusion practices instructors use to improve experiences of underrepresented students in science.

Results

Most instructors reported that they attempted to facilitate inclusion in classrooms by providing students access to cultural and social capital, which included intentionally unveiling science education norms or helping students establish positive relationships with peers, such as other students and Learning Assistants. Additionally, some instructors renegotiated power differentials in the classroom, which provided Learning Assistants and students with more agency to establish classroom norms and meaningfully participate with activities. How
instructors provided access to capital and renegotiated power varied, and some instructors were more successful than others

Conclusions

The interviews revealed that many instructors were aware of issues regarding inclusion in class and felt that they were, to varying degrees, able to transform their classrooms to be more inclusive and student-centered. Instructors perceived that they were able to decentralize their roles in the classroom, and Learning Assistants were instrumental to facilitating more inclusive classroom norms.

Introduction

The number of undergraduate college science educators who are concerned about student diversity and inclusion in their classrooms has been increasing over the last decade (Handlesman, Miller, & Pfund, 2007; Tanner, 2013). Many science educators are speaking up and abandoning the elitist discourses that present introductory science courses as metaphorical “weed-out” courses and instead are embracing inclusive discourses and pedagogies that encourage participation by all individuals, regardless of identity (Cunningham & Helms, 1998). Despite shifting discourses in science education and the progress that many undergraduate science departments have made regarding inclusivity and diversity, change has been frustratingly slow (Malcom & Feder, 2016). For those who focus on creating science learning spaces that are engaging and non-oppressive, the anemic participation of students, especially female students and students of Color (we define underrepresented students of Color as students who are Black, Latinx, Native American, Pacific Islander, and Southeast Asian) is discouraging (National Science Foundation, 2015). This low participation in science can be attributed to several factors, such as college-level students perceiving a hostile environment (Solorzano et al., 2000; Teo,
limited authentic experiences in science for students from lower socioeconomic status backgrounds (Corwin et al., 2015; Hurtado, Cabrera, Lin, Arellano, & Espinosa, 2009; Rodenbusch et al., 2016), deficit thinking from science educators regarding student abilities based on identities such as race, ethnicity, and gender (Settlage, 2011; Solorzano & Yosso, 2001; Weiner, 2006), educators implicitly stereotyping minority groups (Brickhouse, 2001; Carlone & Johnson, 2007; Harry & Klingner, 2007; Ladson-Billings, 1998; Solorzano & Yosso, 2001; Yosso, Smith, Ceja, & Solórzano, 2009), and the lack of concern from some faculty and departmental chairs related to retaining and increasing the number and diversity of graduates in science (McClelland & Holland, 2015; Orgill, Skaza, Marti, Schrader, & Gandhi-Lee, 2017). Despite some progress, science educators must still work to successfully create spaces that facilitate equity and inclusion. Further, these spaces need to be created within an encompassing society where racism, xenophobia, sexism, etc. are normalized (Philip et al. 2017).

Instructors can play significant roles in facilitating student interest in science and student success in their chosen disciplines (Cejda & Rhodes, 2004). They can transform their courses to create a science education experience that addresses the barriers that may prevent some students from continuing in science. Therefore, it is important to understand how instructors perceive of their students and how instructors’ perceive of their personal roles and responsibilities related to creating student-centered and inclusive classrooms.

Classroom contexts influence instructor beliefs and instructional practices. The instructors we interviewed for this study employed the Learning Assistant (LA) model, which uses near peers to facilitate student-centered instruction and increase student success (www.learningassistantalliance.org). Instructors who employ the LA model are committed to transforming their courses toward more student-centered pedagogies and commonly teach in
high-enrollment “gateway” courses. LAs are undergraduate students who have previously finished the course for which they serve as an LA. They work closely with instructors to make the classroom more engaging and collaborative with the goal of increasing learning outcomes and student success (Chasteen, Perkins, Beale, Pollock, & Wieman, 2011). We posit that this collaboration between LAs and instructor can potentially help the instructor be more knowledgeable about their students and more aware of how their teaching practices might influence diverse participation in science and the inclusion of different voices to their respective fields. We provide more detail about the LA program in a later section. At the institutions that were part of the study, instructors chose whether or not they would like to use LAs.

We conducted interviews with LA-supported instructors in order to explore their perceptions regarding student diversity in their classrooms and how their classroom practices might influence inclusion. We made sense of their responses using Bourdieu’s concepts of capital and power as theoretical lenses. The purposes of this paper were to describe:

1. How instructors perceived they provided students access to science education capital to facilitate inclusion
2. How instructors reported renegotiating power differentials in their classroom to facilitate inclusion

In the following sections of the Introduction, we described capital and power and their importance to understanding how traditional science classrooms can feel unwelcoming. Next, we review the research base related to capital and power and their impact on science education. Then, we situated the LA model within our theoretical framework.

Capital and Power in Science Classrooms
We chose capital and power in framing this work because they are mechanisms that maintain the dominant social structure, norms, and values that can disenfranchise underrepresented students in science education. We used Pierre Bourdieu’s work to frame our theoretical considerations of capital and power. Bourdieu and Passeron (1990) deconstructed cultural phenomena to show that practices and norms help maintain the overall structure that oppresses certain populations of people. Specifically, they deconstructed the French education system to demonstrate how social and cultural norms acted as a way to maintain class structure by creating an institution that was unfamiliar and unwelcoming to those of lower class (Bourdieu & Passeron, 1990). They concluded that societies were not unbiased entities. Within each society, individuals who interact with one another maintain certain social norms (e.g., how to converse, how to use body language) that get passed on to future generations (Nash, 1990). The United States educational system is no exception. Education is built on a particular set of cultural values and artifacts (English & Bolton, 2015) that allows for some people to achieve success more easily than others.

In our study, the cultural values and artifacts important to science education can be described using the frameworks of capital and power. When Bourdieu used the term “capital,” he referred to the knowledge, property, and recognition that individuals inherited (either directly or through experiences) that socialized them to particular cultures and traditions (Bourdieu, 2011). Bourdieu recognized the importance of cultural, social, and economic capital in influencing personal success and social mobility. In education, we can posit that people who accrue cultural capital of the dominant class (having values and knowledge that align with dominant or privileged social structures), economic capital (having monetary and material wealth), and social capital (possessing relationships that allows for influence in society) academically perform better
and are offered more opportunities (Bourdieu, 2011; Bourdieu & Wacquant, 1992). Their successes result from life experiences that are better aligned with established cultures and traditions. The capital framework suggests that underrepresented students who do not have capital valued in science education could be provided access to valued capital from individuals who already possess recognized science capital. By accessing this capital, students may be more able to navigate educational structures and be successful. In our study, we primarily focused on ways instructors provided access to social and cultural capital for students.

In addition to capital, Bourdieu theorized about the role of power in maintaining social structure and norms. Bourdieu defined power as a tacit mode of domination in which individuals in a society were expected to adhere to everyday norms, typically reinforced by people who were more dominant on a social hierarchy (Bourdieu, 1998). Power allows some individuals to say what is socially valid and what has value, and power relates to education in that those who possess power dictate the “right” things to study or the “best” way to showcase knowledge (English & Bolton, 2015). In the classroom, power could look like an instructor telling students that they must memorize certain facts and not question the facts; the instructor expects students to adhere to these norms and to do otherwise may lead to repercussions, such as a lower grade. Power, to Bourdieu, was a form of "symbolic violence” in that it was a form of aggression against already disenfranchised people who were made to believe that what they knew about their society was the way things were meant to be (Bourdieu & Passeron, 1990). Therefore, we found it important to interrogate how structural power differentials impact the ways in which undergraduate science instructors talk about classroom norms and their impact on students.

Literature Review
Science, like many other institutions, can be oppressive to people who (1) do not possess capital that is considered valuable (Claussen & Osborne, 2013; Hatt, 2007) and (2) lack power necessary to engage in conversations regarding change and reform (Luehmann, 2007). Individuals who are seen as “science people” succeeded in accruing cultural and social capital that fits within traditional scientific discourse (Bourdieu, 2011). We view the instructors in the study as people who are “science people” and have had succeeded despite potential barriers related to capital and power. We focused our literature review on the roles of capital and power in science education. Though we attempt to focus on instructor-specific literature, we also provide examples of studies focused on students to showcase the breadth of ways scholars have studied capital and power in science education.

**Literature related to capital**

When we [the authors] conceptualize capital in science education, we work from the understanding that it is valued and prized by those who exist within the institutional structure (Bourdieu, 2011; English & Bolton, 2015). While Bourdieu focused on defining three types of capital – economic, social, and cultural – our literature review will focus on social and cultural forms of capital. We acknowledge the importance of economic capital to students’ educational experiences but cannot adequately address the implications of economic capital in our study design. Additionally, there is a scarcity of literature regarding the intersections of science faculty instructional practices and economic capital.

Social capital refers to influential relationships and networks that allow for more opportunities. These social relationships are important because “who you know” can provide an individual with resources that are unavailable to others (Thompson, Conaway, & Dolan, 2016). Lin (2002) more fully explored social capital and described how being provided access to social
capital allowed for upward social mobility and benefited an individual via extra resources and opportunities. Thompson et al. (2016) studied how science students were provided access to capital during a multi-institutional research experience and concluded that many students were able to accrue social capital by developing ties with faculty members, post-doctoral researchers, and senior students. These ties provided students with more opportunities and guidance that may have helped with future endeavors. Ceglie and Settlage (2016) explored the social capital of women of Color who were undergraduates in science. They noted that academic support and connections with faculty members and family were instrumental to student success and motivating them.

Cultural capital relates to the norms, values, knowledge, and skills that individuals possess. Colloquially, we may think of cultural capital in science education as “thinking like a scientist” (Claussen & Osborne, 2013; Thompson et al., 2016). Though cultural capital is abstract and not easily measurable, its implications in equitable science education are profound. Cultural capital is a form of hegemony in that it privileges individuals who already possess the qualities of the dominant class at the expense of marginalized groups (Thompson et al., 2016). Students who wish to fully participate in science must assimilate and align to the values upheld by the dominant class in order to accrue cultural capital (Claussen & Osborne, 2013). Thompson et al. (2016) studied the ways in which students accrued cultural capital in science. They noted that students were provided access to cultural capital via faculty members and postdoctoral researchers providing “big-picture” knowledge and being role models. Additionally, students drew on their cultural capital and sought out opportunities to participate in research because they recognized the value of it in science (Thompson et al., 2016). In work conducted by Ceglie and Settlage (2016), they noted the importance of advisors being able to provide access to cultural
capital because some students, such as the women of Color discussed in the study, would not have had reliable access to the resources (e.g., tutoring, learning communities) that would have made them successful science students.

The above examples show the roles of social and cultural capital in science education and how it is important that students have access to capital in order to facilitate their success. This is particularly important for underrepresented students, such as female students and students of Color because their ways of knowing and making sense of the world often conflicts with mainstream scientific worldviews (Aikenhead, 2001; Ceglie & Settlage, 2016). Consequently, they are often at odds with the science community, which hinders their persistence in science (Ceglie, 2011). Ideally, to be truly equitable to all students, science educators should seek to create spaces where students do not have to be provided access to dominant class capital, but rather, they could use their native capital and still be successful. Bang et al. (2012) stressed that educators should create science education experiences that embrace different worldviews rather than focusing on assimilating students into the dominant worldview. Warren and Rosebery (2011) discussed the importance of interculturality and making sure that educational systems do not reinforce dominant discourses and thus maintain the “status quo”. However, disrupting problematic science education norms is out of the scope of our study and the faculty members interviewed for this study, though well meaning, are not thinking of inclusion and access at this depth. This may be because faculty members do not typically have access to social science expertise, knowledge, or perspectives in their respective fields.

**Literature related to power**

We believe it is important to discuss power and how it affects instructor choices because the power that instructors wield in the classroom and the larger educational system (e.g.,
Bourdieu, 1998). Bourdieu highlighted the fact that power can be used to disenfranchise already oppressed populations. One contemporary example involved the Texas State Board of Education, which urged textbook writers to avoid terms such as “capitalism” and “imperialism” and substitute them for “free enterprise” and “expansionism” (Frank, 2010). By doing so, they highlighted an important example of how those higher in social hierarchies can wield power and determine what is valued or socially acceptable in order to maintain current systems.

In reviewing literature, one study focused on positionality and power through case studies of two female science teachers in secondary school contexts. In this particular study, both teachers shared their stories and experiences and discussed how institutionalized power influenced how they were situated in the department and the norms apparent in their science classrooms (Teo, 2015). They recognized race and gender discrimination, related to power differentials, that impacted their and their students’ experiences. They believed that it was important to create a space for their minority students that allowed for them to be successful. Despite these views, neither questioned institutional policies and continued to emphasize meritocratic views of science content and classroom structure despite knowing that some of their students struggled (Teo, 2015).

Birmingham et al. (2017) completed a study that focused on four girls from nondominant communities. These girls were positioned as “outsiders” in their context because their identities and lived experiences did not parallel what is considered to be a “scientist”. This was because existing power dynamics and stereotypes positioned students of Color as underachievers and failures, a phenomenon coined as the “naturalization of racism” (Bonilla-Silva, 2006). In this article, the girls recognized that their science teachers had power that enabled the teachers to
transform how students engaged with science, but the teachers did not utilize that power for transformation. The girls engaged in consequential learning (engaging in science that connected significant sociohistorical contexts in their lives to content) as a way to show their teachers their knowledge despite ongoing power dynamics that disenfranchised them (Birmingham et al., 2017).

Another study utilized a critical theory lens to look at how well-meaning practices meant to engage minority students in science can still uphold unequal power dynamics and not transform pedagogy. Sheth (2018) focused on secondary science teachers who adopted practices that were meant to nurture an appreciation for science for students of Color. Subsequent findings, however, showed that, despite adopting these practices, the teachers still positioned their students of Color as the “other” and maintained unequal racialized power relations due to systemic master scripting of science content and maintaining colorblind science teaching (Sheth, 2018).

The above examples showed how power may set up barriers that inhibit inclusion and can be used as an “index of privilege” (Nasir & de Royston, 2013). Hearn (2012) asserted that it is important that instructors understand the power they wield and the impact it can have on students.

The Learning Assistant Program

The instructors interviewed in this study all teach high-enrollment “gateway” courses and have all adopted the LA model. The LA model incorporates near peer instruction in science classrooms. The LA model has four major goals: (1) facilitate curriculum and course transformation, (2) enable educational research, (3) facilitate institutional change, and (4) recruit and prepare future K-12 teachers (more information about these goals can be found at: https://www.learningassistantalliance.org). LA programs using this model typically create active
learning contexts for students. LAs engage in training via a pedagogy course that is required for all LAs during their first semester in the program. Instructors and LAs are expected to have weekly meetings to discuss what is going on in class and how class can be improved for students.

The LA model is highly flexible by design, and the models for LA use are highly variable as a result. Because of the inherent flexibility, the model can be modified to fit the needs of particular classrooms and institutions. For example, LAs may answer questions students have about lecture materials or in-class activities, host study sessions where they clarify major talking points, create materials to be used in class, or work in laboratory or recitation sections. LAs have been shown to facilitate increased learning gains on assessments (Otero et al., 2006), promote curricular reform (Pollock & Finkelstein, 2013), and increase student satisfaction. Though these previous studies have described positive success on student learning and attitudes, none have studied instructors who use this model and how LAs impact instructor perceptions about inclusion in STEM. Additionally, there have not been studies documenting whether and how the LA model provided instructors opportunities to provide access to capital and renegotiate power differentials.

Methods

Context and Participants

This was a qualitative interview study in which our sampling unit was LA-supported instructors (which included tenure and non-tenure track faculty members) from three different large public institutions (Mountain West, Midwestern, and Southeast) that represent a diversity of contexts and student populations. The Mountain West institution’s undergraduate population was approximately 60% White students and 40% racial minority students, the Midwestern institution was approximately 86% White students and 14% racial minority students, and the
Southeast institution was approximately 10% White students and 90% racial minority students and was a primarily Hispanic serving institution. This work is part of a larger research project, which focuses on characterizing active learning in LA-supported classrooms and modeling how classroom components (e.g., mediating artifacts, roles, classroom norms, etc.) mediate student success. The larger study targeted all of the larger enrollment introductory science courses at each university. Our aim was to take an exhaustive sample of faculty members (n = 26) who are part of the larger project. After the conclusion of the Spring 2017 semester, we interviewed 17 of the 26 instructors in our population. Some instructors did not respond to our request to be interviewed or were not available to be interviewed. Instructors were in biology (n=8), chemistry (n=5), and physics (n=4) departments at their respective institutions (Table 2.1). All the science departments in our study have majority White faculty membership, and the gender and racial identities of the instructors who participated in our research are reflective of national trends.

Table 2.1. Gender and racial/ethnic identities of interviewed faculty members. Details about specific courses, institutions, and number of years teaching with LAs is not included here to protect anonymity.

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4 White instructors</td>
<td>10 White instructors</td>
</tr>
<tr>
<td></td>
<td>3 instructors of Color (2 Latinx, 1 Asian)</td>
<td>0 instructors of Color</td>
</tr>
</tbody>
</table>

Interviews

Within four weeks of the conclusion of the Spring 2017 semester, each instructor participated in a 45-60 minute semi-structured interview conducted by a member of the research team. The interview protocol broadly focused on instructors’ use of LAs and included prompts on course design and practices, LA use, classroom culture and diversity, and perception of
learners (our interview protocol is available in Appendix A). Our goal was to adequately capture typical classroom dynamics and structure, instructor views of diversity and inclusion in their classroom, and instructor views of the roles of their LAs in course practices and transformation. All interviews were audio recorded and transcribed. All identifiers were modified to protect privacy and reduce bias.

Our goal was not to differentiate between institutions, disciplines, or the relative experience instructors had using LAs. We were more interested in the variation of instructors’ perceived instructional practices and their perceptions of their class and their students. To determine whether or not there were differences related to the instructor practices and perceptions, two authors read through all the interview transcripts and noted quotes that focused on perceptions of learners (e.g., views that faculty have about students’ abilities), classroom culture (e.g., views that faculty have regarding the classroom environment and feel), and student diversity (e.g., faculty perceptions regarding students’ different identities and experiences). After discussing our initial read-throughs and selected quotes, we determined that there were no discernable trends related to institution type or years of LA use. Because these two factors did not seem to have a substantial impact on instructor responses, we pooled all subsequent analyses for all instructors.

Analysis and Coding Scheme

We used a thematic, hierarchical coding approach utilizing Dedoose software (Dedoose, 2016), and the transcripts were analyzed using constant comparative coding (Creswell, 2013). Two members of the research team used capital, power, diversity, and inclusion as starting points and read a subset (n=6) of interviews and independently identified themes and quotes that supported those themes. The two research members who coded were connected to the larger
grant-funded project and were both well-versed in the themes via informal and formal education. We started with two umbrella themes and looked for subthemes under them. The two umbrella themes were: “How do LA-supported faculty perceive student diversity and classroom culture?” and “In what ways are LA-supported faculty facilitating inclusion and providing access to new capital for students?” These preliminary questions were chosen because we wanted to focus on faculty perception of student and the practices that were implemented in the classroom as a result of those perceptions. Within these two questions, faculty quotes were categorized into several emergent subtheme codes (see Appendix B for preliminary codes).

After the initial read of the subset of six interviews, the first author created a list of emergent subtheme codes that were written to be exclusive, precise statements. The two coders, then used that list and coded the subset of six interviews in Dedoose. The two coders then discussed their coding and edited the initial list of subthemes by adding additional themes that emerged and grouping related codes together in a way that aligned with the capital and power framework. The coders then coded the remaining 11 interview transcripts in Dedoose. The themes exemplified ways in which LA-supported instructors helped facilitate access and inclusion for students in their classrooms and codes underneath the themes provided deeper detail. The first major theme focused on ways instructors provided students access to capital and the second theme focused on how instructors renegotiated power differentials in their classrooms (Table 2.2).

Results

We include exemplars from our interviewed instructors to illustrate the range of instructor perspectives. For each of the two themes (capital and power), we present a description of the theme and codes followed by quotes and summaries.
Table 2.2. Coding scheme used to describe ways instructors provided students access to capital and renegotiated power. Numbers in parentheses represent the number of instructors who reported that action.

<table>
<thead>
<tr>
<th>Ways in which instructors perceive they facilitate access and inclusion for students</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Instructors provide students access to science education capital</strong></td>
</tr>
<tr>
<td>Instructors provide access to cultural capital</td>
</tr>
<tr>
<td>1. Instructors provide advice on how to succeed as a student (14)</td>
</tr>
<tr>
<td>2. Instructors showcase mannerisms and dispositions of experts (14)</td>
</tr>
<tr>
<td>3. Instructors make conceptual expert thinking explicit (13)</td>
</tr>
<tr>
<td>4. Instructors provide procedural expectations for activities and tasks (11)</td>
</tr>
<tr>
<td>Instructors provide access to social capital</td>
</tr>
<tr>
<td>1. Instructors help students establish positive relationships with other students,</td>
</tr>
<tr>
<td>LAs, and the instructor (15)</td>
</tr>
<tr>
<td>2. Instructors recognize students as science people/intellectuals (8)</td>
</tr>
<tr>
<td>3. Instructors provide opportunities for interactive learning in class (17)</td>
</tr>
<tr>
<td><strong>Instructors renegotiate power differentials among actors in the classroom</strong></td>
</tr>
<tr>
<td>Instructors are responsive to LA feedback</td>
</tr>
<tr>
<td>1. LAs have agency (13)</td>
</tr>
<tr>
<td>2. Instructors adopt LA suggestions (4)</td>
</tr>
<tr>
<td>Instructors are responsive to student feedback</td>
</tr>
<tr>
<td>1. Instructors elicit student feedback (9)</td>
</tr>
<tr>
<td>Instructors adopt new classroom roles</td>
</tr>
<tr>
<td>1. LAs are perceived as instructors by classroom actors (10)</td>
</tr>
<tr>
<td>2. Instructors are facilitators and not “sages on stages” (9)</td>
</tr>
</tbody>
</table>

Theme: Instructors Provide Students Access to Science Education Capital

This theme focuses on ways in which instructors perceived they were able to provide their students access to capital. The instructors strived to facilitate access, inclusion, and success for students who were in their classroom (Table 2). Because our framework focuses on capital and power as a means of disenfranchising underrepresented students, we describe ways instructors could and did provide capital to underrepresented students, so the students better understood the values, norms, and expectations of science culture. Instructors in our interviews provided examples that we linked under cultural capital and social capital.

Cultural capital
Fourteen of the 17 instructors reported providing access to cultural capital. The most common means of providing cultural capital was explicitly sharing advice regarding how to be successful students and showing the mannerisms and dispositions of experts. Thirteen of the instructors discussed making conceptual expert thinking explicit. Eleven of 17 instructors also provided cultural capital by discussing the procedural expectations of activities and tasks that happen in class (Table 2). The quotes below illustrate the varied ways instructors discussed practices that we view as providing access to cultural capital. We start with Biology Instructor A, who noted that he explicitly told students to shake hands with him at the start of their meetings and taught them about common mannerisms that would be important when they interview for medical and graduate programs:

My argument to them is, and I'm very transparent about this, that it's not fair, but I can't change the whole world. I just want to teach them simple, professional tricks that they can fake it until they make it, so they get into the door and get the job, and then what I ask of them is if they think that is unfair, which they should by the way, it's not ... We shouldn't just be reinforcing professional, upper middle class White people behavior all the time, but the system works that way. – Biology Instructor A

Biology Instructor A acknowledged that the scientific community was less accessible to individuals who may not think and act in the ways that were expected, and that there were implicit expectations and norms of academic and scientific behavior. This instructor gave access to cultural capital to his students by showing them simple things that experts in the field do and that they can do to seem more professional in scientific settings, which may facilitate their success in the professional science community.
Additionally, instructors provided access to cultural capital by making their thinking explicit. Students, as novices, are not familiar with expert ways to think about a topic and providing students with this context can help them be more successful in the future. Primarily, instructors made their thinking explicit to students when they linked concepts that students were learning in class to real life phenomena. This was done to show how they saw concepts connecting and why learning about these concepts mattered. We provide an example from Biology Instructor B, who used cancer to give her class a context on why studying cell division was important:

I will introduce cancer and then say, "What is cancer?" "It's a genetic mutation." "What's a genetic mutation?" Then we can talk about what that is. Then later on, how does cancer spread? It spreads through cell division. What's cell division? That's mitosis. We can talk about that. That's, I guess, how my thinking is … always trying to think of some kind of real-world topic that we can couch these different content issues that we have to learn about. – Biology Instructor B

Lastly, instructors provided access to cultural capital by providing procedural expectations for activities and tasks. By providing the “scientific how to” to students who may not know, instructors allowed students to more effectively participate in class and provided them with the norms of acting and behaving. Biology Instructor B explicitly discussed her procedural expectation for students who were doing clicker and discussion questions:

I tell them that, "Here's a question. Think about it, read it through and then talk to the people next to you. You can think about what your own answer is but then before you actually answer find out what the person next to you thinks, talk about it in groups and come up with what you think would be your consensus. – Biology Instructor B
Social capital

Almost all the instructors facilitated access to social capital by helping students establish positive relationships with each other, LAs, and the instructor. Being provided access to social capital enabled students to create networks of individuals that they then regularly talk to in class. These social networks may be important because they provide students with different experiences and perspectives that can enrich their own involvement with the scientific community and the general college campus and facilitate belonging (Grunspan, Wiggins, & Goodreau, 2014). Biology Instructor C provided an example of how establishing these positive relationships, especially with people who were more experienced, could help students pursue future endeavors. She provided an example of how one of her pre-dental students networked with an LA, who was also a pre-dental student:

‘Oh, I know that she's a pre-dental student and I'm interested in that. She would be a good person for me to talk to.’ I do observe [LAs] talking to students about other classes or about how to be successful as a pre-dental student, those sorts of things. – Biology Instructor C

In addition to establishing positive relationships with one another, some instructors offered access to social capital by recognizing students as science people who have novel insights. It was important for instructors to validate their students’ idea and acknowledge that students can contribute to the science community. Biology Instructor D supported that point:

I also like to do the large group discussion because sometimes people have really neat things to say and the whole class benefits from hearing another student give their perspective. I let students practice being vulnerable and speaking out loud in front of a lot of people. – Biology Instructor D

30
Because Biology Instructor D encouraged students to speak openly during large group discussions, the students may see that the instructor did care about what they have to say and acknowledged and validated their ideas. This may have created opportunities where students felt they belonged and created a space where students believed that they were capable of being science people.

All of our instructors voluntarily incorporated Learning Assistants into their course. The fact that they teach using LAs supported the notion that this sample of faculty members particularly valued learning as an interactive endeavor. Sixteen of our instructors explicitly acknowledged, in their interviews, that activities gave them and LAs opportunities to interact with students. Below is a quote from Chemistry Instructor A:

I literally see what they need, see what my students need so sometimes, I teach for a bit and then I say, "Hey, let's do small activity." Let's say short activities for five minutes long and make models. – Chemistry Instructor A

In this quote, Chemistry Instructor A showed her pro-active approach by facilitating activities at points in which she feels as though students are confused. Throughout her interview, she noted that these activities were group-oriented, and many students worked interdependently to complete the task.

Theme: Instructors Renegotiate Power Differentials Among Actors in the Classroom

Our next theme focuses on power and how instructors were able to renegotiate power differentials (Table 2). When we [the authors] operationalize traditional power differentials, we imagine a traditional lecture classroom in which most, if not all, of the power is constrained to the instructor. Renegotiating power gives agency to different individuals, such as LAs and students. This agency can be used to help facilitate changes that may make classrooms more
inclusive. Instructors were able to renegotiate the power dynamics in their classrooms by (1) being responsive to LA feedback, (2) being responsive to student feedback, and (3) adopting new roles in the classroom.

Fourteen of 16 instructors attempted to renegotiate power differences by being responsive to LA feedback. In most cases, this was done when LAs were given opportunities to critique lessons and give instructors advice. Further, LAs are in a unique position to give valuable feedback because they are students who have recently taken the course. As LAs, they were also required to take a pedagogy course (Otero et al., 2006; Talbot et al., 2015). In this capacity, they were more able to reflect on their own experiences with the course and provide meaningful feedback. The quotes below from Chemistry Instructor A and Physics Instructor A supported these points:

Yeah, absolutely, LAs communicate with me how they feel about the test or about the problem or about the chapter. LAs, I think they feel more comfortable saying stuff, students sharing with LAs stuff about the course… LAs are communicating that with me so, I think I have a better idea of how my students feel about the material. – Chemistry Instructor A

I would say, "Do I not encourage my students to go to the board often enough?" And my LA said, "Yeah, you should do it more often and more insistent," like these kinds of feedback. Or, do you think I'm going too slow, and the LA's would say, "Well, it's slow for me, but I am not sure about other students in the class because ..." And he would give me specific examples how this group needs it, but [another] group was completely ready to go. – Physics Instructor B
In the quote provided by Physics Instructor B, we explicitly saw that the feedback given to the instructor was instructor-initiated. These instructors explicitly asked questions about the class and the LAs were able to contribute their own thoughts on successes and improvements that can happen with the class. In quotes provided by Chemistry Instructor A and Physics Instructor B, instructors stated that they value LA feedback because LAs can give instructors the students’ perspectives on what is going on in the classroom. This might be because students may view LAs as near peers and were more likely to tell them about personal experiences in the classroom. As such, LAs were able to create reflection points for our instructors’ teaching by being a part of the feedback process.

Nine of 17 instructors also mentioned that they were responsive to direct student feedback in their classroom as well. This was important because it signifies that in some cases, students felt comfortable enough with the instructor to bring up their own concerns. Some of these classrooms were attempting to renegotiate power differences in ways that make students more comfortable to talk to those with more power (i.e., the teachers). Biology Instructor E discussed an example of how she received student feedback:

I do little question cards where I hand out note cards and have them anonymously write down questions or areas that are challenging to them. That's surprising lots of times because I get feedback from students who otherwise wouldn't speak up. – Biology Instructor E

In this quote, the instructor acknowledged that some students were reluctant to speak to her directly, implying that there was a power differential present (Eshach, Dor-Ziderman, & Yefroimsky, 2014). She successfully worked around this student tendency to avoid the professor by letting students write down questions anonymously that she can address at a later class. In this
way, she was able to hear voices that may not otherwise be heard. In this case, this instructor was more mindful that students may not want to interact with her directly and was able to circumnavigate it.

In addition to being responsive to feedback, one of the other ways in which instructors renegotiated power differentials was by changing the roles of some of the actors (instructors and LAs) in the classroom. This means that the instructor would play a less dominant role. Primarily, changes in roles in the classroom meant that LAs were perceived as instructors and that instructors saw themselves more as facilitators rather than lecturers. In some cases, instructors imply that they played the same roles that LAs do. The quotes below illustrate this point:

So the LA's in my class, they do two things. The first thing is that they circulate around the classroom during activity time and talk to groups. In fact, we usually have myself, a Graduate TA and some LAs - we have assignments essentially. Certain tables are assigned to us, and so we're supposed to make sure in particular that those tables are being productive and they're getting where they need to get. LA's do that, so that's what they will be doing most of the classroom. When we go into board meetings, what I've started to do in the last couple years is I have LA's run some of my circles. They lead that discussion. They monitor that discussion. – Physics Instructor A

[The LAs] will often check in with me at the beginning of class if they have a quick question about something. Then I'll do my little mini lecture, and we'll start working on a problem. I'm circulating, [the LAs are] circulating, they're answering questions, I'm answering questions. – Chemistry Instructor B

In the preceding two quotes, we noted that the instructors and LAs all performed the same roles during the activity time and moved through groups. By performing the same roles as
LAs, these instructors were more able to redistribute power in the classroom. The instructors, in this sense, showed that the knowledge the LAs had was valuable and that the LAs were equally capable of facilitating discourse among students.

In some of our cases, LAs were not given substantial leadership roles in the classroom and primarily were present as support. In these cases, the instructors did not renegotiate power and still held the primary position of power in the classroom. One example quote is given below. Chemistry Instructor C gave his LAs more administrative tasks that, while important to the classroom experience, did not create a shift in acknowledging and valuing the knowledge LAs brought into the classroom:

Okay, one LA ... I called her the top LA ... [worked with the] online course company. If there was any technical issues, she would contact them. One LA just transferred problems from the [course company] homework question bank to their homework [assignments]. – Chemistry Instructor C

While our instructors did not explicitly used their word “power” in their interviews, their actions showed that they, to some degree, understood that traditional power differentials were not conducive to creating an inclusive environment. As such, they tried to renegotiate power differentials to give agency to other actors, such as LAs and students. We believed that this was important because the inclusion of different perspectives was vital to being able to transform classroom spaces to be more inclusive.

Discussion

Overall, our findings from instructor interviews showed that they were able to provide access to science education capital and renegotiate power differentials in their classrooms through different approaches and to varying degrees. Their practices may have helped facilitate
access and inclusion for students in their classrooms because students were more able to (1) see how science operated and the expectations for and of those who are in science, (2) develop relationships with peers and experts that helped provide them with knowledge and opportunities, and (3) have agency in classroom contexts because power was renegotiated, which led to more student and LA input on classroom structure and culture. The changes in the classrooms that instructors described related to our theoretical framework because potential barriers from lack of science education capital and power were reduced, which allowed students to more fully participate in the classroom.

Providing access to cultural capital is imperative because, depending on a student’s background, the metric of success may be conditional on previous teachers’ expectations and the values of their previous institutions and communities (Hatt, 2007). For these students, their success in the classroom may be contingent on making sure that they know what individuals in the science community value in colleagues. The actions that instructors took, such as making expert thinking explicit or providing advice for success may have helped reinforce scientific values and norms in students who were unaware previously. We recognize that providing access to cultural capital is fundamentally flawed because it forces students to adhere to a “dominant culture” (i.e., White, middle class culture) (O’Shea, 2016). This shows that there was a hidden curriculum that had to be learned in addition to the content and that the instructors we interviewed were generally unaware of these dynamics (Bourdieu & Passeron, 1990). However, we acknowledge the attempts instructors did make to create a better student experience and note that some students were probably more successful because their classrooms provided skill sets that let them navigate existing systems.
Providing access to social capital was vital to facilitating inclusion because social networks of colleagues and friends were more able to understand someone’s struggles and make someone feel as though they belong (i.e., they feel like they are a part of the community) (Grunspan et al., 2014; Tanner, Chatman, & Allen, 2003). The instructors intentionally made sure to provide opportunities for students to build relationships. Previous studies have shown that building these social networks is important to feeling as though you belong to the community (Haberman & Yehezkel, 2008; Sandoval-Lucero, Maes, & Klingsmith, 2014). Further, having friends and colleagues who were further in their careers was important because they are more able to empathize and understand the demands of the discipline, such as described by Haberman and Yehezkel (2008). This was a particularly important point, especially with the LA program, because these peer instructors had previously taken the course before and can offer better insight.

In renegotiating power differentials, a majority of instructors in their interviews seemed to depend on LAs by soliciting feedback on how to improve the classroom experience for students. Talbot et al. (2015) previously concluded that LAs offer important context about students and student understanding about content. Instructors understood that LAs were more knowledgeable about student struggles because students LAs were near peers and students were less likely to critique the instructors directly because of differences in power. Previous literature has shown that conversations with near peers are important and can help facilitate student success in a course (Gardner & Jones, 2011; Hockings, DeAngelis, & Frey, 2008; Wheeler, Maeng, Chiu, & Bell, 2017).

Actively trying to elicit student feedback was also important in renegotiating power because the goals were to create better experiences for students. Because students were less likely to provide feedback, some of our instructors used different practices, such as note cards to
get feedback, in case students were not willing to talk to instructors directly. Power differentials are apparent in science and are known to influence participation of students (Sarah L Eddy, Brownell, & Wenderoth, 2014).

Lastly, adopting new roles in the classroom was especially important in LA-supported contexts because these spaces were meant to be transformed from traditional classrooms and more student centered (Walker & Shore, 2015). In changing roles, instructors redistributed power so that they were not at the top of the hierarchy. Instead, the responsibilities of learning and creating an inclusive classroom fell upon all the actors in the classroom. The trust that instructors had for their LAs to facilitate teaching was important to the renegotiation of power. LAs being seen by faculty as colleagues was important because it meant that these near peers of students held a vital role in the dynamics of a classroom. This was important because LAs are more central in the classroom when compared to students and the access to near peer role models can facilitate student success (Gardner & Jones, 2011; Hockings et al., 2008). In our larger project, we are working to more fully describe and define the LA roles in the undergraduate science classroom system. However, we saw that some instructors had trouble giving up that central role and adopting a more student-driven context. This showed that change can still be tough for instructors to break from prototypical paradigms and adopt a way of thinking that is more transformed (Wieman, 2007).

Conclusions

In this paper, we presented an inquiry regarding ways LA-supported instructors provide access to capital and renegotiate power in order to create facilitate inclusion in science education. We did find it surprising that we did not observe differences among faculty in different science disciplines (e.g., life sciences versus physical sciences) and at different institutions but noted that
underlying these different science disciplines are norms and values that operate in similar ways to one another.

Our findings suggested that LA-supported instructors were thoughtful about creating classroom spaces that provided students access to capital and that they renegotiated power to give LAs and students more agency. The practices that instructors adopted (e.g., group work, regular feedback from LAs and students) facilitated access to capital and did help create new norms in the classroom that renegotiated power and decentralized the role of the instructor, in most cases. In other cases, we found that instructors struggled to renegotiate power. We also found that the instructors were reflective about their teaching during the interviews, but many did not seem to have the space or resources to make significant changes in their classroom practice or at larger scales within their institutions or communities. However, many felt that LAs provided opportunities for transformation that would not have been possible in the absence of LAs.

We were excited to be able to interview LA-supported instructors on their practices and perceptions in the classroom using frameworks that focused on capital and power, as this is an area that has not been explored by LA programs. Through our work, we saw that there were opportunities for transformations that facilitated inclusion and access and believe that this is a rich area that warrants future resources and research. We believe that programs based off of the LA model are excellent frameworks in which instructors can promote and enact more practices that focus on inclusion and access for all students.
CHAPTER III

INVESTIGATING STUDENTS’ SCIENCE IDENTITY PRODUCTION IN INTRODUCTORY BIOLOGY COURSES

Abstract

Identity production is a complex process in which a person determines who they are via internal dialogue and sociocultural participation. Understanding identity production is important in biology education because students’ identities impact classroom experiences and their willingness to persist. As educators, we want to foster spaces where students can engage in producing a science identity that incorporates positive perceptions of who they are and what they have experienced. We used Holland’s theory of identity and Urrieta’s conceptualization of Conceptual Identity Production (CIP) and Procedural Identity Production (PIP) to explore the process of students’ science identity production. We interviewed 26 students from 5 sections of a general biology course for majors at one higher education institution. The interview protocol included items about students’ identities, influential experiences, perceptions of science, and perceptions of their classroom community. From the interviews, we developed hierarchical coding schemes that focused on characterizing students’ CIP and PIP. We described how students’ socially constructed identities (race, gender, etc.) and their experiences may have impacted the production of their science identities. We found that authoring (i.e., making meaning of) experiences and recognition by others as a community member influenced students’ science identity production.

Introduction

Identity is a complex construct that can be thought of as having both socially constructed (e.g., race, ethnicity, gender identity) and experiential (i.e., perceptions of lived experiences)
components. Identity is important in science because of the general perception held among students that one must be a “certain kind of person” to participate in science (Calabrese Barton, 1998). However, what does it mean to be that “certain kind of person”? Do we assume that someone should be intelligent to participate in science (Lemke, 1990; Schinske, Cardenas, & Kaliangara, 2015)? Does that “certain kind of person” happen to be a White male or Asian (Carlone, 2004; Carlone & Johnson, 2007; McGee, Thakore, & LaBlance, 2017; Museus & Kiang, 2009; Riegle-Crumb & King, 2010; Walls, 2012; Yu, 2006)? Educators should foster spaces where undergraduate science students can develop identities in which they see themselves as science people. This is in light of evidence that students’ identities impact their classroom experiences and willingness to persist in science (Sarah L. Eddy, Brownell, Thummaphan, Lan, & Wenderoth, 2015). Identity is difficult to study because of the complexities of defining who we really are and how we come to see ourselves as certain types of people (Aschbacher, Li, & Roth, 2010; Brickhouse, 2001). This speaks to the fact that our identities are working at the individual level (e.g., what we internalize, how we construct our sense of self), interactional level (e.g., how we are othered, what expectations people have of those with our identities) and institutional level (e.g., how resources are distributed across different identities, how identities are impacted by organizational practices) (Risman, 2004). The variety of experiences at these different levels impacts the sense of and creation of self. In other words, differences matter because they affect how we view ourselves as science people and how easily we can form authentic science identities (i.e., identifying oneself as a member of the scientific community) (Brickhouse, Lowery, & Schultz, 2000; B. A. Brown, 2004, 2006; Hazari, Sadler, & Sonnert, 2013).
The current literature base recognizes that the discourse, norms, community interactions, roles, and responsibilities that are apparent in science classrooms may influence students’ identity production (Engeström, 1987) and are historically and socially constructed (Avraamidou, 2016, 2018a; Carlone, 2004; Carlone & Johnson, 2012). For example, Carlone (2004) studied how female high school students’ participation in science impacted their science identities. She explicitly recognized how sociohistorical meanings of school science (e.g., being perceived as smart and attaining good grades) can impact how students connect with science and recognize themselves as “science people”. In her study, the emphasis on good grades perpetuated students’ disconnect with the nature of science. Traditional sociohistorical meanings of science were also relevant in a study of Korean students in an Advanced Placement biology classroom. Students centered their science identities around performing well on assessments and participating in classroom discussions in English (Ryu, 2015). Just like in Carlone’s (2004) study, students’ science identity formation emphasized receiving good grades and knowing answers. Another study conducted by Carlone et al. (2014) showed that students struggled to construct a personal and meaningful science identity in traditional science courses that emphasized rote learning. Carlone et al. (2014) also concluded that pedagogy that incorporated scientific practices like those expected of scientists in the community (e.g., providing explanations, data analysis and interpretation, building models) resulted in more positive science identities because performing these tasks allowed students to view themselves more as science people. These cases illustrate how community norms and student experiences in classes impact their science identities.

For educators focused on educational equity and inclusion, understanding students’ identities and their subsequent lived experiences is vital to transforming classrooms into spaces
where students can thrive (Brickhouse et al., 2000; Carlone et al., 2014; Trujillo & Tanner, 2014). Understanding student identities and experiences allows us to recognize and problematize existing discourses that hinder student access to the science classroom community. One example of a prevailing discourse is deficit thinking, or the conception that some students are more likely to perform better than others based on a socially constructed identity, such as race or gender (Le & Matias, 2018; McGee & Martin, 2011; Settlage, 2011). Though many educators can recognize and articulate how this can be dehumanizing to students, the unconscious enactment of institutionalized and organizational norms inadvertently reproduces some of this deficit thinking (Bourdieu & Passeron, 1990; Carlone & Johnson, 2012). Scholars argue that we can make science education more accessible to all students by challenging norms, understanding who students are, and re-imagining how their identities can operate in a science world (English & Bolton, 2015; Freire, 1970). Our work aims to increase the knowledge base surrounding undergraduate student science identity production by examining that construct in introductory biology classes.

Using Holland et al.’s (1998) theory of identity production as a framework, we described students’ conceptions of who they are, their goals, their practices in the classroom, and the resulting science identity production. We emphasize that the focus of our work was not on describing students’ current science identities during an introductory biology course. Rather, we focused on the ongoing production of a student’s science identity through an introductory biology course.

In the remainder of the introduction, we briefly review literature related to identity and focus on how personal experiences and recognition impact identity production. Next, we introduce figured worlds as described by Holland et al. (1998) and, more specifically, how
figured worlds impacts identity production. Finally, we provide an overview of other identity frameworks and discuss why we chose to use figured worlds.

Defining Identity

Identity is a complex construct and is defined and conceptualized in different manners. Colloquially, we think of identity as a conception of who we are and who others believe us to be. Identity scholars have also thought of identity in different ways. For example, Gee (2000) defines identity as “being recognized as a certain ‘kind of person,’ in a given context” (p. 99). Nasir and Saxe (2003) state that identities “are not located solely in the individual, but rather are negotiated in social interactions that take form in cultural spaces” (p. 17). Authors such as Avraamidou (2018a) and Lave and Wegner (1991) situate understandings of identity within a person’s lived experiences. Other constructs view identity as socially constructed components of who we are, which may include gender identity, race, ethnicity, sexuality, and ability. Additionally, identity may be context specific and how we define ourselves at work may or may not be how we define ourselves in other settings (Trujillo & Tanner, 2014). We acknowledge the intricacies of identity and recognize that identities go beyond the labels that people can place on themselves or others. Identities are formed by the environments in which we exist, the people with whom we interact, and the histories that shape the communities in which we belong (Avraamidou, 2016; Rubin, 2007; Urrieta, 2007a). The science classrooms in which students reside operate with unspoken norms and rules regarding who and what are valued, and that context will impact the science identities that students construct. We define identity using Holland et al.’s (1998) conception, which is the sense-making process of determining who a person is via internal dialogue and sociocultural participation.
In framing this study, we focused on students’ science identity production, and we acknowledge the importance of intersectionality in describing how students’ science identities form. Intersectionality describes the inseparability of different components of our identities (e.g., race, gender, ethnicity, sexuality, etc.) (Avraamidou, 2018b; A. Johnson, Brown, Carlone, & Cuevas, 2011). All of these identities interplay with one another and result in unique experiences that are not additive (Hazari et al., 2013; A. Johnson et al., 2011). For example, the experiences of being female and the experiences of being Black do not necessarily mirror or parallel the experiences of being a Black female. Therefore, we holistically recognize the importance of students’ identities.

Current Literature on Science Identity: the Roles of Experiences and Recognition

Identity production is an ongoing process, and the science identities that individuals produce are dependent on the experiences that either support or destabilize how they may perceive of themselves in science (Robinson, Perez, Nuttall, Roseth, & Linnenbrink-Garcia, 2018). For example, Robinson et al. (2018) concluded that one’s perception of competency in science was a significant predictor of maintaining a robust science identity. Varelas, Martin, and Kane (2012) showed that students make meaning based on the experiences and support that they had in school. These experiences affected how students viewed themselves in science and mathematics. Martin (2006) described racialized experiences in mathematics and how negative experiences can destabilize a student’s perception of their own ability in learning and identifying with that community. Jackson and Seiler (2013) conducted a study which illustrated that authentic engagement (or lack thereof) in the culture of college science resulted in some nontraditional students either continuing in science or leaving science. The experiences of an individual are important in identity production because the individual authors or defines their
experiences and internalizes what the experiences mean to them (Holland et al., 1998).

Therefore, if students have had poor previous or current experiences in science, the way in which they are authoring these experiences may result in an aversion to science later in their lives.

In addition to authoring experiences, another component of the identity framework described by Holland et al. (1998) suggests a social component to identity production. This social component, also posited by other scholars (e.g., Carlone & Johnson, 2007; Lave & Wenger, 1991), highlighted the importance of being recognized as a science person by others in the community. Carlone and Johnson (2007) studied the experiences of women of Color in science and noted the importance of being recognized as a science person. Chapman and Feldman (2017) studied an urban high school science classroom and highlighted that students’ science identities are not only affected by recognition by others but self-recognition of oneself as a science person. Another study with Latino male college students founded the same results, noting that recognition by others, typically through doing well on assessments, and self-recognition fostered the development of a science identity (Lu, 2015). Being recognized as a science person and recognizing oneself as a science person is a significant component of identity production because this recognition facilitates a sense of belonging that strengthens a person’s sense of who they are in a community, in this case, a science person in a science community (Carlone & Johnson, 2007; Wenger, 1998).

The examples above illustrated how personal authored experiences and recognition by self and others may impact the production of a science identity. Many of the studies above only offered snapshots of identity. However, we acknowledge that research into identity production generally recognizes that identities are dynamic and in constant flux (Holland et al., 1998). Like Urrieta (2007b), we focus on students’ sense of becoming and not being. This is because
identities are constantly being re-imagined and re-constructed and should not be thought of as a final product. Identity production is influenced by culture and mediating artifacts (i.e., the tools and symbols used by members of a community) and therefore, can change depending on the meanings that individuals give to different past and current experiences (Price & McNeill, 2013). These get internalized and shape the reality of the student’s experience and consequently, their identity. In this paper, we work from the premise that science identity has no endpoint and is multidimensional, relational, and impacted by cultural, historical, and social institutions of a time and place (Avraamidou, 2018a).

Identity within Figured Worlds

We grounded our understanding of students’ science identity production using Holland et al.’s (1998) theory of identity within figured worlds and Urrieta’s (2007b) operationalization of Holland’s theory using conceptual identity production (CIP) and procedural identity production (PIP). Holland et al. (1998) defined figured worlds as “socially and culturally constructed realm[s] of interpretation in which particular characters and actors are recognized, significance is assigned to certain acts, and particular outcomes are valued over others” (p. 52). Figured worlds have four characteristics (Holland et al., 1998; Urrieta, 2007b). Figured worlds

1. represent a cultural and historical phenomenon in which the world develops and changes because of who is participating. Figured worlds are based on historical traditions that impact culture. This culture can change with time depending on what norms and values people uphold. This means that people are impacted and influenced by the figured world, but the figured world is also impacted and influenced by people.

2. have specific sets of meaning in which where and when the actions and activities conducted by people of different positions are significant. There are particular ways to do
and communicate in the *figured world*, and what we do has meaning. What we do demonstrates how we are situated within the *figured world* and that some individuals may have more agency and power than others.

3. are socially produced and reproduced. Norms and power differentials influence how people sort and relate to one another (Bourdieu & Passeron, 1990). This means that each *figured world* has norms and values that impact how individuals act. These norms and values are historically situated and reinforced by generations of individuals before us.

4. distribute “us” by allowing us to fashion stories from personal experiences that we bring to other *figured worlds*. This emphasizes the ability of people to “author” and make sense of their own experiences.

These characteristics mean that each *figured world* has norms, practices, and discourses that are socially and historically constructed and given meaning by the people in those *figured worlds*. Individuals within these *figured worlds* participate and construct identities to navigate these spaces and contexts (Chang, 2014). These identities, however, are impacted by systems-level meanings of a science person that are culturally and historically produced. This makes *figured worlds* a useful framework to learn how, in a particular setting, the identity production process can take place (Rubin, 2007). In our conceptualization of *figured worlds*, we focus on the people (i.e., the “figures”) and how their histories and engagement in a localized *figured world* (i.e., the science classroom) influences their process of becoming science people.

Given the complexities of conceptualizing the full extent of *figured worlds*, Urrieta focused on identity formation via CIP (Conceptual Identity Production) and PIP (Procedural Identity Production) within these *figured worlds*. CIP refers to the students’ conception of who they are and who they want to be (Holland et al., 1998; Urrieta, 2007b). This is a mental process
in which students consider their socially constructed identities, lived experiences, and aspirations and how those impact their conceptions of their science identity. PIP refers to “the performance” or “the practice” of their science identities (Alexander, Anderson, & Gallegos, 2004; Urrieta, 2007b). In PIP, the students engage within their scientific community socially, culturally, and intellectually. The responses that they get from other actors in the community (e.g., professors, peers) as they engage in tasks and conversations impact their conceptions of their science identity.

CIP and PIP are not isolated but are incorporated into a culture with history, norms, and structures (i.e., the figured world). Like Urietta (2007b), we posit that, through students’ interactions and experiences in the figured world, they are able to re-imagine who they are and construct an identity (in this case, science identity). The manner in which a student authors their identity is related to the students’ subjective experience and personal participation in the cultural activity (i.e., learning science knowledge and discourse).

Relating CIP and PIP to Other Identity Frameworks

Though Holland et al. (1998) and Urrieta (2007b) utilized CIP and PIP in describing the elements of identity production within figured worlds, there has not been empirical work beyond the theorizations and considerations that Holland et al. and Urrieta have provided. We sought to advance research in this area by applying this theorization of identity production to a science classroom context. There have been scholars who do not explicitly use CIP and PIP but still use identity frameworks that parallel the constructs of CIP and PIP. For example, Holland et al.’s original framework was influenced by Lave’s and Wegner’s communities of practice (Lave & Wenger, 1991; Wenger, 1998). Communities of practice describes the engagement of individuals within a community that has explicit goals and ways of being and negotiating meaning.
Individuals who are novices engage and practice with tasks that are deemed important to the community of practice. Through “legitimate peripheral participation”, novices master the ways in which experts understand, interact, conceptualize, and communicate within a socially constructed context that is significant to the members of that community (Lave & Wenger, 1991; Wenger, 2000).

Lave and Wegner describe identity development as intertwined with the community of practice. As novices (in our case, students) engage with the day-to-day phenomena and norms of the community, they internalize and continually conceptualize who they are within the community. Ultimately, cultural elements of the community of practice may shape how students interact with others, what students value, and how they feel they belong (Lave & Wenger, 1991). This idea of “practice” and engaging with a community culturally is directly associated with PIP because students’ identity formation is linked with how well they feel they can develop an identity that parallels the norms and values that are inherent within a community of practice.

Cobb, Gresalfi, and Hodge (2009) studied student identities formed in mathematics education and proposed the constructions of normative identity and personal identity. Normative identity describes the student as a doer of mathematics and how being a doer requires understanding the social structure and norms of the classroom. This parallels PIP in that the “doers” are performing their mathematics identity and engaging in the culture of mathematics education developed by that classroom (Holland et al., 1998). Personal identity describes how students identify with the obligations required in the classroom (Cobb et al., 2009). Holland et al. (1998) noted that the activities and individual decisions that occur are used “to understand and organize aspects of one’s self and at least some of one’s own feelings and thoughts” (p. 121). In
other words, the activities of a classroom aid in the self-making process of identity production, which parallels CIP and PIP.

Carlone and Johnson (2007) studied the experiences of successful women of Color in science, and their model for science identity included performance, recognition, and competence. Their conception of performance related to social performance and being able to interact with other individuals and artifacts in sophisticated ways, which parallels the conception of PIP (Holland et al., 1998; Urrieta, 2007b). Recognition described the ability to recognize oneself as a science person and for others to recognize you as a science person, which can be done through interaction with others (Carlone & Johnson, 2007). Competence referred to the mastery of scientific conceptual knowledge, which is done by purposefully engaging with scientific content. In our further theorization of PIP, we referred to this as engaging with science intellectually.

All of the above described identity frameworks have merits for studying science identity. They capture the importance of “performing” a science identity and acknowledge the social components of identity production. However, many do not readily consider understanding institutional and cultural norms and personal histories and experiences, likely because of the inherent complexity in operationalizing those concepts. Carlone (2012) recognized this deficit in the science education literature and noted that focusing just on agency and participation is not enough because the self-making process is affected by social structures that impact how we make meaning of our experiences. Ultimately, we chose CIP and PIP within figured worlds as our framework because we wanted a framework that not only highlights the “performance” but better conceptualizes culture and emphasizes the ways in which socially constructed identities and experiences intersect and impact identity production (Holland et al., 1998; Urrieta, 2007b). We wanted a framework that more fully acknowledged socially constructed identities (e.g., gender
identities, racial identities, and ethnic identities) and the social, cultural, and institutional histories that undergird social constructed identities. By doing so, we validate the experiences articulated by the students who participated in the study and begin to understand how students’ perceptions of these experiences aid in figuring out who they were in the figured world (Holland et al., 1998)

Using Figured worlds as the framework and student interviews as the data source, this paper addressed the following research question: How does Conceptual Identity Production and Procedural Identity Production inform the production of students’ science identities?

Methods

In the methods, we describe the interview protocol we developed to address the question. We then describe our context, study participants, selection criteria, and data analysis in the following subsections. This research was approved by the local Institutional Review Board (IRB #14-0028).

Interviews

Students (n = 26) participated in 30-minute interviews during the middle of Spring 2017, Fall 2017, or Spring 2018 semesters. No attempt was made to generalize across instructors or semesters, but we sampled from a large number of sections to get a cross-section of students in different classroom contexts. Interviews were conducted either by author PL or author ANT. PL and ANT were graduate students and were not part of the instructional team in any of these courses. We wanted to acknowledge that the visible socially constructed identities of the two interviewers may have influenced the responses given by interviewees. We used semi-structured interviews and broadly focused on identities, past experiences, perceptions of science, and classroom community (our interview protocol is available in Appendix C). Questions from the
interview protocol were asked verbatim, though members of the research team often asked
students to explain or expand on lived experiences students discussed in order to get more
context for interpretation of the student’s response. All questions were asked of students during
the interview, and questions were repeated or clarified if students requested. If students were
confused, we clarified questions by first using the example (e.g.) statements in the protocol and
then by explaining the framing of the question to the student if necessary. Students also had the
option to not answer questions in the interview and could tell us if the preferred not to answer a
question. No student stated that they did not want to answer any of the questions.

To facilitate discussion regarding identity and to prime students to think of identity
throughout the interview, each interview started off with a card sort activity. Card sort activities
are common in educational research and vary depending on discipline and purpose, but are
generally used to facilitate communication and reasoning with participants (Berryhill,
Herrington, & Oliver, 2016; Schoenfeld, 2015). In our activity, students were given 21 pre-made
identity cards and a stack of blank cards. Their task was to choose pre-made cards with which
they identified (available in Appendix D), to write additional identities they felt were important
to them on blank cards, if desired, and rank their cards from most to least important to them.
Conceptualizing identity is abstract and difficult to think about in the moment. We believe that
students’ responses may have been different had they been given time to think about questions
prior to the interview or if we had prompted them with other activities than the card sort.

The interviewer then asked questions regarding the student’s reasonings for their top-
ranking identity (e.g., “Why did you decide to put daughter first?”) as well as their placement (or
lack thereof) of a “Science Learner” card. Since we were looking at a snapshot of their
production of a science identity, we decided to go with “Science Learner” in lieu of other
identifiers (e.g., science person, scientist, etc.) given that they were currently taking introductory science courses. Additionally, pilot interviews with six students, who were not part of the final sample of 26, indicted that identifiers, such as “scientist” or “science person” were not used by students because they felt that their content knowledge was insufficient to be considered a “scientist” or “science person”. Though the card sort included “science learner”, we still use the terms science person or science identity in the results in discussion because we were interested in the process of science identity production and not in describing who students are as science learners.

Next, students were asked questions regarding their past experiences and perceptions of science. We then asked questions regarding classroom community, and these questions were tailored to parallel students’ responses on the Classroom Community Scale (described more fully in Context and Participants). Students were asked to reflect on their responses to several items on the scale and share personal classroom experiences. Lastly, students were asked to provide descriptions of what they believe a positive classroom could look like. Our goals for the interview were to capture student perceptions of their socially constructed identities and of the classroom and to understand how all of their past and current experiences impacted their sense of who they are in science contexts. All the interviews were audio recorded and transcribed using Trint (https://trint.com/services/). Student names were changed after transcription for confidentiality.

Context and Participants

Data were collected from an institution in the central United States between spring semester 2017 and spring semester 2018. The institution’s undergraduate population is approximately 56% White students and 44% racial minority students (Approximately 21%
Hispanic/Latinx, 10% Asian, 5% Black/African, 8% Mixed/Unreported). This study focused on five introductory biology courses taught by five different faculty members at the institution (two in spring 2017, two in fall 2017, one in spring 2018). Each course was approximately 120-175 students. Instructors in all five courses utilized active learning tasks, such as clickers, think-pair-shares, and/or worksheets; we provided examples of tasks because they were readily referred to during students’ interviews and a part of their identity production. Four of the five courses included traditional lecture. Four of the five courses also incorporated Learning Assistants (LAs), which are undergraduate students who help facilitate interaction and discussion during classroom tasks (Talbot et al., 2015). Recruited LAs closely mirror classroom demographics and receive pedagogical training their first semester (more information can be found at: https://www.learningassistantalliance.org). We provide this context because students in the interview reflected on classroom experiences and interactions that sometimes included LAs.

All students in the institution’s introductory biology courses completed the Classroom Community Scale (CCS) (Rovai, 2002) as part of a larger research project. The CCS is a 20-item Likert-scale survey that asks students about their perceptions regarding classroom climate, interactions, and norms. We used the CCS to gain insight into the social and learning components that occur in classrooms. We did not analyze class level responses from this survey. We used the CCS as a way to select a cross-section of students to interview, and further, the interview protocol referenced student responses to specific items (example statement to student available in Appendix C). This survey was given in class during week eight of the semester because classroom norms and routines were likely established by that time. We combined student responses to survey items related to affect (e.g., sense of belonging, trust, care) with demographic data (e.g., gender identity, ethnicity, age) and purposefully selected a variation of
students of different demographics and perceptions to e-mail, recruit, and interview. We e-
mailed White students and students of Color of different gender identities who we perceived
answered positively, neutrally, or negatively to CCS items related to affect in order to interview
a variation of students who perceived the classroom in different manners. Selected students were
directly e-mailed by a member of the research team and asked to participate. Students were
informed that their responses were confidential and that their instructor would not have access to
any of the interviews. Two follow-up e-mails were sent to students who did not respond. We e-
mailed 95 students total, and our final sample included 26 students, for a response rate of
approximately 27% (basic information about interviewed students available in Table 3.1). We
recognize that there was a volunteer bias with the study because many students who were
contacted did not reply to our e-mail. As such, the variation we observed may have only captured
a small portion of the possibilities. Students who participated were interviewed during the same
semester they took the course and compensated with a $10 USD gift card for their time.

Table 3.1. Student reported gender identity, race/ethnicity, and major. Reported demographic
data must be explicitly stated during the interview to be included. Students who did not report
declared majors at the time of the interview were classified as “N/A”. *These students reported
being from Sudan **This student reported being from South Africa ***This student reported
being Middle Eastern

<table>
<thead>
<tr>
<th>Student</th>
<th>Gender Identity</th>
<th>Race/Ethnicity</th>
<th>Major</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alice</td>
<td>Female</td>
<td>Black*</td>
<td>Nursing</td>
</tr>
<tr>
<td>Alli</td>
<td>Female</td>
<td>Asian</td>
<td>Nursing</td>
</tr>
<tr>
<td>Amanda</td>
<td>Female</td>
<td>White</td>
<td>Psychology</td>
</tr>
<tr>
<td>Brandy</td>
<td>Female</td>
<td>White</td>
<td>Public Health</td>
</tr>
<tr>
<td>David</td>
<td>Male</td>
<td>Asian</td>
<td>N/A</td>
</tr>
<tr>
<td>Ethan</td>
<td>Male</td>
<td>White</td>
<td>Nursing</td>
</tr>
<tr>
<td>Hala</td>
<td>Female</td>
<td>Black*</td>
<td>N/A, pre-Pharmacy</td>
</tr>
<tr>
<td>Henry</td>
<td>Male</td>
<td>Asian</td>
<td>Business</td>
</tr>
<tr>
<td>Isaac</td>
<td>Male</td>
<td>Black**</td>
<td>Biology, pre-Medicine</td>
</tr>
</tbody>
</table>
Table 3.1 cont’d. Student reported gender identity, race/ethnicity, and major. Reported demographic data must be explicitly stated during the interview to be included. Students who did not report declared majors at the time of the interview were classified as “N/A”.

<table>
<thead>
<tr>
<th>Name</th>
<th>Gender</th>
<th>Race/Ethnicity</th>
<th>Major</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jason</td>
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<td>White</td>
<td>Biology, pre-Medicine</td>
</tr>
<tr>
<td>Joscelin</td>
<td>Female</td>
<td>Latinx, Hispanic</td>
<td>N/A</td>
</tr>
<tr>
<td>Kaitlyn</td>
<td>Femme Gender Nonconforming</td>
<td>Asian and White</td>
<td>Biology, pre-Medicine</td>
</tr>
<tr>
<td>Karen</td>
<td>Female</td>
<td>White</td>
<td>Biology, pre-Pharmacy</td>
</tr>
<tr>
<td>Kayleigh</td>
<td>Female</td>
<td>White</td>
<td>Public Health</td>
</tr>
<tr>
<td>Lorenzo</td>
<td>Male</td>
<td>Latinx, Hispanic</td>
<td>N/A</td>
</tr>
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<td>Mai</td>
<td>Female</td>
<td>Asian</td>
<td>N/A</td>
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<td>White</td>
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<td>White</td>
<td>N/A</td>
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<td>Sally</td>
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<td>N/A, pre-Physical Therapy</td>
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<tr>
<td>Yulia</td>
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<td>Latinx, Hispanic</td>
<td>Public Health</td>
</tr>
</tbody>
</table>

Analysis and Coding Frameworks

We were interested in the variation of ways in which students conceptualize and create a science identity and how CIP and PIP impacted the production of their science identities. CIP and PIP are based on the theoretical framework of figured worlds, and our coding framework expands on theory by developing descriptors that describe how we saw CIP and PIP manifesting in the data.

We conducted thematic analysis and constant comparative coding (Creswell, 2013; Richards & Richards, 1995) utilizing Dedoose software (Dedoose Version 7.0.23). One member of the research team read all the transcripts and created preliminary descriptors related to CIP and PIP based off of students’ responses during the interview. These preliminary descriptors
focused on students’ self-making (how they construct identities) and sense-making (how they make sense of what happens in their worlds) regarding who they were and their experiences in the classroom. Primary codes were derived from the figured worlds framework. Secondary and tertiary codes were derived from the interviews. All authors engaged in a systematic coding process, which started off with coding two transcripts as a group to familiarize the research team with CIP and PIP and amending codes to better operationalize identity production. After, three of the authors (PL, LD, and ANT) coded two new sets of two interviews (four new interviews total), with discussion of coding after each set. After the first set of interview transcripts, these codes went through several iterations to create more distinctive categories, and we achieved >90% coder agreement (e.g., PL, LD, and ANT marked quotes with the same descriptors >90% of the time) by the last set. Three authors (PL, LD, and ANT) split the remaining transcripts and coded independently. To ensure inter-coder agreement we randomly selected one individually coded transcript from PL, LD, and ANT for further coding by the other two coders. Coding agreement was again >90%. The codes were organized into two hierarchical coding schemes (Creswell, 2013). In hierarchical coding, some codes may act as umbrella codes under which other codes fall. One coding scheme focused on CIP and organized descriptors under theoretical constructs that provided evidence to conceptualize CIP. The second scheme focused on PIP and was organized in the same manner.

Results

The research question focused on the roles of CIP and PIP in facilitating the production of students’ science identities. All of the interviewed students had unique experiences and ways in which they identified themselves. While we have highlighted illustrative instances from student interviews, our results are not meant to be generalized because it is plausible that
students who are at other institutions that have different cultures and distinct classroom contexts will have different experiences and make unique meanings of them. We also did not feel it appropriate to make inferences about differences among students in different sections of the course. Rather, we wanted to describe the variation in student responses and how they make meaning of their experiences and how that informed the production of their science identity. We want to again emphasize that we view identity production as a dynamic and constant process and acknowledge that students’ views of themselves as science people will undoubtedly change as they progress through their schooling and experience new courses and opportunities. In our results, we describe findings for CIP first and then PIP. After, we present ways in which components of CIP and PIP interplayed to facilitate identity production.

Conceptual Identity Production

CIP illustrated that students engaged with the process of conceptualizing who they were and who they wanted to be (Table 3.2). When respondents articulated who they were, they made meanings of past and current lived experiences (e.g., familial, school, etc.). The meaning given to these lived experiences appeared to be impacted by students’ socially constructed identities, such as being female or an immigrant. When students articulated who they wanted to be, they discussed their goals and aspirations. Some students also discussed their reasons for taking the biology course and offered short and long term goals that relate to future aspirations. We viewed students that had concrete goals as those with a clearer direction, which better informed their CIP. Other students either stated that they did not have clear goals or did not answer the question. Exemplars are available in Table 3.3.
Table 3.2. Coding scheme to understand the process of student identity production.

<table>
<thead>
<tr>
<th>Student Identity Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students engage in conceptual identity production (CIP)</td>
</tr>
<tr>
<td>• Students conceptualize who they are</td>
</tr>
<tr>
<td>o Students are shaped by their stories (e.g., familial experiences, school experiences, co-curricular experiences)</td>
</tr>
<tr>
<td>o Students have socially constructed identities that impact their lived experiences</td>
</tr>
<tr>
<td>• Students conceptualize who they want to be</td>
</tr>
<tr>
<td>o Students have clear long-term goals and aspirations</td>
</tr>
<tr>
<td>▪ Students reiterate short-term goals related to long term goals</td>
</tr>
<tr>
<td>o Students do not report clear long-term goals and aspirations</td>
</tr>
<tr>
<td>Students engage in procedural identity production (PIP)</td>
</tr>
<tr>
<td>• Students engage with science intellectually</td>
</tr>
<tr>
<td>o Students participate in course-related activities</td>
</tr>
<tr>
<td>o Students participate in non-course-related activities</td>
</tr>
<tr>
<td>• Students engage with science culturally</td>
</tr>
<tr>
<td>o Students voice elitist and/or exclusive discourses</td>
</tr>
<tr>
<td>o Students voice inclusive discourses</td>
</tr>
<tr>
<td>• Students engage with science socially</td>
</tr>
<tr>
<td>o Students interact with students, LAs, and their instructor</td>
</tr>
<tr>
<td>▪ Students interact around science material</td>
</tr>
<tr>
<td>▪ Students get to know other actors personably</td>
</tr>
<tr>
<td>o Students want opportunities to interact but do not have them</td>
</tr>
<tr>
<td>o Students choose not to interact with others</td>
</tr>
<tr>
<td>o Students have perceived leadership roles in class</td>
</tr>
</tbody>
</table>
Table 3.3. Exemplar quotes regarding Conceptual Identity Production.

<table>
<thead>
<tr>
<th>Students engage in CIP</th>
<th>Example Quote</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students conceptualize who they are</td>
<td>Also, we took, back in Africa, that's probably like 2009 or something - we took this field trip to the forest. We were experiencing nature and all of those surroundings and all that, it was just really beautiful, a beautiful Saturday. I love nature. (Isaac)</td>
</tr>
<tr>
<td>Students conceptualize who they are</td>
<td>I mostly come from a science background. My parents and my family are all in science, and I started learning through that way (Vajra)</td>
</tr>
<tr>
<td>Students conceptualize who they are</td>
<td>The biggest experience for me in science would be junior year [Advanced Placement] biology. I went into that class thinking that I was going to ace it because I love biology so much, but little did I know that I would struggle a lot in biology because I've never taken biology before and I just started biology. I struggled a lot in that class. (Hala)</td>
</tr>
<tr>
<td>Students have socially constructed identities that impact their lived experiences</td>
<td>[I put Latina as my top identity] because my dad is from Brazil. He's an immigrant, so like it's really important to me. I go to Brazil every year. I speak Portuguese. I studied there many times so it's important to me. (Valeda)</td>
</tr>
<tr>
<td>Students conceptualize who they want to be</td>
<td>Long term, hopefully getting through the pre-med track and you know and end with a strong [GPA] and get into medical school. (Yasar)</td>
</tr>
<tr>
<td>Students conceptualize who they want to be</td>
<td>[The] short term goal is to pass all of my classes with A's, you know. Doing well on the midterms, or the finals I should say, because I'm at that borderline risk, you know. I'm working on them. (Yasar)</td>
</tr>
<tr>
<td>Students conceptualize who they want to be</td>
<td>I don't really have a future goal right now, but [sic] I'm taking psychology class right now with biology, so the biology we can relate to psychology. (Henry)</td>
</tr>
</tbody>
</table>

During the interviews, some students reported past lived experiences that strengthened their ideas of who they are and who they want to be. This is because their lived experiences helped them see the application of science and invoked feelings (positive or negative) towards the subject. Some of these lived experiences included past careers, past and current school experiences, and familial influence. Additionally, students’ reflections of their lived experiences
coincided with explicit considerations of their socially constructed identity, such as how their gender identity and race/ethnicity may have intersected with their lived experiences. For example, interviews with some students of Color contained detail about building community with other students of their race and ethnicity, and some discussed the difficulties they faced as minority groups in science. Finally, some students explicitly mentioned short and long-term goals while some students were less clear about goals when prompted. Some students were more explicit and had a better understanding of the requirements and the work that had to be done in order to achieve their goals.

Procedural Identity Production

In the PIP coding tree, we recognized that students performed their science identities by engaging with science intellectually, culturally, and socially (Table 3.2). When students engaged with science intellectually, they regularly participated in course-related activities, such as completing classroom clicker questions or worksheets, or non-course related activities, such as attending museum events or watching science films. Students who engaged with science culturally started to understand and embody the norms and values of a scientific figured world. These may include adopting traditional science discourses that are commonly seen as elitist (e.g., science is only meant for the smartest) or re-imagining science to be more inclusive (e.g., anyone can be a scientist). Lastly, students who chose to engage with science socially may regularly interact with actors in a classroom, such as other students, the instructor, and Learning Assistants. Exemplars are available in Table 3.4.
Table 3.4. Exemplar quotes regarding Procedural Identity Production.

<table>
<thead>
<tr>
<th>Students engage in PIP</th>
<th>Example Quote</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Students engage with science intellectually</strong></td>
<td></td>
</tr>
<tr>
<td>Students participate in course-related activities</td>
<td>So, you know, we're doing the clicker exercises even though we're not actually using the clicker. Sometimes you get that multiple choice and you have to try and figure out what it is. (Kayleigh)</td>
</tr>
<tr>
<td>Students participate in non-course-related activities</td>
<td>We go home and watch documentaries and learn about stem cells and all this other stuff that's going on and we come to class and see and learn all this stuff. (Lorenzo)</td>
</tr>
<tr>
<td><strong>Students engage in science culturally</strong></td>
<td></td>
</tr>
<tr>
<td>Students voice elitist and/or exclusive discourses</td>
<td>If I were to pursue a doctorate or something in science it's a little harder and it takes a little bit more, since it's a male dominant community. It would definitely create some tension if I happened to study hard or work better than my male counterparts. (Amanda)</td>
</tr>
<tr>
<td>Students voice inclusive discourses</td>
<td>Who is science made for? I think that that all people could be scientists. We can all study science in whatever facet. (Tiffany)</td>
</tr>
<tr>
<td><strong>Students engage in science socially</strong></td>
<td></td>
</tr>
<tr>
<td>Students interact with students, L.As, and their instructor</td>
<td>With this semester, I sit around with more people, and I kind of just talk to everyone around me. (Mai)</td>
</tr>
<tr>
<td>Students interact around science material</td>
<td>Within class, [the professor] separates us into groups, so every day we sit in groups, and we help each other through all the questions that we have and through notes and stuff throughout the classes. (Karen)</td>
</tr>
<tr>
<td>Students get to know other actors personably</td>
<td>[With the professor] being a mom and having a family, she's a really easy person to talk to and not just about science but just about really anything that you have in your mind. You know, you can go to her office hours and she is always just kind of a person to talk to and she is a very familiar face to see her on campus and she's also very friendly face to see. So that's kind of nice, to kind of have that warm welcome for her whenever you see her. (Amy)</td>
</tr>
<tr>
<td>Students want opportunities to interact but do not have them</td>
<td>It feels like every time I say, “Let's get together,” like [my classmates] all say “Sure,” but they don't show up, and this is like the third time that it happened... And so every time I reach out to them and say let's do this, I just get no response or I get declined and that's why I'm not connected to them. (Alice)</td>
</tr>
<tr>
<td>Students choose not to interact with others</td>
<td>I feel uncomfortable asking [classmates] questions, just because I don’t want to be judged. Same with the professor and some of the older people in class who have more experiences with the sciences. (Brandy)</td>
</tr>
</tbody>
</table>
Table 3.4 cont’d. Exemplar quotes regarding Procedural Identity Production.

| Students have perceived leadership roles in class | Within the first couple of weeks of the classes, everyone around me realized I was doing good on the tests and homework and knew the clicker questions. I feel like I got to a point where they relied on me for everything. Definitely all the clicker questions … It has helped me. In the sense that teaching someone is the best way to retain information and the way to learn. (Jason) |

“The performance” of being a science person varied depending on the student. Some students expressed that they readily had opportunities to engage in activities and with their classmates and enjoyed their interactions. Others reported poor interactions; they felt like they were not valued, taken advantage of, or being judged by others in class. Within PIP, approximately half of the students had conflicting ways in which they culturally engaged with science. While these students embraced inclusive discourses within science, some of their responses simultaneously showcased elitist views regarding science. We provide an exemplar from Alice, one of the students:

[A scientist is] someone who's always optimistic because they want to grow. I think scientists are always trying to learn, grow, and evolve into newer things. They need to have critical thinking, but I feel like anyone could be a scientist.

Science is extremely difficult. It's a lot of critical thinking and society thinks that it's difficult too. I know a lot of people who are not in the biology field or in science. They are taking music or human development.

Interplays of Components of CIP and PIP

CIP and PIP were operationalized in this work to independently describe the importance of (1) internal dialogue and beliefs and (2) participation, but in many cases, what students believe or do is the result of the intersections of CIP and PIP. We saw that in some instances,
components of CIP interacted with other components of CIP, and components of CIP interacted with components of PIP. In the following section, we described two common interplays of CIP and PIP in our data to illustrate ways in which they influence science identity production.

Who students were strengthened who they wanted to be

In some cases, students suggested that their socially constructed identities and experiences were inspiration for future goals and aspirations. Their goals were the result of their identities and what they have experienced in their lives. We present two examples below:

I think being female and Black, you don't see a lot of Black females in a science field or a science career because just... I don't know if other Black females don't like that or we ourselves are just not get[ting] promoted or not working hard enough for that. I hope in the future I can change that ... [We can] still be a part of that and still make way for other

– Tamara

Tamara explicitly discussed Black representation in her interview and noted that she perceives a lack of Black representation, especially Black female representation in science. Tamara’s focus on the intersection being Black and female also included the recognition of the racial disparities that are still apparent in science. Though she recognized that there were not many Black females in science, she spun this knowledge positively and focused on how she can contribute to changing the culture. In her interview, she stated that she wanted to become a neurologist and show Black females and males that they can be part of the science community.

Another student, Isaac, stated:

I just decided to stay home and do the traditional way, the traditional treatment which is herbals and all that stuff. So that my grandpa was a great guy, seemed to be really good with herb[s]. He's a great herbalist, so I decided I want to do everything he does. I see
him help other people, not just me, or his family. He helps people around the village and all that… I actually want to be someone like him but more advanced. And I really want to be in medicine, be a doctor or be a physician one day in the future to actually help out the community and give back. – Isaac

Isaac was describing a past experience in which he broke his leg and was treated by his grandfather in South Africa. His experiences with his grandfather and how he perceived his grandfather seemed instrumental to his affinity to medicine and wanting to be a doctor in the future. In this case, we see an explicit recognition of past events intersect with Isaac’s future goal of attending medical school.

Who students were impacted how they acted in the classroom

In some cases, students’ socially constructed identities influenced how they would interact with classroom material and with other actors in the classroom. While some students expressed that they had positive interactions, some struggled to engage with classmates or had negative interactions.

For Yulia:

My identity as being Hispanic is very important to me, and meeting more people that are Hispanic in my classroom helps me be able to learn better and socialize better. – Salacia

Fortunately, I've succeeded this semester … but I think that's because you see more minorities and more Hispanics in my class. Like, for example, my professor, he's Hispanic. My [Teaching Assistant], my [Learning Assistant] are Hispanic … it's [sic] greater and positively affected me to continue to succeed in science [and] in my future endeavors. – Yulia
Yulia mentioned how having others who are Hispanic in class had been beneficial to her learning experience and emphasized the relative importance of the intersection of being Hispanic and a college science student. This may be because she perceived that other people who are Hispanic share common lived experiences and would be more relatable. In Yulia’s case, her interview was conducted during her third attempt at General Biology, and she mentioned that the lack of representation of Hispanics in biology made her question her place in science prior.

For Alice:

Well, since I identify as a minority, I feel like it's a little challenging to develop relationships, in a way, because in my class, the majority is Caucasian and it's like, not like it is a problem, but for me, it's harder to develop relationships and things like that. - Alice

Alice noted that her identity as African puts her in the minority in regard to the class population. Because of this, she felt as though it is tougher to meet others in her class, and it was difficult to make friends and have meaningful relationships. Though she recognized the importance of collaboration, she did not seem to have personal support system in the class that she believed was conducive to learning and therefore, had negative perceptions of the classroom community.

We presented the examples above to showcase the complexities of CIP and PIP and provide examples from our data that illustrate the dynamic and multifaceted nature of identity production. The different ways in which CIP and PIP interplay will inadvertently impact the type of science identities that students construct and will affect how they perceive of themselves within science and the science classroom.
Discussion

The stories and experiences that students discussed in their interviews reveal the multifaceted and complex nature of science identity production. The interactions that the students had, the experiences that they shared, and their personal understanding of how they were situated in a cultural and historical place impacted how they viewed themselves as science people. We added to the literature surrounding identity production in science education by focusing on components of CIP. Additionally, we explicitly described certain interplays of CIP and PIP, which had not been done previously. We do so in order to more fully explore the phenomenon of identity production and recognize the complexity (and incompleteness) of the process. The following sections elaborate on these findings and invite readers to think about the implications of this study on both classroom teaching practices and future research about identity.

Research Question: How does CIP and PIP Inform the Production of Students’ Science Identities?

We found that students’ mental self-making process as well as their “performance” of their science identities to be impactful in their becoming a science person. We interpreted a range of positive (e.g., going on influential field trips) and negative (e.g., struggling in a science class in high school) lived experiences and a mix of positive (e.g., being able to interact with people of similar socially constructed identities) and negative interactions (e.g., being stereotyped by classmates) with other actors in the classroom. In the students we interviewed, we observed a variety of science identity productions. Below, we discuss the ways authoring and recognition manifested in our data.
We noted that students placed value in narrating their lived experiences and authoring how these experiences impacted their views of science. Their authoring was an important tool because it gave students space to process their experiences and relate that to how they cultivated a science identity. They used their lived experiences and goals as focal points in understanding how they would like to be situated within a context (e.g., classroom, home). For example, Hala’s memory of struggling through biology in high school or Vajra mentioning that his family has a science background are all experiences that they internalize and author that add to the complexity of the identity production process (Table 3.3). Other studies, such as Basu (2008) and Avraamidou (2013) also found that lived experiences were instrumental in developing science identities and enthusiastically engaging with science.

In addition to lived experiences, many students, particularly females and students of Color, brought their gender identities, races, and ethnicities to the forefront to author their experiences. Drawing from Table 3.3, Valeda focused on the fact that she has studied in Brazil and knew Portuguese as very important to who she was and how she could be uniquely situated, especially given generalized societal views, in the United States, of Latinx women. Calabrese Barton and Yang (2000) previously documented this phenomenon and studied the culture of power using critical theory perspectives. They described how sociopolitical systems elevate certain groups of people, such as upper middle class Whites while disenfranchising other groups. Some of the students interviewed seemed to have nuanced understandings of these systems. For example, Tamara’s quote from the results section focused on the representation of Black people in science. Further, Tiffany’s quote, as stated below, described her perception of gender roles in science:
[Science] still is definitely predominantly hetero White male, and I feel like that is starting to change… I feel like females that are in science, the ones that are known about tend to do things, like astronomy [which is more feminine] rather than astrophysics [which is more masculine]. I feel like the media gender roles people and just stereotypes everyone into little compartments. And I think that's sad, but, so yeah, that's how I feel.

The figured worlds literature suggested that there are significant historical traditions that impact both cultures and how people of different socially constructed identities act (Holland et al., 1998). The interviews we conducted demonstrated how the figured world of science education impacted individuals of different intersections of identity. This study corroborated some of the common concerns females and people of Color had about navigating their science identities (e.g., Close, Conn, & Close, 2016; Kane, 2012; McGee & Martin, 2011; Teo, 2015). However, a limitation of our work being interview-focused meant not being able to thoroughly describe elements of the figured world that uphold problematic historical traditions.

During their interviews, students also recounted how they participated and engaged with science and the science classroom in different ways. In our study, PIP primarily focused on the how interactions with others play a role in identity production. Some students reported positive engagements with PIP and were more comfortable with the performance of being a science person while other students were less comfortable with the performance of being a science person. Importantly, these interactions may have affected students’ perceptions of being recognized as a science person. Recognition is highly important in figured worlds and is often a “space of struggle” for individuals as they produce an identity in that community (Holland et al., 1998). For example, Alice discussed wanting to learn with her classmates and not having
opportunities to do so, which was isolating and may have impacted her recognition in the science community (Table 3.4).

Within PIP, we also noted that students may have situated themselves within a science community if they were recognized by others and if they recognized themselves as a science person. Jason’s quote focused on his ability to do well on assessments and helping others (Table 3.4). His performance on assessments may have impacted his self-recognition as a science person in the community, and his interactions with peers showed that they recognized him as a significant member of the community. Carlone and Johnson (2007) showed that interactions were consequential in identity production. Women who were recognized by others as a science person were more likely to have a stronger science identity whereas women who had weaker science identities were not recognized by others as a science person and had perceived trouble navigating their fields due to gender and racial factors (Carlone & Johnson, 2007). We also noted from our data that interactions with peers may have helped facilitate or hinder identity production and that professors and LAs who shared their own engagements, struggles, and understandings of science may have had better connections with students. Amy’s quote showed how much getting to know her professor impacted how Amy viewed the class (Table 3.4). This was supported by Olitsky (2007), who studied student science identity formation via interactions in classrooms and noted the importance of interactions in students’ identity production.

As noted in the results, students engaged with the culture of science in conflicting ways, such as internalizing both inclusive and elitist discourses in their production of their science identity. We did not find this surprising because the current science discourse prioritizes certain ways of knowing, speaking, and acting “scientifically”. Stanley and Brickhouse (1994) focused on the Western nature of science education and noted that our knowledge of science may be
distorted without acknowledging other ways of knowing science from different worldviews. Additionally, we prioritize a specific linguistic structure in science education, and students who regularly are seen as the “smart” student in class are those who have familiarity with common science vernacular (Lemke, 1990; Robertson & Elliott, 2017; Stanley & Brickhouse, 1994). This inadvertently places value on one form of speech over another and highlights a common bias in language. This may invalidate many of the voices of students who were commonly underrepresented. Students subconsciously internalize this, which may be the reason why many of the students make statements that suggest they think science is for everyone, but also make conflicting statements suggesting that science is for the smartest. Carlone (2012) coined the term “normative scientific practices” after “normative mathematical practices” of Cobb et al. (2009) to remind identity scholars that the science community has shared values, tools, and meanings placed on day-to-day phenomenon. These values, tools, and meanings are a substantial part of the figured world, and changing these historical traditions and ways of knowing are difficult (Holland et al., 1998).

Through analyzing and coding student interviews using *figured worlds*, especially the concepts of CIP and PIP, we noted a recurring idea of stereotyping and bias, especially in interviews from female students and students of Color. Particularly, we noted that there may be an interplay in which CIP affects PIP and vice versa. Though previous research have noted the importance of how shifts in CIP and PIP impacted identity production, current research has not explicitly focused on the intersections of CIP and PIP, as described in the Results (Urrieta, 2007b). Institutionalized systems (cultural and historical ideologies that impact how people of different socially constructed identities make meaning and interact with each other and the world) such as racism, sexism, ableism, etc. undergird science education and perpetuate the
status quo (Carlone & Johnson, 2012). This is an often taken-for-granted phenomenon that science educators do not think about and may result in deficit thinking models that essentialize and stereotype students and is commonly studied in regards to gender identity and race (Brickhouse, 2001; Brickhouse et al., 2000; Solorzano et al., 2000; Solorzano & Yosso, 2001; Teo, 2015). These institutionalized systems may impact CIP and PIP and affect the types of science identities that are afforded to students. For example, Isaac was very explicit about his experiences in his biology class and not being recognized as a worthwhile science person:

Specifically, for this biology class, like in group work, most of the time I actually do most of the work. Because that's the thing - when it's racism, [they think] ‘He probably don't know nothing.’ If you're going to judge someone on looks, that's actually really wrong.

For science educators, we must be cognizant of the systems that we are reproducing in classrooms and think about the culture that is created from these systems. This is because educators can foster spaces where students can author strong science identities and be recognized by others and self-recognize as science person. If science educators want students to defy these norms and produce more positive science identities, educators must be knowledgeable and work to create spaces where students can develop more authentic meanings with who they are in science.

Implications for Undergraduate Biology Educators

Because of the complexities of identity production, there is no one-size-fits all approach. However, our findings indicate that are some considerations that may facilitate the building of more inclusive classroom spaces. As seen above, students’ identity production is partially contingent on the procedural elements of a classroom (e.g., the nature of interactions, the
activities being implemented). These procedural elements were dictated early on by the instructor and were based on what instructors value in a classroom. These values ultimately impacted the discourses, community interactions, roles, and responsibilities that are afforded in a classroom and may affect students’ science identity production (Engeström, 1987). Biology educators need to be cognizant and aware of what they value, especially in considering issues of inclusion and access in their classrooms.

Through student interviews, we noticed how classroom dynamics implicitly showcased instructional values and how that impacted PIP of students. Several students mentioned that their instructor’s discourse made them feel as though they belonged. Kayleigh noted that, “There's just something about [my instructor] that's very nurturing in general. You know, she talks like a person … and gets the fact that being in school's hard.” Additionally, all of the courses these students were from gave opportunities for community interactions, but the implementation of these interactions were positive for some, such as Karen, but negative for others, such as Brandy (Table 4). Some instructors implemented classroom environments that allowed students to have agency to establish their own roles, as we saw with Jason helping his peers (Table 4). This shows that intentionally thinking about personal values and how they could manifest in classrooms through discourse and activities is paramount to facilitating more robust science identity production for students. In one example study, Schinske et al. (2016) intentionally incorporated assignments in underrepresented scientists as a way to enhance the identity production of underrepresented students; their results showed that the assignments strengthened underrepresented students’ science identities.

Directions for Future Research
The exploratory nature of this study has generated thought-provoking findings that we felt were beneficial to starting the conversation about student science identity production in biology contexts. Future research on science identities within biology education research should focus more on understanding the context in which students are situated in. This is because identity production is not solely on the student. The places in which they interact with other actors and learn about cultural norms relate to the types of identities students create. Some of our future work will include a case-study of a biology classroom and understanding how the norms and values that operate in that classroom affect students’ science identities.

Furthermore, our study included students who are in general biology classrooms, which means that they were at the beginnings of the academic career. One potential research avenue could track introductory students through time and place and study how their interpretations of past and current experiences change with time and impact their science identities. Additionally, many of these students were declared science majors or were interested in pursuing a pre-health track. We believe that it would be interesting to interview upper division students who decided to leave science majors and understand the pivotal experiences during their schooling that made them leave science. This would give us a better understanding of the factors that may prevent students from succeeding in science courses and allow science educators to better theorize issues of equity and inclusion.

As students construct their science identities, they are situated in places and circumstances that impact how these science identities are produced (Lave & Wenger, 1991; Luehmann, 2007). Similar to Avraamidou (2018a), this suggests the importance of relationality when discussing science identity. The time, place, interactions, and context all matter when a student produces a science identity. The encounters that students have with the place and with
other actors are significant in that certain ideas and dispositions in that realm are more valued and may position students in certain ways (Holland et al., 1998). As such, we also recommend that future research on identity be framed within relationality.
CHAPTER IV

FACILITATING STUDENT BELONGING IN A LEARNING ASSISTANT SUPPORTED GENERAL BIOLOGY CLASSROOM

Abstract

Traditional classrooms often uphold norms and values that hinder the success of underrepresented students because they exist within social systems that are inherently oppressive to some groups, and thus take on the norm of those systems (sexism or racism). In order to facilitate the inclusion of students and make them feel as though they belong in the science classroom, there needs to be a transformation of the classroom in order to instill new norms and values. We conducted a case-study of one Learning Assistant supported general biology classroom in order to explore elements of the classroom that helped in facilitating a sense of belonging. We found three elements supported a sense of belonging: (1) authentic care from the instructional team, (2) discussions of opportunity, and (3) agency to position and author positive roles. These three elements helped change the classroom culture and create a space where students are more able to be successful and thrive.

Introduction

Setting the Scene: Vignette Reconstructed from Field Notes and Video Observations from Late Semester

At the beginning of class, students rushed up to the whiteboard to write down meeting times for different clubs they are a part of on campus. As students made their way to their seats, I heard conversations and laughs. As class began, the Supplemental Instructor came up to the front of the auditorium and asked students about setting up a time to help
students prepare for the biology final. Afterwards, I heard the voice of Dr. Anderson addressing his students:

“Alright, the first 10 minutes of class or so, I’m going to let you work. I’m going to let you go through [the handout], and if you don’t have a handout, there’s more up here. I’d like you to go through in groups or on your own, answering the front page and some of the back side as well, related to the cell cycle, mitosis, and meiosis. In about 10 minutes, we will stop, and I will go through parts of this.”

Dr. Anderson’s voice over the microphone was easily heard as students began working. He turned off the microphone and began to move through the large lecture hall, a room meant to fit 250 students with two large screens for PowerPoint presentations and whiteboards on the front and side walls. I noted the comfort of the classroom as I heard the hum of student voices talking about their weekend plans, the upcoming quiz, and everyday gossip about relationships and events as they get ready to work.

During the next fifteen minutes of class, I saw the Learning Assistants (LAs) and Dr. Anderson circulating through the lecture hall checking in with student groups and answering questions that students had. When the LAs or Dr. Anderson spent several minutes with a group, I noticed that they took a seat and talked to students at a face-to-face level. As I scanned the classroom, I saw some students working by themselves on the handout or not working at all. Many of these groups were checked by LAs. Eventually, the conversations subsided, and Dr. Anderson reviewed the major phases of mitosis and meiosis through two different videos, lecture, and clicker questions. When he started a subsection on nondisjunction, he prepared for a demonstration and asked for student and LA participation.
“I need at least three volunteers to come up here to do a demo of this real quick,” said Dr. Anderson. A few students and an LA jumped up to volunteer to be sister chromatids and microtubules in this demonstration. Some students laughed as he talked through the demonstration and showed how chromatids move during anaphase, referring to them as “getting yanked” as he bent and pulled to one side of the auditorium. All students clapped and cheered for their classmates at the end of the demonstration.

The remainder of the class session was a mixture of lecture and clicker questions, and I noticed many students seemed comfortable asking Dr. Anderson questions. As he listened to the students, he made clear eye contact with approving nods to acknowledge what students were saying. After their questions, I heard validating comments from Dr. Anderson, such as “That’s a great question” or “I know where you are coming from.” After, he ended class with a “Have a good weekend” and reminded students to “Reach out to the LAs or me” if they had questions while studying.

Traditional classrooms can perpetuate a culture that often ignores or devalues the rich experiences and histories of the students who enter the classrooms (Astin & Astin, 1992; Brickhouse, 1994; B. A. Brown, 2004). For example, Lemke (1990) detailed cultural norms and values that upheld the status quo in science education and inadvertently divested students of their own resources and capital. Focusing on urban youth and an all too familiar phenomenon of failure at inner city high schools, Rubin (2007) described the day-to-day events of an urban high school and how they perpetuated the perception of incompetence for students who attended that school. These examples help educators better understand the higher attrition of non-dominant students, e.g., female students and students of Color, especially in science, technology, engineering, and mathematics (STEM) fields. Rather than change, some instructors continue to
uphold the norms and values of a traditional science classroom, which victimizes the students who are most vulnerable in the system.

In this article, we describe a different scenario - the classroom of an instructor, Dr. Anderson, who is aware of problematic discourses around traditional science education and is actively working to transform his classroom space in order to make sure that all of his students are able to thrive and be successful. Dr. Anderson teaches at an urban institution with a racially, ethnically, religiously, linguistically, and age diverse population. His students, like many students at universities across the United States, enter biology classes with goals of entering medical school, nursing school, graduate school, etc. He recognizes that he and his instructional team, which consists of a Supplemental Instructor (SI) and Learning Assistants (LAs), must leverage available resources and the capital his students have to create a local culture that facilitates a sense of belonging that positions the students as successful. As seen through the vignette, his instructional approach is multifaceted and incorporates many practices, such as intentional time for interaction and use of different mediums for learning. Additionally, his discourse validates student thoughts and encourages students.

In this article, we explore how the utilization of the LA model, which incorporates peer instructors to facilitate active learning (Freeman et al., 2014; Otero et al., 2006; Talbot et al., 2015), can help facilitate a sense of belonging and push back against dominant narratives via re-figuring the science classroom. To do this, we used classroom observations, student interviews and surveys, LA interviews, and interviews with Dr. Anderson to complete a case study that describes the elements of Dr. Anderson’s course that may help students feel as though they belong, thus increasing student success. We chose Dr. Anderson’s course because, based on data from a larger research project (NSF 1525155), we know his pass rate and learning gains are
among the highest in his department, his students report high satisfaction, and his LAs are active in his class sessions. Further, Dr. Anderson was willing spend time talking with us about his course and students. We invoked *figured worlds* (Holland et al., 1998) to explore how norms, values, and discourses in this classroom facilitate student belonging and push against traditional paradigms of science classrooms. We highlight the successes and the struggles Dr. Anderson encountered in his efforts to make sure that his students felt a sense of belonging in his general biology course.

**Literature Review**

**Describing and theorizing the traditional science classroom**

To critically analyze *why* some students struggle to persist in science, we believe it is necessary to deconstruct what traditional science education may look like and problematize existing norms. One of the reasons science educators may see higher than expected attrition from science is due to the current culture of science. For example, Carlone (2004) studied high school female students and noted that the students reiterated prototypical and narrow meanings of science (e.g., being smart and earning good grades), which resulted in their disconnect to science. Ryu (2015) conducted a study of Korean students in the United States which also showed that students have narrow views of science. These students’ experiences with science focused on rote learning, knowing answers, and doing well on assessments. The perpetuation of the cultural practice of “smartness” in science education is detrimental to many students because it celebrates the reproduction of a science education that is wrapped in an elitist mentality and continually marginalizes students who do not fit the standard “science” mold (Calabrese Barton, 2002; Carlone et al., 2014; Lemke, 1990). Unfortunately, this cultural practice is embedded in
traditional science education and can be perpetuated even by teachers who see the harm (Teo, 2015)

Elitism within science transcends beyond the notion of “smartness” and many times, relates to individuals’ socially constructed identities. For example, McGee and Martin (2011) discussed the experiences of students of Color in mathematics and engineering and noted that the students felt as though they were stereotyped by professors because of the color of their skin. This stereotyping inadvertently leads to deficit discourses that maintain beliefs that Black and Brown students are stupid or lazy (Solorzano & Yosso, 2001). Racialization in science education is not a new phenomenon and was also documented in elementary students of Color and their perceptions of science (Walls, 2012, 2015). When we explore male and female differences, studies concluded that there is a notion that males are better suited for science than females because females are viewed as more nurturing, subjective, and soft whereas science is viewed as more objective and calculating (Brickhouse, 2001; Riegle-Crumb, King, Grodsky, & Muller, 2012; Sinnes & Loken, 2012). Teo (2014) documented that gendered societal norms and expectations can deter females’ interest in science. Though we focused our examples in relation to systemic issues of race and gender equity, we recognize that combating and interrogating elitism and “smartness” in STEM and academia includes understandings of additional systems, such as heterosexism (e.g., making assumptions about students’ attraction to other students) (Barres, Montague-Hellen, & Yoder, 2017; J. Freeman, 2018), ableism (N. Brown & Leigh, 2018; Shyman, 2016), classism (Beagan, 2005; Katsh-Singer, McNeill, & Loper, 2016), etc.

STEM fields, as with any other disciplines, operate within a set of established cultural and social norms and values. Bourdieu and Passeron (1990) focused on the phenomenon of reproduction in society and noted that these norms and values are reproduced generation to
generation and that society perpetuates a system that values particular actions and meanings over others. In order to fully participate and succeed within that society, individuals must internalize these norms and values and align their own beliefs and actions to mirror what is valued by that society (Bourdieu & Passeron, 1990; Holland et al., 1998). The norms and values embraced by a community inadvertently embrace “-isms” (e.g., racism, sexism, heterosexism) that undermine and dehumanize certain groups of people, and because our constructions of self are confined to this system, we internalize these “-isms” and form meaning that affects how we operate in society (Holland et al., 1998). The larger cultural and historical structures that exist in society perpetuate these “-isms” and affect the day-to-day phenomenon and practices of a community, such as a science classroom (Chaffee & Gupta, 2018). As such, one can posit that students who may not have learned these norms or internalized the values of particular communities may not be able to or want to persist. However, what happens if a community starts pushing back against the dominant narratives and recreates meaning and modes of engagement to make students feel as if they belonged?

Students’ sense of belonging in science education

Trujillo and Tanner (2014) framed belonging as feeling as though you are a part of a community. Feeling as though you belong is important to persistence in a science field because individuals who feel more “out of place” and believe they do not fit are more likely to do poorly and leave their major or college altogether (Tinto, 1987). The author team felt as though focusing on sense of belonging is important in science classrooms because some research has shown that a sense of belonging is related to success and retention (T. M. Freeman, Anderman, & Jensen, 2007; Good, Rattan, & Dweck, 2012). In science education, much of the literature around a
student’s sense of belonging is situated on socially constructed identities, such as gender identity and race, of which we provided some examples below.

There has been an existing gender gap in female representation in some science fields, and there have been movements to increase access and retention of females in science, though underrepresentation is still pertinent in physics and engineering disciplines (Brickhouse, 2001; Brotman & Moore, 2008; National Science Foundation, 2015). A mixed methods study concluded that females were significantly less likely than males to feel as though they belonged in STEM (Rainey, Dancy, Mickelson, Stearns, & Moller, 2018). J. L. Smith, Lewis, Hawthorne, and Hodges (2013) studied female graduate students’ sense of belonging in STEM fields and noted that they felt as though they had to put in extra effort to be recognized and succeed. As a result, they felt as though they did not belong and had less interest and motivation to continue in their field. Good et al. (2012) focused on women’s sense of belonging in mathematics education and noted that negative stereotypes, such as women having less ability in mathematics in relation to men, diminished women’s sense of belonging in math and resulted in a decrease in their sense of belonging. Another study concluded that, when presented with opportunities for extra engagement in scientific activities, female students could be afforded contexts in which they do feel as though they belong and can succeed (Calabrese Barton et al., 2013).

Similarly to studies focused on female students in science, studies on students of Color show that they are also underrepresented. Maltese and Tai (2011) conducted a study on persistence and noted that their data showed that students of Color, excluding Asian students, were less likely to earn a degree in STEM when compared to their White counterparts. This was corroborated in a study conducted by Rainey et al. (2018) and data collected by the National Science Foundation (2015). In one study on race, Williams Pichon (2016) concluded that sense
of belonging is important to Black STEM students and that they felt that they would be more able to succeed in their context, which was described as a Hispanic serving institution, if they were afforded opportunities to build community. Additionally, perceptions of racial climate may also impact a student of Color’s sense of belonging because “chillier” climates often meant that they felt as though they were outsiders and not part of the community (D. R. Johnson, 2012).

We presented some of the previous work on sense of belonging because feeling as though you belong is a basic human need and profoundly impacts being able to succeed and thrive (Strayhorn, 2012, 2015). Strayhorn (2012) believed that this “feeling or sensation of connectedness, the experience of mattering or feeling cared about, accepted, respected, valued by, and important to the group” was fundamental to education and facilitating success for students (p. 3). Retention is not always grade dependent; some literature points out that females and students of Color may leave STEM majors, even if they are academically performing well, because of negative climates (McGee, 2016; McGee & Martin, 2011; McGee et al., 2017). The idea that belonging can be as important as academic ability has been understudied in undergraduate STEM education. As such, we chose to focus on sense of belonging in our case study.

The Learning Assistant Model

If science educators are to critically have a conversation regarding inclusion in science education, they must understand how traditional classroom norms and structure prevent success of all students, must re-imagine the science classroom, and enact transformations that make classrooms more accessible and allow students to thrive. This would require them to thoughtfully create spaces which would push back against problematic norms of science education and help students create new meanings and relationships with what it means to do science and be a
science person. There are several transformation-orientated models that are used in science education, and one of the models that has been increasingly common is the Learning Assistant (LA) model. The LA model has been implemented by >80 institutions across the world (more information can be found at www.learningassistantalliance.org).

Programs based off of the LA model recruit successful undergraduate students to facilitate student-centered instruction and increase classroom success (Otero et al., 2006). LAs purposefully learn and utilize research-based practices, help faculty with curricular and course-based transformation in order to make classrooms more collaborative and active, and provide the foundation for departmental and institutional change. This allows faculty members to have opportunities to build an environment that allows students to interact, feel safe, and actively think about material while in class.

A study in physics showed that incorporating the LA model into introductory courses resulted in significant learning gains on validated assessments (Otero, Pollock, & Finkelstein, 2010). Programs that use the LA model also believe that LAs can often provide faculty a lens and perspective that can help unveil student motives, interactions, and thoughts. Access to student and LA perceptions can shed light on problematic norms and structures in their classrooms that may exclude students. There have been studies that have shown the LA model increase student engagement and satisfaction (Chasteen et al., 2011; Talbot et al., 2015). While we see the positive outcomes of having an LA program, there has not been work that specifically focuses on why the LA model has been successful. We posit that one reason the LA model has been successful is because it provides faculty members opportunities to create a culture that makes students feel as though they belong.

Figured Worlds
We frame our case study using *figured worlds* because we believe that the specific norms, values, and structures of a *figured world* can be consequential to student learning. Holland et al. (1998) described *figured worlds* as “socially and culturally constructed realm[s] of interpretation in which particular characters and actors are recognized, significance is assigned to certain acts, and particular outcomes are valued over others” (p. 52). *Figured worlds* are useful because they allow us to begin to understand how meanings are shaped in particular settings and explore the dynamics of social interaction, potential feelings of marginalization, and possibilities of cultural change. Conceptualizing the figured world allows us to understand the norms and values that facilitate a sense of belonging in the classroom and afford students opportunities for success.

*Figured worlds* incorporate larger sociocultural and historical patterns and structures (Chaffee & Gupta, 2018; Holland et al., 1998; Urrieta, 2007a). The *figured worlds* in which people exist are grounded in historical and cultural contexts and already have meaning reinforced by previous generations. This gets produced and reproduced as individuals and groups create and recreate meaning from their thoughts and actions. This meaning then affects the day-to-day phenomenon and practices of the individuals of that *figured world*. To put this in context and problematize seemingly banal events that can happen in a classroom, we describe a traditional introductory biology learning context as an example. In this hypothetical classroom, the professor lectures for 50 minutes, three times a week. At four points in the semester, students are given summative exams, and the professor works from the premise that there will be a bell curve distribution and that a certain percentage of the class will fail the exam. Students who do poorly on the exams are encouraged to drop and pursue different majors. When students initially enter this *figured world*, they are offered positions and identities (e.g., the novices) by established
members of the figured world (i.e., the professor). This professor gives meaning to a previously established science culture and shapes the course via established norms in science and views the high failure and withdrawal rates of students as a “weed out” mechanism to prevent incompetent students from continuing on in the sciences and keeping the discipline selective. These perceptions reveal the elitist mentality and focus on competition rather than collaboration within this figured world (Carlone, 2004; Ryu, 2015). By participating in the activities of this figured world (e.g., listening to lecture, taking exams) and engaging with peers and instructors, students make their own meaning about science education and are afforded different identities (e.g., the “outstanding” student, the “rebellious student”, the “dumb” student, etc.) that situate them within this figured world (Holland et al., 1998). Additionally, the activities of this figured world deemphasize the nature of science and devalue learning how to think about science (Lemke, 1990). Students who consistently receive As or Bs on their exams were successful in renegotiating and reconciling other identities and adopting norms and values to better align with this figured world and are recognized by their professor as successful learners. The norms of this classroom (e.g., passively listening, performing well on exams) celebrate certain positions while marginalizing other positions (Carlone et al., 2014).

The previous contextual example displayed an overarching cultural narrative of elitism in science and is reproduced by instructional norms and the subculture of science in education. Unsurprisingly, this results in students’ perception that science is out of reach, and this is compounded by intersections of different “-isms” (e.g. racism, sexism) that pervade in society (Calabrese Barton, 2002). Consequently, issues of access and equity for students remain despite the efforts of science educators and programmatic initiatives.
Despite the overwhelming historical and cultural barriers and discourses that undergird science education, figured worlds recognizes the agency that individuals have within that figured world (Chaffee & Gupta, 2018; Holland et al., 1998; Urrieta, 2007a). Holland et al. (1998) stated that “no human action is singularly expressive” (p. 169). Rather, individuals and groups have a continuing inner dialogue where new meanings can be formed and individuals can modify, construct, and oppose the original cultural and historical structures that were in place (Chaffee & Gupta, 2018; Chang, Welton, Martinez, & Cortez, 2013). The “spaces of authoring” allow individuals and groups to engage and combat the status quo to create a space that is more meaningful (Buxton, 2001; Holland et al., 1998; Price & McNeill, 2013). Though spaces of authoring do not completely eliminate the constraints of a cultural and historical systems, the local engagement of the individuals within the classroom can begin to liberate students and transform what the learning space looks like. Additionally, the creation of a new space may allow students to adopt and develop new identities because the ways in which they engage with science will be different. The new day-to-day phenomena that occur will help students renegotiate and rethink who they are and potentially make them feel as though they belong.

In this paper, we recognize how the instructor, students, and LAs have been shaped by embedded systems and recognize the possibilities of change and the changes that have already occurred. We recognize that transforming classroom spaces to be more inclusive and equitable is a complex endeavor with no one right answer and use figured worlds to describe Dr. Anderson’s classroom and how his transformed classroom allows students to feel as though they belong.

Dr. Anderson’s classroom actively works toward helping students feel like they belong via (1) authentic caring from Dr. Anderson and the LAs, (2) having discussions of opportunity for students, and (3) the ability to positively position and author experiences and identities. We
utilize *figured worlds* (Holland et al., 1998) to describe how the *figured world* of college science learning in this LA-supported course facilitated a sense of belonging and positioned students to be successful. This study describes the local interactions and relationships that make up the *figured world* of college science learning and its facilitation of positive science learner identities. We aimed to (1) more fully theorize the phenomenon of increased student success in LA-supported classrooms and (2) apply the sociocultural framework of *figured worlds* to understand how the figured world of learning in an LA-supported classroom can push back against dominant narratives and facilitate a sense of belonging for students.

**Methods**

**Approach**

We used an exploratory case-study approach for this study (Yin, 2003). We chose this approach because we were studying a specific, real-life context to intentionally illustrate how opportunities for students to develop a sense of belonging manifest in a college STEM course. Given the case study approach, we recognize that the context in which all individuals were situated were bounded by time and place (Creswell, 2013). In this study, the case is Dr. Anderson’s General Biology I course in Fall 2016 and Spring 2017, and we collected multiple sources of information through classroom observations (broad and LA-student specific), surveys and interviews (all detailed below).

**Setting**

This study was conducted at an urban mountain west mountain institution in the Fall 2016 and Spring 2017 semesters of the same class (General Biology I). The undergraduate student population was approximately 56% White and 44% racial minorities (21% Hispanic/Latinx, 10% Asian/Pacific Islander, 5% Black/African, 8% Mixed/Unreported). The
student population in Dr. Anderson’s course reflected the general racial and gender demographics of the undergraduate population. Each semester, Dr. Anderson recruited LAs that mirror the racial and gender diversity of his classroom.

Course Description

The instructor, Dr. Anderson, is half German and half Mexican and has taught the General Biology I class every semester since Fall 2011. His classes met twice a week for 75 minutes during the duration of the study, which spanned 2 different semester-long course sessions. This course introduced students to basic principles of biochemistry, molecular biology, and cell biology. In Fall 2016, he had 4 LAs, and in Spring 2017, he had 7 LAs. His Fall 2016 course had 151 students and his Spring 2017 course had 179 students. The student population in his courses reflected the general racial and gender demographics of the undergraduate population. Each semester, he purposefully recruited LAs that mirror the racial and gender diversity of his classroom.

Dr. Anderson taught in an auditorium lecture hall in one of the newer buildings at the institution. The lecture hall can seat up to 250 students. Every other row has seats that rotated 360 degrees to allow for collaboration amongst students. Additionally, white boards lined the front and side walls and were available for student use during activities. While LAs were free to circulate wherever they are needed during classroom activities, Dr. Anderson asked that each LA choose one section of the lecture hall to focus their time. That way, students could be reached physically by at least one LA or himself. Students were expected to have regular computer access because course materials, weekly quizzes, and homework assignments were available on an online interface. There was one midterm and one final exam in his General Biology I course, both taken in class.
Dr. Anderson structured the course so that he would typically lecture for, on average, 10-12 minutes and then provide students with a task where they could interact with one another. These tasks varied and were a mix of clicker questions, discussion questions, or worksheets. The duration of these activities varied between 2 minutes to 15 minutes. After, he would lecture again for approximately 10-12 minutes and provide an activity for students to complete. This is the repeated pattern until the end of class. A majority of classes observed had this structure, though there were days where activities took a longer time or he lectured longer than usual.

Observation Data Collection

Dr. Anderson’s class was observed 16 times in Fall 2016 and four times in Spring 2017 using the Course Observation Protocol for Undergraduate STEM (COPUS) (M. K. Smith, Jones, Gilbert, & Wieman, 2013) and additional real-time field notes from the researchers. The COPUS is an observation tool which marks the activities of students and the instructor at two-minute intervals. We added a section to track LA actions that paralleled instructional actions given on the COPUS. The COPUS was used as a preliminary tool to gain an initial understanding of the frequency of instructor-led activities (e.g., posing a question, completing a demonstration), student-led activities (e.g., asking questions, individualized activity time), and group activities (e.g., clicker questions, worksheets). The first author was responsible for >80% of the observations over the span of the study. In order to capture day-to-day procedures of the classroom, activities, and participant groups, we also recorded videos of course meetings. These videos were taken from the back of the room and provided a broad picture of the course. At the end of observations, we had a total of 25 hours of classroom video. The research team and Dr. Anderson watched all the videos, and additional notes were taken to supplement real-time field notes from observations.
To capture nuances of LA-student interactions, three LAs in the course volunteered to wear point-of-view (POV) cameras to record interactions with students during Spring 2017. POV cameras were worn by LAs during the entire class period so that we could observe when LAs were moving through groups and when LAs interacted with student groups and observe the nature of LA conversations with students (more fully explored in Nasim Thompson et al., in prep). Given that individual perspectives and experiences in the classroom were crucial to the design of this study, this was a useful method to capture interpersonal interactions. At the end of Spring 2017, we had 9 hours of video (3 hours per LA).

Survey Data Collection

To further capture student perspectives, students were asked to complete the Classroom Community Scale (CCS), which is a Likert scale survey focused on student interactions and sense of belonging (Rovai, 2002). Items on the assessment varied but broadly asked about procedural elements of a class (e.g., being provided with timely feedback or opportunities to ask questions) and students sense of belonging (e.g., trusting others, feeling like a part of the group). All students were given the CCS during week 8 of Fall 2016 and Spring 2017.

Interview Data Collection

Students’, LAs’ and Dr. Anderson were interviewed as a part of the study. All interviews were recorded and transcribed.

LA interviews

The captured video footage was used to facilitate stimulated recall interviews in which the three LAs wearing POV cameras from Spring 2017 generally talked about the classroom interactions captured by the videos. During the interview, LAs were given 2-4 video clips showing their interactions with students. First, they were asked about context of the interaction.
This facilitated memory recall. They were then asked to describe their decision in choosing their style of interaction. This helped the interviewer gain insight into instructional approaches used by the LA. Lastly, they were asked if they thought the interaction was successful and why. They were prompted to describe challenges and possible changes they would make if the interaction happened again. This promoted metacognitive reflection that helped the interviewer generally understand their conceptions of the student population. Compensation for wearing cameras in class and the hour-long interview earned each LA $50 USD.

**Student interviews**

We purposefully recruited students who represented a cross-section of positive, neutral, and negative responses to the CCS and made sure that the students we interviewed reflected the gender and racial diversity of the classroom. Seven highly structured student interviews were conducted in Spring 2017. During the interviews, all students were asked the same questions and the interviewer (first author) rarely deviated from the pre-established protocol. When there were deviations, it was to capture additional context from students and to inquire for expansion of their responses. The interview focused on past and present classroom experiences, student identities, and their perceptions of a positive classroom culture and community (see questions in Appendix 1). Interviews lasted approximately 30 minutes and students were compensated with a $10 USD gift card for their time. The interview protocol can be found in Appendix C.

**Instructor interviews**

Dr. Anderson took part in interviews that were part of a larger study on active learning in LA-supported classrooms. There were sections of the interview protocol related to course design and practices, instructor use of LAs, classroom culture and diversity, and perceptions of learners. Dr. Anderson’s interview was one hour long and was conducted at the conclusion of Spring
2017. We noted the thoughtfulness of his responses and his particular intentionality related to student belonging. For these reasons, we chose to use his course as a case study. The research team asked Dr. Anderson to further participate in unstructured interviews to better understand his perceptions of the classroom and students and his instructional practices. The interview protocol can be found in Appendix A.

Starting in Fall 2018, Dr. Anderson agreed to twelve one-hour weekly stimulated recall interviews in which he watched videos of previous lectures from Fall 2016 and Spring 2017. These were all conducted with the first author. During video viewings, he deconstructed his intentions and practices during those classes. He also discussed how he would change future interactions and procedures based on his sense of students’ reactions in the video. The instructor interview was unstructured due to the frequency and depth of the conversations. The interviewer did not want to constrain the interaction and wanted the product to be as authentic as possible. Dr. Anderson received final manuscript drafts to read to ensure that his thoughts and intentions were captured appropriately. Dr. Anderson approved of the final manuscript.

Analysis

We used abductive reasoning in approaching and analyzing our data. During the initial data analysis process, two of the authors (PL and CG) analyzed the video data and field notes using a constant-comparative approach and open coding to identity features of the interactions and relationships built in the class that allowed students to be positioned as successful (Creswell, 2013). PL and CG identified repeated practices and discourses during interactions in the classroom through several iterations of returning to the data and refining preliminary themes. In addition to coding being conducted by PL and CG, PL and DK also used a constant-comparative approach, viewed two videos, associated field notes to those observations, student interviews,
LA interviews, and Dr. Anderson’s interviews. The data subset that PL and DK used were the ones being used by PL and CG in order to see if consistent themes emerged. PL and DK discussed elements that emerged from these data sources that related to students being positioned as successful. These emergent elements include sense of belonging, implementation of activities, and student interactions with other members of the classroom. PL, CG, and DK, made the collective decision to focus further analysis specifically on the phenomenon of sense of belonging because this was an explicit value of Dr. Anderson, the data were rich in evidence related to belonging, and we felt that focusing on one phenomenon deeply would lead to more insights than focusing on many phenomena. Subsequent coding focused on categorizing themes related to sense of belonging and coding for competing ideas, particularly from interviews of students who stated on the CCS that they did not feel a sense of community or belonging.

Triangulation and Trustworthiness

We recognize that qualitative research is sensitive to different individuals’ perceptions of the world and how they make meaning of their experiences (Patton, 1999). In case-study research, one way to minimize erroneous conclusions is through triangulation; triangulation describes using different data sources and methods as a means to corroborate evidence and test for consistency (Creswell, 2013; Patton, 1999). In order to establish trustworthiness and promote credibility, we underwent methods triangulation and analyst triangulation.

Methods triangulation describes the comparing of data that was collected via different methods (e.g., observations, interviews) and understanding the nature of those methods, such as assumptions or limitations (Denzin, 2017). In this case-study, we collected interviews (students, LAs, and instructor), observations (COPUS, video, notes), and surveys (CCS) in order to explore Dr. Anderson’s classroom. Responses that were given by interviewed individuals or surveys
could be corroborated with COPUS, video, and notes. Additionally, by collecting data from students, LAs, and Dr. Anderson, we were able to compare different perspectives and different viewpoints of the classroom (Patton, 1999). Responses that were not corroborated by other data sources were flagged and not reported in the findings. It is not to say that these responses were not a true reflection of the course, but that they could not be reliably substantiated.

Analyst triangulation describes using multiple analysts in a study to reduce potential bias that may occur if it were only a single person (Patton, 1999). We established analyst triangulation by having three analysts (PL, CG, and DK) discuss and code the data. Analysts independently analyzed the same videos and interviews and then compared findings to one another (Patton, 1999). Additionally, Dr. Anderson provided his reactions to the findings, and his concerns were addressed if certain descriptions of his classroom were not appropriate.

In addition to triangulation, PL completed all of the observations in Fall 2016, which was the heavy video data collection semester, thus establishing “prolonged engagement and persistent observation” (Creswell, 2013, p. 250). Additionally, his frequent attendance to class also allowed him to develop a better understanding of the classroom culture that infrequent observers may not understand.

Findings

Generally, COPUS and CCS data offered a broad sense of what was occurring in the classroom and helped contextualize what was going on in the classroom and how students perceived the classroom as a whole. From COPUS observations, we saw that student-student interactions occurred 40% of the time, student-instructor interactions occurred 15% of the time, and student-LA interaction occurred 25% of the time. From the COPUS data, we posit that Dr. Anderson’s class was fairly active in comparison to a typical lecture-based classroom.
The CCS had several items that we perceived to be related to how we conceptualize sense of belonging in this paper (Table 4.1). Many students reported positively to items on the CCS and not many felt negatively. In all of the items, a substantial number marked neutral for their responses, which suggests that while there are elements in Dr. Anderson’s class that supports a more positive learning environment, there is still some work that needs to be done to make sure all students experience a stronger sense of belonging.

Table 4.1. Select Classroom Community Scale responses from Fall 2016 and Spring 2017.

Numbers represent the number of students who responded that particular way on an item. Not all students enrolled in the course completed the survey. SA is Strongly Agree, A is Agree, N is Neutral, D is Disagree, and SD is Strongly Disagree.

<table>
<thead>
<tr>
<th>CCS Statement</th>
<th>Fall 2016</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Spring 2017</th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>I feel that students in this course care about each other.</td>
<td>13</td>
<td>36</td>
<td>37</td>
<td>14</td>
<td>3</td>
<td>4</td>
<td>25</td>
<td>55</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>I feel that I am encouraged to ask questions.</td>
<td>14</td>
<td>44</td>
<td>36</td>
<td>6</td>
<td>2</td>
<td>8</td>
<td>44</td>
<td>29</td>
<td>18</td>
<td>2</td>
</tr>
<tr>
<td>I feel connected to others in this course.</td>
<td>12</td>
<td>36</td>
<td>29</td>
<td>20</td>
<td>5</td>
<td>3</td>
<td>36</td>
<td>30</td>
<td>17</td>
<td>15</td>
</tr>
<tr>
<td>I feel that it is hard to get help when I have a question.</td>
<td>2</td>
<td>11</td>
<td>29</td>
<td>49</td>
<td>11</td>
<td>1</td>
<td>8</td>
<td>16</td>
<td>55</td>
<td>20</td>
</tr>
<tr>
<td>I do not feel a spirit of community.</td>
<td>5</td>
<td>19</td>
<td>44</td>
<td>26</td>
<td>6</td>
<td>4</td>
<td>11</td>
<td>44</td>
<td>32</td>
<td>10</td>
</tr>
<tr>
<td>I feel isolated in this course.</td>
<td>3</td>
<td>13</td>
<td>28</td>
<td>50</td>
<td>8</td>
<td>5</td>
<td>11</td>
<td>30</td>
<td>43</td>
<td>12</td>
</tr>
<tr>
<td>I trust others in this course.</td>
<td>7</td>
<td>45</td>
<td>38</td>
<td>7</td>
<td>5</td>
<td>4</td>
<td>38</td>
<td>40</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td>I feel that I can rely on others in this course.</td>
<td>6</td>
<td>44</td>
<td>33</td>
<td>11</td>
<td>6</td>
<td>3</td>
<td>42</td>
<td>22</td>
<td>25</td>
<td>9</td>
</tr>
<tr>
<td>I feel that other students do not help me learn.</td>
<td>4</td>
<td>8</td>
<td>23</td>
<td>51</td>
<td>16</td>
<td>2</td>
<td>13</td>
<td>30</td>
<td>46</td>
<td>10</td>
</tr>
<tr>
<td>I feel that I am given ample opportunities to learn</td>
<td>10</td>
<td>56</td>
<td>25</td>
<td>7</td>
<td>4</td>
<td>28</td>
<td>39</td>
<td>22</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>I feel confident that others will support me.</td>
<td>7</td>
<td>43</td>
<td>36</td>
<td>15</td>
<td>1</td>
<td>6</td>
<td>28</td>
<td>48</td>
<td>14</td>
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</table>
In Dr. Anderson’s course, the figured world of science learning that facilitated a sense of belonging relied on three key elements. First, Dr. Anderson and the LAs exhibited authentic caring for students. Second, the classroom incorporated discussions of opportunity to remind students that they belong and to take advantage of the resources offered to them. Third, students and LAs were afforded agency to author and establish roles that would be meaningful to their classroom experience. Each of these elements are explored in greater depth below using information from the variety of data sources.

Authentic Caring

Authentic caring was coined by Valenzuela (1999) in her work describing Mexican children’s experiences in education in the United States. She defined authentic caring for students as demonstrating that teachers not only think of students’ educational needs but also embrace the importance of addressing students’ emotional and interpersonal needs. This is because these intimate relationships are fundamental to helping students navigate their educational experience and setting them up to succeed. Noddings (2002) emphasized the need for authentic caring in education and how fundamental it is to students’ education and development. We utilize authentic caring similarly to Michael, Andrade, and Bartlett (2007), which emphasized student affect and its relation to belonging and success.

Dr. Anderson, from his interview, noted the importance of learning and authentically caring that students received the knowledge necessary to be successful in upstream courses. However, he also focused on explicitly telling students that he and the LAs care for them as a person. Dr. Anderson sought to know more about students’ lives outside of the classroom. In his first interview with us he said:
“[The LAs and I want] to talk with students about things that are not related to class and not related to school because sometimes it's good to check in with someone and ask them, ‘How was your weekend? What are you up to? What are your hobbies?’ We want to know the students on a more personal level. Things not related to class or to the university” (Interview, 12 Sept. 2017).

In relation to this, weekly meetings with Dr. Anderson revealed that he wanted students to pursue extracurriculars and have a life outside of their courses. He stated that he believed students would be more successful as students if they were engaged in multiple areas of the campus community and had opportunities to enjoy events happening on campus and in the city. From course observations, we observed that in >70% of course observations, he made announcements about clubs and ongoing events to his students as a result. We provide an example from class:

Dr. Anderson: Okay, we have a special announcement brought to you by the biology club and their president, Julie.

Julie: Hey guys, so I’m also an LA for this class, so I will see all of you in this section. I’m also the president of the biology club, so I will be doing announcements from time to time. Our first member meeting is this week and we would love to have all of you there. It is right after this class on Thursday. There will be free food, and it will be in this building on the fourth floor, so there’s very little reason not to come for the first five minutes *laughs*. We will be hearing from the Learning Resource Center and talking about study skills and how to do well in biology. We will also be doing some fun ice breaker games so that we learn more about one another (Observation, 8 Sept. 2016).
As evidenced by Julie’s attempt to develop relationships with students, we observed episodes we would categorize as authentic caring by all of the LAs in Dr. Anderson’s classes. Sarah was one of the LAs in Dr. Anderson’s Spring 2017 course and wore one the LA POV cameras. She displayed attentiveness and patience with students. After being shown videos of one of her interactions with students about a transcription activity in class, she had the following to say:

I felt like [this was a successful interaction]. I felt like there were a lot of guiding questions [to help the student] kind of figure out the answer. If she did not get it right, then I would, you know, guide her towards the right answer. I’m glad she asked a lot of questions so that she could clarify anything that she was confused about. I was glad to help her with that too. She’s definitely thinking more in depth, [which] was good (Interview, 1 Nov 2017).

James, another focal LA, also discussed elements of authentic caring in his interview. In the first excerpt, James is reflecting on an interaction in which he provided resources and support for a female student who was struggling in class:

She is a nontraditional student, you know, a little bit older than most people in the [biology] class. She just asked me about my experience, and I was trying to … steer her to the resources that the school has and, you know, give her like a little bit of confidence. You know, you can bomb a test here and there but manage to still pull good grades and stuff … she was asking for advice … and you know, I’ve been there, and I did bare minimum work. Since coming back [to college], I’ve been really taking every opportunity and resource available… I was trying to keep her motivated because I haven’t been in school in forever either (Interview, Nov 2017).
In this interaction, James discussed how he wanted to keep the student motivated and offer her resources because he knew that it was a struggle to get back into school. He said later in the interview that he wanted to give her hope and did not want her to close herself from the rest of the classroom community. Additionally, he stated in his interview that his interactions with her inspired him to start the Nontraditional Students Organization on campus.

Similarly to Dr. Anderson, James emphasized the importance of getting to know students on a more personal level. He felt that developing that comradery will help develop trust and help him get through to students and talked about conversations he has had in class:

[It’s important to] talk to them like they are a person. ‘Hey man, how are you doing?’
‘How was your weekend like?’ ‘Did you catch the game?’ Like, you know, B.S. about hockey for a few minutes. We also end up talking about food and stuff. ‘Did you know he’s a chef too?’ There’s a [few] different people that are nontraditional students, so I end up talking to them about life and … about getting along with being back in school.

Because Dr. Anderson and the LAs indicated they cared about the students and truly wanted the students to be successful, Dr. Anderson reported that during weekly meetings, the LAs and he always discussed new ways to help students engage with material, and together, they developed questions and handouts that were used during active time in class. Dr. Anderson used different mediums to teach his students and regularly mixed drawings, videos, and demonstrations to help the students understand the concept they were learning. We provide an example of a DNA replication teaching demo below to showcase one medium:

The students were finishing a worksheet packet on enzymes that facilitated DNA replication when Dr. Anderson called their attention to the front of the classroom. In his hands was a long chain that had been folded into two.
Dr. Anderson: If I can have a volunteer help me with this. Anyone want to come up and grab some chain here?

One of the students from the front row goes up to Dr. Anderson, and he motions her to hold the end of the chain to his right.

Dr. Anderson: Pretend that this is a DNA double helix. I know that it isn’t, but pretend it is. Trust me, this is worthwhile. This is one end *points to the end he is holding*, this is the region that needs to be copied *pointed to the middle of the chain length* and that’s the other end *pointed to the end the student was holding*. So what’s going to happen is, at some point there is going to be an origin of replication; let’s say that it’s right in the middle *began to pry open the middle with his hand*. Helicase will move in opposite directions and unwind the DNA. When they unwind the DNA it’ll basically look like that *opened the origin of replication more*. When that happens… actually, I’m going to need one more volunteer to hold this end. If I were an octopus, I could do this, but I’m not.

Students laugh at his statement, and a male student came up to grab the end Dr. Anderson was holding.

Dr. Anderson: As I open it more, you can see the tension at the ends that build as I unwind it. You see that knots that have been created. That’s physically the problem with DNA replication, and that’s why there’s this enzyme called topoisomerase. (Observation, 8 November 2016).

Through demonstrations, such as the one described above, Dr. Anderson hoped that students would better understand the processes that they studied in class. He wanted students to enjoy what they were learning and understand why each piece of a process was important.
Many of the interviewed students recognized the effort that Dr. Anderson and the LAs put towards making sure that each class was meaningful and effective. Amanda, one of the students in the class, said the following during her interview:

Right now, Dr. Anderson is probably my best professor. He is always asking questions and making [analogies], like calling a blood cell a household item, to [sic] compare and make the different concepts kind of stick out. This made it easier to remember and study (Interview, 3 May 2017).

David, another student in the class, noted that he liked the general routine of the class and felt that it showed that the instructional team authentically cared about their learning. The opportunities to receive immediate feedback help him learn the material better. He stated:

So I really, really like Dr. Anderson’s [way] of explaining, then letting you practice on a worksheet, and then asking [him and the LAs] questions afterwards. I find it really helpful because if you are being taught something and you can’t practice it until the homework, it’s not as fresh in your mind… you also don’t have the chance for [real-time] feedback.

Dr. Anderson and the LAs demonstrated authentic caring via their intentional efforts to make sure that they successfully (1) helped their students learn and (2) learned about who their students were. The instructional team made sure to foster a culture that allowed both of these components to thrive, and because of that, the tone that was established for the classroom was supportive. Many of the students that were interviewed appreciated the efforts that Dr. Anderson and the LAs put towards the classroom, which may have helped students feel as though they belonged in the class.
Authentic caring from Dr. Anderson and the LAs facilitated a sense of belonging for students in this localized figured world of science learning because interviews with students and LAs provided evidence that positive relationships were being established in his courses. From video observations and LA POV camera data, we saw that Dr. Anderson and the LAs were quick to build relationships with students, and started to talk to and get to know students from earlier class sessions. The conversations that LAs, students, and Dr. Anderson referred to in their interviews regularly fluctuated between talking about the material being presented in class and learning about each other’s personal lives. Because of this, we witnessed that all of his courses had elements of playfulness, calmness, and trust from early on in the semester and that it persisted to the end.

Discussions of Opportunity

One of the elements that we believed facilitated a sense of belonging in this localized figured world was discussions of opportunity. When we conceptualize discussions of opportunity, we describe the discourses and culture of this classroom and how they afforded students the opportunities to better learn the material and better themselves as students and as people. We believed that this was an important element because students could only feel belonging if they were provided opportunities to create meaning on how to belong.

Discussions of opportunity manifested in four distinct ways. The discourses that Dr. Anderson utilized in class presented students with opportunity narratives. Students had opportunities to build community with the people in the classroom. Students were afforded opportunities to engage with personal interests while learning the material. Finally, some students saw their presence in the classroom as an opportunity to pursue an education, succeed, and achieve their goals.
Throughout the course video observations, we noted that Dr. Anderson would subtly offer discourses of opportunity for students when they were in class. From conservations during the weekly interviews, we noted that he worked from the framework that all his students could succeed and would refer to his students as the “Class of 2020”. He will say other little statements, such as “When you go to medical school …” or “When you go to graduate school…” to provide a more positive opportunity narrative. We provide another opportunity example from Dr. Anderson below, which was said after the students took their midterm exam:

You have a lot of scores left, and a lot of time to bring your grades up… there are a lot of opportunities. If you want to do a rigorous assessment of what’s been working and not working [with us], there is still time to improve your grades … remember that your midterm is just one part of your assessment, and I know you can do it if you do your best. Take advantage of the resources we have in class (Observation, 27 Oct 2016).

Students were afforded opportunities to build community with Dr. Anderson, the LAs, and each other when they were in class. The day-to-day activities that occurred in the classroom generally allowed students to work with each other to process new information. Dr. Anderson readily provided opportunities for students to interact and regularly included impromptu discussion time when he could tell that students were confused or lost. We provide an example from class below:

Dr. Anderson: Does anyone remember what the second law of thermodynamics is?

Students were silent and stared blankly at Dr. Anderson. Some students shifted their gazes toward their notes or laptop to avoid eye contact with Dr. Anderson. Dr. Anderson scanned the room for approximately thirty seconds, but no one raised their hand.
Dr. Anderson: That’s okay – this is hard. Take a minute and talk to the person beside you and see if you can figure it out. [The LAs and I] will walk around (Observation, 4 Oct 2016).

Students who we interviewed reported that they generally enjoyed the interactions that they had with each other, the LAs, and Dr. Anderson. These relationships were beneficial, particularly among student-to-student interactions because they were able to commiserate with one another and talk about each other’s struggles. We provide an example from Yulia, one of the students:

I do not have feelings of isolation in this course. Student care for each other, [and] I would say it is because … The people you surround yourself with, I think we're all in the same [situation]. Our goal is to pass the class and [sic] feed off of each other. My peers, those who sit next to me, we feed off each other. Most of the time I'll assist them and they’ll [help me] with like thinking cognitively and applying it. [We think about] what the instructor wants us to get [from the concept]. So yeah that's my experience (Interview, 20 Apr 2017).

From LA videos, we determined that LAs acted as though community was important to learning and did their best to give students who were otherwise isolated opportunities to talk through what they have learned with other people. Sometimes LAs asked groups to include isolated students, and other times, LAs personally spent time with isolated students. We provided an example from James, one of the focal LAs. He was shown a video from one of his interactions in class and was asked to reflect:

James: We were going over the DNA packet, and it was a beefy packet and a lot of the students … just didn’t really know where to start or want to start. [The student] was just sitting there trying to figure out how to do it.
Interviewer: So in this interaction, did the student call you over or were you passing by? James: Just passing by. He seemed like he was a little bit lost and didn't know where to start ... There was like three people that sit with [the student] in that general area and they, over the semester, started pow-wowing a little bit more, and he just seemed like he was a little bit on the outside of the pow-wow than the other [students] … so I just thought you know … [he] definitely still looked a little bit lost so I wanted to … make sure that he at least got the concept (Interview, 6 Nov 2017).

In addition to building community, student interviews illustrated that students were afforded discourses of opportunity by being able to personally engage with their own interests and knowledge and contextualize it with what was happening in class. Sometimes, Dr. Anderson helped contextualize the concepts that students were learning in class. For example, during a lesson on metabolism and energy flow, Dr. Anderson described wildlife from local ecosystems and chatted about how energy is used to meet the metabolic demand of each organism (Observation, 4 October 2016). In the interviews we conducted, students reported varying interests in and out of class, and many described instances of how they had opportunities to connect their own interests with classroom conversations. Lorezno, another focal student, stated:

Well actually, my roommate is in that class, so he is just as interested in science as I am. You know, we go home and watch documentaries and just learn about stem cells and all these [sic] other stuff that's going on, and we come to class and see and learn about all these stuff. It just kind of feel like we build a community because we're talking about things [that we saw] and then other people kind of join in ask questions and we kind of just build that community among us (Interview, 4 May 2017).
Lastly, we observed that students discussed the importance of their opportunity to go to college, a phenomenon that Michael et al. (2007) coined as opportunity narratives. Some students in this class discussed how getting an education and participating in this class will facilitate better opportunities and allow them to achieve goals that they had. Many students said they realized that not all people get an opportunity to go to college and believed that they had to put in time and make sacrifices to make the opportunity worthwhile. Though the class may not be directly facilitating students’ opportunity narratives, we believe that the structure of the classroom allowed students to centralize their story and frame opportunity on their terms. For example, Jason, one of the students in this class, talked about the importance of his education as a first-generation student:

My parents, they didn’t get the opportunity [to go to college] so they’ve always been working to be able to provide me this opportunity … Just the fact that I'm able to have this opportunity it's like, a lot of weight on my shoulders, but it's also exciting as I'm going to make something of myself… As a son [I], you know, take pride in giving my parents an opportunity to say ‘Oh yeah, my boy's going to college. He's doing something’ ... [Because I’m a biology major] I want to spend more time and put more work and effort into the class (Interview, 4 May 2017).

Other students also framed their presence in this class through a lens of opportunity but focused it more so on their socially constructed identities (e.g., gender, race, ethnicity). In their interviews, some underrepresented students indicated that they understood they were afforded opportunities that other students who looked like them may not have been afforded, and these students wanted to make sure that they did their best to be successful. Lorenzo, in particular, focused on his Hispanic background and why it was important for him to succeed:
There isn't enough Hispanics pursuing science as their careers, for whatever the reason. It's maybe because [they think] that they're not capable, [but] maybe I feel like people have to grow some sort of curiosity for it. You know, you have to kind of start digging a little bit, and from there, you kind of start to develop the hunger to learn the stuff and how things work. For being Hispanic like I said, a lot of people come from very religious families or [have] very limited resources and didn't get the opportunity to go to school. So just having the opportunity to go to school is something that defines me as a science learner (Interview, 4 May 2017).

Discourses of opportunity helped facilitate a sense of belonging in students. Students had opportunities to build community with other members of the class, and the opportunities to build communities gave students a network that could help learn the material and be successful in class. Additionally, students had opportunities to personalize the material and make it more applicable to their lives and interests. Finally, the students reiterated opportunity narratives and discussed why being in college and in this class was important to them. They realize that not all students have the same opportunities that they do, and these students wanted to make sure to take advantage of what they had.

Agency to Position and Author

Though figured worlds are often constrained by historical and cultural norms that have been established through previous generations, individuals within figured worlds are often afforded agency to participate in the figured world as they see fit (Holland et al., 1998). Their agency allows them to construct new meanings and values within that figured world and create spaces that allow them to fully participate. This agency is important because it allows students to construct identities that will allow them to better navigate their localized figured worlds and feel...
as though they belong. Positioning refers to how someone may be identified in relation to sociocultural and sociohistorical contexts. Authoring refers to the notion that one’s personal narrative is subjectively created by one’s self based on sense of self, which can be impacted by external and internal factors.

In our data, we recognized that the authored identities of students, LAs, and Dr. Anderson were positive in the context of this course. We posited that these constructed identities allowed students to feel as though they belong in this classroom and that they could be successful. We noticed that students were positioned to be intellectuals, LAs were positioned to be mentors, and Dr. Anderson was positioned to be an approachable professor. Additionally, students authored new roles in the classroom, such as being group leaders.

Discourse observed in the course and LA videos strongly suggested that Dr. Anderson and the LAs wanted students to believe that they were intellectuals and that they (1) were able to learn material and (2) contribute novel thoughts and ideas to classroom discussions. Dr. Anderson regularly validated students’ voices and thoughts during class. We provided one example below when students were working on a photosynthesis packet. Dr. Anderson was moving through groups during their activity time:

Dr. Anderson: Hey, there was a really good question over here on the left side. Somebody made great comments about this process *points to a series of questions on the projector*. The students shifted their attention to the front of the room, and the side conversations subsided. Dr. Anderson proceeded to help the class work through that section of the packet by explaining his intention and the purpose. He also spent a few minutes
reviewing parts of the photosynthetic process on his PowerPoint slides (Observations, 27 Oct 2016).

During his interview, Dr. Anderson noted that he really tried to let students know that they have valuable things to say and that he appreciated their input with daily class. He tries to acknowledge it by thanking them for questions or commenting that they have good questions. He said:

People have really neat things to say, and the whole class benefits from hearing another student give their perspective. I let students practice being vulnerable and speaking out loud in front of a lot of people. That's another skill that I think is valuable for students to [have] - go out and take a risk (Interview, 12 Sept 2017).

The interviewed LAs indicated that also view students as intellectuals. This is in contrast to more traditional models, which may still highlight elitist perceptions in science and treating introductory courses as metaphorical “gateway” courses (Lemke, 1990). In Sarah’s interview, she said that she understood that the course was difficult but knew that the students could be successful:

[I know that Dr. Anderson’s quizzes] are not the easiest thing, so I definitely hear a lot of people saying, ‘Oh, I’m never going to be able to understand what he wants.’ I tell them, ‘No, you will definitely be able to get the hang of it. These tougher classes, like, they are going to be really iffy at first, but before you know it, you and your group will understand things a lot better.’ I [want people to] be open minded and have a positive attitude. They will get better (Interview, 1 Nov 2017).

Shane, one of the other focal LAs, shared similar sentiments to Sarah about students being intellectuals:
I think that they want to do well and also they are willing to prove … I am going to the pedagogy class and talking about metacognition … I want students to know that if they make a mistake they can learn from it and improve … and not accept that it’s an [innate] intelligence thing. If [they] work hard and learn from their mistakes, I think everyone [in the class] has the potential to succeed.

In addition to being positioned as intellectuals by Dr. Anderson and the LAs, students were able to author their own experiences in Dr. Anderson’s class and establish identities that had meaning to them. In the student interviews, we noted that students tend to establish roles in their groups, and some of them were de facto group leaders. We provide excerpts from Brandy’s and Jason’s interviews:

There’s a huge group who sits by me, and we are all really interactive, especially if we do like clickers or questions he asks during class. We will all interact and be like, ‘Oh we think it’s this reason because of this’, and I feel that they all rely on me because I was the social butterfly at first. [I] expanded the group from what it was. Like, it was 2 people, and then I started to talk around and ‘Hey, what do you guys think this one is, or do you guys have thoughts or feelings about this answer compared to this one?’ And it’s the same with outside of class too … finding out what [classmates’] are struggling with and ‘Hey, let’s form a study group or let’s do this’, trying to get more involved with the rest of them (Brandy, Interview, 18 April, 2017).

Within the first couple of weeks of the classes, everyone around me realized I was doing good on the tests and homework and knew the clicker questions. I feel like I got to a point where they relied on me for everything. Definitely all the clicker questions … It has
helped me. In the sense that teaching someone is the best way to retain information and the way to learn. (Jason, Interview, 4 May 2017)

LAs often played the role of mentors in the classroom. We noticed that students asked LAs questions about concepts, activities, and studying for the course. We also observed a high number of interactions that included topics about internships, classes to take in the future, and about how to interact with different professors. Dr. Anderson mentioned that he encouraged LAs to have those types of conversations with students because he knew that they better understood the student experience at the institution:

I do think it’s fine if LAs talk with students about things that are not related to class but related to school, like other classes and advising them. I do encourage LA's to talk with students about how to be successful in the class. We even actually spent one extra session one time just talking about study tips and I had the LA's come after class. It was one evening on campus and we recorded it and talked about how to be successful (Interview, 12 Sept 2017).

The students felt that LAs were mentors as well and appreciated the time and effort that LAs put into the class to help students. Jason particularly bonded with Shane, one of the focal LAs. Jason felt Shane was an excellent mentor because Shane made expert thinking explicit:

I did all right on the first test, and I went and talked to Shane, and he walked me through the whole test and. He didn't just give me the answers, he helped me think through it. He said experts [made connections], and he connected it to things I already knew… Shane’s going to get a raise or something *laughs* (Interview, 4 May 2017).

Of the representative sample of students and LAs we interviewed, all had positive perceptions of Dr. Anderson and felt that he was incredibly approachable. LAs felt as though
they were a valued member of the instructional team and were able to try new pedagogical
techniques to help students learn. Students believed that Dr. Anderson was kind and amicable.
They felt welcomed to the class and appreciated the time and effort he put into his course. We
provide quotes from two students, Brandy and Lorenzo, below:

Okay, what’s positive [about Dr. Anderson] would be him using humor during his
lecture, [without] even meaning to. He is kind of awkwardly funny, and it makes all of us
laugh. So, I feel more comfortable with him, because I can relate. I’m an awkward person
too (Brandy, Interview, 18 April 2017).

He has a lot of charisma. You know he's very passionate about teaching. He really
understands things, and that makes you feel more engaged in it because you know while
he's so passionate about this… I feel like [that] his energy allows you to be more engaged
with the class and with the teacher. He’s approachable, and I really [enjoy] his teaching. I
don't have anything against the way he teaches. He's a really good teacher. You know, I
go to his classes every [day]. I like him, Dr. Anderson (Lorenzo, Interview, 4 May 2017).

Agency for students to position themselves and author facilitated a sense of belonging
because the ability to make meaning of experiences and create positive identities to go with those
experiences helped students better navigate the classroom. Individual agency allowed students to
be positioned as intellectuals, even though they were in their first biology class. Additionally,
students were able to author more engaging identities in this class, which helped them feel as
though they belonged. LAs were positioned as the students’ mentors, and students valued having
mentors close to their age to help with college. Finally, Dr. Anderson was positioned as an
approachable professor, which meant that students were more comfortable with the class and
more engaged.
Dissenting Voices from the Classroom

The suggest that three elements described above, were important mechanisms by which Dr. Anderson and the LAs were able to successfully create a classroom culture that facilitated student belonging for many students. Based on student interview evidence, many of the students seemed engaged with the material and genuinely participated with the daily tasks and activities. Based on LA interviews and observation video, we also saw that there were 10-20% of students in the class who seemed disinterested or a disengaged. The LAs and Dr. Anderson tried to reengage those students, but some students reported that they still did not fully feel like a part of the classroom community despite these efforts (Table 4.1), and we describe some of their reflections below.

Though Brandy discussed feeling like a group leader in class, she still expressed reservations regarding talking to Dr. Anderson and the LAs. When prompted about her discomfort, she replied:

When [we are doing activities] in a classroom, and [Dr. Anderson and the LAs] are walking around, I just, I don’t feel comfortable asking them a question because I don’t want to be judged. And I do feel like some of them do it, but not intentionally. So, to me, it’s better to ask my peers (Interview, 18 April 2017).

Though the LAs and Dr. Anderson all state in their interviews that they want to create a positive classroom culture, students, such as Brandy, still experience some distress when asking questions because they perceive they are being judged. This suggests that there were still elements that were not described about the classroom that negatively impacted students.
Valeda, another student in the class, reported that she did not feel as though she or her classmates were encouraged to ask questions during class. When we were discussing why, she stated:

I mean just the class is just so big ... Yeah, just the fact that there are so many kids in the classroom and like so many people and the LAs and the professor lecturing and stuff. At the end of it all, it [still] kind of feels like [they are distant from you] (Interview, 27 April 2017).

Later in the interview, Valeda stated that she felt like establishing a more personal relationship with Dr. Anderson and the LAs would have helped her feel like she belonged and facilitated her asking questions in class. She believed that they needed to ask more personal questions “about you. Like what did you do this weekend or what kind of music have you been listening to? Just like daily life questions.” While LAs and Dr. Anderson reported that they try to have personal connections with students, Valeda’s comment suggested that there needs to be a more systematic effort to establish stronger and personable relationships with students.

Discussion

Overall, this article sought to describe how LA-supported classrooms, taught by Dr. Anderson, facilitated a sense of belonging for students using figured worlds (Holland et al., 1998). Particularly, Dr. Anderson was successful at facilitating students’ sense of belonging via three different elements:

1. Dr. Anderson and the LAs authentically cared for the students.
2. Discussions of opportunities were apparent in classroom norms.
3. Actors were provided agency to position and author positive identities in the classroom.
These elements more fully explained and provided hypotheses as to why the implementation of LA programs can help student success and provided opportunities for faculty members who use LAs to think about how they could better facilitate inclusion and belonging in their student population. Below, we briefly discuss the three elements present in this article and provide implications for teaching.

*Authentic caring* in education is important because the trusting relationships that students form in class serve as the foundation of learning. Unfortunately, there is often a disconnect with how teachers and students perceive caring. Valenzuela (1999) described a school culture where teachers expected students to care about school and achievement, whereas students expected teachers to care about the student. Conflicts in how teachers and students perceive caring can be detrimental to a student’s experience at school. In Dr. Anderson’s class, we saw authentic caring from him and the LAs; the interviewed LAs and Dr. Anderson wanted to make sure that they created an environment where students could thrive and be successful. When teachers destress the traditional procedural elements of a classroom (e.g., lectures, exams, grades) and focus on developing positive relationships with students, learning comes more readily and naturally occurs (Maulucci, 2010). Curry (2016) also found that authentic caring/authentic cariño was fundamental to a great education and was essential to the well-being of students, particularly students of Color.

*Discussions of opportunity* were important in Dr. Anderson’s class, which included many students of Color, student parents, and older students, first-generation students. From the student interviews, we recollected that they understood the cultural systems that kept people oppressed and that, by being in this class, they were given the opportunity to rewrite that narrative and better engage. The opportunities to build community via working in groups was important
because it fostered positive interdependence and provided students a space where they can process material as well as non-class related conversations (Tanner et al., 2003; Wilson, Brickman, & Brame, 2018). Additionally, students took the opportunity to engage with the material through their own interests, and this free-choice learning will allow them to take advantage of bettering their own knowledge and becoming life-long learners (Jones, Corin, Andre, Childers, & Stevens, 2017). O’Shea, Stone, Delahunty, and May (2018) interviewed first-generation students and found that they viewed attending college as an opportunity to better their lives and push boundaries, which paralleled what students said during their interviews.

Dr. Anderson’s class afforded members of the classroom community the agency to position other individuals and author their experiences. The classroom community did so by establishing positive roles and identities for different members of the class, such as labelling students as intellectuals or perceiving LAs as mentors, and student authored positive roles in the classroom. Most importantly, Dr. Anderson strived to facilitate a space that did not constrain students to prototypical roles (e.g., deficit roles for students of Color) (McGee, 2016; Solorzano & Yosso, 2001) but rather, had a space that facilitated the creation of positive roles that pushed the traditional paradigm. As such, he was seen as approaching and amicable to students. Previous literature points out the importance of position students in positives manners and allowing students to author their experiences in meaningful ways. For example, one study focused on how a Hispanic-serving bilingual high school afforded identities of success that allowed students to author positive school experiences (Michael et al., 2007). Chapman and Feldman (2017) studied high school science classrooms and noted how classroom experiences and classroom culture impacted how students authored their roles and identities.
These three elements, helped facilitate a sense of belonging for students because of a shift in the culture and what was being valued. While students were still learning biology, learning biology was not the entirety of the class. Dr. Anderson recognized that there was much more to being students and wanted to create a class that was empathetic and cognizant to varying experiences (Kelehear, 2003). In this figured world, more traditional norms of a science classroom (e.g., lecture, memorization) were deemphasized. Dr. Anderson and the LAs established new norms and values in his classroom that created new meanings of science learning and allowed students to engage with the content in different ways.

Implications

Throughout our course observations over the academic year, we more and more noticed the importance of having an inclusive culture that centers student voices and narratives that interrogates traditional meanings of science. Though figured worlds have established cultures, ways of knowing, and ways of doing, individuals within the figured world have the agency to reflect, problematize, and change elements of the culture to make it more inclusive (Holland et al., 1998). The harsh reality, however, is that there is not a clear method to creating an inclusive classroom, but for the humanity of current and future educators and students, this work is necessary. Additionally, students who create identities and ways of knowing in this figured world will eventually leave and may be enrolled in a more traditional class. As such, students’ meaning making and doing will differ, and their sense of belonging may change.

In relation to thinking about the culture, the norms established within a culture and facilitate or hinder students’ sense of belonging. Educators must think about what norms they strive for and why those norms are important to them. Glasser (1969) described the norms and how grades and standardized tests have shifted students’ focus from learning and understanding
to wanting to know what will be on tests and viewing other knowledge as distracting. Kelehear (2003) acknowledged that there has to be some accountability in learning but realized that the norms set up by rote memorization and individualism for the purpose of passing is detrimental to students. As such, educators who are striving for classrooms where students feel as though they belong need to critically think about how norms that are fostered in their classroom impact students and what those norms communicate to students about science.

Though the three elements we focused on were centered on sense of belonging, they also relate to growth mindset of students (Dweck, 2008). Though Dr. Anderson had a diverse group of students every semester in his courses, his conversations with the research team never positioned the students as “lacking” or “having gaps”. Rather, he and the LAs believed that the students, though they may face setbacks during their educational journey, can master the material and be successful. He acknowledged that each class took emotional and mental energy, particularly because his class conflicted with the “traditional organizational pattern” of typical science classrooms (Kelehear, 2003, p. 28). At times, he stated that he had contemplated not using LAs one semester to rest, but he did not want to give them up because he knew how much the program has helped his students.

Conclusions

The purpose of this study was to describe some elements in Dr. Anderson’s classroom that helped facilitate a sense of belonging. Through course observations, Classroom Community Scale data, and interviews with students, LAs, and Dr. Anderson, we were able to understand the dynamics of this classroom, particularly authentic caring, discussions of opportunity, and agency to position and author. Students learned to identify with this localized figured world because it made them feel as though they belonged and that they could be successful. When students shared
their stories, it was apparent that students felt valued in class and knew that they were cared for by their peers, the LAs, and Dr. Anderson. This sense of belonging was possible because Dr. Anderson and the LAs were successful in establishing day-to-day norms that fostered respect and understanding. This acknowledged the agency that individuals in this classroom had to engage and participate in ways that were meaningful to them and made them feel as though they belong. Changes, such as the ones described in this paper are complex and require significant thought and reflection. However, re-imagining what classroom spaces could look like and trying out new ideas is paramount to making sure that, as educators, we establish a culture that allows all students to be successful and feel that they are a part of the community.

We acknowledge some limitations of this study. Because the coding focused heavily on sense of belonging, we may have missed other elements of the classroom that helped facilitate student success. However, we believed that placing boundaries on the case study ensured that the presentation of the results above be reasonable and easily discussed. We also understood that different lenses, such as critical theory lenses, would have yielded different implications regarding inclusion and how inclusion may look through different institutionalized systems of oppression. We suggest that future work include different lenses so that the science education community can better theorize transitions to transformed science courses and students’ perceptions of science classroom culture as they experience the course.
CHAPTER V
CONCLUSION

The primary goal of my dissertation research was to understand what classrooms look and feel like for students because perceptions of the classroom community and culture are consequential to whether or not students stay or leave science majors. Understanding elements related to classroom culture and community is paramount to fully realizing inclusion and access in science education.

Describing classroom community and culture and its implications to inclusion and access in science education is difficult. Though there is no way to possibly explore all the aspects of inclusion and access, I decided to approach my dissertation via faculty interviews, student interviews, and course observations as a means to investigate a broad variety of factors. I briefly summarize them below and explain how they intersect with one another.

Research Completed in Dissertation

The instructor interviews were designed to understand instructors’ day-to-day practices in class, their use of LAs, their conceptions of classroom culture, and their perceptions of learners. I interviewed instructors because I recognized that their conceptions of what science education is and should look like influence what happens in their classrooms. In Chapter 2, I focused on how instructors provided students access to capital and how instructors renegotiated power differentials in their classrooms. I focused on capital and power specifically because, as in any community, full participation requires possessing capital that is deemed valuable to that community and having power to determine norms, values, and rules (Bourdieu & Passeron, 1990). We found it important to understand, from the instructor perspective, how access to capital and renegotiating power manifested in their classrooms. To varying degrees, instructors
were successful at providing students access to cultural and social capital and renegotiating power so that LAs and students could provide more input into the classroom culture. The shifting of these dynamics had the ability to create a new culture in which students feel included.

The student interviews were designed to more fully explore the process of science identity production. By asking students about their socially constructed identities, past and current lived experiences, and their perceptions of what a positive classroom culture looks like, I was able to better understand how students came to see of themselves as science people. Using figured worlds Cultural Identity Production and Procedural Identity Production (Holland et al., 1998; Urrieta, 2007b), I was able to understand how science identities were impacted by socially constructed identities, past and current experiences, and interactions with other actors and classroom material. Identity production was complex and multifaceted; students reported a variety of experiences and perceptions of the classroom community. I found two things to be particularly salient: agency for students to author their own experiences and recognition as science people in the community. A student’s overall sense of who they are as a science person will inadvertently impact whether or not they feel as though they are included and determine whether or not they decide to stay or leave a science major.

The course observations, student interviews, and faculty interviews with one instructor informed my case-study, which focused on how one LA-supported class helped facilitate a sense of belonging for students. I was able to more fully describe the day-to-day phenomenon of Dr. Anderson’s classroom and see how he and his LAs were able to transform the classroom space so that students felt as though they were a part of the community. I used figured worlds (Holland et al., 1998) as a framework to make sense of what was happening in his class. Overall, three elements emerged from the data. Dr. Anderson’s class facilitated a sense of belonging for his
students: (1) Dr. Anderson and the LAs authentically cared for students, (2) Dr. Anderson, LAs, and students had opportunities to openly discuss opportunities and establish positive discourses and narratives, and (3) actors in the classroom were positioned positively and students were given space to author positive identities. These elements worked synergistically to establish a positive classroom community in which students were provided a space to feel included and supported.

These chapters relate to one another because they showcased the complexity of inclusion and access and how it takes multiple perspectives and approaches to truly understand the dynamics of a classroom and how this impacts students. The interviews gave me a sense of how different actors view their experiences and roles, and the course observations allowed me to contextualize the space in which these experiences occur. By collecting multiple pieces of data, I have a better picture and understanding of how classrooms can look and feel and how this can impact inclusion and access.

Situating within the LA Program

In my dissertation, the LA program offered a context in which I studied inclusion and access. A different context was important because LA-supported classrooms deviate from traditional classrooms and therefore, may have different norms and values. Additionally, the LA program is highly flexible, and changes are readily made to meet student needs. As such, it afforded a novel context in which I could study inclusion and describe how it impacted students.

In my dissertation work, perhaps one of the most noteworthy components of the LA program is the shift in agency and power. In traditional classrooms, instructors hold most, if not all, of the power, and what the instructors value and how they perceive science education inadvertently and unintentionally shapes the classroom to their views of science, which often
upholds rules and roles that hinder the success of underrepresented students. This is because of cultural and social norms that “others” underrepresented students and forces them to assimilate to dominant worldviews in order to be successful. In classrooms supported by LA programs, LAs and students are provided agency and have some say in classroom norms. This is because LAs are part of the instructional team, having the ability to design activities, and interact with students to understand their concerns and needs. To me, this is an important first step in really understanding what a transformed and inclusive classroom can look like.

Bringing it back to Figured Worlds

I used figured worlds as the framework of my study because I believe it accounts for the complexity and multifaceted nature of how culture, power, experience, and participation impact what a context looks like and feels like (Holland et al., 1998). Figured Worlds considers that actors reinforce and perpetuate historical norms that maintain a “status quo”. It recognizes that actors in that context all experience the figured world differently, and therefore, establish different identities to help that navigate that space. Most importantly, it recognizes that these worlds are not static. Figured worlds are dynamic and have the ability to change. Actors within a figured world can decide to adopt new norms and make new meaning that is accessible to all individuals.

In my dissertation, I interviewed instructors and students and observed courses that were in the process of transforming. I noted that students are afforded different opportunities to engage with the material in personally meaningful ways, and as such, are afforded science identities that may make them feel as though they belong. This could, in turn, facilitate creating an inclusive space where students’ voices are centered and valued within the classroom.

Final Notes
Though the science education community still has a substantive amount of work and reflection to do, I find it encouraging that inclusion is starting to become a value at institutions throughout the country and that departments are taking the lead to problematize and interrogate their practices. This work adds to the growing knowledge base on diversity and inclusion and encourages institutions to think beyond implementing a few pedagogical tricks. We must ask ourselves why we believe inclusion in science education is important and who are students are. To establish lasting change, classroom transformation is necessary. Additionally, we need to think about our own discourses, biases, and conceptions regarding students and actively work to change what we believe and say. It can be accomplished and must be accomplished for our humanity and for students’ humanity.
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APPENDIX A

The following was the interview protocol used in our research. The interview was conducted for the purposes of informing the analyses for this paper, but also to inform other aspects of our project. We used the entire interview transcript in our coding, but parts 2, 3, and 4 were most aligned with the research aims for this paper. Although we coded the interviews based on the capital and power framework, we did not use these terms in the interview because we felt that faculty were not likely to be familiar with them.

Start Interview
   Confirm: Name, College/University, Course (repeat this so that it is clearly heard in the recording)
   State today’s date clearly to record the date of the interview

Course Design/Practices
   1. What do you perceive as the most important things students should get from your course?
      a. What do you think your colleagues and students think the purpose of your course is?
      b. How do you communicate your course goals with your students?
      c. How do you assess whether students are getting what you think is important?
   2. Describe a typical day in your class.
   3. Thank you for filling out the Teaching Practices Survey [Q36]. You indicated that you use the following: ____________________________. For two or three activity types that they checked on the TPI, ask the following for each
      a. Why do you use ____________? Potential Probe - How does the approach align with what you are trying to accomplish with students, for example a specific LO, establishing classroom culture, behaviorism etc.]
      b. Can you walk me through this type of activity?
         i. How did you introduce/explain this type of activity to your students? For example In format do you give them instructions?, what do you tell them about how long they have and what they will turn in?
         ii. How did students engage with it?
         iii. What are the unspoken instructions/routines in your class about how students should engage with this type of activity?
         iv. Describe the follow-up that happens after the activity is completed by students?

LA Use
   1. What do LAs do in your course? In other words, what do you ask them to do and why?
   2. Refer to this list (see the list below and have it printed out for the interviewee to see), do you think that this list of actions represents what you expect your LAs do in their interactions with students in your classroom?
      a. We acknowledge that what you expect your LAs to do and what actually happens in class may not be the same. Do you think that this list of actions represents what your LAs actually do in their interactions with students in your classroom?
      b. Which actions do you think occur most frequently?
      c. Are their actions your LAs do that are missing from the list?
      d. Has your use of LAs changed over time? If so, in what ways?
3. Do you think having LAs in your class has improved teaching and learning of your course? If so, in what ways and based on what evidence? Potential probe - Is there anything you know about your students now that you didn’t know before using LAs in your course? Can you give some examples? How did your LAs help you see this?

Classroom Culture and Diversity
1. Can you describe the classroom culture in your course? In other words, how do your students to engage with other students, you, the material in the course?
   a. How does the classroom culture develop?
   b. What type of classroom culture do you strive to foster?
   c. What actions do you take to establish that culture?
2. Is your classroom community diverse? Can you describe the diversity in your class?
3. Can you describe different practices that you do to facilitate learning by a diversity of students (all types of diversity - learning styles, race, ethnicity, age, gender etc.)?
4. What is your sense of the complexities and challenges related to diversity in science classrooms?

Perceptions of Learners
1. What are some things you think determine whether a student succeeds in your course?
   a. What are qualities that you think students need in order to succeed in your course?
   b. What barriers do you think your students face in learning that keep them from success?
   c. What do you think your role is in helping students learn (or succeed) in your course? Potential probe - What are some specific attributes that different students bring to the classroom and what actions do you take to leverage to help them succeed?

Thank you for your time today. If we have any further questions, would it be okay to contact you?
APPENDIX B

Preliminary questions of interest and the resulting themes founded from the interviews.

<table>
<thead>
<tr>
<th>Preliminary Question: How do LA-supported faculty perceive student diversity and classroom culture?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faculty speak to positionality and power of themselves and their students?</td>
</tr>
<tr>
<td>Faculty discuss that students have different experiences</td>
</tr>
<tr>
<td>Faculty see diversity as an influential factor in the classroom</td>
</tr>
<tr>
<td>Faculty explicitly address diversity through practice/teacher-talk</td>
</tr>
<tr>
<td>Faculty express the need for students to collaborate and learn from one another in order to remove systemic inequities</td>
</tr>
<tr>
<td>Faculty articulate that they are able to see beyond the &quot;student&quot; label (teaching the whole student/person)</td>
</tr>
<tr>
<td>Faculty strive to do actions that facilitate a positive classroom culture</td>
</tr>
<tr>
<td>Faculty hold some deficit views of their students</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Preliminary Question: In what ways are LA-supported faculty facilitating inclusion and providing access to new capital for students?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faculty stop reinforcing a right/wrong answer mentality and work on student thinking</td>
</tr>
<tr>
<td>Faculty talk through thought processes and model for students (making expert thinking explicit)</td>
</tr>
<tr>
<td>Faculty reiterate the importance of scientific communication</td>
</tr>
<tr>
<td>Faculty and LAs create a more personable environment (loosening up, one-on-one with the students, creating a more accessible space, etc.)</td>
</tr>
<tr>
<td>Faculty create new materials and resources for students</td>
</tr>
<tr>
<td>Faculty break down power differentials (Learning from LAs, learning from students, refer to them on a 1st name basis, talking about life) - sometimes an action, sometimes a reflection</td>
</tr>
<tr>
<td>Faculty make the science applicable to their own lives (science in the news, etc.)</td>
</tr>
</tbody>
</table>
APPENDIX C

The student interview protocol is divided into three sections. The first section focuses on identity, the second section focuses on classroom experiences, and the third section focused on students’ recommendations for creating a better classroom environment.

Part 1 - Card Sort - To center students to identity prior to other interview questions

Interviewer: Thank you for taking the time to participate in our research today. This interview will dive deeper into your classroom experiences in order for us to best understand how students perceive science and what we can do in order to create a better science classroom environment that allows students to be successful. The interview will be divided into three parts. Part 1 will focus on identity. Part 2 will focus on classroom climate and culture. Part 3 will focus on your personal recommendations on what we can do to make science classrooms better for students.

In the first part of the interview, you will participate in the card sort activity. In a moment, I will give you index cards that will have various identities listed on them. Your task is to choose the ones that you identify with and to rank them from most important identity to least important identity. You will also be given blank cards that you can write identities that we do not think of. I will take a picture of your rankings when you are finished.

The interviewer will give students index cards that will have various identities listed on them (mother, father, son, daughter, student, science learner, female, male, White, Black, Asian, Hispanic, Latinx, first-generation college student, first born, etc.) They do not have to use all of the index cards and can have blank cards to write identities we do not think of, but they are to rank cards they identify with, starting with the most important identity to least important identity. You will also be given blank cards that you can write identities that we do not think of. I will take a picture of your rankings when you are finished.

1) Things to pay attention to - What did student put first? Why?
   i) I noticed that your top ranking identity is _________. Why did you decide to put this first?
2) Talk me through the rest of your identities and why you chose to rank them in this way.
3) Do they bring up science learner in the card sort?
   i) Yes - Ask them why they placed it in the position that they did. Why did you rank science learner where you did?
   ii) No - Ask them why they chose not to place science learner in their collection. After, ask them to place it. I noticed that you did not include science learner in your rankings - why is that? *After they respond* Can you take the science learner card and rank it?
4) Tell me a little bit about yourself. Why did you decide to take this class? What are your goals (short and long term)? Why are these goals important to you?
5) What were some previous experiences you had in science that stand out (elementary, middle, high school, outside of school)? How do you think they impacted you?
6) What are your perceptions of science in general, and how do you think society generally perceives science? Who is it made for, and what does being a scientist assume?
7) How do you think your identities affect how you participate in/experience science and science classrooms? (e.g., Does someone of your identities have a place in science - is there a tension?)
8) How do you feel people of your various identities are represented in science, and how do you think society influences who gets represented in science? How does this affect you?
9) What traits related to your identities empower you as a scientist? Why? (e.g., What aspects of your identities do you believe will make you a strong scientist/science learner? For example, someone with a mother card can say that being a mother helps her stay organized and scheduled.)

Part 2 - Current Classroom Community and Culture

Interviewer: We will now transition into part two, which focuses on classroom community and culture. I will start by asking you follow-up questions to your responses from the student survey given around midterms.

Students were given individualized questions based on their responses to the Classroom Community Scale. One example is given below:

“Specific to Yasar: Yasar, we noticed that your survey responses show mostly positive experiences and perceptions of the classroom. You feel that you are encouraged to ask questions, you rely on others, others rely on you, and that others will support you. Can you share some experiences regarding that? You also state that you feel like the course is a family, that you are not isolated, and that your contributions to group work are valued. Can you expand on that? On your survey, you checked “Neutral” for the statement, “I feel connected to others in the course” - why did you decide to mark that? Based off of your responses, I have chosen a few key words. Please describe Dr. ______ classroom regarding these keywords: comfort, learning, community.”

Questions for ALL students start up again here
1) What makes you feel valued or not valued in a classroom?
2) What is one thing that the professor does that you feel is positive/negative in creating a comfortable classroom environment?
   i) Any particular experience that sticks out?
3) How does the inclusion of LAs facilitate/hinder creating a comfortable classroom environment?
   i) Any particular experience that sticks out?
4) How do you think your experiences in science classrooms compare to others in your class? Do you think your experiences in the science classroom mirror those of everyone else (e.g., do you think others will answer similarly to you)? Why?
5) What actions do you take to create a better science classroom experience for you? (i.e., do you create groups to do activities with? Do you get to know classmates?)

Part 3 - Establishing a Positive Classroom Community and Culture
Interviewer: We will now transition into the last part of the interview, which focuses on what we can do to establish a positive classroom community for students.
1) What do your best professors do to establish a positive classroom culture?
i) Why are these practices important to you? (e.g., Do they make you view yourself as successful? Do they make a classroom seem like a family?)
ii) If you were a professor, what do you think you would do to help create a positive classroom culture?

2) What do your best LAs do to establish a positive classroom culture?
   i) Why are these practices important to you? (e.g., Do they make you view yourself as successful? Do they make a classroom seem like a family?)
   ii) If you were an LA, what do you think you would do to help create a positive classroom culture?

3) What do you need in a classroom environment to help you succeed?

4) If you were to design a perfect classroom with a positive classroom culture, what would it look like?
Twenty-one identities were pre-made and written on cards for students to choose from. Students also had to option to write identities on blank cards that we do not think of.

<table>
<thead>
<tr>
<th>Family Identities</th>
<th>School Identities</th>
<th>Gender and Sexuality Identities</th>
<th>Race and Ethnicity Identities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mother</td>
<td>Science Learner</td>
<td>Female</td>
<td>Black</td>
</tr>
<tr>
<td>Father</td>
<td>Student</td>
<td>Male</td>
<td>White</td>
</tr>
<tr>
<td>Son</td>
<td>Community College</td>
<td>Gender Nonbinary</td>
<td>Asian</td>
</tr>
<tr>
<td>Daughter</td>
<td>Transfer Student</td>
<td>LGBTQ+</td>
<td>Latino/a/x</td>
</tr>
<tr>
<td>First Born</td>
<td>First Generation</td>
<td></td>
<td>African</td>
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<td></td>
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<td>European</td>
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<td>Hispanic</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Pacific Islander</td>
</tr>
</tbody>
</table>