ANTI-DEFICIT FRAMING TYC TRANSFER STUDENTS' SELF-EFFICACY AS CONTEXTUALLY IMPACTED BY EDUCATION ENVIRONMENTS

By

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ABSTRACT

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The work in this dissertation aims to support a more equitable science education culture that better supports students who have historically and continue to be inequitably pushed out of science. Our equity-oriented and anti-deficit research agenda led us to study community college and transfer students as well as their self-efficacy and self-efficacy experiences. This dissertation opens by overviewing the state of STEM education and explaining how research approaches often frame students in deficit ways. Chapter 1 introduces Wood's researcher positionality and relevant literature to her research approaches. Wood's research agenda prioritizes supporting marginalized students in STEM through studying the construct of self-efficacy. After reviewing the research framing, Chapter 2 introduces relevant literature about self-efficacy and two-year college (TYC) transfer student experiences. Chapter 2 ends by addressing how Wood's research positionality aligns with and impacts the ways she researches self-efficacy and TYC transfer students. Afterwards, each body chapter (Chapters 3, 4, and 5) opens with a transition situating it in the broader story of the dissertation. Chapter 3 opens by reminding readers of the reasons for our qualitative approach to studying self-efficacy. Then, it describes the development of a qualitative codebook for self-efficacy. Chapter 4 opens by explaining our shift to a narrative analysis case study of a single transfer student. This chapter ultimately diverged from self-efficacy, and Chapter 4 will discuss the reasons and the results of that narrative analysis, stating that supporting characters were instrumental in a transfer student's success story. The chapter ends with implications for universities to learn from TYCs. The dissertation transitions to Chapter 5 by

broadening out from a single student's case study to a positively impactful course experience at a TYC for STEM students intending to transfer. This chapter describes design considerations learned from the course as well as opportunities the course provided for student self-efficacy experiences. Chapter 6 discusses the story across all three body chapters as situated in the research framing and concludes the dissertation.

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PREFACE: STRUCTURE OF THE DISSERTATION

This dissertation consists of three body chapters that are stand-alone manuscripts in various stages of publication, all opened with the introduction and literature review chapters. The three body chapters were written in collaboration with other authors. Wood is the first author on those papers and has made substantial contributions to the jointly authored work warranting the inclusion of these chapters in the dissertation. Chapter 4 will appear as a published manuscript in an upcoming special issue of CBE-Life Sciences Education (September 2022) and is included here verbatim. Chapters 3 and 5 are intended for publication but not yet submitted. Chapter 3 was co-authored with Angela J. Little, D'Mario Northington, Abigail Green, and Vashti Sawtelle. Chapter 4 was co-authored with Vashti Sawtelle. Chapter 5 was co-authored with John Byrd, Ronald J. Stamper, Robert Dudock, Charles Wade, and Vashti Sawtelle. For the narrative of this dissertation, there is added transitional writing introducing each chapter. The closing chapter concludes this dissertation by discussing all the chapters. Each body chapter's format has been altered to conform with the dissertation format.

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CHAPTER 1 INTRODUCTION AND RESEARCHER POSITIONALITY

The work in this dissertation aims to contribute to a more equitable science education culture that better supports students who have historically and continue to be inequitably pushed out of science. Science and science education overrepresent and underrepresent some demographic groups as compared to the United States population. Students from marginalized identity groups may face additional obstacles in already difficult science, technology, engineering, and mathematics (STEM) academic paths compared to students from dominant identity groups. My work centers the experiences of some of these students and frames their experiences in ways that challenge common deficit models.

Briefly, my equity-oriented and anti-deficit research agenda leads me to study community college and transfer students as well as their self-efficacy and self-efficacy experiences. Specifically, my research agenda and framing impact the ways I do that research, the methods I use, and the considerations I follow in data collection and analysis. This dissertation opens by overviewing the state of STEM education and explaining how research approaches often frame students in deficit ways. Then, I will shift to describing my research response of using anti-deficit framing. This opening chapter reviews impactful literature, ideas, and experiences that have contributed to my approach to anti-deficit framing and my goal of improving the STEM education system to better support diverse STEM learners. In the next chapter, I will discuss the structure of the following chapters of this dissertation, describe methods I have used throughout my research, and connect my research framing to my studies.

To briefly summarize the structure of this dissertation, Chapter 1 introduces my researcher positionality and relevant literature to my research approaches. My research agenda prioritizes supporting marginalized students in STEM through studying the construct of self-efficacy. Social

identities may seem irrelevant to self-efficacy research, but, for example, Usher (2018) specifically calls out the ways whiteness is treated as normal or default in academic motivation research, including self-efficacy. After reviewing the research framing, Chapter 2 introduces relevant literature about self-efficacy and two-year college (TYC) transfer student experiences. Chapter 2 ends by addressing how my research positionality aligns with and impacts the ways I research self-efficacy and TYC transfer students. Afterwards, each body chapter (Chapters 3, 4, and 5) opens with a transition situating it in the broader story of the dissertation. Chapter 3 opens by reminding readers of the reasons for my qualitative approach to studying self-efficacy. Then, I describe the development of a qualitative codebook for self-efficacy. Chapter 4 opens by explaining my shift to a narrative analysis case study of a single transfer student. This chapter ultimately diverged from self-efficacy, and Chapter 4 will discuss the reasons and the results of that narrative analysis, stating that supporting characters were instrumental in a transfer student's success story. The chapter ends with implications for universities to learn from TYCs. The dissertation transitions to Chapter 5 by broadening out from a single student's case study to a positively impactful course experience at a TYC for STEM students intending to transfer. This chapter describes design considerations learned from the course as well as opportunities the course provided for student self-efficacy experiences. Chapter 6 discusses the story across all three body chapters as situated in my research framing and concludes the dissertation. See Figure 2.1 for a figure overviewing the structure of the dissertation.

1.1 Motivation and Origin of My Research Framing

As I progressed through graduate school and my graduate research, I took classes about Critical Race Theory (CRT) and other frameworks for studying race and racism in education. These frameworks and work from Scholars of Color inform the framing of my work. I became

articulate in recognizing and discussing how scientific culture obscures itself and repeatedly reifies itself as white[1], cisheterosexist, and ableist, excluding certain students from participation. It is important to me to improve education support systems for students who are marginalized in STEM and are not feeling the sense of belonging they want to feel in the STEM community or in STEM environments.

In my dissertation, I attempt to combat common ways of doing science by taking an explicit anti-deficit approach to my research. Anti-deficit framing teaches us that in our research and teaching practice, we as scientists cannot be complacent. When we are confronted with data showing, for example, underrepresentation of a certain group in a certain field, we should not passively interpret that to mean that they are not cut out for that field and throw our hands up and say that there is nothing we can do. We should also not frame the issue as being with the students or individual person and ask how to fix the person or try to teach students the things they did not learn or help them catch up to where they should be. We should instead ask what is wrong and needs to be fixed about the system that is excluding that group of people. In my research, I use this

[1]Dumas (2016, p. 13) describes the reasons that in his work he capitalizes "Black" "when referencing Black people, organizations, and cultural products" (p. 3) but does not capitalize "white."

> "Here, Black is understood as a self-determined name of a racialized social group that shares a specific set of histories, cultural processes, and imagined and performed kinships. Black is a synonym (however imperfect) of African American and replaces previous terms like Negro and Colored, which were also eventually capitalized, after years of struggle against media that resisted recognition of Black people as an actual political group within civil society (Tharps, 2014, November 18). White is not capitalized in my work because it is nothing but a social construct, and does not describe a group with a sense of common experiences or kinship outside of acts of colonization and terror. Thus, white is employed almost solely as a negation of others—it is, as David Roediger (1994) insisted, nothing but false and oppressive. Thus, although European or French are rightly capitalized, I see no reason to capitalize white. Similarly, I write blackness and antiblackness in lower-case, because they refer not to Black people per se, but to a social construction of racial meaning, much as whiteness does" (p. 4).

I adhere to this framework in my own work, following Dumas' reasoning. One of the reasons I appreciate this framing is the way it centers Black people and other People of Color and de-centers white people, in saying that "white is employed almost solely as a negation of others." Often, we, particularly white researchers, refer to white folks and non-white folks, describing People of Color as the "other," the negation of white, so Dumas' accurate framing disrupts that norm.

anti-deficit approach to decide who and what data to center in my work and how to frame the stories I craft about people's experiences.

Deficit framing typically involves seeing STEM as culture-free and believing in the myth of meritocracy (Godsey, 1995; Kwate and Meyer, 2010; Hughes and Bonner, 2006); therefore, one who uses deficit framing would think that students who are overrepresented are the ones that are best at, most interested in, or most suited to STEM. Anti-deficit framing instead says that everyone is capable and has the capacity to be interested in and good at STEM; then, if students are underrepresented in STEM, there must be something wrong with the system of STEM culture. In other words, anti-deficit framing says that STEM culture inequitably welcomes some students and excludes some students.

Central to my own understanding of anti-deficit framing and how to implement it is learning from Scholars of Color and drawing on Critical Race Theory (CRT). Many scholars argue that scientists, educators, and education researchers, particularly in higher education, have a duty to center and support marginalized students in our research and teaching. Particularly, I, as a white education researcher, feel a responsibility to improve STEM education for the people it has historically failed and continues to fail. In many ways, STEM education has failed me, as a mentally ill woman, but since I have made it this far, I have the opportunity to leverage my work to improve STEM education for people who face unjust and unnecessary obstacles. Caring about this as the broad goal of my research impacts both my choice of *topics* in research and the *ways* in which I do my research. My research focuses on self-efficacy and also on students from and at community colleges. Although the concept of self-efficacy does not inherently call for anti-deficit framing, I chose to approach it through an anti-deficit lens. Thus, I aim in my research to support

the creation of education environments that will more equitably improve students' self-efficacy toward academic tasks.

Anti-deficit framing of my research further leads me to the research population of community college and transfer students. Many minoritized[2] students attend community colleges (Jain et al., 2011, 2016; Wickersham and Wang, 2016; Wang et al., 2017; Starobin et al., 2016; Bahr et al., 2017; Traxler and Blue, 2020). Thus, those institutions are an important research site to learn from minoritized participants what support systems are already working for them as well as how to better support them.

In this introduction chapter, I introduce readers to some of the ways science continually marginalizes Students of Color, women, and LGBTQ+ and disabled students through its cultural practices and assumptions. Then, I unpack the ways those works have impacted my research framing, as well as the reasons I consider it important to focus on community colleges and supporting minoritized students' self-efficacy development. This opening chapter includes some literature review and some researcher positionality writing to frame the subsequent chapters about my individual research projects.

1.2 Introducing Anti-Deficit Framing

Anti-deficit framing aims to challenge traditional deficit approaches. At its core, a deficit orientation to research in STEM assumes that there is something missing from a student and if

[2]I like to use the word "minoritized" to replace common usages of "minority" or "underrepresented minority student (URM)". This comes from Harper (2012), who writes:

> "I use "minoritized" instead of "minority" throughout this article to signify the social construction of underrepresentation and subordination in U.S. social institutions, including colleges and universities. Persons are not born into a minority status nor are they minoritized in every social context (e.g., their families, racially homogeneous friendship groups, or places of worship). Instead, they are rendered minorities in particular situations and institutional environments that sustain an overrepresentation of Whiteness" (p. 9).

I love this wording and explanation, but I am not always consistent in my use of this term, sometimes using it interchangeably with "marginalized" or "underrepresented." I also still sometimes use "underrepresented minority student (URM)," because that term is common in certain STEM education research writings.

only that were addressed, the student would be more successful. To place the blame or responsibility with an individual or a certain identity is deficit framing, whereas to place the responsibility with institutions and systems is anti-deficit framing (Davis and Museus, 2019; Menchaca, 1997). For example, if one were to look at the underrepresentation of Black students earning bachelor's degrees in physics (Merner and Tyler, 2019) there are two opposing interpretations of the problem. We might think that the lack of Black physics bachelor's degree earners is due to either (1) some property of Black students or (2) to a property of the larger educational system. The former is deficit framing, and the latter is anti-deficit framing.

Both approaches can encompass different practices. Deficit framing typically involves focusing on individuals and how to fix them or what is wrong with them, rather than focusing on how to fix systems and environments. Davis and Museus describe deficit thinking as holding "students from historically oppressed populations responsible for the challenges and inequalities that they face" (2019, p. 1). Yosso (2005) tells us, "Deficit thinking takes the position that minority students and families are at fault for poor academic performance because (a) students enter school without the normative cultural knowledge and skills; and (b) parents neither value nor support their child's education" (p. 75). Research questions using deficit framing might look something like this hypothetical question, "Why are some students academically behind where they should be?"

Seeking a way to reframe this type of question away from emphasizing what students lack and instead emphasizing their strengths, we turned to work from Scholars of Color and Critical Race Theory. Looking across these scholars we can derive a set of key principles for anti-deficit framing in our work. Overall, we learned to think of the participants in our research as capable, agentic individuals within systems that may be biased against them.

1.2.1 Reframe Questions to Ask about the System Instead of the Individual

The first principle we learn from the literature about implementing anti-deficit framing is to reframe questions to focus on the system rather than the individual. When tempted to ask a research question about why particular groups are behind others or what they lack in comparison, reframe the question "instead" (Harper, 2010) to a question about the system. Harper (2010) provides an anti-deficit framework for the study of students of color in STEM. It includes examples of reframed questions, through thinking of the questions as "instead-of" (p. 68). For example, we might rephrase "Why are some students academically behind where they should be?" to look more like, "What is wrong with our education system that is supporting some students more than others, and how can we more equitably support our students?" In this case, we have reframed the question to focus on the system and how it is differentially privileging some students and disadvantaging other students.

Even when focusing on the environmental level, we need to remain vigilant that we continue to use anti-deficit framing and place responsibility with institutions rather than blaming individuals in a system. Without constant reflection, researchers can fall back into deficit patterns. For example, examining the environmental factors that welcome or exclude students overlaps with cultural difference theory. This theory frames the expectations of the education system as one culture and the cultural backgrounds of students as another, where these two cultures may then be aligned or misaligned. Cultural difference theory can support anti-deficit framing and lead to immediate classroom applications, but it can also "assume static power structures" and "risk essentializing groups" (Carlone and Johnson, 2016, p. 170). Similarly, Langer-Osuna and Nasir point out the dangers in the related "mismatch theory", saying that some students may learn from the educational environment that their cultural backgrounds are less valued than others (2009). Thus, even when taking these research approaches that can support anti-deficit framing, we must

constantly reflect to ensure that we continue to work in anti-deficit ways. We need to keep the responsibility for improvement at the institutional level.

1.2.2 Reframe Questions to Learn from Students' Expertise

We can then take anti-deficit framing a step further by rephrasing research questions to learn from students' expertise in the ways they have overcome obstacles and succeeded. Harper's (2010) "instead-of" approaches include reframing questions to ask how students overcame barriers to their achievement. We could ask, "How have students successfully achieved certain learning goals? What barriers did they overcome to do so?" This type of question would also support researchers and practitioners in improving education environments to mitigate barriers to student success.

This principle keeps our attention on what strengths or "wealth" (Yosso, 2005) students bring to education and how they have expertise in navigating systems of inequity. Scholars encourage framing students, especially minoritized students, as bringing a wealth of experiences and expertise to understanding situations. Yosso does this through Community Cultural Wealth. This model is a good example of an "instead-of" approach which Harper encourages. Using a Critical Race Theory (CRT) lens, Yosso reframed the experience and expertise of Communities of Color as wealth, when dominant narratives have dismissed those backgrounds and skills. This aligns with focusing on students' strengths and how they have overcome barriers. Researchers can either discuss learners' tools and strategies and ways of learning as negative or positive. This principle is useful for anti-deficit framing of minoritized students, particularly Students of Color, and the experiences and expertise they bring to education.

1.2.3 Combine Institutional Responsibility with Individual Expertise to Reconceptualize STEM Culture as a Hybrid Space

An anti-deficit approach that combines aspects of both these principles (institutional responsibility and valuing students' expertise) is hybrid space (Carlone and Johnson, 2016). This is defined as being "created when classroom members bring together elements of school culture and home culture to create something new" (Carlone and Johnson, 2016, p. 155). An example of this theory in practice is Barton (1998) exploring the idea of "science-for-all". She argues that "what ultimately transpires in science class is a joint act between teachers and students," (p. 380). In order to create this hybrid space, teachers need to be mindful about asking who has the power to develop images of identities in science. Barton (1998) tells the stories of three girls in a homeless shelter who developed a science project on pollution and their community and "creating science out of experiences that cannot be neatly categorized as science" (p. 387). It beautifully frames the girls as full participants in science, because the paper conceptualizes science as a jointly constructed, dynamic practice.

1.2.4 My Anti-Deficit Framing

These scholars' anti-deficit frameworks inform the broad framing of my research. We have seen that there are some affordances and limitations to these different specific approaches, but they inform my research through these widely applicable principles. I lean on the quote from Barton that "if all students are to participate in science in genuine ways, then teachers need to find ways to value the diverse ways of knowing brought to class by the students" (1998, p. 391). The responsibility is with the teachers and the education environment to value and work with the tools our students bring to class. I believe that all students should have the opportunity to participate in science in genuine ways, and I aim to support that in my research. Whatever my participants' identities may be, I aim to think of them and tell their story as capable, agentic individuals within

systems that may have flaws and present obstacles. This is particularly important when working with minoritized participants, in order to actively challenge typical deficit framing they may have encountered in their education.

1.3 Critical Race Theory Provides Guidelines for Anti-Deficit Framing Inequity as Systemic

In the previous section I outlined how scholars, some using CRT, inform my work and my orientation to anti-deficit framing in my research. CRT and related ideas, like its offshoot theories, inform my framing of oppression and inequities as systemic and institutional rather than solely by individuals to individuals. Whether we define inequities and experiences of marginalization as systemic or individual will impact our framing of our participants and research environments. Anti-deficit framing calls for placing responsibility with institutions and framing individuals as capable people who move through systems that might impede their success. This aligns well with the ways CRT defines racism, a definition that can also inform framing other systems of oppression as systemic.

1.3.1 Anti-Deficit Framing Requires Understanding Systems of Oppression

The basic tenets and themes of CRT are that race is socially constructed, and racism is normal–the ordinary experience of most people of color. CRT developed from legal work following the civil rights era that critiqued ways the advances of the civil rights era stalled or reversed (Demaske, 2009). Due to "interest convergence," legal advances or setbacks for People of Color generally serve the interests of dominant white groups (Delgado and Stefancic, 2001). This tells us that racism is embedded in systems, rather than individualistic, and requires constant challenging to dismantle it. Defining racism as a system of power used to oppress groups of people on the basis of socially constructed racial groups is an important framing that shifts the discussion of race and racism to be about institutional power (Marable, 1992; Solorzano and Yosso, 2001).

This framing aligns better with finding solutions to inequity, because evidently framing injustice as by individuals to individuals has not successfully ended it. Our framing of research questions is critical to our ability to address issues. Most authors in higher education research define and discuss racism as extreme acts of a few individuals rather than as systemic (Harper, 2012). This limits our ability to anti-deficit frame our participants as well as the questions we can address in our research.

1.3.2 Anti-Deficit Framing Requires Accepting Responsibility for our Role in Oppressive Education Systems

CRT tells us that in order to anti-deficit frame our research participants we need to have an understanding and framework for the larger systems in which our participants exist. Those systems, in general and in STEM education, include systems of oppression, like racism, cisheterosexism, and ableism. CRT has produced offshoots, like Critical Race Feminism, AsianCrit, LatCrit, QueerCrit, DisCrit, and more. Collectively, these frameworks emphasize intersectionality in people's experiences moving through the world. They frame oppression, marginalization, and power discrepancies as systemic issues, embedded in institutions and legal systems. This provides guidelines for researchers to follow in using anti-deficit framing.

STEM education research within higher education is part of these systems of oppression. For example, white scholars who write about race often cite only other white scholars (Delgado, 1984; Delgado, 1992). Additionally, researchers in higher education who write about race do not explicitly attribute racialized differences to racism (Harper, 2012). White researchers often use "colorblindness" as a way to absolve themselves of responsibility (Delgado, 1984). This means, for example, that "Black male students' comparatively higher rates of college attrition are typically explained by factors that have little to do with racist stereotypes they often encounter" (Harper, 2012, p. 11). One of the necessary components in choosing to anti-deficit frame our research

participants is to accept responsibility for the difficulties our participants face in STEM higher education. As researchers and educators, we have an impactful voice in changing the face of STEM education and calling out education systems as racist. This principle taught me to enter data collection with an eye toward systems of oppression and be prepared to explicitly name those as factors that might impact students' experiences.

1.4 Anti-Deficit Framing Requires Understanding Systems of Oppression in STEM Education Including Racism, Cisheterosexism, and Ableism

Dominant narratives of science assume that it is objective and cultureless (Traweek, 2009; Daane et al., 2021). Consider Traweek's description of particle physics as "an extreme culture of objectivity: a culture of no culture" (Traweek, 2009, p. 162). This common view or ideal of science is dangerous in that it directly overlaps with deficit-framing. Our society often espouses meritocracy, thinking that those who are successful are successful because they deserve it and those who are not successful deserve to be unsuccessful. If we think that science is objective and cultureless, we have no language to frame systemic obstacles as systemic. Then, meritocracy makes sense. Ignoring the cultural norms ingrained in science often leads to excluding marginalized groups of people from participating in science and ultimately explains much of the underrepresentation of certain groups of people in STEM. Evidently, we have work to do to improve the culture of science. We need to be actively reflecting on and improving our educational strategies in order to not fall into status quo patterns and reproduce systemic inequities in STEM education. This idea can be summarized by Black activist Angela Davis, who said, "In a racist society, it is not enough to be non-racist, we must be anti-racist." If we do not actively challenge systems of oppression in STEM education, we uphold them.

We often treat white ways of knowing as default in general (Guess, 2006; Morris, 2016) and in science. The culture of STEM marginalizes and pushes out Black and Hispanic students

and employees (Fry, Kennedy, and Funk, 2021; Temming, 2021; National Center for Science and Engineering Statistics, 2021). The culture of physics is cisheteronormative and exclusionary to LGBTQ+ scientists (Feder, 2015; APS, 2016; Guglielmi, 2018). The culture of physics is also ableist, limiting accessibility to disabled scientists (James et al., 2020; Traxler and Blue, 2020; Sevo, 2012; Sutton, 2017).

Assuming science to be objective and cultureless obscures these cultural norms and removes the language to discuss the ways they exclude certain scientists. As an example of these obscured norms in physics, Robertson and Hairston (2022) present a case study of whiteness, white norms, white ways of knowing, and the systematic reproduction of such things in an introductory physics course. They show ways that the structure of schooling, the use of whiteboards, certain physics values, and gendered social norms can uphold and reproduce whiteness in a physics classroom. While a narrow example, whiteboards are a tool we often use in science classrooms and labs for group work and representing scientific knowledge construction. Researchers have previously interrogated limitations and possible inequities in the use of whiteboards in classroom group work, arguing that controlling the marker or even eraser yields greater power to that student (Megowan-Romanowicz, 2011; Lemke, 1990). In other words, even seemingly minute classroom and scientific practices in physics are not neutral or without cultural influences. If we are not active and careful in our teaching and research to be anti-racist, feminist, and accessible, we are in danger of reproducing systemic inequities in our classrooms and labs. If we treat science neutral and without culture, we will probably fall into deficit-framing.

1.5 Science is Subjective and Explicit Positionality Reflection is Part of Anti-Deficit Framing

We cannot responsibly treat science as objective and avoid examining our paradigms, lest we fall into exclusionary patterns in our research. Deficit framing, treating STEM as culture-free,

and viewing science as objective are separate but interrelated ideas that iteratively reify each other. This section discusses the interconnectedness of viewing science as cultureless with viewing it as objective and the ways that contributes to deficit framing.

Even though we often treat science as objective and without bias, few things in the world are actually neutral. For example, Perea (2009) describes how science can fall into certain problematic patterns, such as the "persistent focus of race scholarship on Blacks and whites" (p. 132). This Black/ white binary paradigm is pervasive in "normal research" on race, analogous to "normal science" (Perea, p. 133). In other words, science can have an implicit, unacknowledged paradigm that marginalizes certain participants. This will iteratively continue to happen unless we acknowledge our paradigms, making researcher reflection crucial.

We have seen that science is not without culture, nor is scientific inquiry objective. Science is subjective and impacted by researcher's biases. While we should minimize those biases, it is impossible to eliminate them completely, so we must be as transparent as possible about our positionality (Secules, 2021). Our personal identities, interests, insider-outsider positionality, researcher-participant relationships, and more will affect our data collection and analysis (Richardson, 2000; Mirra and Rogers, 2016; Grant, 2017; Cunliffe and Alcadipani, 2016; Bergman Blix and Wettergren, 2015; Berbary, 2014; Miled, 2017; Milner, 2007). This is not inherently a problem, merely a reality of research, but we cannot responsibly perform research without acknowledging our relationship to and within it. This opening chapter is partly aimed at reflecting on my researcher positionality.

1.6 Anti-Deficit Framing Shows that Systemic Biases Impact Context for Students

We have argued above that in order to research students' education experiences and anti-deficit frame their stories, we must understand the contexts in which they exist. There are positive

and negative aspects to different parts of society and environments in which our students move. At the moment, however, we seem to often see negative aspects. We must consider the difficulties of living in society and how that can impact scientists' learning experiences. It is impossible to separate scientists' lived experiences from their science experiences. Humans do science, and humans are impacted by their environments.

In the education context, Love (2016) discusses the parallels between common stories in the news of race-centered violence with spirit murdering, which she defines in the school context as "the denial of inclusion, protection, safety, nurturance, and acceptance because of fixed, yet fluid and moldable, structures of racism" (p. 2). Mass shootings and gun violence in the U.S. are increasing (Ogasa, 2022), including many police killings of unarmed Black people. This has prompted Black Lives Matter protests as well as calls for racial justice in STEM (Temming, 2021). Even in this time of protest and liberal optimism, traumatic racialized experiences continue to happen. Educators and researchers cannot ignore the reality of students' lived experiences when considering their schooling and academic performance.

My personal experience trying to progress through my science education has also been fraught with external difficulties. These might seem irrelevant to my science-doing, but they certainly have impacted my experiences and my cognitive processes. Even my own undergraduate institution, Seattle Pacific University, despite providing me an excellent physics education and improving my physics self-efficacy and identity, has a board of trustees enforcing homophobic policies trying to police the private sex lives of their employees (Franklin, 2022). As a cis woman–a person who's capable of becoming pregnant–my country's government has told me that I have fewer rights than a corpse and messaged to me that my life and personal plans matter less than a hypothetical unborn bundle of cells that might parasitically latch onto my body without my consent

(Totenberg and McCammon, 2022). For more than two years, I have been working from home on my graduate education as I try not to get COVID-19 in the midst of a global pandemic that our ableist society is increasingly saying has ended even though it has not (Schormans et al., 2021).

I acknowledge that I have privilege as a white, cisgendered, visibly able-bodied woman in the United States progressing through higher education. Many students' social identities are much more marginalized by our society and education system than mine, setting even more obstacles in their path. I think of this like science fiction author John Scalzi, who describes social identities functioning like difficulty settings in the video game of life (Scalzi, 2012). This aligns with the concept of intersectionality and how social forces can express power in compounding ways to exacerbate marginalization (Crenshaw, 2017; McIntosh, 2008; Lensmire et al., 2013).

As educators and education researchers, even in science, where many might think we are insulated from external societal influences, we cannot ignore the environments our students and research participants are navigating. Even if environmental difficulties or traumas do not explicitly come up in research, we must consider their existence and preemptively ensure space for our participants to process whatever they might need and to take care of our participants as much as possible. Particularly white educators and researchers should remember that we do not get to decide if race or racism impacts a student's experience. It is about race if a Person of Color thinks it is about race (Oluo, 2019). This sentiment from Oluo teaches me to take my participants' words at face value and honor their voices and what they tell me. If we aim to research a diverse set of students, especially with different identities from our own, we absolutely need to listen to them and center their voices.

1.7 Acting on Anti-Deficit Framing: Higher Education's Responsibility to Address Historically Embedded Inequities

Institutions of higher education have a history of enacting and benefiting from systemic oppression. Stein (2016) points out that "US universities and their founders directly participated in and benefitted from Black chattel slavery" (p. 169). Our current concept of higher education would not exist had it not been for slavery, and the task of grappling with that, while absolutely necessary, may never be adequate (Stein, 2016; Sharpe, 2014; Wilderson, 2010). Societal and institutional norms mask epistemological violence against marginalized people as normal, so we have a duty to disrupt those structures. We must ask what we can do as researchers within the existing, flawed system.

Windchief and Joseph (2015) are among Scholars of Color that propose ways to claim space in the existing postsecondary education system. They call out assimilative educational practices which exclude American Indians and Alaska Natives in education spaces. Then, they share stories of people who have successfully claimed space, and they specifically frame their examples as showing "levels of claiming so it isn't merely the responsibility of the individual student to navigate education space" (p. 269). This is a great example of anti-deficit, systemic framing in the context of stories about individuals. They emphasize "the legacy of other students' claiming of space…and the connection of students nationally as a resource" (p. 269). The language Windchief and Joseph use in this paper provides excellent examples of centering their voices in the conversation and claiming agency for themselves. Discussion throughout these papers shows time and time again that white researchers and authors often center ourselves and marginalize "others". White scholars, such as myself, need to learn from and listen to Scholars of Color and do better at centering marginalized voices.

The questions raised on how to improve a flawed system from within remind me of a short philosophical, speculative fiction story by Ursula K. LeGuin (1973) called “The Ones Who Walk Away from Omelas”. The story vaguely describes a seemingly utopian city Omelas and the joyous Festival of Summer taking place. LeGuin asks readers, “Do you believe? Do you accept the festival, the city, the joy? No? Then let me describe one more thing” (p. 3). After that, she describes a basement in an Omelas building in which a child is tortured and that the people of Omelas’ “happiness, the beauty of their city, the tenderness of their friendships, the health of their children, the wisdom of their scholars, the skill of their makers, even the abundance of their harvest and the kindly weathers of their skies, depend wholly on this child's abominable misery” (p. 3). She ends the story telling readers of the small minority of the society of Omelas who walk away from the city because of the injustice on which their entire society is built.

We can think of many aspects of our modern society as similar to Omelas, founded on violence against marginalized people. Stein, in a similar question to LeGuin’s, asks what we can do to dismantle the flaws in our education system from within. I want to go further from these questions though and ask where we could even go that does not have the flaws of being a society built on injustice against a set of people. N. K. Jemisin makes this move in her short story response to LeGuin, “The Ones Who Stay and Fight” (2018). If we cannot walk away to somewhere better, must we not work from within the system? Even if we can walk away to somewhere better, how can we leave an existing system with flaws, continuing to let that child suffer? Must we not stay and fight to improve and seek justice for all?

This opening chapter is a researcher positionality statement and a broad introduction to who I am and the experiences that impact how I think, in order to explain the ways I interpreted data and the decisions I made when representing participants and telling their stories. Researchers

do not research in a vacuum of academia, only influenced by academic articles and writings, so I have cited other types of things throughout this chapter that have been instrumental to my personal education (e.g., Ursula K. LeGuin, N. K. Jemisin, and John Scalzi). These authors, among others, have influenced myself and my worldview, but also, as a researcher, I have learned to use these storytelling methods, so I think it is appropriate to cite storytellers in my positionality statement.

CHAPTER 2 LITERATURE REVIEW AND METHODOLOGY

This chapter expands on the ways the framing introduced in Chapter 1 informed the methods and research approaches in this dissertation. First, this chapter reviews literature on self-efficacy and two-year college and transfer students, since these are focuses of the body chapters in this dissertation. Then this chapter summarizes the main methods discussed in this dissertation and the ways the research approaches used anti-deficit framing.

2.1 Overview of Self-Efficacy

Self-efficacy is a construct, situated in social cognitive theory, proposed by psychologist Albert Bandura in 1977 as a way to understand human behavior (Bandura, 1977). Bandura suggested that self-efficacy beliefs, or expectancies, are some of the most impactful determinants of human behavior and behavioral change. We will define self-efficacy throughout this dissertation as one's confidence in one's own ability to perform academic tasks, and this will be discussed in more detail in Chapter 3. Locke and Latham (2002) state that people with higher self-efficacy set higher goals, remain more committed to those goals, use better strategies in achieving those goals, and respond more positively to negative feedback than people with lower self-efficacy. Much research has also shown self-efficacy to have predictive power towards students' persistence in STEM (Lent, Brown, and Larkin, 1984; Lent, Brown, and Larkin, 1987; Dalgety and Coll, 2006; Lent, Brown, and Larkin, 1986; Luzzo et al., 1989).

Bandura, a psychologist, originated social learning theory (which was later connected with social cognitive theory) and the related theoretical construct of self-efficacy. As part of this theory, he proposed four types of experiences that act as sources for impacting one's self-efficacy whether negatively or positively. These four experiences are mastery experiences, vicarious learning, social persuasion, and physiological state (Bandura, 1997). Chapter 3 will go into more detail about these

sources, but here we overview them for readers to have the necessary context for the structure of this dissertation.

2.1.1 Mastery Experiences

A mastery experience is an experience of an individual's past performance and is theorized to be highly predictive of a person's belief in their competence–self-efficacy. These past experiences of success or non-success in a task can lead to a sense of mastery or failure and can impact one's self-efficacy toward similar present or future tasks. Bandura posited that mastery experiences achieved with external assistance are less impactful to one's self-efficacy than successes achieved alone (1997). However, labeling a mastery experience as involving help or not depends on how the situation is viewed by the person. Similarly, when a person reflects on performance experiences, they could either be a person who happens to focus more on failures or on successes. Those would result in respectively under- or over-estimating their efficacy, even though they could be recalling or interpreting the events correctly. Also, effort has different ability implications for children and adults. Children tend to view high effort as high ability gain, whereas adults tend to draw the opposite conclusion (1997). In other words, one's own interpretation of these experiences is central to how they might impact one's self-efficacy.

Mastery experiences provide the source that Bandura suggested is most influential since they "provide the most authentic evidence of whether one can …succeed" (1997, p. 79). These past experiences with attempting a task can be very similar to a present or future task so they are directly related to self-efficacy judgments. Usher and Pajares (2008) agree that mastery experiences are "typically the most influential source of self-efficacy, [but] the strength and influence of the sources differ as a function of contextual factors such as gender, ethnicity, academic ability, and academic domain" (p. 1). We will return to this idea later in this section.

2.1.2 Vicarious Learning and Social Persuasion

Another type of source experience that can influence an individual's self-efficacy is an experience of observing or hearing about a peer attempting a certain task. Experiences where individuals are able to compare themselves to others (Hutchison-Green, Follman, and Bodner, 2008) or perceive the success or failure of others (Hutchison et al., 2006) are referred to as vicarious learning experiences. Hutchison et al. (2006) define vicarious learning as "perceptions of the outcomes experienced by others who have performed similar tasks" (p. 40). Then, someone's self-efficacy to perform a similar task to what they saw a peer perform might be informed by either (1) assessing how similar they are to the peer they watched and therefore concluding they will also succeed or fail like their peer did; or (2) assessing how much better or worse their own performance is compared to their peer's and thus increasing or decreasing their self-efficacy.

Social persuasion experiences are those where an individual receives feedback from others about their performance (Hutchison-Green, Follman, and Bodner, 2008) either verbally or nonverbally (Hutchison, 2006). Hutchison-Green, Follman, and Bodner (2008) describe social persuasion as "feedback received from others" (p. 178). We also often see social persuasion used to mean encouragement (or discouragement) from others, such as by Usher (2009). In summary, we define social persuasion as verbal or non-verbal messages from others conveying how capable one is of performing a specific task.

Regarding models from whom one may draw vicarious learning and social persuasion experiences, Bandura describes the factors in determining a sufficiently similar model. These factors include performance similarity and attribute similarity (1997). In terms of performance similarity, a model could either be a "coping model" or a "masterly model," meaning respectively the model is either a person whom one considers less skilled or more skilled than oneself. Bandura

proposes that "diversified modeling …is superior to exposure to the same performance by a single model" (p. 99). Marshman (2018) adds that gender can be a "determinant of being similar" and that not seeing "'many people like me' can negatively influence women's self-efficacy and reinforce stereotypical beliefs about women's ability in physics" (p. 12). Thus, a lack of available models can harm one's self-efficacy.

2.1.3 Physiological State

Lastly, what we will call physiological state experiences, Bandura and other authors also sometimes call emotional arousal, arousing experiences, or affective states. Bandura says, "Arousing [physiological] experiences contain three significant events, one of which remains private and two of which are publicly observable. These include environmental elicitors, expressive reactions, and social labeling" (1997, p.106). Chen and Usher (2013) describe "physiological and affective states" such as "anxiety, stress, and fatigue." Focusing on anxiety is common in literature about physiological state, but theoretically it should encompass embodied, emotional, and mental states broader than that. Physiological state is a difficult type of experience to study and measure, and it shows up less in literature and self-efficacy measurement tools than the other sources. We define physiological state as a person's emotional, physical, and embodied feelings about given tasks that might impact their self-efficacy towards similar tasks.

2.1.4 Impact of Experiential Sources Varies by Social Identity

Bandura hypothesized these four experiential sources of self-efficacy without attention to differences in groups. Yet, there are some researched differences in the ways groups of people interpret self-efficacy experiences. We already saw above that Bandura and others have argued that mastery experiences are the most impactful source of self-efficacy, but in a review of the literature, Usher and Pajares saw some differences based on contextual factors (2008). They cite

eight studies in which mastery experiences were found to be the most impactful on students' self-efficacy (Britner and Pajares, 2006; Hampton, 1998; Klassen, 2004; Lent et al., 1991; Lopez and Lent, 1992; Lopez et al., 1997; Pajares et al., 2007; Usher and Pajares, 2006), and one study in which mastery experience did not actually predict self-efficacy. That was a study of the mathematics beliefs of Black undergraduates (Gainor and Lent, 1998). Even in that study mastery experiences were correlated with social persuasion which did predict self-efficacy, so Usher and Pajares (2008) conclude that mastery experiences are typically predictive of self-efficacy.

However, Zeldin and Pajares' study (2000) found that women successful in STEM careers emphasized exposure to competent models as supporting their confidence to pursue their careers. Similarly, Hutchison's (2006) findings about an influential factor "help" seem to overlap with vicarious learning and support Zeldin and Pajares' findings. Hutchison et al. (2006) describe some additional factors influencing their participants' self-efficacy beyond Bandura's four sources, including what they classified as "help". They said that "significantly more women discussed getting help as a factor influencing their confidence" (p. 43).

Evidently, there is some nuance in the ways people with different identities might interpret these source experiences. Usher and Pajares (2006) found that all four sources predicted self-efficacy for white students, but only mastery experiences and social persuasion predicted self-efficacy for the Black middle schoolers in their study. Hutchison-Green, Follman, and Bodner (2008) found that "only female students described being affected by the nonverbal actions of others" (p. 186). Sawtelle, Brewe, and Kramer (2012) similarly found that female students in introductory physics relied more on vicarious learning and social persuasion than male students did. More research is needed exploring the differential ways self-efficacy is interpreted by different social identity groups.

2.1.5 Approaching Self-Efficacy Research through an Anti-Deficit Lens

The study of self-efficacy does not inherently call for either deficit or anti-deficit framing. In fact, Usher (2018) calls out "the ways in which Whiteness has shaped research on academic motivation" (p. 131). She suggests that acknowledging the whiteness of our research and confronting white supremacy and colorblindness are important first steps toward a more equitable, accurate, and complete understanding of academic motivation. Researchers choose how to approach self-efficacy, and, as we saw in Chapter 1, our framing inherently affects the questions we can answer.

In this dissertation, I approach self-efficacy through an anti-deficit lens by using qualitative methods. For example, Marshman (2018) found that women with A's in a physics class had similar self-efficacy as men with C's. Marshman frames this as a possible explanation for the low representation of women in STEM, saying, "Women who have high standards for achievement in physics may drop out of physics courses and leave a STEM major at a higher rate than male students if they underestimate their own capability to succeed in physics" (p. 3). This interpretation can support anti-deficit framing, but without specific reflection, one might interpret this finding in a deficit-oriented way as suggesting that we simply need to improve women's self-efficacy. Instead, a qualitative approach would allow us to explore the ways the context of the physics class is disproportionately encouraging men and discouraging women.

Chapter 3 describes the development process of a qualitative codebook for self-efficacy statements, developed from common indicator words used in quantitative surveys. Much of self-efficacy research has traditionally been quantitative, and qualitative methods allowed us to use more of the research principles of anti-deficit framing. Qualitative data can unpack the experiences and nuances of what specific experiences students tell us impacted their self-efficacy. Then, from students' own words we can develop instructional environments to better support diverse learners'

self-efficacy growth from the support systems they found successful or unhelpful. Thus, qualitative methods helped me frame self-efficacy from a systemic lens, and also helped me honor my participants' voices and counterstories.

2.2 Overview of Community College and Transfer Student Education

In Chapter 3, I will discuss the participants from whose data we developed the self-efficacy codebook, which largely included two-year college (TYC) transfer students and students at TYCs. In Chapters 4 and 5, I will narrow in on specific stories of transfer students and students at community colleges[3]. This section provides an overview of the state of community college and transfer student education. At the end of this section, I will explain why my anti-deficit equity-orientation leads me to focus on these populations.

Most commonly, when researchers study transfer, they focus on vertical transfer, the transfer of a student from a TYC to a four-year college (FYC). There are many other kinds of transfer, including lateral, swirling, reverse, and more (Lester et al., 2013; Taylor and Jain, 2017; Wickersham, 2020). Many community college programs aim to support their students to vertically transfer, and many students who begin their paths at community colleges aim to vertically transfer (Wang et al., 2016).

Part of the reason for so much emphasis on vertical transfer are the differences in attainment of bachelor's degrees between STEM degree seekers and the general population. "At initial enrollment, approximately 80% of first-time community college students of traditional age indicate a desire to earn a baccalaureate degree or a higher-level credential" (Horn and Skomsvold, 2011). From there, students who successfully transfer to FYCs are equally as likely to earn a

[3] The terms two-year college (TYC) and community college typically mean very similar things, and we use them interchangeably throughout these chapters.

bachelor's degree as their first-time-in-any-college (FTIAC) counterparts who start at FYCs (Jackson and Laanan, 2011; Reyes, 2011; Handel, 2011). However, when we narrow into STEM programs, Wang (2015) found that community college students are less likely to earn a STEM baccalaureate degree than students who start their paths in STEM programs at FYCs. Using an anti-deficit lens, the problem is that institutions are not supporting TYC students in STEM through transfer and to baccalaureate degree attainment in the same ways that the general population of TYC transfer students are supported.

Compounding the problem of poor institutional support for TYC transfer students in STEM are the social identities of students likely to begin their educational paths at a TYC. Women, first-generation students, Students of Color, students with disabilities, and students from low-income families are more likely than other students to attend or begin college at TYCs (Jain et al., 2011, 2016; Wickersham and Wang, 2016; Wang et al., 2017; Starobin et al., 2016; Bahr et al., 2017; Traxler and Blue, 2020). However, "white students transfer at higher rates on a national scale" in the United States (Jain et al., 2016, p. 1013). Plus, even though Students of Color make up more than one-third of the students enrolled in TYCs, this percentage drops for students who transfer to FYCs and for students in STEM programs (Hagedorn and Lester, 2006; Wang, 2013; Wang et al., 2016; Bahr et al., 2017). Similarly, Wickersham (2016) says, "It is evident through the limited existing research that female students continue to be delayed or deterred from progressing through community colleges and routed away from the transfer path" (p. 1002). Looking across these data we see that STEM programs do a particularly bad job of supporting minoritized students who start at TYCs. Thus, we need to take anti-deficit framing in our research about TYC and transfer students in order to learn how to better support them to their goals.

Locally, in the state of Michigan, many students attend TYCs. If we care about supporting all our students, we must research this population. In Michigan, 43% of all bachelor's degree graduates who began college after 2009 and graduated by 2015 "transferred at least once, and 31% transferred at least once via the community college" (Taylor, 2019, p. 4). Of those who transferred at least once via community colleges, a little more than half began at the community college while the rest attended the community college at some other time before graduating with their bachelor's degrees. Also, a higher percentage of bachelor's graduates who transferred changed programs at some point in their academic pathway as compared to students who did not transfer (Taylor, 2019). Furthermore, bachelor's graduates in engineering and physical sciences programs were among the more likely to start at FYCs and enroll in a TYC at some point prior to completing a bachelor's degree (Taylor, 2019). In short, many local students attend community colleges, so if we continue to overlook that research context, we will miss capturing a common student experience.

For researchers who want to support more equitable and diverse participation in STEM, particularly in Michigan, community colleges are research sites to find Students of Color, first-generation students, women, and more minoritized students in STEM. That alone is enough reason to research the community college and transfer experience. Centering an anti-deficit approach to doing that work tells us that we need to challenge common storylines about community colleges and TYC transfer students. There is unfounded stigma in academia against community college education and students from community colleges, and TYCs are underrepresented in research studies (Kanim and Cid, 2017). We follow the lead of scholars like Wang (2015), Bahr et al. (2017), Laanan et al. (2010), and Urias et al. (2016) who use counter-storytelling to challenge common narratives and share stories of community college student success and the benefits of attending community colleges. Our anti-deficit framing also encourages us to focus on learning

from minoritized students. Why did they choose that school and what support systems are successful for them there? Chapters 4 and 5 will address these research sites and participants in more detail.

2.3 How Equity Orientation Impacts My Work: Why I Research Self-Efficacy and TYC Transfer Students

This dissertation has so far introduced my researcher positionality and anti-deficit equity orientation, and reviewed literature on self-efficacy and TYC and transfer student experiences. The past two sections began to address why my positionality leads me to focus my research on self-efficacy and transfer students. This section continues that explanation. Researchers and practitioners in higher education have a duty to provide equitable support and access to resources for all students, especially those who have been historically minoritized and continue to be minoritized. Particularly in science education, we have a duty to address institutional inequities that contributed to discrepancies in the representation of women, People of Color, LGBTQ+ students, and students with disabilities in STEM education and jobs.

Much of my work has focused on student self-efficacy toward academic tasks and how to foster opportunities for students to have experiences that might increase their self-efficacy. We saw in the first section in this chapter that there are disparities in people's self-efficacy depending on their social identities, so we need to focus on increasing support for minoritized people's self-efficacy. Especially given that self-efficacy is highly predictive of persistence in STEM, self-efficacy is a promising area of research in order to improve educational environments for minoritized students. If we can understand how best to support minoritized students' science self-efficacy, that will likely directly impact persistence in STEM for those students and increase diverse participation in STEM.

I also have often worked with research participants at community colleges or who have transferred from community colleges. Community colleges are a research site at which the students are more likely to be women, students with disabilities, or Students of Color (Jain et al., 2011, 2016; Wickersham and Wang, 2016; Wang et al., 2017; Starobin et al., 2016; Bahr et al., 2017; Traxler and Blue, 2020), thus providing an important site to work on improving support for those students. Those students have also chosen to attend TYCs, so FYCs should learn from their successes. Centering the learning FYCs can do from community colleges is one way that I approach my research from an anti-deficit perspective. This orientation is important for anti-deficit framing of community college education, challenging the stigmatization common by researchers, teachers, and students, even for TYC transfer students at FYCs.

2.4 Overview of Methods and Use of Anti-Deficit Framing

The work I present in this dissertation has varied in methods, units of analysis, settings, and populations. Across the studies, I have leveraged qualitative methods and ethnographic principles. Using these qualitative methods, I always aim to anti-deficit frame the difficulties students in STEM face that impede their academic paths and ask how to improve support and resources for minoritized students in STEM.

Qualitative methods easily allow for rich storytelling as well as strong participant relationships and getting to know and work alongside one's research participants. The methods in my data collection and analysis have been oriented to ethnographic research principles. Ethnography has a troubled history of the ways it has been used but it is also a methodology in which activist scholars have challenged problematic cultural and scientific norms. Ethnography's origins are in social anthropology, and the goal of ethnography is richly detailed description of a culture or a group of people (Jones, 2010). It is important to note that humans have been doing

some form of ethnography for ages, but the term is not neutral, as ethnography has been used as a tool to present a different culture than the researcher's own as "other". Ethnography has even been used to justify unethical treatment of certain groups of people. Much of early ethnography meant focusing on the "other," typically in a colonizing sense (Jones, 2010). However, activist ethnographers have also challenged the cultural norms and implicit boundaries of their fields. For example, feminist scholars in the 1970s "challenged the macho culture of surviving and suffering fieldwork as a rite of passage" (Jones, 2010, p. 23; e.g., Adams et al., 1975). Thus, with thoughtful reflection, ethnographic methods can be appropriate for anti-deficit framed work.

Ethnography involves different methods, tools, and strategies. These include research approaches of immersing oneself in the research settings, observing participants in their own settings, taking longitudinal data, and gathering a wide range of data on many different aspects of the research settings. Data collection methods often include taking observational field notes, conducting multiple interviews, and triangulating across data streams (Tracy, 2010; Creswell and Miller, 2000). Ethnographers are often participant-observers as part of immersing themselves in settings, they engage in researcher reflexivity, and they consider their positionality as insiders or outsiders (Richardson, 2000; Mirra and Rogers, 2016; Grant, 2017; Cunliffe and Alcadipani, 2016; Bergman Blix and Wettergren, 2015; Berbary, 2014; Miled, 2017; Milner, 2007). In ethnographic research, we need to think carefully about how we represent our participants and how we give them voice in our analysis and representation of results (Barab et al., 2016; Ashlee, Zamora, and Karikari, 2017; Perry, 2011).

Paired with ethnographic methods, all of the analytic methods discussed in this dissertation have grown out of some level of qualitative coding. In Chapter 3, I discuss the development of a qualitative codebook for self-efficacy statements based around indicator words pulled from

quantitative survey language. This qualitative approach to self-efficacy and expansion of traditional measurement tools is motivated by my anti-deficit framing. I want to research how to create experiences to support self-efficacy development for a diverse set of students. Qualitative data collection allows researchers to broadly explore student experiences without limiting their descriptions by closed-ended survey questions. The self-efficacy codebook described in Chapter 3 supports self-efficacy researchers in identifying self-efficacy statements in the context of qualitative data from students. Then, researchers and practitioners can build educational environments to provide opportunities for those experiences to students. Qualitative methods work well with anti-deficit framing self-efficacy and examining self-efficacy development from a systemic lens.

In Chapter 3, the coding process involved mostly deductive coding, using pre-existing literature and survey language and developing a priori rules for coding instances of those indicator words. There was some inductive coding involved in the process of iterating on that codebook to the final version. In contrast, in Chapter 4, I began my analysis of one TYC transfer student's longitudinal story using the self-efficacy codebook but branched into using narrative inquiry to analyze her data. When I made that switch for this student, the story expanded beyond focusing on self-

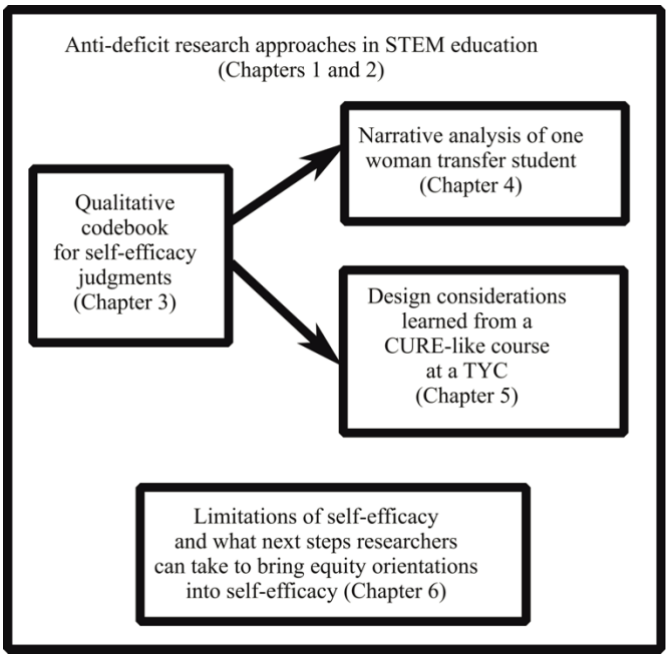


Figure 2. 1 Structure of dissertation. Chapters 4 and 5 build from Chapter 3, all of which are situated in the framing from Chapters 1 and 2. All these chapters lead to discussion in Chapter 6.

efficacy. In chapter 4 I discuss in more detail how the early coding guided the development of Nicole's narrative. In chapter 5, I again began with self-efficacy coding but brought in other pieces to the analysis and story. Chapters 4 and 5 are anti-deficit framed counterstories of community college and transfer student academic success and the systemic structures that supported that, including systemic structures supporting student self-efficacy. See Figure 2.1 for a figure overviewing the structure of the dissertation.

2.5 (Counter)Storytelling as One Anti-Deficit Research Method

Across my dissertation I strive to combat the stigma surrounding community college education by telling counterstories that highlight the strengths of that environment and what students have gained from it. Stories have a lot of power and are embedded in our ways of interacting and communicating. Specifically, we have seen in the literature in Chapter 1 many impactful examples using storytelling. Here I focus on the method of storytelling and the ways scholars use that to approach research with an anti-deficit framing.

Rosa and Mensah (2016) examined the lived experiences of six Black women physicists, obstacles they faced in their career paths, and strategies they used to overcome those obstacles. They leaned on CRT and specifically the use of "counter-storytelling", one of the themes of CRT and a method used to magnify undertold stories. One of Rosa and Mensah's arguments is that it is insufficient to only think about the education of physicists within physics education, because scientists are mentored by a larger community. We cannot control the training of that broader community, but we must take those contexts into consideration, as we saw argued in Chapter 1. Rosa and Mensah recommend to the physics education community, "From a classroom perspective, teachers and teacher educators can make use of storytelling to unveil and validate the experiences of students of color in science" (2016, p. 12). This implication also applies to

researchers. One way of doing anti-deficit framed research is to tell counterstories and center marginalized voices.

Brickhouse (2000) uses a similar approach in a paper about four case studies of the science identity of African American middle school girls. She avoids presupposing a science identity and instead describes the myriad of science identities of girls who say they are interested in science. Brickhouse tells the girls' stories as counternarratives to dominant narratives about what a science identity must be. She asks the participants to define success in science in their own terms. Her conclusion challenges education researchers who might be tempted to ask if these girls developed an understanding of science, since she says they "saw little evidence of much struggle to understand an idea in science class" (p. 456).

These examples of counter-storytelling as an anti-deficit research method provide blueprints for some of my work, and you will see this discussed in more detail in Chapter 4. Rosa and Mensah employ anti-deficit framing by focusing on stories of successful Black women physicists and how they were successful. Brickhouse utilizes anti-deficit framing by not predefining a science identity and asking her participants to define their science identity and their idea of success in science in their own terms. I also aim in my research to avoid presupposing the ways my participants will define things. This is hard to do, because humans cannot eliminate all ingrained biases and expectations, but it is part of the reason we must explicitly state and consider our positionality.

I have particularly been careful throughout my research to not define academic success for my participants. I want them to tell me what it means for them to be successful. My research has typically focused on students' academic self-efficacy in STEM. In researching student self-

efficacy toward completing tasks, I try to remain open-minded about what goals students might have and the idea of success toward which they are aiming.

With this agenda in mind, I was informed in my research on self-efficacy by Zeldin and Pajares (2000) and Urias et al. (2016). These authors provide two more examples of crafting counternarratives from data in anti-deficit ways. Zeldin and Pajares analyzed narratives of several women excelling in STEM careers to "understand the ways their self-efficacy beliefs influenced their academic and career choices" (2000, p. 215). This retrospective approach of looking at successful people from marginalized identity groups in STEM is a good way to anti-deficit frame how to better support such marginalized folks to similar successes. Urias et al. challenge the common deficit perspective by examining the stories of "men [of color] who successfully navigated the community college system" (2016, p. 23). Readers will see these papers inform my data collection and analysis throughout the following chapters.

CHAPTER 3 DEVELOPING A QUALITATIVE CODEBOOK FOR SELF-EFFICACY EXPLICIT STATEMENTS FROM SURVEY INDICATOR WORDS

We have seen above that (1) self-efficacy is a strong predictor of persistence in STEM (e.g., Dalgety and Coll, 2006), (2) cishet white men in STEM tend to have high academic STEM self-efficacy (e.g., Marshman, 2018; Kalender et al., 2018) and marginalized people in STEM tend to have low academic STEM self-efficacy (e.g., Marshman, 2018; Smith et al., 2012; Harper, 2010; Kalender et al., 2018), and (3) marginalized people are underrepresented in STEM and face contextual obstacles that can inhibit their persistence. Then, we should support self-efficacy growth for diverse learners as one way to work towards equitable STEM participation. We know that there are essentially two pieces to evaluating the development of a person's self-efficacy–their actual self-efficacy judgment of their ability to do some task, and also the experiences that they reflect on when evaluating their self-efficacy. In our work we separated these two pieces when describing the development of a codebook to systematically capture self-efficacy in qualitative data. This chapter presents a qualitative codebook that captures what we call "Self-Efficacy Explicit Statements" or verbal expressions of a person's self-efficacy judgment regarding an academic task.

Ultimately, the goal is to develop two codebooks, one which is completed and described in this chapter, and the other one for capturing descriptions of the experiences that students use when evaluating their self-efficacy. Even before that second codebook is finished, this Self-Efficacy Explicit qualitative codebook adds a useful tool for research on self-efficacy that has not previously existed. Much of the research on self-efficacy in education has traditionally been quantitative, relying on pre- and post-surveys and discussing quantitative shifts in groups of students' self-efficacy in certain courses. In this chapter, we describe creating a qualitative codebook for self-efficacy drawing from words commonly used in these self-efficacy surveys. We

created a set of specific rules allowing us to broaden into other kinds of data, like interviews and written journal reflections. This tool is designed to allow researchers to examine instances of self-efficacy judgments in a broader context. Then, researchers will be able to characterize the specific aspects of education experiences to which students attribute impacts on their self-efficacy. Being able to qualitatively research the specific ways students' self-efficacy is impacted will support researchers and educators in building opportunities for those experiences into learning environments.

3.1 Introduction and Motivation

Social cognitive theory, used in psychology, education, and other fields, relates people's knowledge acquisition to interacting with other people and observing others as models situated in social and external media contexts (Bandura, 2005; Schunk and DiBenedetto, 2020). Psychologist Bandura's social learning theory and construct of self-efficacy advanced social cognitive theory, providing one lens through which to examine motivation. In education, self-efficacy is one way of understanding academic motivation. Self-efficacy involves one's explicit self-efficacy judgments as well as four types of experiential sources that can impact one's self-efficacy. We will provide an overview of the construct of self-efficacy and briefly define these four source experiences before detailing how we constructed a qualitative codebook for identifying academic self-efficacy statements.

Self-efficacy, particularly in physics education research, has typically been studied quantitatively through large-N studies using closed-ended survey questions, often numerical scale response type questions (e.g., Wang Elhady et al., 2021; Singh and Malespina, 2021; Kalender et al., 2019). Recently, some studies of self-efficacy have more frequently used qualitative methods (e.g., Cardona, Zohrabi Alaee, and Zwickl, 2021; Stoeckel and Roehrig, 2021). We sought to

support such efforts by creating a qualitative codebook for identifying explicit statements of self-efficacy judgments in interviews and written reflections. We drew from quantitative survey language to develop this codebook, thereby connecting traditional quantitative methods of studying self-efficacy with qualitative methods that afford different types of information.

When we say we developed a codebook, we mean we have developed a specific tool to identify sentences that indicate a person's judgment of their self-efficacy to complete a certain task. This tool includes a set of nearly exhaustive rules to determine whether a sentence is likely an indicator of a self-efficacy judgment. The qualitative process we used to develop this codebook began with examining instances of common words used in self-efficacy surveys. We could expect words from self-efficacy surveys to indicate self-efficacy judgments as many scholars have examined self-efficacy using those tools for decades. Then we scrutinized the context in which those words were used in student interviews and interrogated self-efficacy literature to determine in what instances the survey words being used did indeed indicate self-efficacy judgments. From the combination of that contextual examination and literature-based definitions we developed rules allowing or disallowing instances of certain word uses to be tagged as statements of self-efficacy judgments.

So far this codebook only describes how to identify statements that are explicitly about one's self-efficacy judgment. It does not yet address the experiences that provide the source of one's self-efficacy. However, this codebook development is part of a larger study aimed at identifying sources of self-efficacy in qualitative data as well. As a result, understanding and using this codebook requires a basic understanding of how self-efficacy develops. Thus, we briefly review Bandura's theorized source experiences in the next section.

The overarching motivation of this codebook is twofold: (1) to identity verbal statements in qualitative data expressing self-efficacy judgments in order to support qualitative study of self-efficacy drawing from the traditional quantitative methods; and (2) to work in tandem with a future codebook for characterizing the four source experiences. To describe the roadmap of the paper, we will review self-efficacy literature and define self-efficacy and describe the source experiences. Then we will recount the development of the codebook and the lessons we learned in the process. In the discussion we will outline future work which will include discussing the further development of a codebook for the source experiences.

3.2 Literature Review

3.2.1 Defining Self-Efficacy

Self-efficacy is one measure of an individual's competence beliefs (Pajares, 1996; Pajares, 2010), which is traditionally linked to achievement oriented tasks such as passing courses (e.g., Usher, 2009), earning a degree (e.g., Wang et al., 2017), or entering a particular career (e.g., Robinson et al., 2020; Zeldin and Pajares, 2000; Ali, McWhirter and Chronister, 2005; Love et al., 2007). As a construct, self-efficacy must be linked to a specific task (Bandura, 1997). There are decades of research demonstrating self-efficacy's predictive nature for STEM persistence (Lent, Brown, and Larkin, 1984; Lent, Brown, and Larkin, 1987; Dalgety and Coll, 2006; Lent, Brown, and Larkin, 1986; Luzzo et al., 1989). From those decades of research, we see definitions of self-efficacy that vary slightly in language, like the following:

- "The confidence in one's own ability to perform a particular task" (Sawtelle et al., 2012, p. 1)
- "Task-specific confidence" (Locke and Latham, 2002, p. 2)

- "Dynamically responsive judgments of one's ability to organize and execute the courses of action required to produce given attainments in the activity at hand" (Nissen and Shemwell, 2016, p. 7)

To synthesize these definitions for the purposes of this paper and resulting codebook, we define self-efficacy as ***one's confidence in one's own ability to perform academic tasks***. Self-efficacy is used in other settings besides education, and it has its roots in psychology. Our decision to focus on self-efficacy as related to academic tasks was specific to our context and research interests.

Clearly, understanding the task being evaluated is imperative when considering a self-efficacy judgment. Furthermore, one's self-efficacy toward particular subskills of a task do not necessarily add up to their self-efficacy towards an overall task (Bandura, 1997). Relatedly, Bandura remarks that "a common misconception is that general efficacy beliefs spawn specific efficacy beliefs" (1997, p. 41). Therefore, we should neither assume that one's efficacy beliefs regarding a general task lead to their efficacy beliefs for a specific task nor that their efficacy beliefs for a small grain size task impact their efficacy beliefs for the broader task encompassing that subskill.

To describe the broad range of tasks about which we might ask and refer in our research, we draw on Usher and Pajares' (2008) language of "students' confidence in their academic capabilities" (p. 5). This allows our focus to be self-efficacy in academic contexts, which could include a range of tasks, from homework to tests to finding study groups to completing one's degree. In this research, we define self-efficacy as one's confidence in one's own ability to perform particular tasks in academic contexts.

Self-efficacy is a dynamic construct that changes based on the time and situation. The context in which people are situated impacts their self-efficacy. Environmental impacts to a person's self-efficacy are crucial. Bandura says that self-efficacy is not "the number of skills you have, but what you believe you can do with what you have under a variety of circumstances" (1997, p. 37). This means that when measuring a person's self-efficacy, we are not concerned with their actual ability, but their perceived ability.

3.2.1.1 Source Experiences

Bandura theorizes four types of experiences that provide sources for building self-efficacy. These experiences that can impact one's self-efficacy include mastery experiences, vicarious learning, social persuasion, and physiological state experiences (Bandura, 1997). We refer to these as Mastery Experiences (ME), Vicarious Learning (VL) experiences, Social Persuasion (SP) experiences, and Physiological State (PS) experiences.

In this paper, we do not discuss qualitative coding for descriptions of these source experiences. However, we consider it important to briefly describe them, because they relate to explicit self-efficacy judgments. We will also discuss our future work toward developing a codebook for these experiences. There is also overlap in the language used to discuss the experiences and used to express explicit self-efficacy judgments. Thus, it helps to have an overview of the sources to understand why certain language might not count as a statement of a self-efficacy judgment.

3.2.1.1.1 Mastery Experiences

An individual's past performance is highly predictive of their competence beliefs. Thus, an experience that leads to a sense of mastery or failure is one that can build or dismantle a person's self-efficacy. A statement describing this type of experience would emphasize some perceived

success or failure in the past that might affect one's confidence in their ability to do a related task in the future. This is a commonly researched and discussed source experience, because Bandura and other authors suggest that mastery experiences are the "most influential source of efficacy information because they provide the most authentic evidence of whether one can ...succeed" (1997, p. 79). Usher and Pajares (2008) similarly state that mastery experience is "typically the most influential source of self-efficacy" (p. 1). However, they do add that the strength and influence of the sources can vary depending on contextual facts and one's social identities. We will see this idea of the different strengths of influence of the source experiences discussed throughout the other definitions. In our work, we define a mastery experience as an experience attempting a certain task resulting in failure, success, or an unclear outcome that might inform a student's self-efficacy toward a similar task in the present or future.

3.2.1.1.2 Vicarious Learning

Another type of experience that can influence an individual's self-efficacy is one where an individual observes a peer attempting a task. Experiences where individuals are able to compare themselves to others (Hutchison-Green, Follman, and Bodner, 2008) or perceive the success or failure of others (Hutchison, 2006) are dubbed vicarious learning experiences. In this way both performance comparisons and modeling experiences contribute to the assessment of an individual's self-efficacy. Hutchison-Green, Follman, and Bodner (2008) write, "During modeling experiences, an individual's focus is on assessing how similar his or her ability is to that of a peer (i.e., a potential model). Performance comparisons are more concerned with determining how much 'better' or worse a person's performance was in comparison to those of his or her peers" (p. 178). We define vicarious learning as the experience of watching or hearing about peers performing or attempting to perform a given task. Then a student's self-efficacy to perform a

similar task might be informed by either (1) assessing how similar they are to the peer they watched and therefore concluding they will also succeed or fail like their peer did; or (2) assessing how much better or worse their own performance is compared to their peer's and thus increasing or decreasing their self-efficacy.

3.2.1.1.3 Social Persuasion

Social persuasion experiences are those where an individual receives feedback from others about their performance (Hutchison-Green, Follman, and Bodner, 2008) either verbally or nonverbally (Hutchison, 2006). This feedback could come from instructors, peers, family, and more models, and the impact of the social persuasion varies depending on features of the model and the situation (Ahn, Bong, and Kim, 2017; Ahn et al., 2015). We also often see social persuasion used to mean encouragement (or discouragement) from others (e.g., Usher, 2009). In summary, we define social persuasion in this work as verbal or non-verbal messages from others conveying how capable one is of performing a specific task.

3.2.1.1.4 Physiological State

What we will call physiological state experiences, Bandura also sometimes calls emotional arousal, arousing experiences, or affective states. About these experiences, Bandura says, "Arousing [physiological] experiences contain three significant events, one of which remains private and two of which are publicly observable. These include environmental elicitors, expressive reactions, and social labeling" (1997, p. 106). Chen and Usher (2013) describe "physiological and affective states" such as "anxiety, stress, and fatigue." They also say that different students might view anxiety as threatening or as energizing, making the ability to tell if an emotion's valence is positive or negative very complex and difficult. Physiological state is a difficult type of experience to study and measure, and it shows up less in literature and self-efficacy

measurement tools than the other sources. There is much research on emotions in academic situations and their impact on student engagement (e.g., Pekrun and Linnenbrink-Garcia, 2012), but explicitly as a source of self-efficacy, physiological state is less researched than the other three sources. When researchers study physiological state, they often focus on one type of feeling, like anxiety (Pekrun et al., 2007; Hembree, 1988). Our definition is therefore currently broad for this experience. We define physiological state as a person's emotional, physical, and embodied feelings about given tasks that might impact their self-efficacy towards similar tasks.

3.2.2 Self-Efficacy Beliefs are Different from Outcome Expectations

Self-efficacy is related to other constructs, like identity, self-concept, and more. We will discuss some of these overlapping areas when sharing the development of the codebook, but we must review some literature here to provide context for some codebook decisions. Competency beliefs, and thereby self-efficacy, are strongly linked to individuals' success and achievement, as we have seen. However, the judgment of one's ability to perform an action is different from their judgment of the likely consequence of that action (Bandura, 1997), even though those things sound quite similar. The literature terms the expected consequence of a set of actions as "outcome expectations" (Maddux, Sherer, and Roger, 1982). Outcome expectations (or expectancies) sound similar to self-efficacy, and they certainly have overlap, but a person's expectation of a certain outcome is not always due to their self-efficacy and may have other explanations. Because these two constructs are closely related it can be easy to confuse them. In our work, we take care to distinguish between self-efficacy and outcome expectations. Self-efficacy judgments often explain one's outcome expectations, but this is not always the case (Bandura, 1997). Outcome expectations may be informed by other factors. Since we wanted to create this codebook as a tool for specifically

identifying self-efficacy, we must distinguish outcome expectations which may or may not be motivated by self-efficacy.

In fact, outcome expectations may be motivated by external circumstances rather than any type of competency belief. Bandura writes, "Where performance determines outcome, efficacy beliefs account for most of the variance in expected outcomes" (1997, p. 23). In other words, oftentimes outcome expectations can be explained by a person's self-efficacy, but if the reasoning behind an outcome expectation is not explained, we cannot know if it's related to a self-efficacy belief. Particularly, there are situations where a person might feel that some external circumstance makes a certain outcome definite, regardless of their estimation of their performance capabilities. For example, a Black student taking a class from a bigoted teacher who regularly enacts racist ideas in their teaching might have an outcome expectation of getting a bad grade, but this does not tell researchers that the student has low self-efficacy towards earning a good grade. Thus, we distinguish between outcome expectations and self-efficacy in our codebook, which we will discuss more in later sections.

3.2.3 Impacts of Self-Efficacy

Although self-efficacy is not actual ability, performance, or a quantity of one's skills, Bandura does state that "effective functioning requires both skills and the efficacy beliefs to use them well" (1997, p. 37). Thus, self-efficacy is not the only determining factor in a person's success toward a certain goal, but high self-efficacy does afford many benefits and reliably predict certain outcomes. Self-efficacy is related to goal-setting theory, and researchers have shown that efficacy beliefs affect people's strategies (e.g., Wang and Wu, 2008; Graham, 2007; Beck and Blumer, 2012), persistence (e.g., Garza, Bain, Kupczynski, 2014; Bolkan et al., 2018), and other impactful approaches towards achieving goals (e.g., Robinson et al., 2020), which in turn impacts

one's realized performance (Locke and Latham, 2002; Bandura, 1997). People with higher self-efficacy towards some task will set more challenging goals, maintain a stronger commitment to them, and respond more positively to negative feedback and obstacles (Bandura, 1997; Locke and Latham, 2002). Bandura adds that people with high self-efficacy for a particular task will "attribute failure to insufficient effort, which supports a success orientation" (1997, p. 39) In other words, self-efficacy interacts with the concepts of fixed and growth mindset, or learning, mastery, and performance goals (Elliott and Dweck, 1988). Additionally, as Marshman et al. (2018) say, self-efficacy can also "impact one's interests" (p. 1) and thus indirectly impact one's engagement in classes and academic settings. Self-efficacy and related beliefs about oneself are considered so impactful that Pajares and Schunk state that we could argue that it is more important for teachers to attend to their students' "self-beliefs as to actual competence, for the belief may more accurately predict students' motivation and future academic choices" (2002, p. 24).

3.2.4 Self-Efficacy Origins and New Directions in Education and Physics Education Research

As we saw above, self-efficacy has its origins in psychology, but it has expanded to be used in other fields. Pajares summarizes two decades of early self-efficacy research (1997), saying that self-efficacy has been tested in numerous disciplines and settings, including clinical problems, social skills, stress, athletic performance, smoking behavior, and more. It has grown as a focus in educational research for a few decades now, in studies of academic motivation and self-regulation (Pintrich and Schunk, 1995), studies relating efficacy beliefs and major and career choices, particularly in STEM (Lent and Hackett, 1987), and studies examining efficacy beliefs of teachers and their impact on instructional practices and student outcomes (Ashton and Webb, 1986).

In contrast to the long history of self-efficacy in psychology and education research, self-efficacy is a newer, growing focus of studies in Physics Education Research (PER). As of summer

2022, a search of PER-central on compadre.org for "self-efficacy" revealed 79 results, of which the earliest publication was from 1999, and only 9 articles were published before 2010, so most of the search results are recent. Counting the search results that have "self-efficacy" in the title there are only 31, and looking at abstract results specifically there are only 38 articles. Thus, self-efficacy is a new and expanding field within PER.

Quite a few of the papers in the search results are quantitative, with 25 of the most recent 30 (looking back through 2019) being quantitative, and 9 of the first 13 (from 1999 to 2010) being quantitative (e.g., Wang Elhady et al., 2021; Singh and Malespina, 2021; Kalender et al., 2019; Whitcomb et al., 2019; Esparza, Wagler, and Olimpo, 2020; Doucette, Clark, and Singh, 2020; Li and Singh, 2021; Hutchison et al., 2006; Kost, Pollock, and Finkelstein, 2009; Fencl and Scheel, 2004; Shaw, 2004). Many of the papers on self-efficacy in PER address the impact of gender on variations in self-efficacy (e.g., Cwik and Singh, 2021; Franklin et al., 2021; Stoeckel and Roehrig, 2021; Li and Singh, 2021; Ikkatai et al., 2021; Li, Whitcomb, and Singh, 2020). There are very few papers about the impact of race or Students of Color or students outside of the U.S. (e.g., Kalender et al., 2017; Marzoli et al., 2021; Ikkatai et al., 2021). A lot of work is on linking physics self-efficacy with academic success (e.g., Cavallo, Potter, and Rozman, 2004; Kost, Pollock, and Finkelstein, 2009; Shaw, 2004). The codebook we describe in this paper aims to be a tool for qualitative researchers to expand on quantitative survey work, supporting qualitative focuses in PER.

3.2.5 Motivation of Qualitative Self-Efficacy Research

For much of the history of self-efficacy work, researchers have used quantitative methods and looked at self-efficacy across large groups and examined the impacts of interventions on self-efficacy shifts. This involves using surveys or "omnibus-type instruments that attempt to measure

a general sense of efficacy" (Pajares, 1997, p. 4). While researchers understand the value of complementary qualitative studies, it remains the case that self-efficacy researchers have primarily relied on quantitative methods (Pajares, 1996; Holmes, 2016; Sawtelle et al., 2012).

There has been a growing number of qualitative or mixed methods studies regarding self-efficacy. Qualitative research on self-efficacy has often focused on interviewing participants regarding the source experiences for developing self-efficacy (Usher, 2009; Zeldin and Pajares, 2000; Zeldin, Britner, and Pajares, 2008). As we saw in the above section, much of the self-efficacy work in Physics Education Research has also been quantitative. In physics, the work has mostly used pre- and post-testing to measure self-efficacy shifts from specific course experiences (Sawtelle et al., 2010; Shaw, 2004). Yet, some of the recent papers have been qualitative (e.g., Cardona, Zohrabi Alaee, and Zwickl, 2021; Stoeckel and Roehrig, 2021).

Qualitative methods reveal different types of data and answer different types of questions. Few researchers, for example, have interrogated possible source experiences of self-efficacy besides those proposed by Bandura (e.g., Hutchison et al., 2006). In order to examine possible additional experiences, we need to use qualitative methods to explore the experiences students might tell us about with broad, open-ended questions. This motivated our work developing this codebook.

Relatedly, Usher (2018) encourages more researchers to engage in qualitative motivation research as a way of better supporting "academic motivation for diverse learners" (p. 131). She says that many motivation researchers take a color-blind approach and do not acknowledge the whiteness of motivation research or seek to disrupt white supremacy and white norms in motivation research. This was a part of our motivation for creating a qualitative codebook to identify self-efficacy judgments in contextual qualitative data, because the codebook will then help

us craft richly detailed stories of the experiences our participants tell us were impactful to their self-efficacy. Our goal is that those stories honoring our participants' voices will contribute to work building experiences to impact self-efficacy into educational environments.

3.3 Methods

One of the grounding questions in our approach to this work was if we could reliably capture statements of self-efficacy judgments in qualitative interview data and distinctly separate it from other things like outcome expectations or sources of self-efficacy. Interviews are a common tool in qualitative data collection in education broadly (Witz et al., 2010; Thomas, Tiplady, and Wall, 2014; McLellan, MacQueen, and Neidig, 2003; Roulston, Demarrais, and Lewis, 2003) and PER specifically (Ornek, 2008; Docktor and Mestre, 2014). Thus, being able to reliably identify self-efficacy statements in interview data would provide a tool for more exploratory qualitative research about self-efficacy and contextual factors that might impact it.

3.3.1 Data Sources and Context

The development of this codebook has gone through three iterations. Initially it was begun as an undergraduate research project using just three interviews with students. The first author (Wood) took up the second and third iterations of this codebook by further examining 16 additional student interviews and journal reflections from 13 students. All of the interviews and journal reflection prompts were designed to elicit and probe statements about self-efficacy and growth mindset (Little et al., 2019).

The research team are STEM education researchers interested in researching and creating supportive educational environments for students, especially transfer students and students from and at two-year colleges (TYCs). Thus, our research population included students in STEM majors, first-time-in-any-college (FTIAC) students at four-year colleges (FYCs), students FYCs

who had transferred from TYCs, and students at TYCs who generally intended to transfer to FYCs. Some of these students were also in specific cohort programs designed to provide academic and holistic support to transfer students, first-generation college students, and Students of Color (Wood, 2019). The reasons for focusing on this diverse research population includes (1) that they are relevant to our research interests, and (2) that we hypothesized that cohort programs and specific supportive educational environments might provide a lot of self-efficacy source experience opportunities and produce students with high self-efficacy. Thus, the population of students in supportive cohort programs and environments is a good set of participants about which to gather a lot of rich self-efficacy data.

Table 3. 1 Interview questions intended to elicit self-efficacy

QUESTIONS	FOLLOW-UP QUESTIONS
Tell me one memorable story that would help me understand how you came to be pursuing your major. (modified from Zeldin & Pajares, 2000)	
What do people you know (family/teachers/peers) say to you about your decision to pursue this major plan? (modified from Zeldin & Pajares, 2000)	
Have you gotten any messages from society about your choice? (modified from Zeldin & Pajares, 2000)	
Looking back at your academic career, is there anything you would do differently if you had the chance? (modified from Zeldin & Pajares, 2000)	
How do you define success in your science classes? What do you need to do to consider yourself successful? (modified from Hutchison et al., 2006)	
How successful do you think you will be as a science student? To what degree do you think you will be successful in your science classes? (modified from Hutchison et al., 2006)	On what experiences are you basing your judgment?
	How have other people influenced how you think you will do?
	How have people (family/teachers/peers) encouraged/discouraged you to succeed?
Tell me about a time you felt really confident about your performance in a particular science class. It could be a class you're taking now or one you've taken in the past. (modified from Hutchison et al., 2006)	What about that experience made you feel confident?
Finish this statement: When I'm looking back at my college days, I'll think I was successful if _____ (modified from Hutchison et al., 2006)	How do you believe your peers would finish this statement?
What do you think the main challenges are in completing the requirements for your major?	What are you most worried about?

The interviews used questions targeted to elicit self-efficacy judgments and description of self-efficacy source experiences (See Table 3.1).

Table 3. 2 Written reflection prompts

QUESTIONS
What did you work on for class during this past week?
What were your course goals last week, and how satisfied do you feel with your progress on these goals? What are your goals for next week, and how confident do you feel about your ability to complete those goals?
What did you learn this week that helped you move forward in your class?
Describe an experience from class this week that stands out to you as memorable.
Discuss any interactions you had with your instructors this week. What went well and what could be improved?

The questions in Table 3.2 are pulled from various authors as cited and probe self-efficacy directly and through source experience descriptions. For example, questions intended to elicit an explicit self-efficacy judgment would include, "How confident do you feel about your ability to complete those goals?" and, "How successful do you think you will be as a science student?" (adapted from Hutchison et al., 2006). Questions intended to elicit descriptions of social persuasion experiences include, "Discuss any interactions you had with your instructors this week," and, "What do people you know say to you about your decision to pursue this major plan?" (adapted from Zeldin and Pajares, 2000). Questions regarding what the participant believes about their peers could elicit descriptions of vicarious learning experiences, and questions about how one feels and what one is worried about could elicit physiological state descriptions. Many of these questions are also worded in a way that might elicit any of Bandura's proposed source experiences but also possibly other, broader experiences that one found impactful to their sense of confidence. For example, those would include, "Describe an experience from class this week that stands out to you as memorable," and, "Tell me about a time you felt confident about your performance in a class; what about that experience made you feel confident?" (adapted from Hutchison et al., 2006).

We coded transcribed files of these semi-structured interviews in MAXQDA, a coding software[4]. The written journal reflections prompted students to respond to open-ended prompts. Since the prompts for those journal entries were open-ended, they provided a source of data that was similar to transcribed interviews. Thus, this codebook is intended for analyzing interview and open-ended reflection data. We specifically focused on self-efficacy towards academic tasks and our research participants were typically all students, so we will often refer to the research participant as a "student." We make no claims that this codebook can be generalized to any other types or contexts of data, but with some thoughtful modifications, the steps could likely be applied to other types of data if needed. We will discuss possible modifications to allow researchers in different contexts to generalize this codebook to other contexts in the discussion section.

3.3.2 Coding Approach and Method

In the next sections, we present the codebook and the major decisions we made throughout different versions of the codebook in the development process. We used a process of mostly deductive coding, a priori theorizing the codes we would have based on self-efficacy literature and survey language, but we also allowed our development of the code definitions to be guided by our data. As we developed the definitions and rules for tagging a statement as a self-efficacy judgment or not, we repeatedly brought the codebook to our larger research group for feedback and discussion. There have been many different people involved in the development of the codebook and discussions around questions as we developed the codebook. This helped the primary codebook developers both check the validity and reliability of the codebook as well as use clear

[4]As a note on how we coded in MAXQDA, we would often link the interview video and/ or audio to the transcript file in our coding software. One could use this codebook for coding any format of interview file, but for the steps we lay out here, it would be easiest to code a transcribed file in a searchable format like we did.

language that would make sense to a different set of coders wanting to use this codebook in a different setting.

This codebook is specifically one that centers around indicator words or phrases as the starting point for coding a statement, but the unit of analysis is broader than a single word because the context is necessary to determine whether the use of the indicator word signifies a self-efficacy statement or not. Thus, the coding process was aligned with qualitative content analysis (Zhang and Wildemuth, 2009). The steps laid out in the codebook are clear and restrictive so that coders can identify a statement to likely indicate a self-efficacy judgment. In this way, the codebook does allow researchers to quantify a number of self-efficacy statements made by a participant or a group of participants. We do not use the codebook this way or specifically intend it, but it is a way this tool can be used. We think of the codebook more as a tool for qualitative thematic analysis of the context in which a person makes a self-efficacy statement. This supports researchers examining the types of experiences that positively impact students' self-efficacy and designing instructional environments to provide opportunities for those experiences.

We call this the Self-Efficacy Explicit Codebook, which describes how to tag statements as Self-Efficacy Explicit. By that, we mean a verbal statement of an explicit self-efficacy judgment of one's feeling of competence to do some task. The process of developing the codebook began with reading through all data, rather than searching for a priori code indicator words, because we wanted to explore additional indicator words to add. In that initial process, we would tag anything we thought might indicate a person's self-efficacy judgment, and then we would iteratively return to pieces of data from that set of coded excerpts. We would discuss the quotes that seemed unclear, like they could indicate a different motivation than self-efficacy or were lacking some essential piece of the definition of a self-efficacy judgment. We would take open questions to our broader

research group for discussion when needed, and we would turn back to the literature with specific questions as needed.

3.3.3 Developing List of Indicator Words from Self-Efficacy Surveys

We developed the indicator words for self-efficacy explicit statements by examining established surveys for self-efficacy language. The self-efficacy surveys we examined were all designed to measure academic self-efficacy either broadly or in a sub-discipline. Table 3.3 shows our codebook's indicator words and examples of cited survey items which use that indicator word.

Table 3. 3 Survey items used to develop indicator words

INDICATOR WORD	SURVEY ITEMS USING INDICATOR WORD
can	"I **can** complete the physics activities I get in a lab class" (Marshman et al., 2018, p. 4) "I am confident that I **can** perform effectively on many different tasks" (Chen, Gully, and Eden, 2001) "One of my problems is that I **cannot** get down to work when I should" (Sherer et al., 1982)
could	"If I went to a museum, I **could** figure out what is being shown about physics…" (Marshman et al., 2018, p. 4) "I am confident that I **could** deal efficiently with unexpected events" (Schwarzer and Jerusalem, 1995) "How confident are you right now that you **could** exercise three times per week for 20 minutes if…" (Resnick and Jenkins, 2000)
able	"I am often **able** to help my classmates with physics in the laboratory or in recitation" (Marshman et al., 2018 p. 4) "I feel insecure about my **ability** to do things" (Sherer et al., 1982) "No matter what comes my way, I'm usually **able** to handle it" (Schwarzer and Jerusalem, 1995) "Has your confidence level in your **ability** to do science changed as a result of taking this course?" (Fencl and Scheel, 2005)
confident	"Describe something that happened that made you feel less or more **confident** in math or science" (Usher et al., 2019, p. 5) "I am **confident** that I can perform effectively on many different tasks" (Chen, Gully, and Eden, 2001) "I am **confident** that I could deal efficiently with unexpected events" (Schwarzer and Jerusalem, 1995)
capable	"I do not seem **capable** of dealing with most problems that come up in life" (Sherer et al., 1982) "I am **capable** of receiving good grades on my assignments in this class" (Fencl and Scheel, 2002)

Looking across the indicator words in this table, we can see trends in how self-efficacy surveys typically use these words. For example, the indicator word confident rarely shows up on its own and is typically accompanied by another indicator word. Can (and could, which is technically the same root word) are more commonly used than other indicator words.

3.3.4 Validity and Reliability

Our goal with this codebook was to develop a tool that could reliably detect statements indicating explicit self-efficacy judgments in qualitative data. Thus, we used inter-rater reliability (IRR) as a measure of the codebook's validity to capture statements accurately and consistently. IRR between different coders also points to the ease of an outside coder picking up, understanding, and implementing this codebook in other work.

Wood trained Northington on the Self-Efficacy Explicit (SEE) codebook in an intermediate version. At that time, we calculated IRR. We chose to use Gwet's $\boldsymbol{AC_1}$ due to the low trait prevalence in our Self-Efficacy Explicit (SEE) codebook (2002). This is due to the fact that, for example, there are many reasons a searchable indicator word might not be coded (e.g., if the can statement is not related to an academic task). In other words, out of the set of all possible instances of an indicator word, a small percentage actually gets coded (i.e., low trait prevalence). Thus, we chose to use Gwet's $\boldsymbol{AC_1}$ to calculate the IRR$_1$, which is defined by:

$$AC_1 = \frac{\frac{a+d}{n} - 2P_+(1-P_+)}{1 - 2P_+(1-P_+)}$$

The measurement a is the number of coded subjects, both raters coded as + (in other words indicating self-efficacy), d is the number of coded subjects both raters coded as - (not indicating self-efficacy), n is the total number of possible subjects to code, and $P_+=(A_+ + B_+)/2\ /n$. A_+ and B_+ are the marginal totals of subjects that raters A and B respectively coded as +, which in Gwet's terms could also be written as $a+c$ and $a+b$ respectively.

Gwet's $\boldsymbol{AC_1}$ is for the case of binary coding. When Wood and Northington calculated their IRR, they only examined cases of coding the parent code SEE. Our $\boldsymbol{AC_1}$ value in that initial round of IRR was 0.92 which is in the range of excellent agreement (Gwet, 2014). In the next sections,

we will see that there are various sub-codes of SEE, on which we have not examined our IRR value.

3.4 Developing a Self-Efficacy Codebook

3.4.1 Conceptual Overview of Coding Process

Broadly, the coding process for SEE statements involves examining each instance of the indicator words or phrases and then answering a flowchart of binary yes or no questions to determine whether the indicator word in context is evidence of a person's self-efficacy judgment or not. Although there are many complicated instances where the use of one of the words or phrases from our list of indicator words is not indicative of a self-efficacy explicit statement, we have found that these instances can be broken down into straightforward categories that get discounted by the flowchart of questions. We can consider the space of indicator words as the set of all uses of an indicator word whether ultimately tagged as SEE or not. After answering all the questions that might disallow the indicator word in the context used, if the coder has determined that the specific instance of the indicator word is indicative of an SEE statement, everything in the sentence should be coded from (and including) the indicator word to (and including) the task about which one is evaluating their self-efficacy. Table 3.4 and Figure 3.1 provide overviews of the coding steps. Also see the appendices for a short reference version.

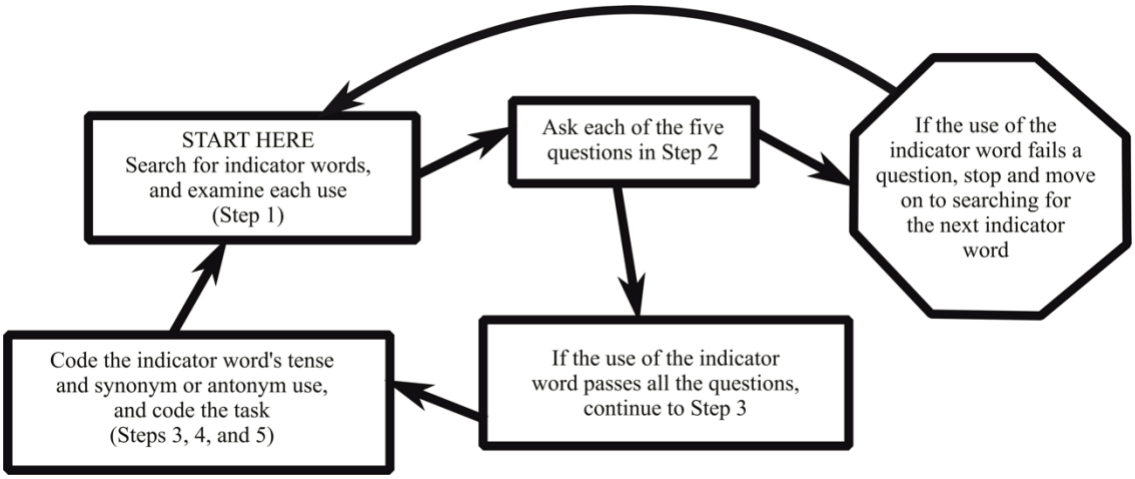


Figure 3. 1 Overview of coding steps

3.4.2 Indicator Words

We pulled from survey language to develop the list of indicator words that might, in context, indicate a sentence to be an explicit self-efficacy judgment. The final list of those words is shown in Table 3.5. In the far right column, we list the ways we searched for these indicator words within the files in MAXQDA. For example, we would type in "confiden" to search for uses of "confident" and "confidence", since searching "confiden" would capture both of those words.

Then, Tables 3.6-3.11 show real, imagined, and counter-examples of statements using each indicator word in ways that would or would not indicate a self-efficacy judgment. For each sentence using an indicator word, we would think through each of the steps of the codebook. Either the use of the word would get disqualified at a step in the codebook, or pass all the steps, at which point we would code the sentence as an SEE statement. The right hand column of each of Tables 3.6-3.11 discusses the steps in the codebook at which the example gets disqualified. The words in the quotes that are italicized are what we would code as SEE, the bolded words would be coded for tense and synonym/ antonym, and the underlined words would be coded as task. Like we saw in Table 3.4, "can" is a very commonly used indicator word on surveys, and it was also an extremely common

Table 3. 4 Coding steps

#	OVERVIEW	DETAILS	NOTES
1	Search for indicator words one at a time and address all steps for each use of the word/ phrase	able (ability), can, could, capable, confident (confidence), possible	It is up to the coder whether this literally means "search," using something like CTRL+F or instead read through.
2	Examine the context of each instance of the indicator word and address these questions.	Check that the phrase is not (i) an outcome expectation, (ii) a statement of present confidence about past performance, (iii) a simple description of what happened in the past. If the statement is one of these things, stop. If it is none of these things, move to the next question below.	
		Is this word being used to describe confidence about a specific task, discipline, or career? If No, stop. If Yes, continue to the next question below.	
		Is the task about the student's academic or career-related experiences or something plausibly related to that? If No, stop. If Yes, continue to the next question below.	
		Are you sure that the student is using this word to describe themselves? (e.g., they are not describing someone else, what someone else thinks, or the general "you"). If No, stop. If Yes, continue to the next question below.	
		Is the statement of confidence inside a conditional phrase? If Yes, stop. If No, then select all text from (and including) the indicator word/ phrase to (and including) the task about which the student is evaluating their self-efficacy and code that whole excerpt as SEE. Then, move on to Step 3.	
3	Code the tense of the statement, selecting and coding only the indicator word/ phrase itself.	There are two possible tense tags: (i) Past Self-Efficacy (Simple, Continuous, Perfect, Perfect Continuous) The task itself could be in the past, present, or future (ii)Present Self-Efficacy (Simple, Continuous, Perfect, Perfect Continuous) The task itself must be in the present or future and cannot be in the past	Note that regardless of the tense of the self-efficacy and the task, the task must always be more in the future than the self-efficacy.
4	Code the indicator word or phrase as synonym or antonym.		
5	Code the phrase describing the task.		

SEE indicator in our data. It seems to be one of the most common ways people verbally express their sense of ability. However, there are many ways it is also used that do not indicate explicit self-efficacy, like simply as a figure of speech.

"Could" as an indicator word is tricky because grammatically it is the past tense of can, but this does not mean that people always use it in the past tense. People can say that they "could" do

something in a sense that either implicitly or explicitly tells us that they currently believe that they could, in which case the word can indicate present self-efficacy. “Capable” was a very uncommon word in our data, but we included it because of its use in survey language and its very near synonym definition to confidence.

The indicator word “confident” very rarely shows up on its own. Typically, it would be used in phrases like, “I am *confident* that I *can* do X,” or “I am *confident* in my *ability* to do X.” Those examples show “confident” being used in conjunction with other indicator words (“can” and “ability”). Thus, we learned to search for the words “confident” and “confidence” last, because often most uses of the word would already have been captured in searching for the other indicator words.

We added one more indicator word that wasn’t shown in any survey items from Table 3.3. This was the word “possible”, but we specifically defined the uses of possible that count as SEE to be ways in which possible functions as a synonym for can.

Table 3. 5 Indicator words

INDICATOR WORD	SYNONYMS AND OTHER FORMS	ANTONYMS	SEARCH FOR
able	ability	not able	“able”, “ability”
can		can’t, cannot, can not	“can”
could		couldn't, could not	“could”
capable	capability	incapable, not capable, no capability	already captured when searching “able” and “ability”
confident	confidence	unconfident, not confident	“confiden”, or “confident” and “confidence”
possible	possibility	impossibility, impossible, not possible, not a possibility	“possible”

3.4.3 Self-Efficacy Explicit Statements Must Relate to a Specific Task, and We Focused on Academic Tasks

As discussed in the literature review, the relation of confidence to a specific task is an integral part of the definition of self-efficacy. We think about the relevant tasks in our codebook

Table 3. 6 Examples and counter-examples of "able" indicating self-efficacy explicit

ABLE	QUOTES	DISCUSSION OF CODING STEPS
REAL EXAMPLES	"*I will be **able** to leave this class and still know what's happening.*" (Leyla)	A concern arises in Step 2.i.1, because the use of the word "will" cues that this might be an outcome expectation, but we interpret this to mean Leyla is stating her confidence to in the future retain knowledge from her current class. More ideally this would be worded in present tense.
	"*I actually thought there was no way I would be **able** to [build a spirometer]."* (Leyla)	A concern arises with this example in Step 2.ii because Leyla does not state the task in the sentence. However, we can learn the task from the broader context in the interview.
IMAGINED EXAMPLES	"*I believe I am **able** to pass my upcoming test.*"	
	"*I am confident in my **ability** to pass this physics class*."	This is an example of a statement using the noun form "ability" rather than "able".
	"*I feel good about my **ability** to complete my major*."	
COUNTER-EXAMPLES	"Malcolm was **able** to help me with the homework" (Victoria)	This violates Step 2.iv, because Victoria is describing what someone else, Malcolm, was able to do.
	"I'm **able** to say that I actually went [to the job fair]" (Shaina)	This violates Step 2.iii, because this is a turn of phrase ("able to say") regarding a non-academic task (ability to express something in the context of the interview).
	"I wasn't **able** to do well on my homework last week." (imagined quote)	This violates Step 2.i.3, because it is a simple description of what happened in the past that deceptively uses an indicator word.

broadly as academic tasks, similar to Usher and Pajares' (2008) language of "students' confidence in their academic capabilities" (p. 5). This means we were interested in students' self-efficacy to do a broad range of tasks from homework to tests to finding study groups to completing one's degree. Additionally, our context focused on students in STEM majors as well as community college students, often interested in transferring to FYCs, and transfer students at FYC who transferred from TYCs. Academic tasks about which we saw students evaluate their self-efficacy thus also included transfer, integration into their receiving institutions after transfer, and other transfer-related tasks. Tasks were also often regarding STEM classes, programs, and activities. Our academic focus contextualized our development of the codebook to be a useful tool for examining self-efficacy in STEM and TYC and transfer contexts.

Table 3. 7 Examples and counter-examples of "can" indicating self-efficacy explicit

CAN	QUOTES	DISCUSSION OF CODING STEPS
REAL EXAMPLES	"[W]ith math and science there's a lot of concepts to understand and those concepts aren't always the easiest to remember or the easiest to understand but like I said the part where it comes in for me is the absolute answer. …[T]here is an answer for things so that's where ...I get excited ...since *there's something I **can** do to find the answer*." (Shaina)	A concern arises with this example in Step 2.v, because the statement of confidence is in a clause opened with "since". However, the statement of confidence is not conditional; it is a present tense statement of confidence. Thus, we would code the italicized text as SEE, and the bold word as synonym and present.
	"I'll probably do quite well. It's like I put in the work I know how to do that math. It's that math, *I **can** do that math*." (Victoria)	The italicized text would be coded as SEE, and the bold word coded as synonym and present. However, "I'll probably do quite well," is, for example, an outcome expectation. Similarly, "I know how to do that math," could also be explained by something other than self-efficacy and is not SEE.
IMAGINED EXAMPLES	"*I **can** do my upcoming physics homework*."	
COUNTER-EXAMPLES	"I **can** tell [the upcoming test]'s going to be a lot harder [than the previous test]." (Shaina)	This violates Step 2.iii, because the task is not academic, but rather being able to perceive the difficulty of an academic task.
	"That's probably the best example I **can** come up with." (Shaina)	This violates Step 2.iii, because the task is not academic; it is about being able to say something in the interview.
	"I like [lab course] because it's more lab-based where I **can** just be in there, do my experiments." (Victoria)	This violates Step 2.iii, because the bold indicator word is not linked clearly to the underlined academic task, but rather to the task of "be in there."

3.4.3.1 Grain Size of Self-Efficacy Tasks and Defining Academic Tasks Broadly

In developing this codebook, we purposefully thought of the range of tasks for which a student might assess their self-efficacy as broad. This is why in the section above, we use the language of academic tasks, and that is the most that we restrict the tasks that might be discussed in an SEE statement. Our purpose is to try and capture the broad range of SEE statements we saw from students about a range of tasks, from small to large specificity. Mark told us, "I can do the work in the profession," in answer to a question about successfully performing necessary work in his intended career. This is fairly broad and non-specific. On the other side of things, Lynn said, "I didn't think I was going to be able to transfer [my last class at my community college]" which is a very specific task, being able to transfer credits from a course to one's receiving institution.

Table 3. 8 Examples and counter-examples of "could" indicating self-efficacy explicit

COULD	QUOTES	DISCUSSION OF CODING STEPS
REAL EXAMPLES	"*There was someone I **could** call like, hey, this class is looking pretty bad, is there a light at the end of the tunnel? Like yeah, it gets easier as you go on; the first chapter is a little rough and then I was okay, cool.*" (Victoria)	This seems like it might violate Step 2.iii because the direct task Victoria describes is her ability to "call someone," which is not academic. However, we interpret the underlined context to mean that the task Victoria is considering is accessing supportive faculty for help and encouragement on academic difficulties. Thus, this task is academic and we would code all the italicized text as SEE, and the bold word as synonym and past.
IMAGINED EXAMPLES	"*I felt that I **could** get a job as an engineer*."	
COUNTER-EXAMPLES	"I **couldn't** do my physics homework last week." (imagined quote)	This violates Step 2.i.3, since it is a statement of a past outcome.
	"I'm one of the biggest procrastinators hands down. I don't think anyone can beat me. It's to the point where I **could** like make my friends help me procrastinate, like if there was a contest, I would win." (Victoria)	This violates Step 2.iii, because it is an explicit statement of Victoria's perceived ability to generally procrastinate, which is not an academic task.
	"I **could** just get in bed and watch videos and just do nothing." (Victoria)	This violates Step 2.iii, because it is an explicit statement of Victoria's perceived ability to "get in bed, watch videos, and do nothing", which is not an academic task.

In addition to choosing to code statements about a range of grain sizes of tasks, we also chose to maintain a broad definition of what counts as an academically related task. Part of this was motivated from our researcher positionalities as people who care about supporting students from marginalized identities through navigating systemic inequities or oppression, like racism, sexism, and heterosexism. For example, if a student talks about their self-efficacy towards dealing with the experience of a bigoted microaggression in a class, even if the broader discussion is not about academic experiences, that might impact the ways they feel about other academic experiences. We did not see many examples of students discussing such experiences in our data, but we were informed by anti-racist frameworks for research to consider this language in creating the codebook. This is partly in response to Harper (2012) calling for more explicit discussion in higher education research of racism as a system in which students exist, as well as Usher (2018)

Table 3. 9 Examples and counter-examples of "capable" indicating self-efficacy explicit

CAPABLE	QUOTES	DISCUSSION OF CODING STEPS
REAL EXAMPLES	"*I feel **capable** [to build a tool in my honors project.]*" (Leyla)	Without context telling us the task about which Leyla feels capable, this would fail Step 2.ii. Although she did not restate the task she was discussing in this exact sentence, the context in the interview tells us what Leyla was considering.
IMAGINED EXAMPLES	"*I felt **capable** to do last week's test*."	
	"*I think I am **capable** of graduating in five years*."	

calling for more acknowledgement of the whiteness embedded in motivation research and work to dismantle white supremacy and norms.

Literature and research framing led us to include tasks relating to navigating systemic oppression as potentially academically relevant tasks, but we did not see examples of that often in our data. On the other hand, we did see a lot of examples of rapport-building discussion, often early in interviews, that contained SEE statements but not about academic tasks. This rapport-building would often be off-topic conversations about things that were likely not related to one's academic experience at all (e.g., science academic self-efficacy in Robinson et al., 2020). For instance, imagine an interviewer finds out that a student traveled to Oregon and the interviewer and student briefly chat about that during an interview. The students might say, "I learned I can actually hike up a mountain." This is not a context we would tag as SEE in our codebook focused on academic self-efficacy. However, if a student mentioned going home on Spring Break and said something like "I'm going home and I'm excited that I can actually explain a physics concept to my brother!" we would count this. This last example counts because it seems plausibly related to the student's physics course experience in college. An example of this type of speech in our data comes when Angelo told us that he *can* speak a certain language early in a rapport-building conversation in the interview. In summary, we thought of our academic focus very broadly in order to avoid presupposing the contexts in which a student might consider their self-efficacy judgment

Table 3. 10 Examples and counter-examples of "confident" indicating self-efficacy explicit

CONFIDENT	QUOTES	DISCUSSION OF CODING STEPS
REAL EXAMPLES	"*I'm just not as **confident** with online classes as I am in in person classes.*" (Nicole)	
	"*Okay yes so there's a lot of times that I feel **confident** in some of my classes. Like for example in the biology of birds, I felt really **confident** in it. Simply for the fact that not only did I like the content, I also knew some of the content. Same with even though I didn't get like the grade I would have hoped for, for fundamentals of genetics, I knew a lot of the information, I knew I wasn't going to get like a horrible grade, I still felt really **confident** even though I only got the 3.5.*" (Nicole)	
	"Again kind of along the lines of I'm not really that confident a person. As much as I try to be, pretend to be, I'm not. *So I feel like the only time I've really actually been **confident** was one biology class that really just was really easy.* I don't know if it was really easy because of the teacher. She was a really good teacher, so I feel like that made it really easy. But, like the tests were like super-duper easy. So I guess I was confident in that class." (Allison)	
IMAGINED EXAMPLES	"*I'm **confident** to do well in this class.*"	
COUNTER-EXAMPLES	"I'm confident I will get an A in this class."	This fails Step 2.i.1, because it is an outcome expectation.

relevant to their academic experience. This aligned with our research approach of centering our participants' voices, listening and learning from what they told us, and taking their words at face value biased as little as possible by our backgrounds. In short, we remained open-minded in our conceptualization of task specificity and what contexts of a task might count as academic.

3.4.4 Further Clarifying Questions about Context of Indicator Word

In the following sections, we explain in more detail the development of specific clarifying questions in Step 2 that might lead someone to not code a certain use of an indicator word. The following sections cover deceptive uses of indicator words that look like SEE statements but are not, and certain grammatical structures or tenses that do not count as SEE. Particularly, we tried to separate self-efficacy from these deceptive uses of indicator words, because of our goal of developing a highly reliable, easy-to-use codebook for solely identifying self-efficacy judgments.

Table 3. 11 Examples and counter-examples of "possible" indicating self-efficacy explicit

POSSIBLE	QUOTES	DISCUSSION OF CODING STEPS
Real Examples	"She like lays it out and so right now, I'm on a four year plan. And after she like, put everything on this little schedule *I could like visualize like, oh, like this is* ***possible*** *…For me I was like okay, it's been done, someone else is doing it. I* ***can*** *do this, it's like* ***possible*** *here.*" (Victoria)	
Imagined Examples	"*It's* ***impossible*** *for me to do physics*."	
Counter-Example	On the next two tests, if I get a 45 out of 50, and then on the final, I think I need a 95, I'll get a 4.0 in the class, on the dot. So like I said, it doesn't sound doable at all. It sounds very **impossible**. *Those are the things that you should aim for.* (Angelo)	This fails Step 2.iv because it is unclear if Angelo is evaluating his own self-efficacy to get the test grade he needs to 4.0 the class, particularly because of the italicized text at the end of the quote.

3.4.4.1 Statements that Look like SEE but Are Not

As we iteratively addressed possible SEE statements to determine what rules should include or exclude a statement from being SEE, we encountered wordings that might look similar to SEE, but could be explained by some other motivation than a self-efficacy judgment. For example, sometimes students would use SEE indicator words in a sentence where they followed up with a "because" clause that gave a different explanation than self-efficacy for their sense of competence[5]. When a student says something like, "I don't think I can do this homework assignment, because I'm just not interested in it," that would be an interest-based explanation, rather than self-efficacy. One example in our data comes from Lynn who said, "I just can't relate [material in this class] to anything, because I don't find it that interesting".

A case of students saying indicator words outside of SEE statements that did show up often in our data was simple descriptions of what happened in the past. This looks like turns of speech when people might say, "We were able to do some task in the past." This does not indicate someone's past sense of confidence, merely what actually happened in the past. This type of

[5]Although this is one of the things we refer to as a "deceptive use of an indicator word," this does not show up as a step in the codebook, because it occurred very rarely in our data.

sentence construction showed up most often using the indicator words “able” or “could.” An example includes Shaina’s quote from Table 3.6, “I’m able to say that I actually went [to the job fair]”. Encountering this type of statement specifically contributed to the development of both Steps 2.iii and 2.i.3 (as presented in Table 3.4 and in the appendices). Step 2.iii is the rule that requires a coded SEE statement to be a self-efficacy judgment of ability to do an academic task. Step 2.i.3 is the step that disallows simple descriptions of past performance. Shaina is both using a turn of phrase (“able to say”) to tell us that she did in the past go to a job fair–thus the statement is a simple description of a past performance–and she is also stating her ability to “say” something–which is not an academic task in this context. These types of examples specifically led us to write the codebook step disallowing simple descriptions of past performance.

3.4.4.2 Outcome Expectations Differ from Self-Efficacy Explicit Statements

We frequently encountered statements that seemed to indicate self-efficacy, but, upon closer inspection, were actually outcome expectations. Thus, we included a step in the codebook to check that the use of an indicator word is not an outcome expectation. Here, we describe in detail the ways we learned to recognize outcome expectations. Bandura distinguishes between self-efficacy evaluations and outcome expectations in the following. “An outcome expectancy [or expectation] is defined as a person’s estimate that a given behavior will lead to certain outcomes, [whereas a]n efficacy expectation is the conviction that one can successfully execute the behavior required to produce the outcomes” (1978, p. 3). In other words, this definition shows that a big difference between the two types of beliefs is whether a person believes a certain event will come to pass as a result of their behavior (outcome expectation) or whether a person believes they can perform the tasks necessary to achieve a certain outcome (self-efficacy judgment). As we saw above in the Literature Review, and as is evident in this definition, self-efficacy judgments are

often chronologically prior to outcome expectations and often explain a person's outcome expectations belief. That is to say, if a person believes they can enact the necessary steps (self-efficacy) that they expect will lead to an outcome (outcome expectation), the outcome expectation follows logically from the self-efficacy. However, as we also saw in the Literature Review, sometimes one's outcome expectation is explained by some other circumstance or factor than self-efficacy. Thus, we distinguish between them in our codebook so that coders can be sure of the indication of a self-efficacy judgment in all statements coded as SEE.

This means that a student making the outcome expectation statement that they expect to get an A on a test could suggest that they believe in their ability to get an A and have high self-efficacy in their ability to accomplish the task of getting an A. However, it could also mean that regardless of their self-efficacy judgment they expect to get an A for other reasons, like the teacher is lenient and generous in their grading so the student expects to get an A. In that case, the student's outcome expectation does not tell us information about their self-efficacy judgment. We encountered such statements often, where a student expressed an outcome expectation without explicitly stating its explanation as a self-efficacy judgment. For example, Nicole told us, "I actually think I will be pretty successful. Microbiology is just something that I'm not really interested in. So, it is more difficult. But when it comes to my other classes and learning about the cells, and animals, and stuff, it's easier for me to understand and comprehend that kind of stuff." In that quote, Nicole was contrasting her performance expectations in an upcoming class with her previously stated negative sense of competence in Microbiology. However, she does not say that her self-efficacy is high for the future class, but rather that she expects an outcome of success, because (she implies that) she is more interested in the topic than she was in Microbiology, and cells and animals are easier topics for her to understand. The fact that the topics are easier does

suggest her positive self-efficacy toward the future class, but the statement is unclear. Particularly, the task about which she might be evaluating her self-efficacy is unclear, so by definition such a statement would not clearly indicate self-efficacy.

Often, these outcome expectation statements showed up, whether using an indicator word or not, using the word "will," like in Nicole's quote above. This makes sense since outcome expectations are one's future prediction of what will happen. It is hard to even discuss outcome expectations and not use the word "will." This does not mean that all uses of the word "will" would discount a statement from indicating a self-efficacy judgment. We saw examples in the tables above that were SEE and used the word "will." However, we learned to be cautious in our coding of SEE when we encountered the word "will."

3.4.4.3 Self-Efficacy Explicit Statements Must be about Oneself

A person's self-efficacy must by definition be their own, so SEE statements must be first-person about oneself. In fact, we encountered many statements that used SEE indicator words in the context of discussing a different person. These instances both helped us define specific uses of indicator words that do not indicate explicit self-efficacy and they also began to point out the possibility of using this codebook's indicator words for identifying descriptions of source experiences. For example, we will dissect pieces of the following quote from Victoria. Part of this is shown and briefly discussed in Table 3.11, but we will discuss it in more detail, since it is a rich and useful quote that prompted us to make a few different codebook decisions. Victoria said,"

> "[The academic advisor] lays it out and so right now, I'm on a four year plan. And after she put everything on this little schedule I could visualize like, oh, this is **possible**. And they're super, super nice, really for you, for your success. So they're like no you *can* definitely do it. There's all these resources you *can* use if you're having trouble in your

classes. For that, for me, I was like okay it's been done, someone else is doing it. I **can** do this, it's **possible** here."

The tables above already discuss the ways that pieces of this quote are indicative of explicit self-efficacy. Those uses of indicator words are bolded in the quote. For example, although her uses of "possible" are not clearly connected to a defined task, which might raise a concern regarding codebook Step 2.ii, we can extrapolate from context that she sees graduating in four years as possible for her. Similar logic could be used regarding the accompanying indicator word "can".

There are other indicator words used in this quote that we noticed as exemplifying a set of rules disqualifying a statement from counting as SEE. The italicized words do not indicate Victoria's explicit self-efficacy, because they do not describe her own sense of her own confidence. However, we were interested in the statements using those italicized words, as well, because they suggest that the context of Victoria's self-efficacy explicit statement involves some source experiences. We will expand on this idea in more detail in the Discussion section regarding intended future work. For the development of the SEE codebook, this quote and others like it helped us define the category of uses of indicator word instances disqualified in Step 2.iv.

3.4.4.3.1 Discussing Collective Efficacy

Despite the fact that one's own self-efficacy must be evaluated by themself about their own perceived ability, the literature tells us that collective efficacy is similarly predictive with self-efficacy. Social-cognitive theory names three types of agency: "personal, proxy, and collective", where agency is the "perspective in which individuals are producers of experiences and shapers of events" (Bandura, 2000, p. 1). Related to collective agency is collective efficacy, a group sense of efficacy. Sometimes outcomes people seek are not achievable by individuals, so "people have

to work together to secure what they cannot accomplish on their own" (Bandura, 2000, p. 1). This informed us that for the purposes of the SEE codebook, we could treat statements about "we" as similar to statements about "I".

In our data, we saw examples of collective SEE statements made by students discussing group research projects. An example would include a student in an undergraduate research methods course who told us, "I don't feel satisfied with our [project] goals because we aren't able to start analyzing [until] the next week". In that statement, the student expresses their own dissatisfaction with their research progress, but their collective group efficacy toward starting the task of data analysis, in saying, "we aren't able." Because the student is part of the group, this "we" statement is a statement of their self-efficacy. It did not seem necessary to code self-efficacy separately from collective efficacy, but this quote also contributed to the decision to treat collective statements similarly to individual statements.

3.4.4.4 Conditional Sentence Constructions are Not Self-Efficacy Explicit

On the same lines, since self-efficacy must be about oneself and one's own estimation of ability, we saw SEE indicator words used in our data within conditional phrases, and we realized that in certain cases those would not indicate self-efficacy judgments. Many of the instances in our data that used conditional phrasing were actually indicative of explicit self-efficacy, but these examples prompted us to consider other uses of conditional phrasing. For example, in Table 3.7, we saw Shaina say,

> "[W]ith math and science there's a lot of concepts to understand and those concepts aren't always the easiest to remember or the easiest to understand but like I said the part where it comes in for me is the absolute answer. …[T]here is an answer for things so that's where ...I get excited ...since there's something I **can** do to find the answer."

Despite the bolded indicator word "can" being used in a clause opening with "since," this quote from Shaina does indicate her explicit self-efficacy to solve mathematics problems. It is similar to what we could imagine someone saying, like, "I am excited to go to math class, because I am confident about my ability to solve math problems." The word "since" functions similarly to "because", and both words indicate a causal relationship originated by the statement in the because- or since-clause. Then, statements phrased thus can indicate real explicit self-efficacy. However, this quote prompted us to consider conditional phrases, where an indicator word is embedded in a hypothetical clause. Imagined examples of this include, "If I were more confident, then…," or "If I had been able to do X, then…" These conditional phrases use an if-then format, and we consider that the use of "if" would disqualify an indicator word from indicating real explicit self-efficacy.

Similarly, cases of modal phrasing (e.g., "should have", "could have", or "would have") will not describe confidence. A student Rosie told us about transitioning and socially integrating to the FYC, saying, "I was a little afraid to put myself out there and I feel like I could have really– eventually I did stuff and I got out there–but I *could have* started a lot earlier and done a lot more." The italicized use of "could have" in that quote includes the indicator word "could" but suggests that Rosie retroactively considers alternative paths which she might have taken and might have preferred. This is a past hypothetical situation that has not played out in reality. That does not tell us about Rosie's self-efficacy judgment toward socially integrating into a school.

Considering these phrasing types, we also considered phrases like, "I wish I felt confident". This might seem like it does give researchers some evidence towards a person's explicit self-efficacy by implying that the student does not have high confidence, since they wish they felt more confident. However, we typically did not decide to code such examples because the step of

interpreting implication seemed too hard to generalize and agree on across coders. As an example, a student in an undergraduate research methods course told us that they "wish[ed they] could have done more [on their research project]". This does not necessarily indicate the student's perceived ability to do work on their research project, since it is hypothetical. Thus, we generally decided to forego tagging hypothetical statements as SEE.

3.4.5 Discussion of Temporal Tenses of Self-Efficacy Explicit Statements

We have now outlined the process of developing all of the steps for the primary code SEE from our codebook, and in these next sections, we will describe our process of developing sub-codes for temporal tense and synonym or antonym. We consider these codes less important or useful than the main code for SEE, since they are simply additional classifications of the word or phrase that indicates self-efficacy. These sub-codes are most useful for researchers using this codebook to organize and reduce large amounts of data, and they would allow coders to examine different types of SEE statements separately. We will address this more in the Discussion section.

We considered all possible tenses as possible temporal codes for self-efficacy, and we debated internally for a period of time over whether an explicit statement of self-efficacy could express future confidence, i.e., use the future tense of the indicator word. Quotes that we considered in this decision included the following quotes from students in an undergraduate research methods course:

"I feel confident that I will be able to [collect our research materials]".

"If I ever do anything else [like this research project], I won't feel as nervous or anything".

The first quote is actually indicative of SEE and would be coded as such. Although the indicator word "able" is in future tense, the indicator word "confident" is in present tense making the evaluation of perceived ability set in the present about a future task, which fits the definition

of self-efficacy. The second quote does not even use an SEE indicator word, but it was a quote we considered as possibly indicative of SEE earlier in the coding process when we were still developing the list of indicator words. We could imagine a similar quote that does use an indicator word for the sake of discussion, like "If I ever do anything else [like this research project], I won't feel as *incapable* or anything." Examining that sentence, we concluded that it describes the student's expectation to in the future feel less incapable, or nervous. Since the future has not yet happened, there are too many levels of extrapolation to consider future indicator word use indicative of SEE. A person's expectation of how they think they will feel in the future does not tell us about their actual self-efficacy, just their hypothetical self-efficacy. In this way, such grammatical constructions are similar to conditional phrases.

Thus, we decided that there are two possible tenses of SEE statements, (1) past and (2) present. We saw no reason to separate those further, so those both include simple, continuous, perfect, and perfect continuous tenses in their definitions. Furthermore, when considering how to code the tense of the self-efficacy indicator word, we were not considering the tense of the task itself, beyond that the task must be more in the future than the self-efficacy indicator word. This is because of the definition of self-efficacy as an estimation of perceived ability to do some task; therefore, the task must be more future temporally than the estimation of perceived ability toward it.

3.4.6 Synonym or Antonym Self-Efficacy Explicit Indicator

Functioning similarly to the tense sub-code, we chose to create a sub-code we call "synonym" or "antonym". This would also allow coders of large quantities of data to quickly separate out the uses of synonyms of the indicator words from antonyms of the word or phrase. We define this code as essentially a binary weighting to self-efficacy statements. We used to call

this code "positive" or "negative", but we wanted to remove the implied value judgment. This language helps describe the original intention of the code, though, and a possible application for it.

For example, in Table 3.6, we saw Leyla say, "I actually thought there was no way I would be able to [build a spirometer]". Using our codebook, that sentence would be coded as "SEE". Then "able" would be coded as "antonym", because Leyla said "I …thought there was **no** way I would be *able*". We do not care about the task for this code, only the positive or negative sense of the indicator word. Alternatively, the following quote from Victoria is an example in which the indicator word would be coded as "synonym". "I *can* [graduate in four years]". No word in that sentence negates the indicator word "can", so it would be coded as "synonym".

Differentiating synonym and antonym SEE statements could support drawing quantitative conclusions from large numbers of qualitative data analyzed with this codebook. However, since we removed the complexity of defining positive or negative self-efficacy, synonym and antonym cannot be used synonymously with positive and negative to make claims. We will address potential future uses and developments of this code in the Discussion.

3.5 Discussion

3.5.1 What Does this Codebook Not Capture: Comparing Self-Efficacy, Self-Efficacy Judgments, and Self-Efficacy Explicit Statements

This codebook will not capture every self-efficacy judgment. We sought a highly specific definition of an SEE statement, and we aimed to design a codebook with high IRR that could easily be used by other coders. This means that sometimes the strictness of the codebook's rules defining an SEE statement might disqualify statements from being coded that are indicative of a person's self-efficacy. This is the limitation of a codebook, centered around indicator words, that walks the line between quantifying qualitative data and providing a tool to add qualitative nuance to an often

quantitatively studied construct. This is, however, balanced by the affordance of doing qualitative research. Human coders can use their best judgment and make arguments, crafting stories from data, to explain pieces of evidence that contribute to a claim about self-efficacy. Thus, this codebook can be a starting point, but researchers should use it in conjunction with broader qualitative methods to support their claims.

Furthermore, this codebook allows for coding SEE statements, which are a single small piece of evidence towards understanding a person's self-efficacy. Self-efficacy is a belief that people evaluate for themselves which can change over time. Whether a person consciously or unconsciously evaluates their self-efficacy, they have some sense of their competence toward doing a task at hand (see largest circle in Figure #). When a person consciously evaluates their self-efficacy, we could call that a self-efficacy judgment (see middle concentric circle in Figure #). These judgments could be made publicly or privately, but, as Bandura says, self-efficacy affects one's performance regardless (Bandura, 1997).

Our codebook allows us to identify SEE statements which are the public self-efficacy judgments our participants share with us (see innermost circle in Figure #). Of course, our participants also have self-efficacy judgments they have publicly or privately, consciously or unconsciously, made about certain tasks, and this codebook will not capture what our participants do not tell us. It also will not capture every self-efficacy judgment our participants do express to us. SEE statements are almost synonymous with self-efficacy judgments, but since there may be other self-efficacy judgments not captured by this codebook, they are slightly different. Hence SEE statements are the smallest circle in the figure below, but they provide evidence towards a

person's overall self-efficacy and, in context, can tell us about what informs a person's self-efficacy evaluations.

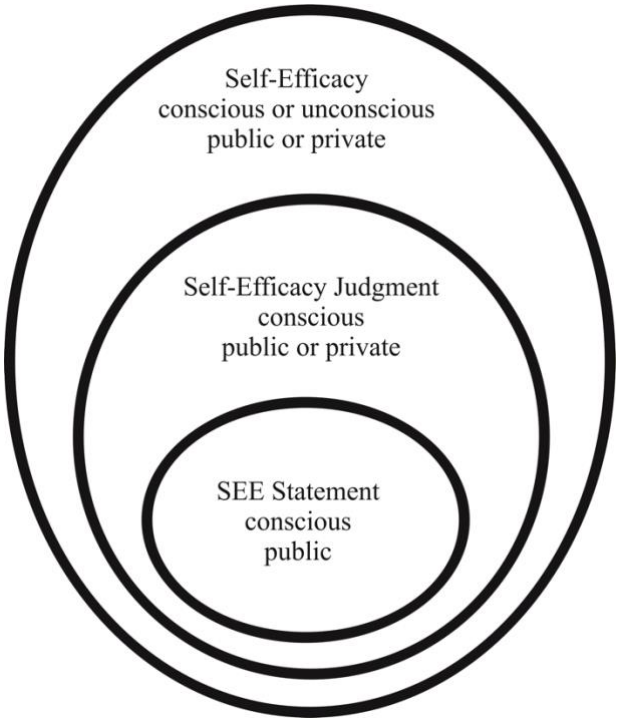


Figure 3. 2 Comparing self-efficacy, self-efficacy judgments, and SEE statements

3.5.2 Generalizing this Codebook to Other Contexts

Our codebook was developed specifically for the context of examining self-efficacy toward academic tasks, and we developed it with student participants from undergraduate STEM majors, many of whom were community college transfer students. We primarily used one-on-one, semi-structured interview transcripts in developing this codebook, but in later iterations drew from written reflections responding to open-ended prompts. We can imagine this codebook being generalized to other types of qualitative data or subject populations.

Motivating our choice of data sources for developing this codebook was our goal to identify indicator words of self-efficacy judgments from survey language and create a tool to support identifying such judgment statements in qualitative data. Thus, the codebook needed to describe the steps for identifying a person's own self-efficacy evaluations in their spoken or written words to open-ended questions. We could thus imagine using this codebook with any qualitative data where a person expresses their sense of ability publicly (e.g., classroom video data, focus groups, field notes). Some of those types of data would need more thoughtful modifications in order to be used with this codebook as it is written. For example, considering that field notes often involve

recording the researcher's perception of an environment, this would not necessarily capture this codebook's definition of evidence of other people's self-efficacy, since self-efficacy judgments need to be made by oneself about oneself. Nonetheless if the researcher were recording in-the-moment quotes from students, this codebook could be used on that data. One could also think of this codebook as a set of guidelines for what phrases and constructions to look for in people's verbal expressions, so a field noter could potentially be guided a priori in their observations by this codebook if they aimed to examine self-efficacy.

Since we developed this codebook using transcribed interview data or written reflections in searchable file formats, we wrote the guidelines assuming a process of being able to automatically search for indicator words. If a coder wanted to use this codebook for a video file, they would need to manually scrub through the file, listening for the indicator word. Certain types of data then might be easier or harder to use with this codebook, but the guidelines could be followed and applied to numerous situations.

Considering possible generalization to other disciplinary contexts of tasks we initially made no decision limiting the contexts of tasks. In other words, we intentionally wrote the steps of the codebook to be discrete. This was motivated by the aim of creating a clear, complete flowchart of questions to disqualify statements that do not indicate self-efficacy and only capture statements that likely do indicate self-efficacy. However, the discrete nature of the steps also allows for the possibility of other coders in different contexts editing a single or a few steps to generalize the codebook to their unique needs. For example, if a coder wanted to adapt this codebook to a different context of tasks than our academic context, they would simply need to develop their own rule for Step 2.iii.

3.5.3 Future Work

3.5.3.1 Experiences Codebook

As we were developing this self-efficacy explicit codebook, we were simultaneously working on a codebook for capturing student descriptions of experiences in Bandura's four source experience categories. That codebook is unfinished and remains open as future work, but we learned some potentially useful indicators of the source experiences in developing the SEE codebook.

First of all, we consider this SEE codebook as a tool to be used in tandem with an experiences codebook for identifying source experiences. Without knowing that an experience impacted a person's self-efficacy, we could not identify the experience as a source of self-efficacy. We could only identify descriptions of experiences that seemed to align with the definitions of mastery experiences, vicarious learning, social persuasion, and physiological state. We then hypothesized that using an experiences codebook in conjunction with the SEE codebook could allow coders to identify overlapping excerpts coded as a likely source experience alongside a coded SEE statement. This could confirm that the experience impacted a person's related self-efficacy judgment. This potential future use of the SEE codebook is another motivation for creating a qualitative codebook for self-efficacy. Examining the contextual qualitative data situating SEE statements would support in-depth analysis of the ways experiences impact people's self-efficacy.

We also hypothesized some instances of indicator words that did not indicate explicit self-efficacy to perhaps indicate source experiences in certain situations. Consider the following quote from Victoria.

> "[The academic advisor] lays it out and so right now, I'm on a four year plan. And after she put everything on this little schedule I could visualize like, oh, this is **possible**. And they're super, super nice, really for you, for your success. So they're like no you *can*

definitely do it. There's all these resources you can use if you're having trouble in your classes. For that, for me, I was like okay it's been done, someone else is doing it. I **can** do this, it's **possible** here."

Victoria says the academic advisors "are like no you *can* do it; there's all these resources you can use if you're having trouble." That italicized use of the indicator word "can" is encompassed in a quote Victoria shares having heard from someone else. This excerpt fits the definition of a social persuasion experience, since an advisor is telling Victoria about their belief in Victoria's ability to graduate in four years. It seems likely then that instances of SEE indicator words used in a quote someone relates hearing from a different person might indicate social persuasion.

This excerpt from Victoria also has a textbook example of a vicarious learning experience in the underlined text, "It's been done, someone else is doing it". Although this does not use one of the indicator words, it suggested to us possible indicator word uses that might indicate vicarious learning. For example, a student might make a similar statement, "Someone else *can* do it, so I *can* do it". In that case, a student attributes an indicator word to a peer. Such uses of indicator words seem likely to indicate vicarious learning. In this way, future work on an experiences codebook could grow out of Step 2.iv in the SEE codebook, which states that self-efficacy explicit statements must be about oneself. Perhaps when statements look like SEE but are not about oneself, they might indicate vicarious learning or social persuasion.

3.5.3.2 Task Coding

We chose to include a step in our coding process of coding the task in the SEE statement as "task". We used this merely as a step to check that the student was discussing a specific task, because if the indicator word is not attached to a task, we cannot know that it indicates a self-

efficacy judgment. Self-efficacy must by definition be regarding a task. We began the process of taking task coding one step further and creating sub-codes of the parent code "task", so here we discuss possible future work that could be used with this codebook.

To do this, we created in-vivo subcodes for each task phrase we encountered. For example, in the quote, "[in math] there's something I can do to find the answer", we would select the underlined text and code it as the task sub-code "find the answer". These task sub-codes are highly context dependent, so we did not choose to finish developing a set of sub-codes. The purpose of this codebook was also not to examine the types of tasks about which students might make self-efficacy evaluations, but rather to define verbal indicators of such evaluations. Developing a condensed set of sub-codes from our in-vivo codes was not within the scope of that goal. Other researchers may be interested in research questions at the task level regarding the types of tasks about which people make SEE statements, so future work could involve fleshing out such a codebook.

3.5.3.3 Expanding the Role of Tense and Synonym/ Antonym Sub-Codes

The motivation of our codebook was only to define a set of rules for uses of indicator words that do or do not indicate an explicit self-efficacy judgment to create a tool to support qualitative studies of self-efficacy. Depending on one's research questions, researchers might use pieces of the SEE codebook in different ways. Specifically, we defined sub-codes for temporal tense and synonym or antonym indicator word use. Choice of research questions could motivate different uses of those sub-codes.

Considering the synonym/ antonym sub-code, this currently differentiates between uses of indicator words in the positive grammatical sense of the word (i.e., not negated by some word used with the indicator word as listed, e.g., just "confident") and the negative sense (i.e., negated by a

word like “not”, e.g., “*not* confident”). Because we wanted to remove the implied value judgment in the connotations of the words positive and negative as good or bad, we called this code synonym or antonym, as in aligned with or opposite to the way we listed the indicator words. Thus, a student might say, “I am confident about my ability to find completely wrong answers to math problems”. In that imagined quote, “confident” would be coded as “synonym”. If researchers aim to ask questions about positive or negative self-efficacy, this would require making a decision on whether “confident” indicates positive self-efficacy because the indicator word is used in the positive sense, or if the SEE statement indicates negative self-efficacy because the task (to find completely wrong answers to math problems) could be called negative. A possible way to approach work examining positive and negative self-efficacy through using the SEE codebook might be to use the “task” sub-code in conjunction with “synonym/ antonym”. In other words, researchers could examine the task in an SEE statement and consider it positive or negative. Connecting with the synonym/ antonym code would allow determining the positive or negative sense of the entire SEE judgment, i.e., an antonym indicator word with a positive task would suggest low self-efficacy to do a desired task. This is a way of expanding the role of the synonym/ antonym sub-code to address certain kinds of research questions.

Next, we consider the tense sub-code. Researchers might be interested in examining past self-efficacy for different reasons from present self-efficacy. For example, separating out past SEE statements could allow a researcher to examine the ways past experiences impacted students’ past senses of self-efficacy. If students had positive experiences in the past that positively impacted their self-efficacy, or negative experiences that negatively impacted their self-efficacy, those stories might inform development of certain educational environments. Researchers could also compare students’ past senses of self-efficacy with current senses of self-efficacy, either for a

single student or a group of students within a certain environment of interest. This could show shifts in self-efficacy in a qualitative sense. The affordance of the qualitative lens is being able to examine the context of what changed environmentally that impacted students' self-efficacy to shift and why their sense of self-efficacy might have changed from the past to the present. Thus, there are reasons this sub-code could be useful in separating sets of data to use for different questions, different time periods of focus, or to compare.

A related open question is if we have captured all possible temporal tenses and grammatical constructions that should be allowed or excluded as indicative of SEE. In intermediate codebook versions, we had four possible tense sub-codes for SEE statements: past, present, future, and gray area/ miscellaneous. As discussed above, we ultimately decided that a future explicit statement of self-efficacy is not allowed. For example, such a statement might look like, "after I graduate, I think I will feel confident to get a job." This statement describes an imagined, hypothetical future that may or may not happen wherein the person feels confident. It does not describe how the person has felt or does actually feel. There are also other complicated grammatical and temporal tenses that might not be captured by simple, continuous, perfect, and perfect continuous past, present, and future, which is why we had the gray area sub-code. These cases might be interesting to code and examine in certain situations, but we decided in the codebook to not code anything that does not clearly fall into past or present tense. Depending on one's research questions, there may be reasons to expand one's thinking about tenses that indicate a self-efficacy judgment, but for the purpose of defining a set of indicators of self-efficacy judgments as defined in the literature, we decided that only past or present indicator words should be coded.

3.5.3.4 Using Qualitative Methods to Address Racism in Studies of Self-Efficacy

We saw in the Literature Review that Usher (2018) has called for more motivation researchers to use qualitative methods as one step toward addressing and disrupting racism and white supremacy in motivation research. This paper and codebook do not explicitly do anti-racist work yet, but in creating the qualitative codebook we aimed to provide a tool that could be used in anti-deficit, equity-oriented qualitative studies of self-efficacy. Qualitative data collection focused on self-efficacy can more broadly explore students' experiences than, for example, traditional survey methods that involve closed-ended questions. Researchers have observed some differences in the ways different social identities, like gender and race, impact one's interpretation of certain self-efficacy experiences or lead to different self-efficacy judgments (e.g., Marshman, 2018; Usher and Pajares, 2006; Hutchison et al., 2006; Zeldin and Pajares, 2000; Sawtelle et al., 2012). It is also possible that a broader range of types of experiences than just the four Bandura proposed might provide sources of self-efficacy. Embedded white norms in motivation research can limit the scope of our research and findings. This codebook could be used as a tool for qualitative researchers interested in learning from a diverse set of learners about their self-efficacy and the experiences that impacted their self-efficacy, in order to develop environments to more equitably support learners' self-efficacy. We encourage researchers using the SEE codebook to take anti-deficit framing and seek ways to work toward equitable learning environments through self-efficacy research.

3.6 Conclusion

Motivational researchers are interested in understanding more about the mechanisms through which a person's self-efficacy changes. There also has been little research on potential other types of impactful experiences than Bandura's proposed four types. Qualitative research in

self-efficacy could work towards addressing these questions, through broadly exploring the experiences students discuss around statements of self-efficacy evaluations. To that end, we developed a qualitative codebook for tagging statements expressing explicit self-efficacy judgments as indicated by certain words or phrases used in specific ways. This tool can support qualitative researchers in approaching self-efficacy work with limited preconceived notions in order to learn about the experiences participants want to describe as impactful to their self-efficacy.

CHAPTER 4 NARRATIVE ANALYSIS OF A WOMAN'S EXPERIENCE TRANSFERRING REVEALS IMPACT OF SUPPORTING CHARACTERS

In collecting longitudinal, embedded case study data about some transfer students and various course environments at community colleges and universities, "Nicole" stood out as a potentially interesting case study focused on physiological state. Nicole talked about her social anxiety compounding difficulties socially integrating post-transfer and also described her emotions often throughout written reflections in a project-based course. We used the codebook described in Chapter 3 to tag Nicole's statements of self-efficacy. While coding Nicole's data, we noticed that the excerpts which we felt told an impactful story were not indicative of self-efficacy, but something adjacent. We saw her describe experiences that echoed social persuasion and vicarious learning, but she rarely talked about them in ways that clearly stated the impact on her self-efficacy. She described these experiences more as impactful to her comfort in academic settings, something related to but broader than self-efficacy.

This chapter describes narrative analysis of Nicole from which we developed a story about the impact of supporting characters for Nicole and the ways her community college better provided those supporting characters than her university. In this chapter, we then discuss lessons universities could learn from TYCs to better support transfer students like Nicole. In Chapter 6 of this dissertation, we will discuss possible reasons we broadened away from self-efficacy in Nicole's analysis and what Nicole's story tells us about the limitations of self-efficacy.

4.1 Abstract

In this paper, we use narrative analysis to examine the case study of "Nicole" (pseudonym), a student in a science, technology, engineering, and mathematics (STEM) program who transferred from a 2-year college (TYC) to a 4-year college (FYC). We draw from longitudinal qualitative data that follow Nicole's experience pre- and post-transfer, while acknowledging the impact of her

experience at the TYC. We use an anti-deficit lens by highlighting the role of supporting characters for Nicole, especially at the TYC. Narrative analysis of Nicole's experiences highlights differences in her sense of community at the two different institutions. Organizing our data in these narrative components revealed how impactful supporting characters are in Nicole's story and how drastically they can shape the outcome of scenes in her story. Instructors and programmatic staff at FYCs who aim to better support transfer students in their transition can learn from the kinds of scenes Nicole cited as helpful in her time at the TYC as well as the FYC. It is our aim in sharing Nicole's story to provide guidelines for how faculty and program directors could be impactful supporting characters to create welcoming settings for transfer students.

4.2 Introduction

Academic institutions need to improve support for students who want to transfer between schools. There is research on how to do this, but it has mostly focused on the pretransfer student experience or the transitional period without a focus on longitudinal data into the post-transfer experience. We not only need to support students to transfer but also to continue this support at their new institution. Transfer students have different needs than students who start their college careers at an institution.

Additionally, the literature calls for more research specifically focused on transfer in science, technology, engineering, and mathematics (STEM) fields. In this paper, we share the case study of Nicole (pseudonym), a transfer student from a 2-year college (TYC) to a 4-year college (FYC) who also participated in a cohort program for science students at "River College" (TYC pseudonym) and at "Lake University" (FYC pseudonym).

We will begin with an overview of background literature on TYC and transfer student experiences. Then we will describe our qualitative methods, using embedded case study and

narrative analysis. After introducing the settings and characters in Nicole's story, we share vignettes that highlight the differences in Nicole's sense of community at the TYC and FYC. We close with a discussion of the ways FYCs and TYCs can partner to support transfer students.

4.3 Literature Review and Motivation

In this section, we open with an overview and summary of transfer and definitions of various terms. Then we summarize the current state of research on transfer and point out the gaps in the existing literature. Gaps include: 1) a need for more work focusing on the experiences of women TYC students; 2) a need for more research on the experiences of TYC students in STEM through and post-transfer; 3) care on the part of TYC researchers to use an anti-deficit perspective and position our students as capable; and 4) a need for more partnerships between TYCs and FYCs in research, policy, and practice. In short, we need to better support TYC students in their academic experiences and in meeting their goals.

4.3.1 Overview of Transfer

Transfer can mean many different things in educational pathways. Most common in the literature is a discussion of vertical transfer[6], the transfer of a student from a TYC to an FYC. Oftentimes, this transfer takes place after a student earns an associate's degree or spends about 2 years at the TYC and transfers into the FYC at a "junior" level. There are, however, many other kinds of transfer pathways, including lateral, swirling, reverse, and more (Lester et al., 2013; Taylor and Jain, 2017; Wickersham, 2020). Outside the literature, institutions may consider students to be transfer students if they come in with any college credits. This definition of a transfer student could include students who gain college credit in high school (e.g., advanced placement

[6]Although these are commonly used words in the transfer literature, we encourage researchers to develop other terminology that does not inherently reinforce stigma against TYCs and TYC students by implying that transfer from a TYC to a FYC is vertically upward.

courses) or those who move from one FYC to another. Vertical transfer is often a mission of community colleges (Wang et al., 2016), and many students who start at TYCs ultimately aim to receive bachelor's degrees.

Eighty percent of first-time-in-any-college (FTIAC) students beginning at TYCs indicate a desire to earn a bachelor's degree or higher (Horn and Skomsvold, 2011), and those who successfully transfer to FYCs are equally as likely to earn a bachelor's degree as their FTIAC counterparts starting at FYCs (Jackson and Laanan, 2011; Reyes, 2011). Yet, of students in STEM programs, those who start at TYCs are less likely to earn a bachelor's degree than FTIAC students starting at FYCs (Wang, 2015). Thus, the problem would appear to lie in supporting TYC students through transfer.

Although nearly half of all postsecondary students of color were attending a community college[7] as of 2016 (Juszkiewicz, 2016), the transfer function is inequitable, in that "white students transfer at higher rates on a national scale" in the United States (Jain et al., 2016, p. 1013). Although students of color make up more than one-third of the students enrolled in TYCs, this percentage drops for students who transfer to FYCs and for students in STEM programs (Hagedorn and Lester, 2006; Wang, 2013; Wang et al., 2016; Bahr et al., 2017).

Despite the barriers to success in TYC student transfer, we want to be sure to not deficit-frame these students. Wang (2015) also found unique benefits to attending community colleges that could moderate the "penalty" of community college attendance, specifically by fostering students' "momentum" in their STEM course work. Additionally, Bahr et al. (2017) found that "[Black, Hispanic, and Native American] students who exited the curriculum without transferring were, on average, more likely to complete a community college credential than were their

[7]Note that community colleges and TYCs are essentially synonymous for the purposes of our work, and we have chosen to tend to use the term TYCs, except when citing work and using the terminology of the authors being cited.

advantaged peers" (p. 20). In short, we are not supporting TYC students in meeting their goals of transferring and receiving bachelor's degrees.

4.3.2 Transfer Student and TYC Women's Experiences

Students who start at and attend TYCs are more likely to be women, first in their family to attend college, students of color, or from low-income families as compared with their counterparts entering FYCs (Jain et al., 2011, 2016; Wickersham and Wang, 2016; Wang et al., 2017; Starobin et al., 2016; Bahr et al., 2017). More than half of women enrolled in postsecondary education are attending community colleges (Snyder and Dillow, 2015; Wickersham and Wang, 2016). Despite this making TYCs an important site for potentially increasing the participation of women in STEM, "the majority of research, in particular of women, in colleges and universities, has focused primarily on the pathway from high schools to four-year colleges and universities" (Starobin et al., 2016, p. 1040). Most research on "the gender gap in STEM education" (Marco-Bujosa et al., 2021, p. 542) documenting differences in pay and positions in STEM fields has not included TYCs.

There are also specific areas in which TYCs have not been researched as much as their FYC counterparts. The vast majority of research on the transfer process has historically been quantitative (Kozeracki, 2001; Laanan et al., 2010). Wickersham and Wang (2016, p. 1002) say: "The current literature base dealing with transfer intent and life experiences of female students beginning in STEM at community colleges is very limited." Additionally, few studies have investigated the social, institutional, and environmental contexts of STEM learning experiences for women (e.g., Starobin and Laanan, 2008; Wickersham and Wang, 2016; Shadduck, 2017; Marco-Bujosa et al., 2021). Wang et al. (2017, p. 596) add: "Despite the fairly rich body of research on active learning, empirical literature in this vein is primarily situated within the 4-year

college context, and 2-year college students and their experiences have been largely neglected." In short, more work needs to be done focusing on the experiences of women attending TYCs.

4.3.4 More Research Needs to Examine the Posttransfer Transition

While there is some research on STEM-intending TYC students broadly, this literature is quite general and does not cover the post-transfer experience or the impact of time at a TYC on the student's FYC experience (Shaw et al., 2019). Nor does the literature focus on more complex patterns of transfer, such as swirling (students who move between TYCs and FYCs) or lateral transfer (FYC to FYC or TYC to TYC), and instead generally focuses on vertical transfer. In fact, vertical transfer (from a TYC to an FYC), despite being the most commonly discussed form of transfer in the literature, is actually rare (Taylor and Jain, 2017; Lester et al., 2013; Wickersham, 2020). TYC students do not follow linear educational pathways. Wickersham (2020, p. 108) describes TYC students as "the most mobile in higher education," and Taylor and Jain (2017, p. 278) argue that one reason transfer pathways are ineffective is a "higher education system that was not designed for nor has adapted for the mobile college student."

Furthermore, the literature that does examine the transfer students' experiences at the receiving FYC generally focuses on a short period of time early in the transition to the new school, and little research follows students longitudinally (Wickersham and Wang, 2016; Jain et al., 2016; Bahr et al., 2017). Exceptions include Wickersham and Wang (2016), although their focus is on the TYC experience that leads to successful transfer. To further the research in diversifying STEM, we need more work that studies the experiences of STEM-intending TYC students through their transfer to FYC and all the way to earning a degree.

4.3.5 Research on TYCs Should Adopt More Anti-Deficit Framing

As researchers turn to the post-transfer experience, there is a tendency to focus on challenges faced by students without explicitly adopting anti-deficit framing (Laanan et al., 2010; Jain et al., 2011; Starobin et al., 2016; Urias et al., 2016). Exceptions to this discourse include Urias et al. (2016, p. 23), who state, "Rather than adding to the deficit-oriented literature and discourse on men of color, insights for this study were derived from men who successfully navigated the community college system." Similarly, Laanan et al. (2010, p. 177) aimed to "move beyond the 'transfer shock' concept" and instead focus on transfer student capital.

Historically, transfer shock (Hills, 1965) has been a very common topic of focus in much of the research on transfer students. Laanan et al. (2010, p. 177) describe transfer shock as follows: "Researchers sought to describe transfer students' academic performance as measured by grade point average (GPA) and the extent to which the GPA drops after the first or second semester of attendance at the senior institution."

Recently, some studies have focused more on logistical, physiological, and social factors impacting the transfer experience, although something akin to transfer shock remains a commonly cited difficulty for transfer students. However, students often talk more about difficulty acclimating to a big university rather than an explicit GPA decrease (Townsend and Wilson, 2006; Urias et al., 2016). Shaw et al. (2019) point out that even successful students at FYCs post-transfer are "susceptible to negative stigma of having attended community college" (p. 658). Townsend (2008, p. 77) argues that we need to consider that "transfer students are experienced college goers," despite a common stigma against transfer students and deficit framing of attending and transferring from TYCs (Jain et al., 2011; Shaw et al., 2019; Gauthier, 2020). In short, as TYC researchers, we should mindfully position our students as capable in systems that might fail.

4.3.6 Need for Partnerships between TYCs and FYCs

Traditionally, research on (and programming for) transfer students has put the responsibility of promoting transfer on the TYCs (Townsend and Wilson, 2006; Mery and Schiorring, 2011; Wang et al., 2016). More recently, there has been some acknowledgment and recognition of the role of FYCs in the transfer process. We do see examples of research focusing on the FYC role, like Urias et al. (2016) looking at the institutional responsibility of the FYC to the students who transfer there; and Jain et al. (2011) in creating a critical race theory–based set of elements for a transfer-receptive culture at an FYC. Additionally, research is clear that effective articulation agreements between TYCs and FYCs are critical to successful transfer (Starobin et al., 2016; Bahr et al., 2017; Wickersham, 2020), and strong relationships between TYCs and FYCs seem to increase transfer rates (Mery and Schiorring, 2011).

Ideally, partnerships would exist between TYCs and FYCs valuing the roles of both types of institutions. Researchers have also pointed out the need for TYCs to be included in such partnerships, not solely moving the responsibility to FYCs. Mery and Schiorring (2011, p. 33) claim that "community colleges must be involved in any effort to increase baccalaureate attainment rates." There are many models for what these partnerships might look like (e.g., Phelps and Prevost, 2012; Hirst et al., 2014; Cochran et al., 2016; DeLeone et al., 2019), but they all have in common an acknowledgment of shared responsibility in the transfer process.

While policies and practices to support transfer students are important, we also know that institutional culture is critical (Ishitani and McKitrick, 2010; Wang et al., 2017). After students transfer, social integration into the receiving institution and its culture is crucial to success, including participating in organizations, and experiencing positive student–teacher relationships and supportive classroom environments (Townsend and Wilson, 2006; Jain et al., 2011; Starobin et al., 2016; Urias et al., 2016). However, transfer students have different needs and expectations

from students native to the institution (Townsend and Wilson, 2006; Jain et al., 2011; Mery and Schiorring, 2011; Wang, 2013; Wang et al., 2017). For example, TYC and FYC students are motivated by different factors, like the applicability of learning to finding jobs (Wang et al., 2017; Wickersham, 2020). Given these different needs, the FYC student social integration efforts intended for FTIAC students may work against the integration of transfer students (Townsend and Wilson, 2006; Townsend, 2008). Similarly, Nuñez and Yoshimi (2017) found that transfer students considered their needs to be different from other students' native to their receiving institutions, "particularly with respect to the emphasis on academic engagement and goal orientation and a de-emphasis on purely social engagement" (p. 185).

Along these lines, Urias et al. (2016) found that people matter, maybe more than programs, to transfer students from TYCs to FYCs. Urias et al. (2016, p. 28) wrote, "What was made evident throughout these discussions was that the people with whom the participants connected and the relationships that were established were what made these programs special." Lopez and Jones (2017, p. 176) saw similar results, saying, "The more that students visit and approach instructors after class, discuss career plans, and ask advice about class projects at both the community college and university, the more likely they are to adjust better academically in a university." Additionally, at the TYC level, Marco-Bujosa et al. (2021) found that women and men students considered peer "social support essential to their academic success and persistence" (p. 551).

In this paper, we build on the literature by telling the story of a successful woman's (Nicole's) experience of transfer in a STEM program from a TYC to an FYC. This addresses the calls for more research to seek to understand "local needs of particular communities and students" (Banks et al., 2007, p. 25) by focusing on transfer students from TYCs in STEM programs specifically, as well as focusing on the transition from TYC to FYC and the post-transfer

experience while at the FYC. We use longitudinal data that follow her experience post-transition, while acknowledging the richness of her experience at the TYC. We use an anti-deficit lens, as we saw the literature call for, by highlighting the role of supporting characters in Nicole's story, and we discuss how ingrained partnership between the TYC and FYC would impact a student's experience.

4.4 Methods

Our goal in this paper is to share the story of one student, Nicole, as she moved from the TYC to the FYC. In the following sections, we describe our methods for collecting longitudinal data over 4 years using an embedded case study approach. We first describe our positionality and the broader work in which this study of Nicole is situated. We then describe our embedded case study data collection and then our process of narrative inquiry to synthesize the rich details of Nicole's story.

4.4.1 Researchers' Positionality

The broader project in which this case study is a part focuses on self-efficacy (Bandura, 1978), or the confidence and ease people feel regarding their ability to perform a task (Ajzen, 2002). Thus, the data collection and analysis were initially oriented toward observations on how self-efficacy might be influenced (often referred to as sources of self-efficacy). While Nicole's narrative ultimately turned away from being about self-efficacy (see Supplemental Appendices D and E for more details), the underlying design and focus of the study prompted and analyzed for statements about students' confidence in their academic abilities and the experiences that would influence those statements. Neither L.A.H.W. nor V.S. transferred from a TYC in their baccalaureate educations, and thus they committed to centering the voices of the TYC students in

their work. The data collection and analysis tools in the larger project and in this case study privilege the sharing of the firsthand experiences of the TYC students.

Additionally, L.A.H.W. is a PhD candidate in physics education research. She is a white woman who struggles with anxiety who finished her baccalaureate degree at a small school with a supportive, tight-knit physics department and struggled finding community after starting graduate school. She is interested in supporting women and students of color to succeed in STEM, particularly in terms of finding community and feeling they belong, as well as in how emotions interact with learning. The larger project in which Nicole is involved is part of her dissertation work, so L.A.H.W. was intentional about recording and eliciting students' emotional responses as they relate to the physiological state sources of self-efficacy. V.S. is also a white woman in physics, and L.A.H.W.'s PhD advisor, who has a long history of exploring self-efficacy in qualitative work (e.g., Sawtelle et al., 2012; Sawtelle and Turpen, 2016).

4.4.2 Data Collection: Embedded Case Study

The story of Nicole is part of a larger study understanding the transition of students from a supportive TYC environment to a receiving FYC and examining the self-efficacy experiences in their transitions. Across this larger study, we gathered data in the style of an embedded case study (Scholz and Tietje, 2002; Yin 2003). This means that we gathered different kinds of data and examined different levels of our research sites—data that focused on individual students and instructors and data that focused on the environments in which those participants were situated. Broadly, then, we have taken field notes in many environments, including classrooms and study group/tutor spaces, and these field notes have focused on individual students and instructors and their interactions as well as the environments in general; we have also conducted interviews with student participants, and we have gathered written journals from these student participants. For

Nicole's case, our data included more than 100 pages of field notes (focused more broadly than just on Nicole), around 3 hours of interviews with Nicole, and about 10 pages of journal entries from Nicole (See Supplemental Appendices A, B, and C for data collection materials and some direct excerpts of data).

Our focus on investigating student self-efficacy across the TYC and FYC environments influenced the data collection. For example, in L.A.H.W.'s field notes, she attended to interactions and situations that could be opportunities for self-efficacy source experiences or indicate a student's self-efficacy judgment (e.g., noting peer interactions that seemed conducive to vicarious learning experiences and student–teacher interactions that seemed conducive to social persuasion experiences). In student journal entries, the prompts were designed to elicit self-efficacy statements and self-efficacy source experiences. In interviews, the questions were largely drawn from protocols designed to elicit self-efficacy experiences (e.g., Zeldin and Pajares, 2000; Hutchison et al., 2006).

For the specific case of Nicole, the types of data from which we draw are field notes on the classroom environments of her TYC and FYC and her journal reflections and interviews with her (See Figure 1). We will call data explicitly from Nicole or focused on Nicole "primary data" and other data that may be about surroundings relevant to Nicole "secondary data." We determine secondary data to be relevant to the narrative if it relates to primary data. For example, in an interview, Nicole might describe an experience in a class about which we also have field notes, so the secondary data in the field notes would be relevant to the primary data that Nicole discusses in the interview. Alternatively, secondary data might include another student's journal entries. Thus, journal entries and field notes are used as both primary and secondary data depending on the

subject. In our analysis, we would then triangulate these data to arrive at a claim about Nicole's experience.

4.4.3 Data Analysis: Narrative Inquiry

Given the kinds of data and their rich and longitudinal nature, as well as our strong research relationship with Nicole, we used narrative inquiry, or narrative analysis, to examine the data to tell Nicole's story of academic experiences throughout the process of transferring from a TYC to an FYC. As we argued in the Literature Review, we need more qualitative research with an in-depth analysis of the multifaceted transfer student experience. Narrative analysis allows us to provide this more in-depth analysis.

We chose to focus on Nicole for the narrative analysis in large part because of our own positionality as researchers. In our interview with Nicole just after she began attending Lake University, she mentioned her social anxiety and the ways that made it difficult for her to get to know peers and faculty at Lake University and feel a sense of belonging. We had specifically been paying attention to physiological state experiences of self-efficacy (the emotions and somatic influences of experiences) because of L.A.H.W.'s positionality, and because that source of self-efficacy is less well developed and studied. Nicole's mention of social anxiety made her stand out as a candidate for a case study focused on physiological state. Using an in-progress codebook, we qualitatively coded primary data from Nicole (journal reflections from Spring 2019 and two interviews) for explicit statements of self-efficacy and descriptions of the self-efficacy source experiences. On a secondary analysis, we used a deductive process to examine physiological state experiences, coding for emotion words and descriptions of emotional and physical feelings and examining her body language in our interviews and our descriptions of her from field notes. Particularly, emotion words stood out from Nicole's journals during her River College research

methods course, so we compiled a table of those data from journal entries (see Supplemental Table 1A). Throughout the weeks of that course, Nicole described difficult challenges she and Colette (her research partner) faced in their research project but generally remained positive, which she continually attributed to the course instructors.

Ultimately, we felt that Nicole's narrative was about something broader than self-efficacy (see Supplemental Appendices D and E for more details), and we stepped back from that coding analysis and instead followed Clandinin et al.'s (2007) framework of narrative inquiry (although we will typically refer to it as narrative analysis). The framework has three "commonplaces"—temporality (or time), place, and sociality (See Supplemental Table 4A for referencing definitions). Note that sociality includes internal and external conditions and their interactions, so for a given person, sociality could include, for example, the person's mental health or estimation of personal abilities as well as the environmental factors of supportive or unsupportive peers and mentors, and the interactions between those internal and external states. According to Clandinin et al. (2007), while narrative inquiry does share characteristics with other types of qualitative inquiry, all three commonplaces must be examined for analysis to be narrative inquiry. Thus, the essential components of a narrative analysis are a story about people, places, and events that we view as "always in transition" (p. 23) through past, present, and future, as well as in personal and social conditions, and we, as narrative inquirers must examine "the impact of each place on the experience" (p. 23).

We also drew heavily from the example of Wickersham and Wang (2016) documenting the experience of women in the TYC. Wickersham and Wang used Clandinin et al.'s narrative analysis (2007, 2009) as well as Riessman's thematic analysis (2008), and additionally applied the five components of plot structure as analytic features, which are characters, setting, problem,

actions, and resolution. Drawing from Clandinin et al.'s methodology and Wickersham and Wang's example of using the methodology, we combined the use of plot structure components and the three commonplaces in our analysis. We conceptualized the components of plot structure in terms of who, what, where, when, and why/how. This helped us think about the commonplaces in simpler terms—temporality as when; place as where; and sociality as why, how, and who (supporting characters). The story and research participant of focus in our case is then who (main character) and what. We then operationalized our application of the framework in the graph shown in Figure 2, thinking of each commonplace as an axis in a three-dimensional space.

We can see the complexity of the place axis by thinking about Nicole's River College research methods course classroom as one place in which we might tell her story. Experiences in that course did not just take place in the one classroom, though. They also took place in the computer lab, the river and creek, a professor's car on the way to the riverbed to collect water for the experiment, and more. Additionally, Nicole's story takes place in many more settings than just at River College or Lake University. While we do not have firsthand data observing her in other, nonacademic settings, in interviews she has discussed her family, friends, and roommates, as well as volunteering at the zoo and participating in clubs, some of which are sites she describes as academically relevant and some which are less relevant to our focus. While we might not be able to represent these places based on a firsthand account or in as much detail as others, these types of settings can be important points on the axis of place for Nicole.

Then, a coordinate on these axes we will call a "scene," in other words, some experience from the case study's narrative. For example, one scene for Nicole might be given by the coordinate (time = a class day in Spring semester 2019, place = classroom, sociality = Nicole works with her partner on their research project with a few other students in the room and one

professor helping them use a machine for measuring pH of water). Sociality is harder to describe succinctly and to know precisely than time and place, making this graphical representation somewhat messy. The time axis is similarly complex. It consists of more points than just chronological time. For example, a coordinate on the time axis could be a day in Fall semester 2020 when Nicole is reflecting on an experience in Spring 2019 (like a flashback). This representation of narrative analysis does not result in brief three coordinate descriptions of complex scenes from a human's life, nor should it. Narrative inquiry is, by nature, the complex process of telling the story of some experiences from part of one's life. This representation of the framework as three-dimensional axes merely allows us to simplify and organize the analytic process.

4.5 Results: (Re)Creating Community After the Community College

The themes we pulled out of our analysis of Nicole's story highlighted the importance of supporting characters in her experience at River College, Lake University, and in transitioning between them. We will describe how these supporting characters include her professors, her peers and classmates, and some advisors and staff at each institution. In this Results section, we will first introduce Nicole and the settings and supporting characters from the TYC and FYC. Then we will tell several short stories from our analysis of Nicole's data that illustrate this theme. Next, we will examine all the vignettes through the lens of the central theme of the role of supporting characters, and finally, we will discuss the physical settings and how they contributed to the scenes.

4.5.1 Introducing Nicole

So, I have a lot of social anxiety. It's very hard for me to go up and talk to people.

—Nicole, Fall 2019

The main character in this story is Nicole (See Supplemental Table 2A for details on how we constructed this character introduction). Nicole is a transfer student who received her associate degree from River College, which is a TYC. Nicole is a white woman and of roughly "traditional" student age. She attended that TYC for 2 years before transferring to a large, in-state, research-intensive baccalaureate-granting institution, or an FYC, Lake University. She has since attended Lake University and intends to get her bachelor's degree before possibly continuing onto veterinary school, maybe at the same university, or searching for jobs. River College has about 10,000 students enrolled, and Lake University has about 40,000 students. The two schools are located about 50 miles apart. At Lake University, she has been double majoring in integrated biology and zoology with a concentration in zoo and science.

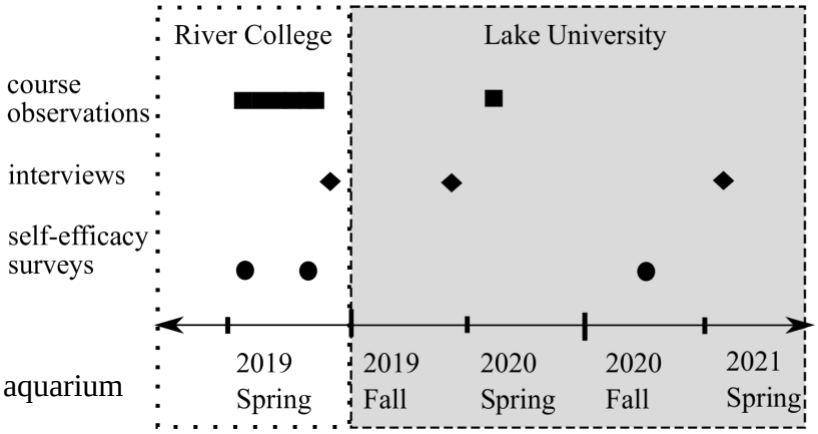


Figure 4. 1 Data collection timeline. This chronological timeline displays the types of data we collected about Nicole, starting in Spring semester 2019 at River College through Spring 2021 at Lake University.

We have interviewed Nicole three times (see Figure 1), first near the end of her time at River College (Spring 2019), second in her first year at Lake University (Fall 2019), and third in her second year at Lake University (Spring 2021). In our second interview with her, during her first year at Lake University (Fall 2019), Nicole said she has "always wanted to be a veterinarian since [she] was little." She added,

> Over at [River College] at the beginning of the [cohort] program there, we had to take a course over the summer.… [I]t had something to do with figuring out what you wanted to

do. And that solidified what I wanted to do, but it also directed me to a specific type of veterinarian. So, I found out that I really want to work with wildlife or a zoo.

For her, that means she decided to major in integrated biology, and she also said that at Lake University, she added a double major in zoology during her first semester, “since there’s a lot similar in the two.”

Nicole is a quiet young woman in her academic settings, tending to passively reside in the background of socializing scenes. A casual observer would likely notice her less than her peers, as her peers often said more or laughed more or were louder than she. She often wears comfortable clothing that many college students would wear, like gray sweatpants and black beanies, but added to the fact that she often keeps a dark-colored cold weather coat on, even indoors, her attire aids in her coming across as shy and reserved. We have interacted with her several times over the past couple years. In our interviews, as well as in the daily observations, in addition to wearing subdued clothing, she held her body in a reserved way that suggested some shyness and possibly even discomfort in some situations. There was, in fact, a marked difference between her physiognomies in each of the three different settings in which we interviewed her, indicating her varied levels of comfort in the environments. For example, Nicole held her body in slightly more closed-off ways while we interviewed her at the FYC. She hunched over more, hid behind her hair, kept her jacket

and hat on, and just seemed less comfortable in the space than she had at the TYC, where she held a more relaxed posture in her chair and kept her hair out of her face.

Our third and most recent interview with Nicole, which was during her second year at Lake University, was a virtual video call interview due to COVID-19. She was at her family's home and seemed a bit more at ease being in that setting, although of course there were many factors affecting her experience throughout that time, including the difficulties and anxieties of virtual school and COVID-19.

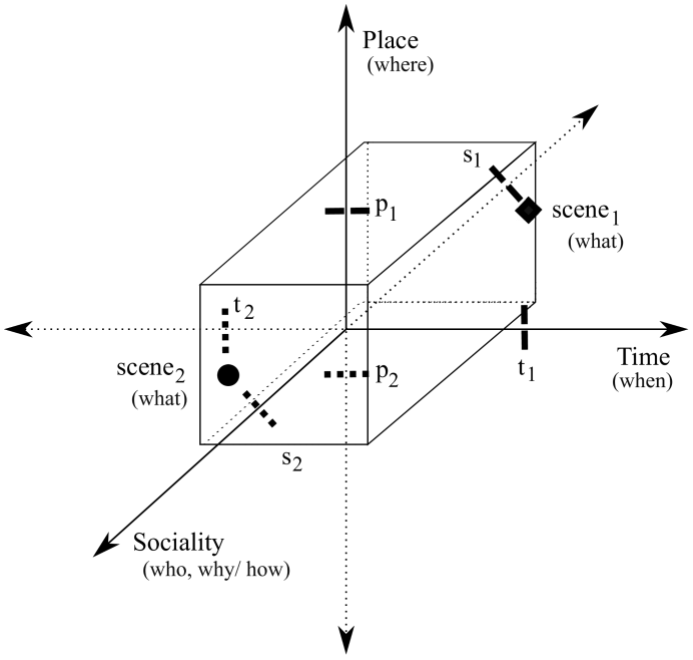


Figure 4. 2 Narrative analysis graphical representation. This three-dimensional graph depicts how we conceptualize using narrative analysis. It features each of Clandinin et al.'s (2007) commonplaces as an axis.

While we only directly observed Nicole in academic spaces, we see again and again that Nicole has strong family ties and is influenced by her family. However, we also see that she is very independent in making academic and career decisions, and she largely attributes finding information to personal internet searches. For example, when asked how she decided she wanted to be a veterinarian, Nicole simply said, "My love for animals and in high school we started dissecting things and I enjoyed being able to learn about the anatomy of different animals." She added that she "pretty much" did a Google search for jobs that would fit her interests, as well as that there were "some career quizzes that sometimes [she] had to take for classes." We can also

see that Nicole is quite driven and focused on her goals. We will continue to see this theme of a balance between helpful support structures and Nicole's own independence, resilience, and drive.

4.5.2 Data Overview

> Right now, I'm like generally comfortable with you because I've been around you so often.
>
> —Nicole, Spring 2021

As Clandinin et al. (2007) point out, "another dimension of the sociality commonplace [i]s the relationship between participant and inquirer" (p. 23). We first met Nicole while conducting a participant-observer study of a research methods course at River College. L.A.H.W. sat in on that class every week for 15 weeks. At the end of the semester, Nicole volunteered to participate in an interview with L.A.H.W. reflecting on her experiences. At the time this paper was written, Nicole was a student at Lake University in a natural science cohort program. This program requires transfer students to take a "sophomore seminar" course within their first year of enrolling in the university (See Supplemental Figure 2A for a drawing of the classroom). Nicole took the course in Spring semester of 2020. L.A.H.W. sat in to observe the class one time in that semester. L.A.H.W. had also observed the same class every week when it was offered the year before (when Nicole was not enrolled). Chatting casually with Nicole in various moments of that course felt natural and easy, despite both Nicole's and L.A.H.W.'s experiences with social anxiety. In short, over time, L.A.H.W. and Nicole developed a rapport, and we feel well prepared to share her story. The authors' relationship to these data of course colors our interpretations of the salient themes. However, we have a wealth of various data about Nicole in many different forms from which we

triangulate our arguments (Creswell and Miller, 2000) (See Supplemental Table 3A for data excerpts detailing this process).

4.5.3 Introducing Settings and Supporting Characters

> I went from [River College] where everything basically seemed more like high school and then I came here. I was like, Wow, this is so much more different. So much more difficult than the classes that I previously took.
>
> —Nicole, Fall 2019

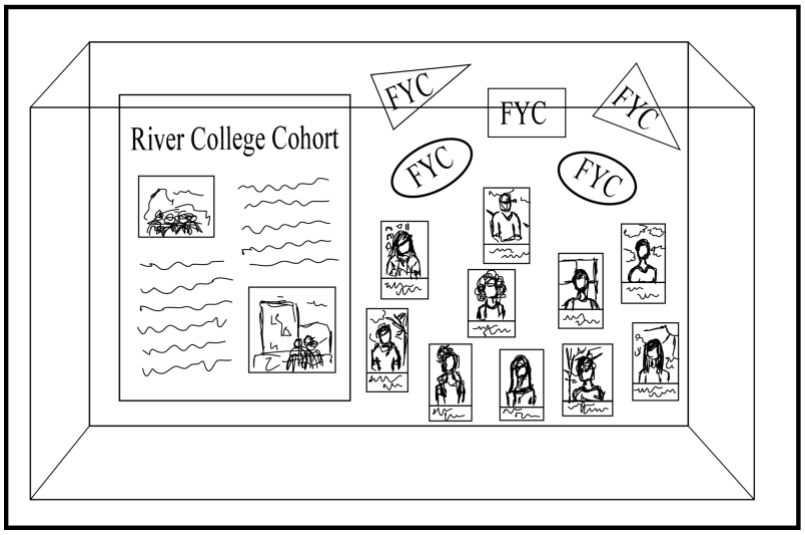


Figure 4. 3 River College Scholars cohort spotlight. In the hallway outside the River College Scholars methods classroom, there is a display highlighting the River College Scholars cohort and members. The drawings in this paper are adapted from field notes.

The narrative of Nicole's transfer experience largely exists in two temporal phases: her past experiences during her time attending River College and her present and ongoing experiences attending Lake University. We began this section with a quote from Nicole discussing her perception of the differences when she transferred from River College to Lake University. She says that, at River College, "everything … seemed more like high school." This could be interpreted from a deficit perspective to mean that TYCs might not be as rigorous as universities. However, taking an asset perspective, we could also interpret this to mean that TYCs can provide an easier transition out of high school, which is an important role.

4.5.3.1 River College and Cohort Program for Science Majors

> Everyone was excited because I was [in] the first [class of the cohort program] to graduate from [River College].
>
> —Nicole, Fall 2019

A story that stands out from River College and exemplifies much of what we know about Nicole's experience there is from her cohort's science research methods course. River College's cohort program, River College Scholars, in which Nicole participated, consists of advising and academic support, both for the students while at the TYC as well as with a focus on their intent to transfer, and supporting students in the transfer process to an FYC. Another aspect of the River College cohort program is a research methods course designed to give students research experience to both prepare them to be good candidates for transferring and to be successful in future scientific research experiences.

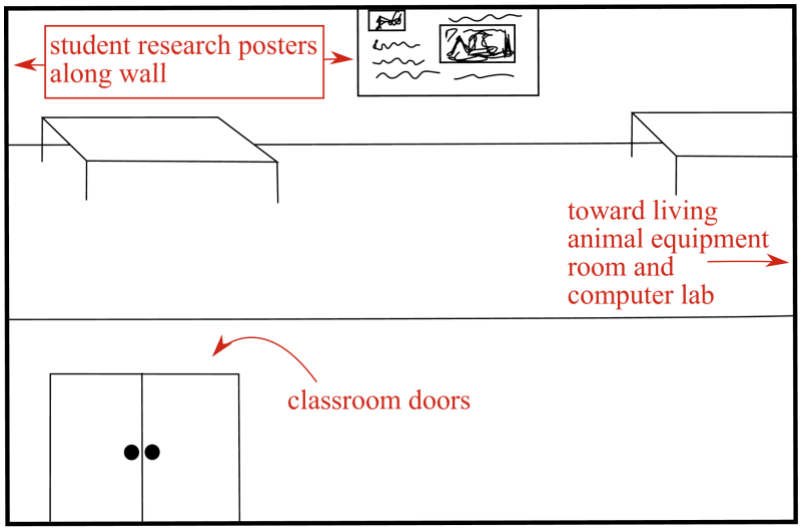


Figure 4. 4 River College hallway outside methods classroom. The hallway outside the door to the River College Scholars methods classroom was a socially generative space for Nicole and her peers.

In the hallway of the science building at River College in which the research methods course is taught, there are pictures of the cohort students in groups and individually, with their names. Surrounding those cohort pictures, there are names and paraphernalia of in-state four-year universities to which the students will likely transfer (see Figure 3). Plus, part of the River College Scholars program includes local FYCs advertising to students, introducing them to the schools, and informing them of the transfer processes. In the research methods course, some days would

include representatives from the various schools coming in to present about programs and opportunities.

The research methods course is one semester long and is offered in the Spring semester, with students meeting once a week for 2 hours. The course is small, and it is co-taught by multiple instructors. The 15 week course focused on teaching the scientific method; research skills like finding literature, writing literature reviews, and learning to use equipment; and completing a research project from hypothesis and procedure writing to a final poster. Most people in the class worked on their projects in self-selected pairs. Nicole and her partner compared fish growth in two types of water. In this course, students wrote journal entries one time each week as part of their course assignments.

The research methods course takes place in a standard small classroom with about 30 combined desk chairs facing a white board and a pull-down presentation screen with a podium off to one side. Often, the door to the classroom is locked before class time, and the students wait outside in the hallway until one of the instructors arrives and unlocks the door (See Figures 3 and 4). In the first half of the semester, the students would also sometimes head to the computer lab a few doors down the hallway. These three locations, the classroom, the hallway, and the computer lab, were the sites where students in the course most often had casual conversations among themselves (see Figures 4, 5 and 6). Except for a few of the students who seemed to be friends before and outside the course, everyone indicated in their journals that little time was spent working together outside class time.

In addition to the classroom, the hallway, and the computer lab, different research groups generally went to specific rooms in the science building to work on their projects. Once students had decided on their projects, a small room down the hallway from the classroom on the second

floor and near the computer lab was designated as the living animals room (see Figure 7). This was where Nicole and her partner Colette typically worked on their project.

As a research team, we were generally impressed with the course throughout our observations. While the instructors had ideas about improvements they would like to make to the course, they remained upbeat and positive when communicating with students. The students, in turn, remained positive and optimistic in part because of the instructors' actions, expressly attributing their confidence to the instructors' teaching, skills, and expertise. The professors worked hard to mask their personal concerns in order to remain encouraging with the students. Nicole shared in her journals from Spring 2019 how she found the instructors instrumental to her success and to maintaining positive feelings about the course, saying:

> This week, [my partner] and I talked with both [Professor 1] and [Professor 2] about our research project. We were having a difficult time coming up with a back-up idea in case we cannot work with fish. Both instructors agreed on how we can choose a certain amount of different heavy metals to test for in the water and do multiple samples throughout the river. They then went on saying that even if we do not find a heavy metal that we are looking for, then that is still a result. It was encouraging to me to hear that last part as it is easy to forget that.

Additionally, the research methods course instructors and other cohort faculty and staff made an impression on Nicole. She told us that she had not been planning on walking in her graduation ceremony from River College, as she did not consider graduation from a TYC to be a big deal, but cohort staff told her how excited they were for the first set of cohort students to graduate from the program, and it caused her to change her mind. While on the surface it might appear that attending a graduation ceremony might not be important, the encouragement that

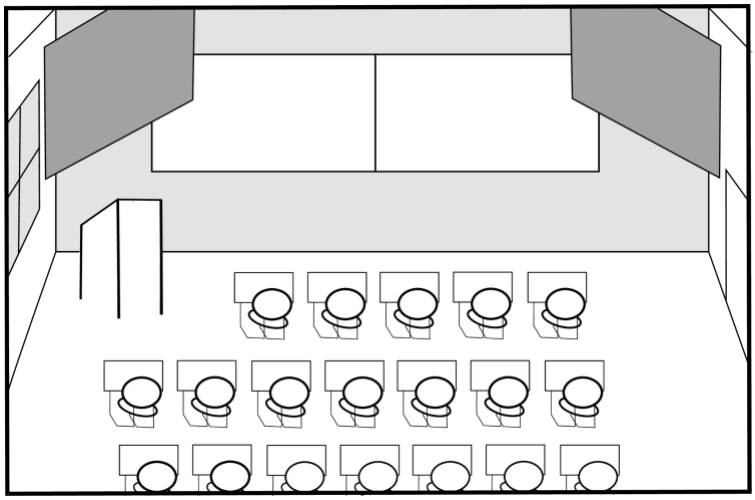


Figure 4. 5 River College methods course classroom. This drawing depicts the River College Scholars methods course classroom. Notice the small size and the personal style of desks.

Nicole received to attend communicates that graduating from the TYC is an accomplishment to be proud of. This message seems especially important when considering the stigma students face pre- and post-transfer from TYCs.

4.5.3.2 Lake University and Cohort Program FYC Counterpart

I have an older brother... He didn't really make much of a big deal of graduating. He also went to [River College], so he didn't really make a big deal about graduating there and he didn't really make a big deal with his bachelor's. So, I don't really see it as a big deal either.

—Nicole, Fall 2019

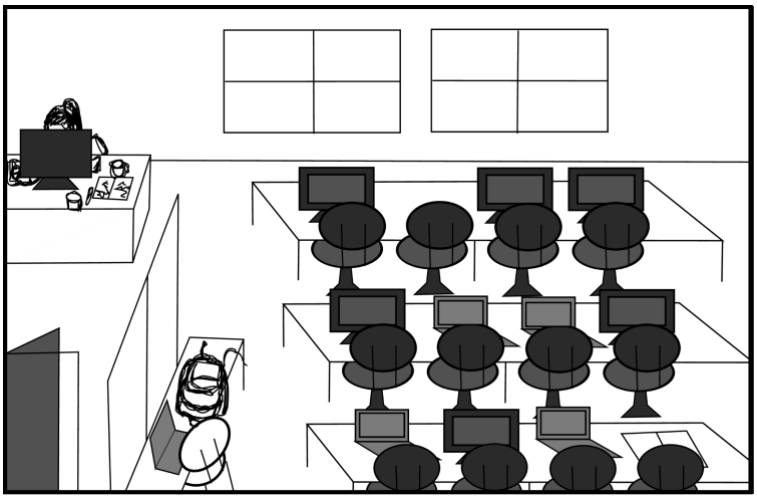


Figure 4. 6 River College computer lab. Early in the semester of the methods course, the class would sometimes travel to the computer lab to work on the initial stages of their projects (e.g., collecting articles for literature review).

Nicole said that she did not think that graduating from an FYC was a big deal, and she was also not planning on attending the graduation ceremony there. It is significant that no one at Lake University has influenced her to change her mind in the way influential faculty and staff did at River College.

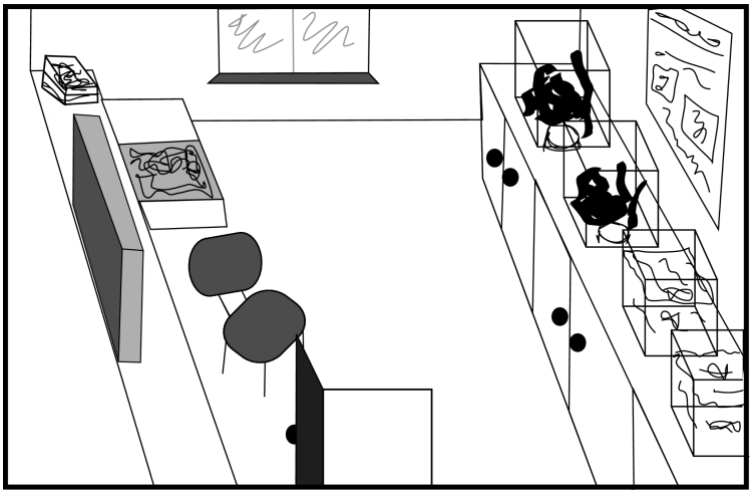


Figure 4. 7 River College living animals research equipment room. This small room seemed to have been a storage closet of some kind before being used as the equipment room for the groups of students who were conducting research projects with animals.

Similar to the River College cohort, the Lake University cohort program for transfer students is on the order of 10 students per academic year. However, Lake University's transfer student cohort is a small part of a recently expanded cohort program that has run for decades supporting first-generation college students and students of color. This program recently expanded to support transfer students and makes available all of the resources of the already existing cohort program. The transfer students have access to resources, including tutoring and homework help for various specific classes and subjects that many students in the cohort all take as part of their natural science majors; holistic advising on planning for graduation; support finding research positions, especially summer research positions; being placed in courses with other cohort students when possible; and cohort social events. There is no specific research methods course at Lake University, and there are no courses or environments that are reserved only for the transfer students in the cohort.

Analogous to the STEM research methods course at River College, another aspect of the Lake University cohort is a one-semester course for cohort students offered as a class for "freshmen" and "sophomores," and the sophomore version includes TYC transfer students (though it is not exclusive to transfer students). The course teaches professional development, study habits,

how to find research positions, information to consider for deciding on post-graduation plans, and more related skills.

4.5.4 Vignettes That Illustrate Nicole's Narrative: The Role of Supporting Characters

The overarching story we tell about Nicole is that she was surrounded by impactful supporting characters while she attended River College, and this helped her be successful at River College and in the transition to and after transferring to Lake University. However, she then faced difficulties finding supporting characters at Lake University. In this section, we describe four vignettes from Nicole's story that highlight the role supporting characters play in her transfer story. First, we tell a story from Nicole's time at River College during which she took a research methods course and completed a partner research project. We show how the supporting characters of her instructors and partner mitigate challenges in the Nicole's pretransfer story. Second, we will recount Nicole's struggle to find academic peer groups at Lake University shortly after having transferred. Third, we will narrate Nicole's difficulty getting to know her professors at Lake University. We argue that the setting and sociality of Lake University make it difficult for Nicole to form connections that would lead to supporting characters in her transition. Finally, we will share the resolution to our story of Nicole in which she has found community at Lake University after spending more time there post-transfer.

4.5.4.1 Nicole's Backstory: Partner Project Researching Fish at River College

> I just remember standing in the hall.… [I]t sounded like [Colette] also wanted to work with animals so I just asked her if she had a partner yet. I think, at the time, she was thinking about working with [another student] as well. But I asked to join the group and that's kind of how it started.
>
> —Nicole, Spring 2019

The students in River College's research methods course completed a research project with a partner in the last half of the class. In this section, we share the overview of that successful project (from Nicole's perspective), and we highlight the role Nicole's partner, Colette, and Nicole's instructors played in Nicole's narrative. In this vignette, we draw from the primary data of interview 1 and Nicole's journals from the River College research methods course. We then fill out the details of the story by triangulating with secondary data from the field notes and Colette's journal entries. (See Appendices D and E for more information on how this vignette was constructed.)

A little less than halfway into the semester, and a few weeks before spring break, the students had formed their research project groups, and Nicole had settled on a partner. They had both wanted to work with living animals, particularly fish, and they easily settled on the research project of comparing fish growth and health in two different living environments. There had been several weeks of class mostly consisting of lectures on the scientific method and so on, and partly due to inclement weather and unforeseen setbacks, the students did not begin their research projects until halfway through the semester. Thus, around spring break, Nicole and her partner planned to measure the growth of yellow perch, but before the semester ended, they would face many unexpected changes to their project.

A pivotal first step in acquiring the materials needed for their project was gathering the river water to be used in one of the fish tanks. One of the instructors took his car out to get water in buckets from the river with Nicole and her partner as well as another group who were going to use water in their project. This was outside class time, maybe after a class one Thursday. Apparently, no one had a specific spot in mind to park and make it down to the river to get water,

so they ran out of time for some reason and were pushed back again a few more days in being ready to begin the experiment.

They also needed to acquire fish for their experiment. Nicole was not there when her partner Colette went to buy the fish from the store, so she does not know how exactly this turn of events happened. Somehow, the yellow perch were not available, and Colette instead bought perch minnows. These fish are apparently just common baitfish, and there is little information available regarding these fish. Whereas Nicole and her partner were prepared with the necessary growth charts to be able to compare their fishes' growth rates to an external standard for yellow perch, there was no such information available for the baitfish they ended up having to use.

By the time Nicole and her partner did have their materials and equipment gathered and set up, there were only about 3 weeks left in the semester in which they could collect and analyze data and prepare their final presentation. Additionally, Nicole and her partner were not even able to do the data collection or analysis they had planned. They had intended to use a specific tool to test for heavy metals in the river water, which they hypothesized might impact the fishes' health. Nicole expressed to us in our interview that they had been told by the instructors that a local FYC satellite campus was going to let students in the course use a piece of equipment they had available for testing heavy metals; however, according to Nicole, they changed their mind and did not share access to the tool.

If that was not enough, Nicole's partner, who worked in a pet store and seemed quite confident in her knowledge of animals, noticed the fish developed a sickness called ich partway into their experiment. In the few weeks they actually could collect data, around half of their fish died due to ich, which was likely from the pet shop rather than anything about their experiment. Looking at all the difficulties Nicole and her partner faced in completing the research project, it is

astonishing that they were not expressing more stress or annoyance throughout the project. Nicole remained fairly calm and optimistic, as we can see throughout her journals, and this was mostly due to the influences of supporting characters—the professors and Nicole's project partner.

4.5.4.1.1 Addressing Sociality: Instructors as Influential Supporting Characters for Nicole

Throughout this difficult and potentially stressful experience, Nicole's journals and demeanor remained fairly positive. She frequently attributed her positive attitude to the instructors, as she often talked about them and their impact on her project work throughout the course. Nicole never wrote about being stressed or anxious in her journals, despite saying that she was stressed about the time frame when asked in our interview at the end of the semester. What she does talk about in the 4 weeks of journals surrounding data collection is generally positive. At one point, she says she is proud of having the fish and both tanks prepared, and she says that she would "normally be frustrated about feeling behind but she is not frustrated about anything because the professors talked about students being able to continue their research into the next semester." In her last journal, she said she was proud that they "completed their experiment and created a decently good poster," but she was "frustrated that [they] never really had a lot of time to work on their project outside of class." She wrote that she was most proud that not all of their fish died. Overall, she remained optimistic.

The instructors of the research methods course were very supportive in helping the students get what they needed for their projects, while also allowing students a lot of freedom in decisions and maintaining the students' control and agency over the projects. One of the instructors took two project groups in his car to get water from the local river for their projects. This was outside class time, and when they ran into issues finding a point at which to gather the water, they had to go back out on another day.

Nicole wrote in her journal, “I was hoping that by this Thursday we would have everything we need to finally get the fish in the tanks. Unfortunately, during our drive with [professor], we were unable to find a good place to collect the water, so I only feel a little satisfied with our progress. On Thursday, we will be going out again to try and get all of the water that we need … I feel pretty confident with our ability of getting it and preparing it for the fish.”

This experience of gathering materials outside class time with a professor and other students in a professor’s car is a temporal and spatial location that impacted Nicole’s sense of community and feeling of being supported. Obviously, the instructors put a lot of energy, time, and work into making the course successful and a positive experience. We can see evidence that such experiences helped strengthen the student–teacher relationships, as well as improve the trust Nicole has in the instructors and enhance her experiences in the course.

4.5.4.1.2 Addressing Sociality: Nicole’s Research Partner Colette Is Another Supporting Character

Nicole’s research project partner also had a big impact on her during the class. She did not know her partner before this project and found her project partner in what appears to be an almost accidental way. In our Spring 2019 interview with her, Nicole said:

> I just remember standing in the hall. …[I]t sounded like [Colette] also wanted to work with animals so I just asked her if she had a partner yet. I think, at the time, she was thinking about working with [another student] as well. But I asked to join the group and that’s kind of how it started.

Thus, sometime in the hallway waiting for the professors to open the doors and start class, Nicole easily and naturally found a successful project group. This time before class started and the place of the hallway outside the classroom were critical settings to Nicole finding the supporting character of Colette. Nicole frequently discusses that it was easier for her to find a community at

River College because of its smaller size, but this is not the only relevant factor. The space and time of casual chatting in the hallway outside the classroom before class started was essential to making River College feel smaller, and similar settings could be implemented at any institution of any size. We will address this in more detail in the section Comparing the Physical Settings. and in the Discussion. Colette seemed to be an outgoing extrovert, ready to talk to anyone around her and share her thoughts and talk about her experiences. She often talked about her love of and experience with animals, particularly that she was working in a pet shop. L.A.H.W. wrote the following in field notes early in the semester.

> Professor giving example of using aquarium for fish, need all variables about aquariums controlled, [Colette] supplying terminology like "bubbler;" very confident person, seems to have background working in aquariums or zoos or with fish.

Colette's experience also seemed to impact Nicole's perceptions of her partner, as Nicole wrote in her journal:

> As we were preparing the tanks, [Colette] showed me what to do for the tank containing the river water as she was preparing the one with the distilled water. I helped put in the filters, air pumps, and the natural hides into the tanks. I feel very good about my contribution and I am very excited to learn more about how to take care of fish and how to measure them.

Throughout the project, Nicole's partner showed Nicole how to do a lot of things and shouldered a lot of the work that directly involved the fish. Elsewhere in her journals, Nicole mentions wishing she "could help out more with the fish" but being "too afraid of hurting them." Colette helped Nicole a lot with being and feeling successful in their project.

4.5.4.1.3 Plot Resolution at River College: Supporting Characters Help Mitigate Challenges

The research methods class is an academic experience for Nicole, but we can also see that it was an experience that provided many supporting characters in Nicole's science student narrative. The sociality and place of this setting from Nicole's past were very conducive to a supportive environment. This helped Nicole have a fairly easy time getting to know her professors and her peers even as a person who deals with social anxiety. As we saw in the Literature Review, academic integration supports social integration, so the class helping Nicole feel comfortable with her professors and peers is tied to her overall sense of belonging at the institution. Thus, the temporality of her time as a community college student and the place of this cohort-based research methods course intersect with the sociality of supporting characters to support Nicole through successful transfer and in her subsequent time at Lake University. Institutions can learn from this story how to support similar students who might need additional support to find community and feel a sense of belonging.

4.5.4.2 Story Conflict: Unhelpful Assigned Groups at Lake University

After talking with Nicole at Lake University, one element that emerges about Nicole's changing narrative is the difficulty in finding supporting characters for her continued science student narrative. Nicole, in her own words, relates finding study groups of peers and classmates to a sense of belonging at a school. She also describes herself as having social anxiety, which is another factor influencing her achieving a sense of belonging. This means she faces a unique type of challenge in integrating as a transfer student into an FYC.

In our second interview with Nicole in Fall 2019 (after her first semester at Lake University), we asked her to elaborate on how she found study groups easily at River College but has struggled to find study groups at Lake University. Nicole's response was,

> I kind of feel like it was easier to find people who you get along with over at [River College] because it is a smaller school. So, it just seemed like—I don't know how to explain it. Here I find it's more difficult to find that sense of belonging and harder to find people that you get along with. That's just my personal experience so far though.… There have been some times in some of the groups that I was assigned with that I just don't really get along with the people. They don't have the same sense of—they don't really put as much effort into the project sometimes and I can't really see myself as getting in a study [group] with them when they don't seem to care as much as me [chuckles] … So, I have a lot of social anxiety. It's very hard for me to go up and talk to people.

In this excerpt, we see Nicole was satisfied with group work at her TYC, which is confirmed by our evidence of her working well with her partner on a group project at River College (see Nicole's Backstory). In contrast, Nicole is saying that she is having difficulty finding successful study groups or working well with the groups in which she has been placed at Lake University. Having assigned groups at Lake University is an interesting distinction as well, because she found her study groups at her TYC organically without the groups being assigned. For example, she described finding her research partner at River College by just overhearing her saying she was also looking for a partner and jumping in. On the other hand, Nicole's FYC instructors have placed her in some study groups, rather than letting students choose their own. It could seem like, especially at a bigger school like Lake University with courses regularly four or more times the size of those at River College, assigning study groups could mitigate issues faced by students with social anxiety. However, for Nicole, it is not working as well as her groups at River College. This is partly due to the fact, as Nicole says, that River College is smaller, and it is easier for a person with social anxiety to navigate smaller groups of people.

However, the size of the institution does not explain all of the difference, although Nicole frequently emphasizes the size as being a big factor for her. In addition to the size difference, in the excerpt shared, Nicole says that she perceives a difference in the type of person at River College and Lake University. She perceives her group partners at Lake University as not caring as much about the projects and not putting in as much work, so she thinks of herself as caring more about doing well at the FYC than her peers.

Nicole continues in this same interview to make distinctions between her perception of her peers at the TYC and FYC, saying, "I know over at [River College], since it was only two years and the classes are definitely easier there than they are here, I can see people being more difficult with themselves and putting more stress on getting a better grade."

This quote shows us that Nicole thinks that these differences between her peers are in part due to the disparate structures of the classes and maybe some of the different attitudes toward the two types of institutions. While the size of an institution is not a factor that can be easily changed, addressing those structural differences of courses and attitudes toward course work at the institutional level could ease the process of finding a sense of belonging for Nicole.

4.5.4.3 The Plot Thickens: Difficulty Getting to Know Professors at Lake University

Nicole also faces difficulties getting to know her professors, something that she struggled with less at River College. We asked Nicole about people besides her peers encouraging or discouraging her. In answer, Nicole told us,

> Not so much [at Lake University] because I haven't actually been able to talk to any of the professors, mainly because I really haven't made the time to. I couldn't find the time to. But I know over at [River College] there were some faculty who supported me in what I

wanted to do.… I keep hearing from professors a lot that it's very difficult to get into the vet program.

We asked which professors she was "hearing from," and she described hearing it was difficult to get into the vet program from some Lake University professors, even though she had just said she struggled to talk with those professors. She reflected, "There's been a couple of cases where I have [talked to FYC professors]. But not in detail on trying to get help for my classes and getting to know them a little on a more personal level."

Despite the fact that she acknowledges differences in the encouragement of her professors and the extent to which she has gotten to know them, Nicole does not say she sees this as a big issue at Lake University. We asked if she considers hearing that it is difficult to get into a veterinary program encouraging, discouraging, or neutral. She said, "Neutral statement. I know it's going to be hard to get into. I know how competitive it is. So, I don't really see it as being discouraging or encouraging. I just see it as they're stating a fact that I already know [chuckles]." Nicole went from a supportive, actively encouraging environment at River College, where she knew her professors well and was comfortable with them, to a neutral environment at Lake University, where it was difficult for her to find a sense of belonging and her social anxiety was exacerbated.

It is not surprising that Nicole seems unperturbed by what she has heard from her professors at Lake University, because throughout our interviews she tended to take the responsibility for difficulties before blaming any external factor. For example, she said she had not made the time to talk to her professors at Lake University. We as researchers would choose to interpret this a little differently from Nicole and ask what institutions could do to improve Nicole's experience. Particularly, what is different about the FYC experience that Nicole does not have the same time available to make connections with professors that she had at the TYC? Nicole's narrative shows

us that the sociality and physical places of Lake University are less conducive to forming connections with her FYC professors than the settings of River College (See the Discussion for suggestions of what an FYC might learn from the River College settings that provided Nicole with good support).

4.5.4.4 Resolution: After More Than a Year Nicole Has Found Community at Lake University

All these pieces of Nicole's story may paint a picture that she struggled after transferring to her Lake University, but she had settled in a lot more when we interviewed her in the Spring semester of her second year. She had found friends in her peers and was an officer in an academic club as well as happily working at the zoo. She also described a professor she liked and from whom she had taken multiple classes. However, most of her classes have been largely online since the start of the COVID-19 pandemic, having gone virtual around halfway through the Spring semester of her first year on campus. It had been quite difficult for many professors to maintain a student community in online classes, and Nicole's experience had been no different. She told us that, although she was comfortable with us interviewing her over a video call because she has been around us so often, she struggled a lot with her social anxiety meeting and interacting with people in virtual spaces. The elements professors have tried to implement to maintain student community, like online group chats or discussion boards, felt mandatory and not very engaging to Nicole. This is notably a similar experience to what she described earlier about assigned class groups not working well for her.

We asked her if there had been any changes to her finding community and overcoming social anxiety in the year of time she spent at Lake University. She told us,

> So, during last semester like I kind of said before, it's mainly just been like me by myself for the most part, just focusing on my homework. Of course, there's not so much with

> people [at Lake University] like community or anything but I'm lucky enough to be able to say, come home, spend some time with my family or even spend some time with my roommates or my boyfriend. But in terms of community for [Lake University] there really hasn't been much interaction.

Despite this initial discussion of not knowing many people very well at her FYC, Nicole does later in the interview say that she has found a professor whom she is getting to know. Nicole related,

> It's just been basically getting to know them through their classes more so than anything else … My professor for, I believe it was biology of birds, I got to kind of know all of the work she does … She does a lot of, like, citizen science where she goes out and does e-birding and stuff. Which I think is really cool. Actually, I think that class also kind of got me into birding as well now. And then there's been a couple classes where I've had the same professor and I believe it was, I can't think of her last name right now, I think it's [name].

We were glad to hear that Nicole had found some supporting characters at Lake University as she had at River College, particularly professors. However, Nicole does talk about this professor substantially differently than any professors at the TYC. Notice that most of the quote she discusses knowing what that professor does rather than the professor knowing about Nicole. Although Nicole says she has been "getting to know [her professors] through their classes," she goes on to only talk about what she thinks is cool about the professor's science and the hobby the professor inspired her to start. She only describes a one-directional interaction in which she admires aspects of her professor, but the professor does not necessarily know about Nicole. She has not told us about any more bidirectional interactions or even a conversation she has had with this professor,

in contrast to the casual, conversational interactions she described with River College professors. She also struggles with even remembering the professor's name, so the relationship appears less impactful than her connections with the instructors at River College.

As we saw before, Nicole continues to mainly attribute social difficulties at Lake University to the larger size compared with River College. She said, in the Spring 2021 interview,

> I would say it's definitely harder to get to know professors here compared with over at [River College] for the simple fact that [River College] is just smaller, less people in the class. You get to know professors more on like a one-to-one level and they get to know you back too [at River College]. Because I'm sure it's very difficult when they have a class of like 500 people to even remember your name, you know?

We checked with her on whether she thought the biggest reason getting to know professors was harder at Lake University was just the size of the school, and she said yes. However, she also mentioned other factors, and we stress that factors besides the size of a school that are changeable should be improved in order to more effectively support transfer students at FYCs. Nicole also mentioned a friend with whom she had gotten close, who encouraged Nicole to become a part of an academic club, in which Nicole has since become an officer. We had the following interaction with Nicole:

> One of my friends in particular … And she was, like, the president of the [animal science club], oh my goodness, and she actually helped me get the, well helped kind of, like, pushed me a little bit, but in a good way, to get the secretary position for the club.

Again, it is great that Nicole has become socially involved with Lake University clubs and has made friends associated with the club and her academic interests. It took a while in the interview to get Nicole talking about those experiences and people, though, so it seems that

negative feelings and lack of connections are more present in her mind when talking about her Lake University experiences.

4.5.5 Theme of Salient Impact of Supporting Characters

> I haven't actually been able to talk to any of the professors, mainly because I really haven't made the time to. I couldn't find the time to. But I know over at [River College] there were some faculty who supported me in what I wanted to do and the same with my family and friends.
>
> —Nicole, Fall 2019

Nicole and her research partner faced a number of challenges in completing their project in the River College research methods class, but the story we developed from Nicole's data shows that the supporting characters of her peers and her instructors made it an overall positive experience. Comparing this with Nicole's experience at Lake University, we see that it took more than a year for Nicole to start identifying supporting characters. Furthermore, there were substantial differences in the way she talked about them at the two different institutions, contributing to her feeling a lower sense of belonging at the FYC.

We can see throughout Nicole's interviews, journals, and surveys that the research methods course and cohort program at River College were very impactful to her. We have frequently seen Nicole contrast the difficulty of getting to know her peers and professors at Lake University to the ease of getting to know people at River College. Specifically, in our second interview with Nicole, she talked about not having planned to walk in graduation from River College. She said this was because her brother had also graduated from River College and had not made a big deal out of graduation. However, she did walk in graduation because faculty and administrators of the River

College Scholars program told her how excited they were for her cohort, the first cohort of the program, to be graduating.

Important supporting characters in this experience include the three professors, her research partner, and her other classmates. Nicole describes working most closely with two of the professors, because they "were looking at more animal biology and some chemistry." Nicole also knew those two professors before the course, and although she had not met the third before, she had him for another class simultaneously with the research methods course. While at River College, she says,

> I knew [Professor 1]. I had him in my very first biology class in my first year here. He probably doesn't remember me [chuckles]. So, I had him and then I think that was a semester before I had [Professor 2] for my chemistry lab. At the time, I was taking Organic 1, which he was also my professor for that as well. I had never actually met [Professor 3] before that class.… It was very helpful to also get to know [Professor 3] even more because that was my first time meeting him and I had him for that class, and another class at the same time. Now I have him again.

On the other hand, Nicole described difficulty finding peer groups and community at Lake University. We see a marked difference between how Nicole talks about those professors at River College from how she talks about a professor at Lake University whom she considers she has gotten to know after a year and a half at the FYC. She struggles to remember that professor's name and talks much more one-sidedly about knowing what that professor does rather than the professor knowing Nicole well or having a connection with Nicole. Other than that specific professor, Nicole told us that she has not "been able to talk to any of [her] professors," and she attributes this to not having "made the time" or found the time. At Lake University, Nicole seems to think it is her

responsibility alone to get to know her professors, whereas her River College professors made the space to get to know their students.

4.5.6 Comparing the Physical Settings

In this section, we narrow in to focus on Clandinin et al.'s (2007; 2009) narrative inquiry element of place. Looking at the sketches of the environments above in the section Settings and Characters and throughout the vignettes in the Results section, we see differences in the physical setups of River College and Lake University. Nicole talks a lot about the size difference between the two institutions, but along with a size difference comes a difference in the physical environments that might exacerbate the feeling that a school is significantly larger. Notice that the classroom and the computer lab at the TYC are small (Figures 5 and 6). There were about 40 combined desk chairs in the classroom and about 25 chairs in the computer lab, most of which were at computers, but some of which were at empty spaces at the tables where students could work on their personal laptops. When the methods class and instructors went to the computer lab, the students would take up about two of the four rows of tables in the room (See Figure 7 and Supplemental Figure 1A for more classroom settings at River College).

In the classroom, there was an overhead projector for using transparencies on the podium or table in the front of the classroom. Because this was something L.A.H.W. had not seen since high school, it added to the feeling that River College felt more like a high school than many FYCs. This was also due to the smaller size of River College in terms of number of students, as well as the size of buildings, and the close, inexpensive, and pay-per-use (rather than prepaid or reserved) parking near the campus buildings. The space outside the classroom was a small hallway with some benches scattered throughout and some posters on the walls. The hallway was never very full or packed with people; even at its fullest, there was plenty of walking space.

On the other hand, a typical lecture hall at Lake University has on the order of 100 or more seats and they are either the kind of chairs with a tiny desk that can be pulled up from the side or just several long tables with about 10 to 20 chairs at each table (see Figure 8). The spaces outside these classrooms are much bigger than at River College, but also generally more packed with people (see Figure 9). When classes have just let out or students are waiting in line at a vending machine or convenience market or students are waiting to be let into class to take an exam or get their exam grades back, hallways can be packed, with little room to move.

While it was hard to not sit in the front two rows in the classroom of Nicole's STEM research methods course at River College, it is very difficult to sit in the front two rows in a classroom at Lake University. Additionally, although it is an unchangeable aspect of a large university, parking and buildings are farther from each other, making it take longer for students to get to different places on campus and making the FYC campus much more intimidating to new transfer students from smaller TYCs.

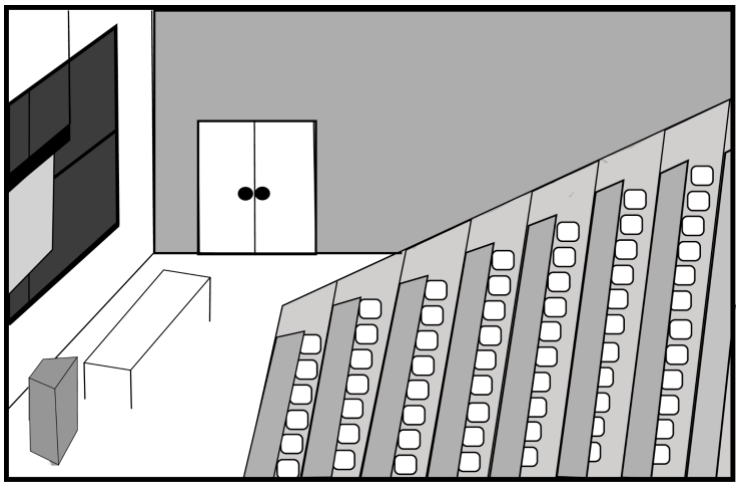


Figure 4. 8 Lake University lecture hall. This drawing depicts an example of a lecture hall at Lake University. Notice the large size and the shared desk style.

4.6 Discussion

4.6.1 Discussion and Implications

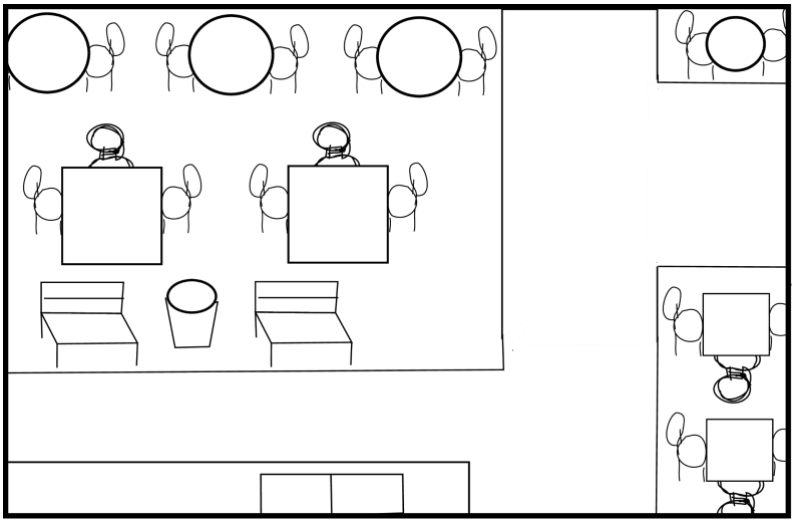


Figure 4. 9 Lake University hallway outside the lecture hall. This drawing depicts an example of a hallway outside a lecture hall at Lake University. Although the hallway is bigger than the hallway at River College, it would also typically be much more crowded.

In the Literature Review, we highlighted that, rather than position TYC students as struggling in the transfer process, we should work to use anti-deficit framing that interrogates how capable students might fail within our academic systems. This is important in general, and especially when discussing a woman's experience in STEM, where women are historically underrepresented; discussing that woman's social anxiety and physiological experiences; and discussing vertical transfer and TYC experiences, which can be stigmatized or overlooked in research. Narrative analysis aligned well with this anti-deficit framing, providing a lens to examine the settings (through the three commonplaces) that supported or hindered Nicole. Throughout the paper, we have described challenges Nicole faced in terms of institutional responsibility. We have also focused on the importance of supporting characters in Nicole's story and highlighted Nicole's strengths and positive experiences. We particularly narrate Nicole's story as involving many positive experiences and environments while at River College. In this section, we discuss what a school like Lake University could learn from River College to better welcome transfer students like Nicole.

4.6.1.1 Institutional Responsibility: Place and Sociality's Role in Creating Supporting Characters

In this section, we continue to focus on institutional responsibility and aim to suggest ways institutions might address the types of challenges we saw Nicole face and implement the types of

support systems that helped Nicole. From Nicole, we learn that she feels less of a sense of belonging at Lake University than she did at River College, which she again and again attributes to the overwhelmingly larger size of the FYC. However, the size of an institution is a factor we cannot change, so we will discuss what could be changed at FYCs to ease the transition for Nicole and other TYC students. Nicole describes more difficulty in getting to know her peers and finding study groups at Lake University than at River College. Nicole attributes this difficulty as being due to both the larger size of Lake University and the difficulty finding the time to get to know many of her professors. Yet we know that Nicole got to know many professors at River College well, which we see in the research methods course, even though she spent little time interacting with them each week. Therefore, we argue that, even though Nicole assumes the responsibility for getting to know her professors at Lake University, this is not solely her responsibility, and the physical place settings and sociality of the environments have a big impact on students' chances to feel comfortable with their professors. Nicole gives us some clues in this direction—at River College she described feeling more comfortable with those instructors from whom she took multiple classes. Similarly, she describes getting to know an instructor at Lake University whom she has had for multiple classes, although she still seems to be less close with that professor than those at River College.

The literature supports Nicole's experiences suggesting that when faculty are more approachable, transfer students are more successful (Laanan, 2007) and that social integration into the university is led by academic integration (Braxton et al., 2000; Deil-Amen, 2011). As Townsend and Wilson (2006) found that FYC social integration efforts may support FTIAC students native to the institution more than transfer students and may be opposed to efforts necessary to integrate transfer students, it is important to consider what can be done differently.

We should note here that, while Lake University is larger, it is also true that Lake University has bigger classes, which would make it harder for professors to get to know their students. Additionally, the River College methods class instructors put in a large amount of work to support and encourage their students. Still, we ask how FYC faculty might support academic and social integration for transfer students.

4.6.1.2 Specialized Programs Are a Site for Supporting Characters

As we see in Nicole's story and in the literature (Urias et al., 2016; Nunez and Yoshimi, 2017; Marco-Bujosa et al., 2021), people, more than programs, are impactful to students' experiences. Yet specialized programs like clubs with academic and recreational focuses can help get students connected to the right people and involved in smaller groups of peers, where it may be easier for them to find friends and feel they belong at the school. Although the size of an institution is an immutable trait, there are ways the physical settings of a larger school can be altered to make the school feel smaller and more personal. Among these possibilities are more teachers assigned to a course, such that large lecture courses could be split up into smaller groups (as in learning assistant classrooms; e.g., Otero et al., 2010), and more active-learning setups with students sitting at smaller tables more conducive to discussion and group work rather than large lecture halls with fixed seating (Braxton et al., 2000; Wang et al., 2017). There are other ways that large FYCs could be even more creative with making spaces and opportunities for students to feel they are part of smaller communities and areas. Perhaps classrooms could be open for student use when they are not actively being used for teaching a class (e.g., see the "Physics Learning Center" in Sawtelle et al., 2012). This informal access could provide more spaces for students to hang out and work together that would supplement the non-classroom areas in buildings on campus that get very full between class periods (see Figure 9 as compared with Figure 4).

Being a part of a smaller cohort program might also help, providing smaller spaces and smaller groups of students. We saw the River College Scholars program provided Nicole with influential experiences to build relationships. For example, we saw Nicole change her mind about the experience of walking in graduation and celebrating that accomplishment because of the impact of cohort administrators. Cohort programs like this, and at larger FYCs or other institutions, could help the setting feel smaller by putting students into smaller groups in which it could be easier to get to know their peers as well as the administrators and faculty associated with the cohort. Such programs would typically group students with some shared trait or interest. Nicole is in a cohort program at Lake University for transfer students from TYCs, and such programs can help with something as simple as making the number of transfer students in a program more visible to other transfer students.

4.6.1.3 Sociality Can Provide Opportunities to Get to Know Peers

We have seen in our discussions with students (Wood et al., 2019) and we see in the literature (e.g., Townsend and Wilson, 2006; Deil-Amen, 2011; Lester et al., 2013) that transfer students upon entering the receiving institution can feel that their peers all already know one another and are already set in their social groups. Sometimes, just making the transfer students at the institution visible to each other could improve their experience (Laanan et al., 2010). To this end, an orientation for new transfer students at the receiving institution could also help. Related to the differences in size between the institutions, Nicole also faced issues with assigned groups in classes at Lake University. She found that these did not work, and she did not think she had an easy time finding her own peer groups and study groups. So Nicole and presumably other transfer students might benefit from support in both assigned groups and/or finding their own community from which to choose their own groups. This could also be aided by higher numbers of teachers

allowing for early implementation of smaller groups of students led and taught by a teacher (on the order of 20–50 students rather than hundreds). Then students could get to know some of their peers more easily and closely and could choose their own groups going forward, which might work better than assigned groups.

4.6.2 Limitations and Future Work

In this paper, we begin to address the idea of supporting characters' effect on a student's academic and scientific self-efficacy. This unique approach to self-efficacy using narrative inquiry aligns well with vicarious learning and social persuasion types of contributing experiences for self-efficacy, as we know that other people are impactful to a person's self-efficacy judgments. Still, work remains to research the nuances of supporting characters' influence, looking specifically at questions of what types of people and relationships lead to the biggest impacts, and how to foster such impactful relationships for transfer students.

In future studies, we would ask more specific questions to pull out additional factors besides size to know exactly what to improve at FYCs for transfer students from TYCs. This would allow more design of research and interventions to work on factors that are changeable. While the ideas presented in this Discussion address the feelings of a difference in size that Nicole expressed, they do not explicitly target the sense of belonging Nicole wished for and said she was missing at Lake University. There is a need for more research into this experience, as well as more ideas for how to make transfer students feel a greater sense of belonging and find more community at receiving institutions.

Additionally, while we share here the story of just one student, this experience is representative of those from many students with whom we have spoken. There is more work to be

done to continue to share and explore the experiences of transfer students at TYCs and FYCs, but this qualitative narrative analysis of Nicole's story opens the door to many new questions.

4.7 Conclusion

We used narrative inquiry to explore and tell Nicole's story of her experiences through and after a TYC to FYC transfer process. From this story, it is evident that Nicole found it a little harder to socially integrate into the FYC, which she generally attributed to the size, but other aspects could be altered to help Nicole and other students find community at their receiving institutions.

Our work contributes to the body of literature calling for more work with women STEM students at TYCs and following their stories after transfer. We specifically shared a qualitative case study following a student longitudinally before, during, and after her transfer from a TYC to an FYC. We strove to share this student's story using anti-deficit framing, calling attention to the institutional changes that should be made to better support Nicole's transition and the transition for other students like her.

4.8 Acknowledgements

We are deeply grateful to the student participants in this work, particularly Nicole, who generously shared such a rich story of her life with us. We also acknowledge our support from the ANSER and S-STEM research team as well as the entire PERL at Michigan State University. Additionally, without the editing support of Carissa Myers and Bryan Stanley, as well as their openness to discuss ideas and help the authors navigate writing obstacles, this paper would not have been completed. This work was supported by NSF award number DUE 1742381.

CHAPTER 5 LESSONS LEARNED FROM AN EMBEDDED RESEARCH COURSE AT A COMMUNITY COLLEGE

Broadening back out from a case study focused on Nicole to focus on the types of environments that supported her, this chapter discusses an impactful course at a community college. We describe ways the project-based, research methods course provided opportunities for student self-efficacy experiences. The course research projects were highly student-driven, contributing to high student project ownership. Coupled with supportive instructors, we saw student outcomes of the course include increased research self-efficacy and tolerance for obstacles. This chapter shares design considerations learned from the observation and analysis of this course for practitioners aiming to create a similar course environment.

5.1 Abstract

This paper is a collaboration between faculty at Mott Community College (Mott) in Flint, Michigan, and our research team at a four-year college (FYC). In this paper, we discuss the project-based course STEM-199, offered in the winter semester for students in their first or later years at Mott. In this paper, we discuss lessons learned from this embedded undergraduate research experience at the community college, and we compare themes to the literature on course-based undergraduate research experiences or CUREs (Lopatto, 2010; Dolan, 2017; Cooper et al., 2017). Using emergent coding—and being informed by our observations, field notes, and interviews—we identified themes in the students' weekly journal reflections. The main theme we found was that students often described support from the instructors as helping them feel more resilient in the face of research difficulties when given significant ownership over their projects. The lessons learned from this course provide guidelines for how teachers, particularly in TYCs, can facilitate research experiences for students who are early in their college careers. In this paper, we contribute qualitative evidence supporting Corwin et al.'s (2015) model on the impact of CUREs, as well as

adding research at the TYC setting. We also build out the model by proposing direct links between project ownership and self-efficacy.

5.2 Introduction

In this paper, we share lessons for practitioners, teachers, and course designers, learned from instructors and researchers of a course at Mott Community College (Mott) called Undergraduate Research Methods, or STEM-199. STEM-199 is designed to give students first-hand experience of designing and conducting their own research project. The course was offered to students from a cohort program for STEM students intending to transfer from the two-year college (TYC) to a four-year college. We approached the analysis of this course with the goal of identifying the key elements for implementing a similar supportive embedded research experience, particularly at other TYCs. Our goal is to describe some of the benefits students reaped from this course, to share ideas for implementation, and suggest changes that would need to be made to create a course like this at other institutions. See Figure 5.1 for the structure of this paper.

In this study, we use qualitative ethnographic methods to flesh out the elements of a CURE-like course at a TYC. Many studies of CUREs use quantitative survey methods (Gin et al., 2018; Lopatto, 2010; Hanauer and Dolan, 2014), and most research on CUREs has focused on student outcomes, that have been largely self-reported, rather than the causal mechanisms of what specific features of CUREs impact student outcomes (Auchincloss et al., 2014; Corwin et al., 2018; Dolan, 2017; Rodenbusch et al., 2016). Also, as we have seen above, CUREs and research experiences for undergraduates are limited at TYCs. As Hewlett states, “Any national effort to increase the number and diversity of science, technology, engineering, and mathematics (STEM) graduates must include our nation’s community colleges” (2018, p. 1). This work contributes to that goal.

In this paper we will present the analysis from a course – STEM-199 – that we argue is CURE-*like*. The STEM-199 course does involve all students in addressing a research topic of relevance to the community, which is one of the criteria of a CURE. However, it allows for greater variation in student project topics and more student project ownership than most CUREs in the literature. Whereas many CUREs involve all students in working on parts of a single specific research question, the STEM-199 instructors constrained the general area of study for students but allowed them a lot of control and agency over their specific projects. Thus, we argue STEM-199 is a CURE-like course that is more student-driven and high-challenge than many traditional CUREs.

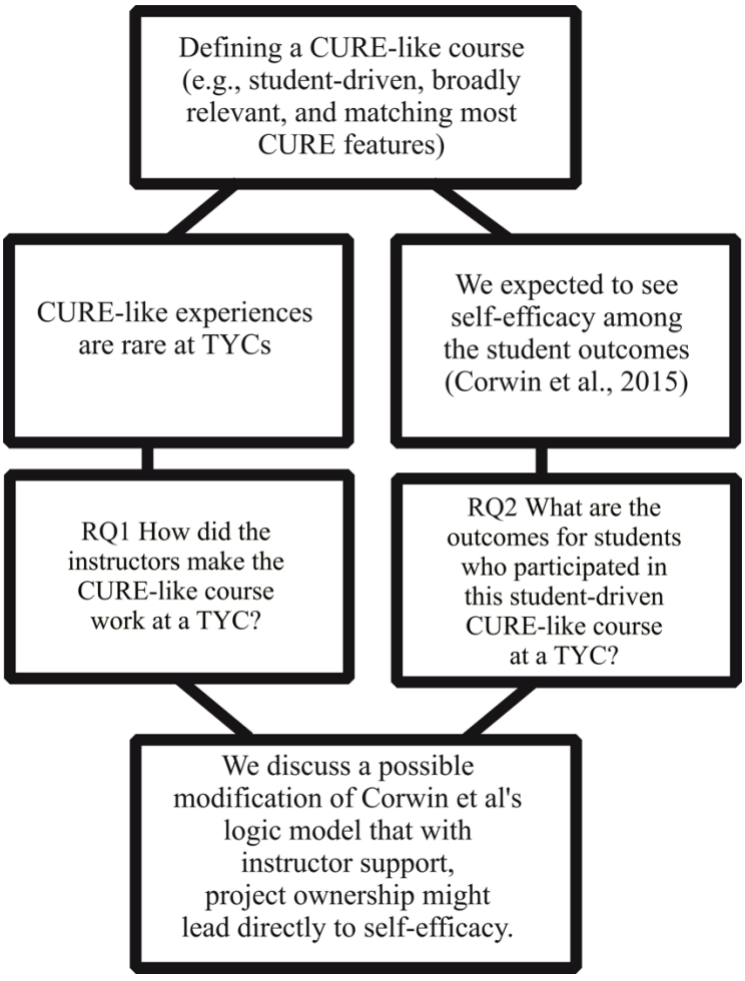


Figure 5. 1 Diagram situating this paper in literature and overviewing the structure of the paper

5.3 Literature Review

Undergraduate research experiences have been a part of higher education's science curricula for decades. They have been garnering more attention since they have been identified as having significant benefit on student retention and persistence in STEM (Lopatto, 2004; Seymour et al., 2004; Rodenbusch et al., 2016; Morton, 2021; Bangera and Brownell, 2014). Researchers have shown that undergraduate research experiences can have a positive impact on diversity

in STEM fields, with a higher percentage of minoritized students who have participated in undergraduate research continuing to pursue further education and careers in STEM (Bangera and Brownell, 2014; Eagen et al., 2013; Rodenbusch et al., 2016). The National Research Council (NRC) said, "All students should be encouraged to pursue independent research as early as is practical in their education. They should be able to receive academic credit for independent research done in collaboration with faculty or with off-campus researchers" (2003). One effort to increase research opportunities for students who may not see themselves as future researchers are Course-based Undergraduate Research Experiences, or CUREs (e.g., Auchincloss et al., 2014; Corwin et al., 2018; Lopatto, 2017). CUREs are classroom-based experiences that involve all students enrolled in the course in addressing a research question.

5.3.1 Defining CUREs

At the heart of a CURE is the goal of addressing a research question or problem that is relevant to the broader scientific community (Auchincloss et al., 2014; Cooper et al., 2017). In this paper we lean on the definition of CUREs from Corwin et al. (2015) since their definition is intentionally broad – they define a CURE as, "a course in which students are expected to engage in science research with the aim of producing results that are of interest to a scientific community" (p. 3). Common activities across CUREs include reading scientific literature, designing methods, collaborating with peers, presenting scientific results, and developing a sense of ownership (Corwin et al., 2015; Corwin et al., 2018; CUREnet, 2022; Majka et al., 2021).

CUREs offered early in students' undergraduate trajectories can be highly influential to students' academic and career paths. These classroom research experiences provide more opportunities than traditional lab courses for students to make "discoveries that are relevant to the broader scientific community and to engage in iterative work" (Corwin et al., 2018, p. 2). Key

components of CUREs include “opportunities for collaboration, discovery and relevance, and iteration" (Majka et al., 2021, p. 3). Students who participate in CUREs see similar positive outcomes as students who participate in apprenticeship style undergraduate research experiences (UREs) (e.g., Harrison et al., 2011; Jordan et al., 2014; Corwin et al., 2018; Rodenbusch et al., 2016; Corwin et al., 2015). Given this, we treat the expected outcomes documented in the literature as similar between the two types of research experiences, although UREs and CUREs are implemented in different contexts and have different affordances and limitations for students and instructors.

5.3.1.1 CUREs are Rare at TYCs

While one of the early implementations of a CURE was at a community college (Bangera and Brownell, 2014), the literature is sparse on documented efforts to implement undergraduate research at TYCs. Hewlett (2009) proposes that this shortage is due to a few key constraints. First Hewlett suggests that faculty members have much higher teaching loads at TYCs than many of their university counterparts. Thus, they have difficulty making time for student research activities, especially if they do not get any credit from administration for this additional work. Furthermore, community college labs are often more underfunded, lacking the resources of four-year institutions. Finally, the research programs that do exist are often maintained by specific partnerships between faculty members and suffer from not being incorporated at the institutional level. If those specific faculty leave, most of those programs would fall apart.

Thus, research experiences are rare for TYC and community college students (Hewlett, 2018). Particularly at TYCs, but also in general, CUREs can be more attainable than apprenticeship-style undergraduate research experiences (UREs) in that they serve multiple students in a class at once rather than a limited number of students able to work directly with a

single professor on active research projects (Lopatto et al., 2014; Shortlidge, Bangera, and Brownell, 2015; Rodenbusch et al., 2016; Wei and Woodin, 2011; PCAST, 2012; Auchincloss et al., 2014). Yet, CUREs are still much less common at TYCs than at FYCs (Cejda and Hensel, 2009, Goedhart and McLaughlin, 2015, Genné-Bacon et al., 2020). There are many calls to expand the development of CUREs at a larger range of institutions (Linn et al., 2015; Spell et al., 2014; Bangera and Brownell, 2014; Carrese, 2015). However, there are still few studies on implementation of CUREs at TYCs and community colleges.

5.3.1.2 CUREs are Often More Instructor-Driven than Student-Driven

We see a spectrum in the literature about CUREs from courses which are more structured and guided by instructors to less structured and more driven by students themselves (Cejda, 2009; Hewlett, 2009; Owens and Murkowski, 2009; Perez, 2003; Corwin et al. 2015). Many CUREs discussed in literature are on the more instructor-driven end of the spectrum. The courses involve projects that were predetermined and decided by the instructors with almost everything pre-planned except the data collection and write-up of the final results. Corwin et al. (2015) state,

> "[S]tudents generally do not perform more central tasks that determine the overall direction and scope of research. …[I]n many CUREs, instructors do the central work of posing overarching research questions, which helps steer students in scientifically fruitful directions. Students then do the very real (legitimate) but more peripheral work of collecting and analyzing data to answer those questions" (p. 2).

CUREs typically involve all students in the course in working to answer a research question of relevance to the broader community (Genné-Bacon et al., 2020; Gin et al., 2018; Auchincloss et al., 2014; Wei and Woodin, 2011; Bangera and Brownell, 2014). The examples of CUREs discussed in the literature typically mean that all students are doing a piece of the research to

answer a single research question as a class. For example, Genné-Bacon et al. (2020), describe the following: “students working in groups to analyze soil samples and check one another’s work” in order to answer the research question of what “factors might be correlated with prevalence of antibiotic resistant organisms in soil samples” (p. 4). Gin et al. (2018) discuss how instructors commonly may select or be tempted to select projects for students “of technical simplicity with higher probability of student progress” or “troubleshoot anticipated issues …independent of students …to help students progress towards a research goal” (p. 2). However, they found that even in a “high-challenge” (and more student-driven) course offering in which instructors did not do those things, students still left the course with many of the common positive CURE outcomes.

Table 5. 1 Student outcome categories by Lopatto (2004) and Corwin et al. (2015) showing overlap in classifications

Lopatto (2004)	**Corwin et al. (2015)**
Self-confidence	Probable: self-efficacy
Becoming part of the learning community	Probable: external validation Possible: sense of belonging Possible: interaction with peers Possible: science identity
Understanding of the research process Understanding how scientists work on real problems Understanding how knowledge is constructed Understanding science Understanding how scientists think Assertions require supporting evidence	Probable: content knowledge Probable: technical skills Possible: science identity Proposed: understanding nature of science
Learning lab techniques Learning to work independently Skill in the interpretation of results Ability to analyze data Ability to integrate theory and practice Understanding primary literature Learning ethical conduct	Probable: content knowledge Probable: technical skills
Skill in oral presentation Skill in science writing	Possible: communication skills
Clarification of a career path	Probable: career clarification
Readiness for more demanding research	Probable: persistence in science
Tolerance for obstacles	Probable: persistence in science Possible: tolerance for obstacles

5.3.2 Student Outcomes of Undergraduate Research and CUREs

To research and evaluate the benefits of undergraduate research programs, such as CUREs, Lopatto (2004) conducted studies to measure "gains" that students received from participating in research at various types of institutions–ranging from TYCs to FYCs. Lopatto categorized these gains into twenty types (see Table 5.1). Lopatto showed that the gains for students at community colleges were equal to those of their university counterparts across all genders and racial groups studied (2004). While Lopatto's work on assessing CUREs is beneficial for understanding the impact on students, these measured outcomes did not describe alignment between the design of the CURE and the targeted outcome.

In Corwin et al.'s (2015) review of literature on CUREs they emphasize the importance of aligning a program model with the targeted outcomes. This meta-analysis references many outcomes from the literature and categorizes them as probable, possible, or proposed (see Table 1). Corwin et al. identify increased self-efficacy as a likely outcome of a CURE model that emphasizes selecting and identifying data collection methods, analyzing results, and reading and evaluating current scientific literature. The paper also identifies increased tolerance for obstacles, project ownership, and other similar gains also found by Lopatto, as likely outcomes of CUREs involving these activities.

Corwin et al. (2015) go on to examine the link between specific activities involved in CUREs and their probable and possible student outcomes. Their model suggests that activities like reading and evaluating current science literature and analyzing results and collecting novel data can ultimately lead to increased self-efficacy. Working collaboratively with peers and presenting work outside of class will likely also lead to increased tolerance for obstacles. Additionally, collecting novel data and designing data collection methods can lead to project ownership, increased tolerance for obstacles, and increased self-efficacy. Specifically, increased self-efficacy

and a tolerance for obstacles is linked to an increased project ownership and mediated by motivation. Corwin et al. (2015) state,

> "This model depicts how students develop a sense of project ownership when they have agency to design their own studies, choose experimental methods, and collect data of interest to them or their community. A growing sense of ownership increases students' tolerance for obstacles and perseverance, motivating them to complete their projects even in the face of challenges" (p. 6).

Corwin et al. (2018) later "found that collaboration positively predicted both cognitive and emotional ownership, discovery positively predicted cognitive but not emotional ownership, and iteration positively predicted both cognitive and emotional ownership" (p. 4).

Regarding student tolerance for obstacles, Gin et al. (2018) ask what the experiences are for "students who encounter high instances of scientific obstacles and ultimately do not achieve instructor-defined research goals, i.e., fail to make relevant discoveries within a CURE" (p. 2). This is a unique CURE experience not often discussed in the literature. They compared two course offerings, one "high-challenge" and one "low-challenge" (2018, p. 3). In the high-challenge offering, they said that "the instructors' philosophy regarding course challenges stems from their desire to allow students to experience science as an iterative process that involves failure" (2018, p. 3). They also stated, "The instructors repeatedly give their students permission and encouragement to direct their own work" (2018, p.3). The types of research challenges that students faced (in both courses, with more reported in the high-challenge offering) included their research projects being slow and taking a long time, difficulty getting results, and other logistical, academic, and social challenges. Even with facing these challenges, student outcomes from the

course included an ability to navigate scientific obstacles, an understanding of the nature of science, a sense of belonging, and increased research self-efficacy.

5.4 Introducing STEM-199 as a CURE-like Course

STEM-199, Undergraduate Research Methods, is a collaborative, project-based science research methods course at Mott Community College for natural science students who typically attend the school for one or two years. The course is part of the STEM Scholars program at Mott, and the school is a public TYC located in the heart of Flint, Michigan. The course runs in the winter semester and has been taught three full times so far since 2019. Our analysis for this paper focuses on the initial course in 2019, which was not impacted by the COVID-19 global pandemic, although we will briefly describe changes the instructors made after the first implementation. Most students in the course have been in their first year when taking it. STEM-199 was not explicitly developed with CUREs in mind or trying to be a CURE, but since we saw similarities we drew from CURE literature in our analysis of STEM-199.

We describe STEM-199 as a CURE-*like* course. STEM-199 fit many of the key features of CUREs, like collaboration and particularly relevance to the community. The instructors gave little restriction on student project topics except that they must have to do with the local Flint River and Gilkey Creek. The water quality in Flint has been an issue of importance and relevance to the community in the area and the broader scientific community for some time now (Pieper et al., 2018; Associated Press, 2021). In addition to this initial course restriction keeping students on a relevant topic in their project choices, students ultimately created public presentation-worthy posters sharing their work with folks in the last week of class. Students from STEM-199 have also taken their projects to present at external conferences after the semester.

The feature of CUREs with which STEM-199 least aligned is student research iteration, part of why we call STEM-199 CURE-*like*. This was largely because of a short time frame as instructors were behind where they wanted to be on students starting their initial data collection. We focus on this paper on the first offering of the course from 2019, so since the instructors were teaching the course for the first time, they were still working on the course schedule. However, iteration was always an intended aspect of STEM-199, and the professors have been trying to get a second semester follow-up course off the ground since that first offering of STEM-199. This was encouraging and exciting to some students who wanted more time to keep working on their research projects. Considering the ways STEM-199 is similar to and also different from the traditional understanding of CUREs, we argue that STEM-199 is a "CURE-like" course.

5.4.1 STEM-199 is more student-driven than most CUREs

Of note, STEM-199 is more student-driven than most CUREs. The student agency in project topic choice and procedure design aligned with Hanauer and Dolan's (2014) description of student ownership. They describe student ownership as having 5 categories, for which we saw examples in STEM-199 of "agency combined with mentorship" and "overcoming challenging moments in science" (p. 150). Students decided on their own project ideas, which they could draw from a list of possible inspirations, but many diverged from these listed ideas or started with their own idea. Many of the students' projects were very ambitious, since the instructors supported the students in what they wanted to do and gave the students a lot of freedom in their choices. Wood wrote in her field notes about one of the professors "talking about how [the students] need to take their ideas and narrow it down" in order to achieve a manageable project scope since students' initial topic ideas were "at the level of an R1 research grant". Other than this encouragement, though, students mostly stayed near their original ideas, and remained ambitious with their plans.

Furthermore, the projects were student-driven in that goals and timelines were both established by students, except for the broad-scale restrictions imposed by the semester end deadline of a final poster presentation. In the field notes, Wood wrote that "groups seem[ed] pretty independent," since two students "ha[d] a lot of petri dishes and were already talking to [professor] about which ones grew stuff and which ones didn't." This was about two weeks after students had just gotten started on their projects. The professors checked with that project group on if someone had taken microbiology to make sure they could take the lead on the project themselves.

Students also overcame all but the most severe obstacles on their own, and generally tackled difficulties independently before seeking or explicitly being offered instructor help. (Examples of student research project challenges are in the appendices.) We saw students struggle with a late start in the semester delaying data collection, difficulties getting equipment materials they wanted, interpersonal intragroup conflicts, not getting the results they expected, and so on. Thus, STEM-199 was also a high-challenge CURE-like course, similar to the course described by Gin et al. 2018).

5.5 Conceptual Framework: Self-Efficacy

We provide more details below in the Methods section, but this paper is part of a broader study focused on self-efficacy and experiences that provide opportunities to impact students' self-efficacy toward academic tasks. As we see above, Corwin et al. (2015) and Lopatto (2004) show increased self-efficacy to be a common student outcome of CUREs. Corwin et al. (2015) further discuss the connections between project ownership and self-efficacy. To provide a brief overview of self-efficacy, which was our conceptual framework entering this data collection, we will define self-efficacy as confidence in one's ability to successfully perform a specific task (Bandura, 1978; Sawtelle, Brewe, and Kramer, 2012). Bandura proposed four types of experiences that contribute

to a person's evaluation of their self-efficacy. Three of those four types of experiences which we observe most often in STEM-199 are mastery experiences (past experiences successfully or unsuccessfully completing a similar task to a current one at hand); vicarious learning (observing a peer successfully or unsuccessfully doing a task and/or comparing oneself to a peer doing a task similar to a current one); and social persuasion (encouragement or discouragement from people to whom one looks up and respects).

We saw opportunities for self-efficacy source experiences frequently in STEM-199, aligning with Corwin et al.'s links between CURE activities and increased self-efficacy. Corwin et al.'s (2015) model specifically links self-efficacy with tolerance for obstacles. They argue that student ownership impacts self-efficacy indirectly through impacting student motivation as well as students' tolerance for obstacles. Because of Corwin et al.'s (2015) model linking project ownership, tolerance for obstacles, and self-efficacy, we expected to see such outcomes from STEM-199.

5.6 Methods

Our research of this course STEM-199 was embedded in a larger study about student self-efficacy and opportunities for experiences to impact self-efficacy toward academic tasks. We used ethnographic methods, including taking field notes (Becker and Geer, 1957; Emerson, Fretz, and Shaw, 2011; Aron, Gospodinoff, and McDermott, 1978), collecting reflective written journals from the students weekly, and interviewing student volunteers, using the LifeGrid format (Rowland et al., 2019).

Our research questions evolved from our initial self-efficacy focus during our analysis process. We will discuss how our data collection tools targeted our planned research questions and then how the data we observed and analyzed led us to edit our research questions. Initially, we

were interested in student self-efficacy shifts from their time in STEM-199 and the opportunities for self-efficacy building experiences in the course. Thus, our journal prompts (see Table 5.2) and our observational field notes (see Appendices A and C) were focused on self-efficacy and self-efficacy experiences (i.e., mastery experiences, vicarious learning, social persuasion, and physiological state).

The ideas of a student-driven course and instructor support are related to self-efficacy building (see Literature Review above), but we stepped back from only focusing on specific self-efficacy source experiences. We focus in this paper more broadly on the instructor support provided to the students and the ways that impacted students. Some of the student outcomes did align with self-efficacy. We also saw opportunities provided in STEM-199 for self-efficacy experiences.

Table 5. 2 Weekly reflective journal prompts

Two required response prompts given each week	• What were you working on this week? (e.g., what concepts have you been learning, what have you learned about using your equipment, what data have you collected, what analysis are you doing, etc.) • What were your project goals for this week, and how satisfied do you feel with your progress toward these goals? What are your project goals for next week, and how confident do you feel about your ability to complete those goals?
Additional prompts varying each week from which students were asked to choose four to answer	• Describe one thing you're proud of, one thing you're frustrated by, and one question you're still working on from this week. • What changes did you make this week to your experiment? -- or -- What science concepts/skills did you learn this week in order to move forward in your project? • Describe an experience or event from working on the project this week that stands out to you as memorable. • What did you personally contribute to the project and/or your team this week? How do you feel about your contribution? • Discuss how your team worked together this week. What went well and what could be improved? • Discuss any interactions you had with your instructors this week regarding your project. What went well and what could be improved? • Is there anything that's going on in your project that we're not asking about that you would like to discuss here?

5.6.1 Research Questions

Therefore, our research questions can be stated in the following two pieces:

(1) How did the instructors make the CURE-like STEM-199 course work at a TYC?

(2) What are the outcomes for students who participated in this student-driven CURE-like course at a TYC?

5.6.2 Introducing Course Instructors

The instructors and designers for STEM-199 (authors Dudock, Stamper, and Wade) have backgrounds in botany, molecular biology, and biochemistry. Around 10-20 students have taken STEM-199 in each of the three semesters it has run so far. Most students have worked on projects in those disciplines in which the professors have backgrounds, but STEM-199 students have also worked on projects in engineering, mathematics, social science, and other fields, sometimes with the added help of external experts at Mott and neighboring institutions. Projects in the first year, when students were constrained to focus on the Flint River, included chemical and microbiological testing of water quality, testing of plant growth in creek water, and observational studies of animal behavior and growth in the areas sampled (See Appendix B for more information on the student project descriptions).

The instructors described the goals of this course as the following: (1) to educate students in the basics of laboratory research in STEM disciplines, and (2) to give students the first-hand experience of designing and conducting their own independent research projects. To that end, the course can be thought of as having both a classroom and a laboratory component. In 2019, this classroom and laboratory component were somewhat split up, such that the first several weeks of the course were largely the classroom component and the last several weeks were largely the laboratory component. In subsequent years of the course since 2019, the instructors aimed for students to start work on their projects earlier in the semester, so the classroom and laboratory components overlapped more.

Some of the instructors' thinking about the design of the course also included more medium to long-term goals for student affective gains. Dr. Ronald Stamper (3rd author and one of the STEM-199 instructors) thinks of the STEM-199 course as differing from typical lower-level lab courses (as well as many upper-level courses). He has found that many lab courses focus more on the mechanics of following procedures and performing experimental steps. There is typically little emphasis on the design of the experiments themselves, or on the broader considerations of practicing scientific inquiry. Thus, he wanted the STEM-199 course to do something a little different and to help students see the big picture of scientific discovery, and to prepare them to find opportunities for future research during their university studies after transferring. These goals articulated by the instructor team align with Corwin et al.'s (2015) CURE models that emphasize building knowledge and skills and student ownership. Similar to Corwin et al.'s models, Stamper notes that he hopes for long-term outcomes to include students gaining appreciation for the overall process of conducting research in STEM fields.

Each classroom course meeting was focused on a particular aspect of research, including finding and critically reading scientific literature; types of experimental designs (observational, synthesis, analysis, etc.); laboratory safety; responsible conduct of research and research ethics; data collection and statistical analysis; research funding and grant writing; and presenting research in both written and oral forms. The typical class meeting involved an instructor-led discussion of the topic and presentation of relevant examples, followed by a class discussion and/or group activity led by the students.

The laboratory sessions are more open format, with activities dependent on the progress of the students' projects. The early meetings are focused on finding background information on the topic through conducting a literature review. Next, students find and assess various methods for

conducting their desired project plan and generate a materials list. Once relevant materials have been obtained, the students conduct the experiments they have planned, collect data, and analyze their results. Finally, the last few meetings of the course are focused on presenting their work, which has been done in the form of written submissions and public poster presentations. Most students spent very little time working on their projects outside of the scheduled class time, at least on lab work like taking data and using equipment. When students did work outside of class time, they primarily worked alone, having split up the tasks among the group members. One student told us, "I am so busy during the week that I cannot go work on the experiment outside of class." Another student wrote, "I still feel a little frustrated that my partner and I never really had a lot of time to work on [our project] more outside of class."

5.6.3 Positionality Statement

Authors Wade, Dudock, and Stamper were the instructors of STEM-199. We have heard about their philosophy and design for the course in the previous sections. Authors Wood, Sawtelle, and Byrd completed the data collection and analysis. Our research team is interested in self-efficacy (Bandura, 1978), or the confidence and ease a person feels regarding their ability to perform a task (Ajzen, 2002). Therefore, the field notes Wood recorded while observing the course each week and the reflective journals administered to the students each week were focused on students' self-efficacy judgements, student experiences in the four self-efficacy source types, and opportunities provided in the course for students to have such self-efficacy source experiences. When analyzing the data, we noticed broader themes than just self-efficacy, though.

Neither Wood nor Sawtelle began their baccalaureate education at a TYC, but they are committed to centering TYC students and professors in their work, learning from TYC institutions, and supporting transfer students at FYCs. Wood is a PhD candidate in Physics Education Research,

and Sawtelle is Wood's PhD advisor. Sawtelle has a long history of exploring self-efficacy in qualitative work (e.g., Sawtelle et al., 2012 and Turpen, Little, and Sawtelle, 2018). Second author Byrd was an undergraduate student in a summer research experience for undergraduates (REU). Byrd has started his baccalaureate education at a TYC and transferred to a FYC to complete his degree in Physics. Byrd provided a useful perspective to the research team in analyzing the data, since he was able to point out things like experiences that he wished he could have had in his time at a TYC.

5.6.4 Data Collection

Wood (first author) observed this course in its first iteration (2019) in entirety, attending the course every day of class for the 15-week semester, and taking observational field notes on the topics of the course covered each week, as well as student-student and student-teacher interactions. This data collection was conducted in accordance with Michigan State University's IRB approval (# x17-810e). As we described in the Conceptual Framework section, we were particularly interested in the construct of self-efficacy, especially the perspective of how the course might make opportunities for students to have vicarious learning and social persuasion experiences. Given our focus on self-efficacy, this meant that Wood wrote field notes specifically attending to the interactions students had with each other or with instructors, as the situations that might afford opportunities for social persuasion or vicarious learning. The journal questions with which we prompted students in their weekly reflections also probed about such interactions, asking about things like what help they got from instructors, how they felt about and what they contributed to their project group, how working with their group was going, and what or whether they had past experiences that impacted their confidence in their ability to successfully complete the tasks they were working on for their project each week (see Table 5.2).

About five weeks into the 2019 semester of STEM-199, we began administering these journal reflection assignments to students. This coincided with students starting to decide on research project topics and the groups in which they would work. In Table 5.2 we share a set of example questions that we asked throughout the weeks. The first two questions were asked each week, and the rest are examples of the kind of additional questions we would list, with slight modifications depending on the week and the course content at that time. Students were asked to answer about six questions each week. These were always supposed to include the first two questions below with an additional four chosen by each individual student. These questions were meant to elicit both a general summary of students' project experiences each week as well as self-efficacy explicit statements and descriptions of self-efficacy experiences that students may have had while working on their projects each week. This meant we asked about students' interactions with each other and with instructors to elicit students telling stories of vicarious learning or social persuasion experiences they may have had; and we asked about students' prior experiences that impacted their sense of ability to complete their research projects to find out about potential past mastery experiences; and we asked about students' emotional and physical feelings about their confidence to elicit descriptions of physiological state experiences.

Though we emphasized self-efficacy, Wood also took broader field notes, particularly during the first couple weeks of the course, on observing the environment, physically and socially, getting to know the instructors and the students, learning names, noticing general patterns of interaction, and taking note of general factors.

The students in STEM-199 split up into project groups of two or three people doing a variety of research projects. This meant that later in the semester when the main focus of the class was on gathering data and physically performing the experiments, the groups of students scattered

all over the science building. Thus, Wood did not always observe every group each week. Decisions on which group to observe, or observe first in the class period each week, largely depended on whom Wood had not observed the last week, coupled with multiple groups going to the same place. Wood did regularly go to a project room in which two or three groups all worked because that way we could observe more people at once. Wood was physically present to observe the course only during the two official course hours each week of the semester. In the journal reflections, students also reported about what they might have been working on outside of class hours, although as mentioned above few students discussed doing much project work outside of class time.

5.6.5 Data Analysis

In the summer following STEM-199, Wood initially used qualitative emergent coding to categorize the data for a report to the instructors on the outcomes and effectiveness of and student attitudes towards the course. Examples from that process are shown in the appendices. Alongside that, Wood also coded the majority of the student journal responses using a qualitative codebook for capturing explicit self-efficacy statements. Then, we started to hypothesize certain themes arising from the data, like the centrality of the student-driven nature and high instructor support for the students. Our initial analysis included synthesizing more than 100 pages of observational field notes and student weekly reflective journals (see Appendix C for more details about this). We brought in second author Byrd to help us analyze the data. He initially explored the data before Wood and Sawtelle told him the hypothesized claims, and he also noticed things like the high amount of student project ownership.

We needed a way to decrease the overwhelming amount of data, so we used emergent and a priori qualitative coding to identify particularly rich excerpts of data and neglect less meaningful

pieces of data. We organized the data and our analysis around the qualitative coding of student journal reflections. Byrd searched the literature about CUREs and found Lopatto's (2004) framework useful to our analysis as it aligned with our data in assessing student outcomes of CUREs and observing outcomes like tolerance for obstacles and self-efficacy. Shortlidge, Bangera, and Brownell (2016) describe 30 assessment methods for CUREs, as well as best practice guidelines for designing assessments. Almost all of these require incorporation into the course before or during its being taught. Thus, we decided to begin our process of examining the benefits of STEM-199 using Lopatto's gains as the framework for our work, having not originally approached the data collection from the perspective of examining a CURE-like course overall. We used a deductive coding process - coding for these common student outcomes of CUREs because we viewed STEM-199 as a CURE-like course. Byrd did the bulk of the coding but also discussed and shared the work with Wood and Sawtelle as well as a larger group of researchers engaging them in discussion of trial coding excerpts of data to check for agreement and validity. Since the codes for student-driven project nature and student tolerance for obstacles covered a significantly larger amount of data than the other codes of Lopatto's student outcomes, we focused on those. Thus, the coding also confirmed our hypothesized themes in the data.

As we coded, we found that many of Lopatto's gains also align with Corwin et al.'s (2015) model, particularly the ones we saw most often in our data, including increased self-efficacy, tolerance for obstacles, and project ownership due to student-driven projects. In our process we also added emergent codes, including "frustrations/ worries," "student-driven," and "impact of faculty." The frustrations code overlaps with tolerance for obstacles, student-driven overlaps with project ownership, and impact of faculty seemed to contribute to many of the student outcomes we saw. Byrd first looked through all the data including journal entries, survey responses, field notes,

and interview transcripts, and initially coded the journal entries for positive student outcomes using Lopatto's gains (2004). Then Byrd, Wood, and Sawtelle reviewed and discussed the initial coding and once more skimmed through the data. Byrd then coded the 2019 journals again and brought segments of data to a larger research group for peer debriefing (Creswell and Miller, 2000) and discussion of the validity of the codes. This group meeting resulted in minor refinement of the coding and confirmation of the use of the codes to describe the data.

We collaborated with the instructors of STEM-199 to produce this paper, asking the professors to do auto-ethnographic personal reflections (Hesse-Biber and Leavy, 2006). This reflective writing from the instructors is included throughout this paper, and we used it as first-person accounts of the classroom that supported our analysis of our observational field notes, student journals, and student interviews. The process we used was first analyzing our field notes, journals, and interviews, and then developing an outline of our proposed claims. We next asked the instructors to reflect on their design processes and philosophies in initially creating, implementing, and iterating STEM-199. In this way, the auto-ethnographic reflection was a type

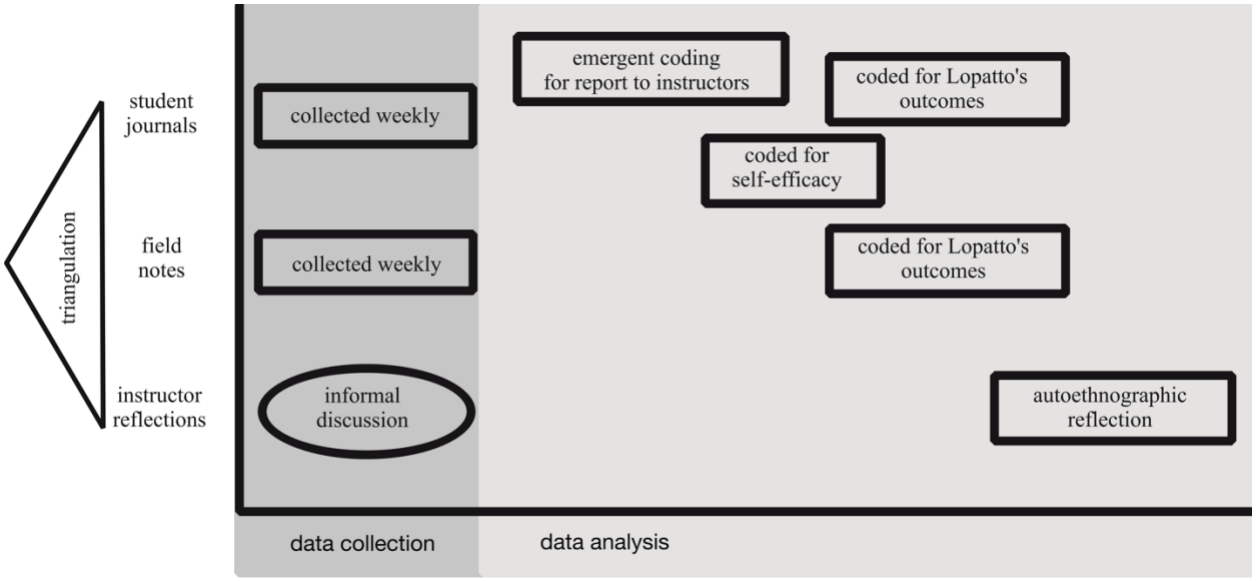


Figure 5. 2 Data collection and data analysis timeline

of data as well as a form of member checking our understanding of STEM-199 with the professors. (See Figure 5.2 for a data collection and analysis timeline.)

5.6.6 Validity and Reliability

While the analysis process we described highlighted the use of qualitative coding, emergent or deductive coding does not capture the entirety of this study. We did not go through the process of iteratively defining codes, creating a codebook, and performing inter-rater reliability. Instead, the coding process was used as a tool to reduce the copious amounts of data collected directly from the students by extracting excerpts of data identified in the coding process. The reduced data excerpts were used as triangulating evidence with field notes and interviews. Wood's regular involvement and attendance in the course allowed her to build trust and establish rapport with participants, providing additional reliability of our account through developing a holistic case. Finally, we used researchers external to this project as peer debriefers and readers to examine our audit trail. These researchers were familiar with the project goals and objectives and the site of study but were not directly involved in the data collection or analysis and thus provide credibility to the account.

5.7 Results

Here, we first remind readers of our research questions, and then describe the results answering each sub-question in the sections below:

(1) How did the instructors make the CURE-like STEM-199 course work at a TYC?

(2) What are the outcomes for students who participated in this student-driven CURE-like course at a TYC?

5.7.1 Research Question 1: Design Considerations Learned from STEM-199 for Student-Driven CURE-like Courses at TYCs

STEM-199 had its obstacles for students and was also a lot of work for the instructors because of the highly open-ended and student-driven nature of the projects. This also had benefits though in impacting positive student outcomes (see next section). Thus, in this section, we examine how we might strike a good balance between maintaining that student experience and making a more sustainable course with less cost and workload for the instructors that could also be implemented at other institutions.

We propose that there are affordances and limitations to being anywhere on the spectrum from instructor-guided to student-driven, but that student-driven experiences like STEM-199 are more authentic to the science experience and the obstacles that scientists face (Corwin et al., 2015; Spell et al., 2014). Thus, in designing a similar course, one must balance the potential student gains with the difficulties to the teaching experience that come from giving students a lot of control.

When we distill the key aspects there are two main considerations: the design which leads to student gains of self-confidence, ownership, and tolerance for obstacles; and the choices that mitigate the level of work, time, and energy the teachers need to put into the course for it to succeed. Briefly, the essential components of the course we saw included the high teacher-to-student ratio; the high amount of work and availability from the instructors; high student project ownership; and the professors' varied science backgrounds, among others. We will now explore these individual components and break down the elements that made them successful.

5.7.1.1 Essential Course Components and Mitigating Instructor Workload with More Teachers

The high teacher-to-student ratio worked in concert with the amount of work instructors put into the course as well as the availability of the professors to the students in and outside of class. Instructor support was critical to students' attitudes about the course and their progress on

Table 5. 3 Student-teacher interactions

THEME	OBSERVATIONAL FIELD NOTES	STUDENT JOURNALS
Students comfortable with instructors	When [instructor] said is this making sense to everybody? Most of the class mutter mh hmm or yes pretty quickly without hesitation … (Students seem pretty comfortable Fairly equitable distribution of who's been talking so far) (First day) …to [student] [instructor] said "I said a lot of nice stuff and lied about you in that letter so you better be good" She seems quite comfortable with him (Third day) [instructor] said, after needing to check names with at least half the class, "I haven't had many of you in my class- just a few of you" (What classes do these instructors teach besides this? How do these students seem so comfortable with these instructors if they haven't had them before?) (Fourth day) [student] doing a lot of the testing while [student] helps her by holding the tubes of water When she was lighting the Bunsen burner the instructors said "you sure you know what you're doing?" (Jokingly) (Eighth day) [instructor] to [student]: "it's okay if I show people yours?" [student]: "I'm ready for you to roast me" [instructor]: "It's not that bad" [student]: "What do you mean? It's not bad at all" (Ninth day)	"I think that all my professors are really approachable and funny/friendly. I wouldn't change anything about them so far. I think they are all supportive." (5/2) "...I also feel more at ease knowing that I have such approachable professors to ask questions and they're knowledgeable enough to supply me with accurate and relevant advice and information." (3/1) "...But I have confidence that my professors will help me, they are all very approachable." (2/21)

their projects. Students faced difficulties in their research projects, but overall remained optimistic, attributing their confidence to the instructors (see Table 5.3 and Table 5.4). For example, one student said, "I'm proud of how much I'm learning even though I have yet to take microbiology. I know that I'll have a head start for when I take that class. …I have some questions …but my partner and professors have been very helpful answering them." Other students also talked about their professors being helpful with answering questions, approachable and friendly, and their source of confidence in being able to complete their projects (more quotes are in Table 5.3). This level of instructor support is only possible with either or both a high teacher-to-student ratio or a high amount of work from professors. We see both of those components fairly balanced in STEM-199, but as there is a higher number of teachers, the amount of work by any one teacher would

Table 5. 4 Student project ownership and student-driven nature of STEM-199

OBSERVATIONAL FIELD NOTES	STUDENT JOURNALS
[instructor] talking about how they need to take their ideas and narrow it down to the almost absurdly narrow level even though it sounds ridiculous … [instructor]'s point with his example was that it was an R01 grant and they've been doing it for 7 years and that that's the level the students' ideas are at so far (Fourth day) [instructor] checking if someone in the team has had micro and if they're confident in being able to do that … [instructor] just said in a perfect world it would make your life so much easier if you could find an article about someone who did exactly what you want to do but with water somewhere else and then you could do it with flint water (I would not expect first year students to be able to do a research project that's so much self-guided as this- this isn't something I had to do until junior year and even then I feel like I had more structure) (Fourth day) (The instructors sort of hold the students' hands but this week did seem to be more letting them go, at least from what I saw of [instructor]) [student]'s partner labeled the droppers with a sharpie without being told or even asking if she could When [instructor] saw he said "ah smart the ones that aren't labeled will be the deionized water" "Let's hope it works" (I also thought this was cool that she felt she had ownership over the objects in the space to do this) (Sixth day) All of these students seem reasonably self-sufficient to me at methods and forms of science I know nothing about In interviews I am also curious about the science classes they've taken that prepared or didn't prepare them for this project I'll fold that in with previous science experiences (Ninth day)	"Initially my group and I had put together a list of about 15 different microorganisms that we wanted to look for in the samples. Through further research we narrowed it down by eliminating some of the more rare microorganisms. Then our [professor] helped us narrow the list down even more by eliminating some of the more dangerous or slow growing microorganisms. Our original list of 15 was then narrowed down to three, legionella, ecoli, and salmonella. Although we were initially bummed about not testing for more than 3 we decided that it would be better to do 3 microorganisms and study it in detail rather than doing a bunch and not having the time to really analyze why they were there and their effects on the surrounding ecosystems, etc." (3/12) "This week I discussed with [professor] the different topics I could research about frogs. I wanted to [do] gas exchange in the beginning, but [professor] helped me and my team narrow our focus down to this topic. He really helped us decide on a topic. Everything went well." (3/12) "I'm proud of how much I'm learning even though I have yet to take microbiology. I know that I'll have a head start for when I take that class. I don't really have any frustrations. I have some questions but they're mainly basic ones since I haven't taken micro yet, but my partner and professors have been very helpful answering them." (4/11) "I am proud that we even got the project to work out. We didn't get the fish we wanted and it wasn't easy to get the water, but we managed to finish it all." (5/2) "I am very proud that we have officially completed the experiment and created a decent poster. However, I still feel a little frustrated that my partner and I never really had a lot of time to work on it more outside of class. While we are no longer working on the experiment, I still wonder how it would be different if we had the [the species] that we decided on. Would it have affected them in a similar way? Would we be able to continue our experiment in the summer semester (assuming more of them would have lived compared to the [species we had])?" (5/2) "I had done most of the analyzing and testing of our samples. I feel great about my contribution because I was the one getting new data and information for our project. I had also taught my partner different techniques in testing our water samples." (5/2)

decrease, so there is an inverse relationship between the need for those two components. The instructors were also very open with the students when they did not immediately know the answer

to a student's question, and they would model real science-doing to the students (see the Appendices). Tables in the appendices show many specific examples of the way the instructors would teach the scientific method as highly explorative and based in asking questions, and they taught students to make posters and engage in scientific writing. For example, one student said that their professor was "looking into finding something to test for the oxygen levels." The professors also reached out to other local institutions to ask for resources to help their students complete their research projects. The instructors' willingness to bring in external support and take their time helping students answer questions and address issues is a teaching method that can mitigate difficulties, because instructors do not need to be fully prepared in advance for any eventuality students might encounter.

Next, the teachers' varied science backgrounds allowed for greater student control over their own projects, because students had more freedom in the topics they chose since the professors could support them in a variety of topics. In 2019, the STEM-199 projects were constrained to focus on some experiment regarding the Flint River water, but the instructor backgrounds supported projects from tracking the rate of plant growth, to measuring chemicals in the water, to observing living animal growth (see Appendix B for more details on student projects). In the years since then, students have done an even broader range of projects, so the professors brought in support from other experts at Mott and beyond, which is also a good option for others implementing a similar course.

It is important to note that student ownership can be maintained even when instructors are a little more prescriptive, like the instructors have been in the online versions of the class offered since 2019. Students do not have to develop their own project ideas and procedures completely in order to have project ownership (Hanauer and Dolan, 2014; Corwin et al. 2015). In STEM-199,

some students developed project topics entirely from their own ideas, and others chose from a list of options. A list of options of project topics is a great way to narrow what students work on while still giving them agency and control over their projects.

5.7.1.2 Unique Two-Year College Traits to Consider

So far, we have presented aspects that one would want to maintain when designing a similar course to STEM-199 in any setting. Focusing on TYC settings specifically, we notice the fact that when students on occasion did project work outside of class, they mentioned in their journals that their delegation of tasks to individuals was due to difficulties finding shared times to meet and work outside of class time. Additionally, some students who explicitly talked about not meeting or working outside of class attributed this to that same difficulty. While this obstacle may be true for many students regardless of academic institution, we can assume that this is especially challenging for students at TYCs, more of whom may be "non-traditional" aged students, have added family care obligations, commute to campus rather than live close to or on-campus near their peers, or have work obligations outside of school (Ishitani and McKitrick, 2010; Starobin et al., 2016; McConnell, 2000). Thus, another specific criterion that we saw exhibited in STEM-199 is to design the work such that students can keep most of their project work confined to class time or requiring only short periods of work in between classes.

Another specific point to consider in the TYC setting is how to minimize the work by having multiple teachers. The high teacher-to-student ratio does not necessarily mean there needs to be many professors. These other teachers can also include folks like undergraduate learning assistants or graduate teaching assistants. However, using a student teaching assistant may not be feasible at a TYC, but we still encourage the use of multiple instructors. Plus, there may be ways to lean on past students who have taken the class, who still provide a valuable resource, possibly

even after those students have graduated and likely transferred. Maybe students could come back and give brief presentations on their projects and experiences from the course in the past.

Table 5. 5 Research project challenges and student tolerance for obstacles

THEME	OBSERVATIONAL FIELD NOTES	STUDENT JOURNALS
Social persuasion about physiological state, instructors want to make science less intimidating, and instructors remain calm messaging to students to remain calm as well, helping students navigate emotional distress and making science less intimidating	[instructor], after showing some working in smart art "Simple and easy to manipulate, and I don't want you guys to be afraid to manipulate it" "I mean if you wanted to, you could put your text in triangles and circles and stuff. So don't be afraid to play around with this. We're only going to print the poster once, but I've copied and pasted posters into another PPT and then printed it on regular paper size [not to read the words but to see the layout]" "No template, but you guys are using your own creativity" (Seventh day) "Learn now, will benefit later, and it's incredibly simple and easy to do" … Mentioned downloadable online templates Also that some schools have templates, but Mott doesn't, so "easy" … "When I cut and pasted this [graph] I missed the title, but no biggy" (Seventh day) [instructor] bringing up how when you ask new questions that amount of options and ideas can be paralyzing so you want to limit yourself by resources, etc. What can you answer? (First day)	"I am proud of how we've made everything work despite the delays and mishaps we've been through. I am frustrated, though, because since our [animal species] have quite short life spans. Some of them have died, but we will be unable to determine why, exactly, they died. We are still working on how we will determine the differences in the [animals] because some of them have died." (4/18) "While we are just starting on finalizing our project idea, I'm proud of the fact that we know specifically what we want to do our project on and that we have a back-up idea in case we are unable to do what we initially wanted to do. My main concern is that we still do not know if we can do research on [target animal], but I'm hoping to have the answer to that very soon." (3/12) "We completely changed our experiment. We went from just testing water to raising [animal]in two different types of water." (3/26) "We have also made changes to our original hypothesis. It was originally, Microbes can grow in the Flint river in cold water/weather. Now that it's not so cold outside we have changed it from using temperature" (3/26) "because one group was not able to do their project it made me and my partner have to do a little shifting and build almost like a bigger team" (4/4) "Our goals were to start analyzing our samples. We unfortunately didn't get to that this week because we had to figure out what medium we should use to grow those specific bacteria. I don't feel satisfied with our goals because we aren't able to start analyzing till the next week. I feel confident in my group being able to complete that goal by next week." (4/11) "I have learned that I am not as brave as I thought. Weighing the frogs wasn't easy. I took a while to get all 6 frogs weighed. So I am thinking about changing the project to observing the behavior and skin color of the frogs instead of size." (4/11) "We did a bunch of tests this week which was very exciting because most of the actual handy work for the project was done this week. [Student] and I amassed a bunch of hours in the lab this week probably 10+ hours in the lab. Our test results proved our hypothesis to be false but we were not disappointed by this because it actually means good news for the city of Flint! In the process we identified 2 other kinds of bacteria we are going to be pursuing research on this spring semester." (4/25)

Additional aspects observed in STEM-199 that worked well for the logistical side of the course include a central theme to narrow students' project topic choices; splitting students into groups to limit the number and variety of projects; and groups using similar or overlapping equipment and working in physically close locations so a single instructor can help multiple groups at the same time.

5.7.2 Research Question 2: Experiences and Outcomes of Students in a Student-Driven CURE-like Course at a TYC

This section addresses Research Question 2 regarding the student outcomes we observed from STEM-199 and the student-driven nature of the CURE-like course. Tables 5.3, 5.4, and 5.5 shows evidence of these outcomes. The student journal quotes in all these tables are pulled from Byrd's coding, organized by themes described in the title of the table or in the left hand column for each row, depending on whether the tables show a single theme or multiple. Wood added excerpts from field notes as relevant to the themes coded in the journals.

5.7.2.1 Interactions with Instructors Led to a Sense of Confidence in Completing Research

Corwin et al. (2015) hypothesized that supporting a sense of project ownership would in turn lead to increased self-efficacy. Our qualitative analysis also supports this hypothesis. Specifically, we saw students expressing a sense of ability and self-confidence, as well as opportunities throughout the course for self-efficacy contributing experiences. We inquired about students' self-efficacy towards tasks such as doing scientific research in the course and in the future.

Early in the course, most students said they were confident in their ability to successfully complete their research projects (see Table 5.3 and Appendix C). Some students did early on have low confidence in their ability to successfully complete their projects, which was most often because they were nervous due to their lack of experience, or they did not know their weekly goals

or steps to take to complete the project. For example, one student wrote in their journal, “I have some doubts, only because I have only been a student prior and never taken on the researcher role. But I have confidence that my professors will help me, they are all very approachable.” Another student wrote, “I’m nervous because I’ve always been the student and not the researcher. But I’m confident in myself and my work ethic. I also feel more at ease knowing that I have such approachable professors to ask questions and they’re knowledgeable enough to supply me with accurate and relevant advice and information.” Students generally said they felt good about their ability after they had decided on their topics, settled on their procedures, and/ or figured out how to use the necessary equipment. (See Appendix A for more information.)

Students cited most often the instructors as the source of their confidence (followed by their research partners), and the instructors stand out in the field notes as critical characters encouraging students and alleviating their research anxieties. In other words, students were typically attributing their self-efficacy to social persuasion and vicarious learning type experiences. When examining student-teacher interactions in student journals we see corroborating evidence suggesting the instructors were critical in their support. A student wrote in their journal, “With adequate help from our professors, I feel very confident that we can achieve these tasks.” The next most common source to which students attributed their confidence was their group for working on the project. A student wrote in their journal, “We are fairly confident that as a pair we could complete a research project of this size.”

Overall, when discussing interactions with the instructors, most students said they were very helpful. Particularly, students most often wrote about the professors not being judgmental on any questions they had, and getting help from the instructors on research skills, like gathering equipment and materials, and making posters. One student wrote, “[the professors] have been very

helpful, and not judgmental about any of the questions I have had even if I felt like they were 'dumb' questions at the time." Another student wrote, "an interaction we had with our professor was that [professor] showed us someone's poster that used to attend Mott and that was pretty cool because we got a general idea on what to do for our poster." We see throughout these quotes that the professors' approachable demeanor, helpful information, and general support helped the statements express a lot of high self-efficacy judgments.

5.7.2.2 Supportive Instructors Helped Students Gain Tolerance for Obstacles

There were a lot of difficulties students ran into throughout their research projects, but this may have provided good opportunities for student learning. The issues which students encountered were "authentic" (Corwin et al., 2015; Spell et al., 2014) obstacles so with instructor support and encouragement students could learn how to handle real scientific processes. As Krim et al. (2019) say, in STEM we tend to aim for students to engage in real science, "by which educators often mean science that reflects practices of scientists and engineers and engagement in scientific habits of mind" (p. 2).

Although students generally remained quite positive and confident in their journals, they did still discuss many difficulties they encountered in working on their projects. Early in the process, many students expressed difficulty in finding articles related to their project topics. One student wrote, "My goals this week were to find articles related to my project, and so far, I haven't really been able to find anything useful. I feel that it is hard to find any source related to my topic. Next week I plan to get help towards finding resources." Later in the course, a lot of students struggled with feeling behind schedule for various reasons. Some students felt behind because of snow days and canceled classes. Others felt behind because they had run into issues getting their materials for their projects that slowed them down. Many students simply felt like they should be

further along in their projects than they were at certain points throughout the semester, even though the whole class was generally in a similar position. (See Appendix A, tables 4A and 5A for more information.)

However, we saw the students remain confident and demonstrate a tolerance for obstacles throughout the semester (Lopatto, 2004) (see Table 5.4). Students repeatedly stated things like, "I would normally be frustrated about the feeling of being very behind in our project, however, the professors talked about us being able to continue our research into the next semester. Therefore, at the moment, I do not feel that frustrated about anything." Another student said, "Our test results proved our hypothesis to be false but we were not disappointed by this because it actually means good news for the city of Flint! In the process we identified 2 other kinds of bacteria we are going to be pursuing research on this spring semester." The students stayed confident and positive in the face of research obstacles, often attributing this to the instructors' influence. The instructors supported the students, making the environment of the course safe for mistakes and less intimidating or threatening (see Table 1A in Appendix A). Thus, students could be exposed to such obstacles and leave with a tolerance for obstacles and higher, rather than lower, self-efficacy.

Tolerance for obstacles was a fairly common gain Lopatto (2004) observed. However, self-confidence was very low in Lopatto's list of student outcomes and not frequently observed. We were specifically focused on self-efficacy in our data collection, but it is still notable that we observed many positive judgments of the students' self-efficacy to complete their projects successfully.

We also saw students talk about learning what to consider regarding ethical conduct and indirectly clarifying career paths by confirming or denying the academic paths students were interested in. These are also less common gains in Lopatto's work. Additionally, when students

Table 5. 6 Evidence of instructors supporting students physiologically, logistically, and technically

THEME	OBSERVATIONAL FIELD NOTES
Social persuasion	A student just had a revelation out loud and then seemed embarrassed and said "my bad" [instructor] said "that's alright you didn't have all the information you can't say my bad if you didn't have all the info" [instructor] said, "that's great but what if we change it a little" to a student about his experiment design (First day) [instructor]: "You could have come up with a definition that meant the same thing. I copied and pasted that from the computer, from the internet, from the google" (These teachers are encouraging and maybe the right word is down-to-earth/ relatable) [instructor] said "she (student) has a good idea- she just has to convince herself it's a good idea" (Third day) [instructor] just looked at [student's] computer because [student] is talking to computer lab people working at the front desk and said "that's on the right track, using duckweed would be cool" (Fourth day)
Emotional encouragement	[student] just asked somewhat dejectedly seeming with his head down and his hood on "why do all these papers always use such big words?" And [instructor] went over and sat next to him and said "it's what makes those researchers feel important" (Fourth day)
Social persuasion and vicarious learning through instructors' personal anecdotes and near-peer example stories	[instructor]: "the longer you are doing this the better you will get- I mean I'm still not perfect" I may not be able to question all of the methods someone is using if it's not what I do Also ask what further questions arise from this literature That's good- that means you're critically thinking about the literature and how it applies to your project (Third day) [instructor] was quick to assure students who said they didn't know what they wanted to do (~3) that that was okay He shared after everyone introduced themselves that he was a Mott student, didn't know what he wanted to do, transferred to [local FYC], was proof that it could be done even when everyone said it couldn't, and that most people don't know what career they want until junior year (First day) [instructor] just bragged about his two sons a bunch- how they graduated high school with 5 and 8 varsity letters and also 25 college credits each without ever having been dual enrolled and the students said stuff about how these were some achievers and [instructor] said you guys will all do well too, you're in this class (#encouragement How [instructor] talks about this class as helpful) (Fourth day) [There was an REU presentation from a local FYC as part of class this day] [instructor] flagging that there was a question in the first half of class about if they're qualified and pointed out that there's a Mott student in the picture that [local FYC] is showing of their REU (Second day) [instructor] just showed a really cool example of a world travel poster he made Just referenced a poster in the hallway just down the hall from "the guy that went to [local FYC]" (Seventh day) [instructor] just talked about how he left in the reference numbers in the excerpts even though there's not citations because it used to really bother him to come across all these random numbers, so "you guys are gonna have to learn to read through those" (First day)

Table 5. 7 Evidence of instructors supporting students physiologically, logistically, and technically

THEME	OBSERVATIONAL FIELD NOTES
Instructor messaging about possible student mastery experiences	[instructor] said I strongly suggest you run your resume by one of your professors, maybe us (Implied that all 3 instructors are quite willing to write letters of rec given warning) You'll also put on like lab skills, etc. and you'll have some of that to put on a resume after this class (Second day)
Instructors excited for their students	[instructor] said is anyone thinking about internships Boy said "I kinda am now" [instructor] said "NOW?" "Did I do that?" kind of excitedly (Second day) Posters will stay where they are for now and will ultimately be on the third floor [student] asked about being able to fix them and [instructor] said they have the digital copies but are also thinking about reprinting them He also told me that they printed multiples of the posters including a copy for each student of their own poster (Seems like a cool pride-building opportunity) (Ninth day)
Instructors caring for students	[student] wanted to print something and asked if there was a printer in here and [instructor] pointed to the printer and [student] said oh I probably have to pay and then [instructor] asked the student working at the check-in desk what the requirements are to use the printer and she said you have to pay and you have to have a card to pay so he asked if they could just keep a running tab that he could take downstairs to turn in for reimbursement and she said I don't think so but I just work here and [student] said I have a card it's okay and [instructor] said it's for a class, and then something, I forget already, but like that's a load of crap Then he said he's going to run downstairs to try to get a generic card for everyone to print (I think all the teachers really care about supporting these students) (Fifth day)
Accommodating a range of students' background experiences	[instructor] just said, "it's really important that you guys are honest in this class; he said he wasn't done reading so you get more time. You guys come in with different backgrounds, different reading levels, different backgrounds in science." (First day) (It is cool and noticeable though that these instructors never seem to assume students have personal at-home laptops, etc.) (Seventh day)
Impressed by or proud of students' project work	I decided to go check out the progress of plant people in greenhouse They had left but [instructor] showed me their progress on the plants Said "these guys can think- I didn't ask them it they've been taking pictures" told me they've been coming every day and left a notebook down there I said how it seemed all the projects were coming along really well but maybe the [living animals groups] were running into some difficulties and he said yeah but the instructors have talked and the students will still learn something (Seventh day)
Messaging to students that their research matters to others	[instructor] just said 3 times he'll be around to help everyone in the next week, I think Friday, Monday, and Wednesday Presenting in three weeks, need to be printed, "so other people can see them," "we've already invited [other people]" (Seventh day)
Relatable instructors	"I'll tell you who's not going to be able to help [with that specific project topic]- me" - [instructor] (Fourth day)

would reference in their journals the skills taught in class that they used in working on their research projects, they most often referenced the skills of following the scientific method, using research databases, and performing literature reviews.

Table 5. 8 Evidence of instructors supporting students physiologically, logistically, and technically

THEME	OBSERVATIONAL FIELD NOTES
Instructors mediate student self-efficacy and make students feel better, more confident, less nervous, etc. about scientific research	"I'm mostly satisfied with our progress so far. I feel confident about being able to finish on time. Next week we hope to be able to actually collect some data. I'm confident in our abilities to do this with the help of our professors." (4/11) "I'm nervous because I've always been the student and not the researcher. But I'm confident in myself and my work ethic. I also feel more at ease knowing that I have such approachable professors to ask questions and they're knowledgeable enough to supply me with accurate and relevant advice and information." (3/1) "I think that I would feel more confident about my ability to successfully complete the project if I knew exactly what I wanted to do. Nevertheless, I think that I should be able to do decent research on my topic with both the help of a partner and a professor when needed." (2/21) "Very confident [in successfully completing my project] because we have 3 full time professors to help us." (2/21)

5.7.3 Tying RQ1 and RQ2 Together: STEM-199 Design Provided Opportunities for Student Self-Efficacy Experiences

We have seen in the above two sections that STEM-199 involved instructors highly supporting students through selecting or designing their own research projects and procedures. This led to student outcomes of increased scientific research confidence and relatedly tolerance for obstacles. We will now expand on the aspects of the course design that offered opportunities for impactful self-efficacy experiences.

The course in itself offered opportunities for mastery experiences that might impact the students' self-efficacy toward future scientific research tasks. The instructors took steps even further to enhance these opportunities by messaging to students about these potential mastery experiences. The instructors told the STEM-199 students to put skills and experiences from the course on their resumes when applying to summer research apprenticeships and when transferring to universities and seeking research opportunities. There were also class sessions advertising such research experiences to the students.

Furthermore, we see in Tables 5.6, 5.7, and 5.8 many pieces of evidence of the instructors offering positive social persuasion and encouragement to the students, as well as the students

attributing their confidence to the instructors. The many times throughout the course that the instructors told students that they were proud of the students' work or encouraged them about their research processes could provide social persuasion experiences to the students. Also, the instructors often emotionally encouraged and supported the students, providing the opportunity for physiological state. Sometimes overlapping with social persuasion, the instructors also told many stories of their own lives and presented themselves as near peers to the students in ways that provided vicarious learning opportunities.

5.8 Discussion

5.8.1 Nuancing Corwin et al.'s Model with this CURE-like Environment

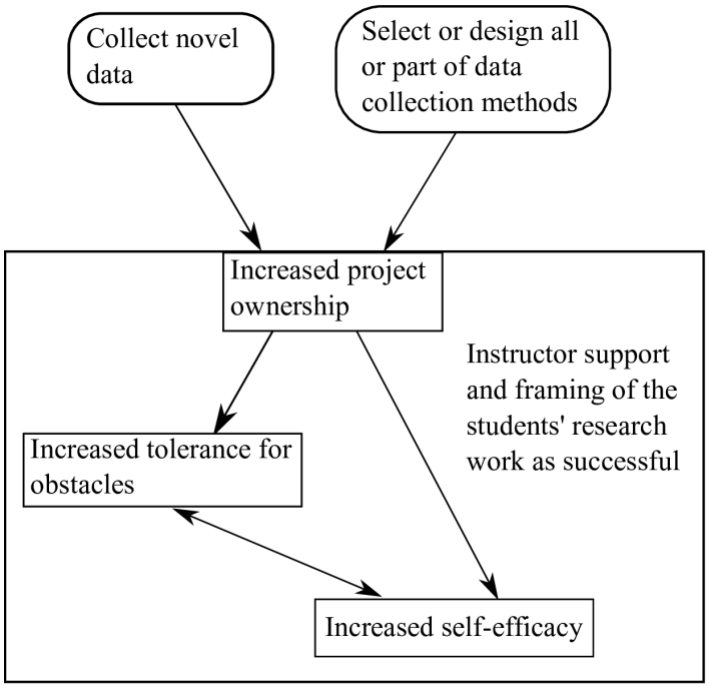


Figure 5. 3 Qualitatively proposed ownership mini-model for comparison with Corwin et al.'s (2015) model

We propose a similar model to Corwin et al.'s (2015) ownership mini-model, with slight differences, notably the possibility of a direct link between project ownership and self-efficacy given appropriate instructor framing, as well as a bi-directional link between tolerance for obstacles and self-efficacy.

As shown in our qualitatively proposed logic model (Figure 5.3), analogous to Corwin et al.'s (2015), our data supports Corwin et al.'s model. We suggest the possible addition that project ownership alone might directly impact self-efficacy without having to go indirectly through impacting tolerance for obstacles, if instructors frame student experiences appropriately (See Figure 5.3). Relatedly, we

argue that self-efficacy and tolerance for obstacles also have a bidirectional relationship as shown by the two-way arrow connecting them in our logic model, since we know from the literature that self-efficacy supports persistence in the face of difficulties (Bandura, 1978; Sawtelle, Brewe, and Kramer, 2012).

Corwin et al. (2015) call for more research to examine the connection between aspects of CURE design and the connections to outcomes, like increased student self-efficacy toward doing scientific research tasks. Their work made logical models from a meta-analysis of student outcomes from CUREs in the literature. We begin to contribute qualitative nuance and describe an environmental framing in which student-driven projects led to student self-efficacy. We not only add the qualitative study of the context of the course to this conversation, but we also suggest that increased project ownership can lead directly to increased self-efficacy in this type of context.

5.8.2 A Note on Moving a CURE-like Course Online Due to COVID-19 while Maintaining Student-Driven Nature

As a brief note about online classes in the time of COVID-19, a bootcamp program about which Majka et al. (2021) write went online due to COVID-19, and their students still reported a positive experience and showed positive psychosocial gains, like a sense of belonging, self-efficacy, and identity. This suggests that CUREs for students are still beneficial even if offered online in virtual environments. However, much more research remains to be done on such experiences as Majka et al. (2021, p. 7) point out that there is literature about very few "fully online, interdisciplinary" course-based undergraduate research experiences.

In 2020 and 2021 when STEM-199 was mostly or entirely online, projects were more varied in their topics and did not involve hands-on lab work, instead being more focused on literature review and proposed procedures. For example, the projects from 2021 included titles like: "What societal attitudes contribute to transphobic views?"; "A look at synthesizing inorganic

life"; and "How to increase battery life in electric vehicles?" We can see there was a much broader spectrum of projects, ranging from sociology to math to engineering and more.

5.8.3 Limitations of this Study

This study is a small-scale, qualitative embedded case study of a single course with around 11 students in the 2019 offering from which we primarily pull our data for this paper. Thus, we cannot make statements on the self-efficacy of the STEM-199 students pre- and post- the course as compared to the rest of the college. This also means we have limited amounts of data describing the student outcomes of the course, which is why we largely focused in this paper on the instructor moves that provided support to the students and how this CURE-like course worked at a TYC to provide suggestions for other similar implementations. We address these limitations by focusing on our qualitative case study and presenting large quantities of rich data as evidence for our claims, throughout this paper and in the supplemental materials. Though we did not primarily lean on qualitative coding as our form of analysis, it helped us organize our data into these excerpts for evidence.

5.9 Conclusion

We used qualitative methods to observe and characterize a CURE-like course, its elements, student outcomes, and lessons learned for instructors. From this analysis, it is evident that this course was positively impactful to the students and could be implemented at other institutions in beneficial ways. We described key elements to maintain if implementing a similar course, like high student-teacher ratios and instructor support as well as strong student ownership over their project directions. Supporting what was described by Corwin et al. (2015), we also see project ownership affecting student self-efficacy and tolerance for obstacles, but with the added possibility of direct impact on self-efficacy with the appropriate framing from instructors.

5.10 Acknowledgements

We are deeply grateful to the student participants in this class, as well as Todd Troutman, who was the dean of Science and Mathematics in 2019 and was instrumental in connecting our research team with the STEM Scholars program. We also acknowledge our support from the ANSER and S-STEM research team at MSU. We are also grateful to two confidential reviewers whose feedback substantially improved the organization of this paper. This work was supported by NSF award number DUE: 1742381.

CHAPTER 6 DISCUSSION AND CONCLUSION

This dissertation takes readers first through literature that informs our anti-deficit research framing and its impact on our implementation of qualitative methods studying self-efficacy and TYC transfer students. Then, Chapter 3 describes the development of a qualitative codebook to identify statements expressing explicit self-efficacy judgments. This provides a tool for answering certain qualitative research questions about self-efficacy by supporting reliable identification of self-efficacy explicit statements in qualitative data, in similar ways to quantitative survey methods. We used this tool, along with other methods, in the analysis for Chapters 4 and 5. Chapter 4 shares the story we crafted using narrative analysis of a transfer student Nicole who thrived at River College and then faced difficulties socially integrating after transferring to Lake University. We framed Nicole's story in anti-deficit ways, by focusing on how she overcame obstacles, examining the support systems in her environments that helped her from which we can learn, and presenting lessons universities can specifically learn from TYC environments to better support transfer students like Nicole. Chapter 5 continues this theme by broadening out and explicitly examining a supportive environment at a TYC. We observed and analyzed a research methods course at Mott Community College to share design considerations for implementing similar student-driven CURE-like courses. We saw ways the instructors and the course design provided opportunities for students to have potential self-efficacy source-type experiences. We specifically saw evidence that the course did support students' self-efficacy toward completing scientific research projects. In this concluding chapter, we discuss the common threads across the three body chapters and encouragement for future work in self-efficacy expanding on the work in this dissertation.

6.1 We Began Analysis with Self-Efficacy but Expanded

In all of the studies discussed in the body chapters, we approached research with anti-deficit lenses, positioning our students as the experts in letting us know how to best support them, aiming to learn from their experiences. The SEE codebook from Chapter 3 was a starting point in our analysis for Chapters 4 and 5, from which we crafted stories of successful STEM TYC and transfer students to support the creation of more helpful environments. Self-efficacy remained a thread throughout these stories, but we did expand our analyses to address broader constructs around self-efficacy.

Specifically, Chapter 4 focuses on supporting characters who impacted the directions of Nicole's story. We could frame an environment providing supporting characters as one that might provide social persuasion and vicarious learning experiences for self-efficacy. However, we turned away from focusing on self-efficacy in Nicole's story, because when we coded her interviews and journals for SEE statements we did not see many, as compared with other students we have interviewed. There are a variety of reasons we hypothesize for why Nicole did not express many explicit self-efficacy judgments in our data. We will discuss those in this section.

In developing the SEE codebook, we noticed that individual students use very different language from each other. Our codebook was designed to capture these different ways of talking about self-efficacy in qualitative data. However, our codebook does not necessarily allow for direct comparison across different people's sense of self-efficacy. For example, our codebook does not have a way to identify whether a person tends to focus on negatives or positives. The fact that Nicole did not verbally express many statements the codebook considered indicative of self-efficacy judgments does not tell us conclusively whether Nicole had high or low self-efficacy. It seems that she may just be a person who does not use language about confidence often.

From the perspective of self-efficacy, we became interested in Nicole as we gathered longitudinal data, because we thought we saw interesting experiences that might align with social persuasion, vicarious learning, and physiological state. As we shared in her story, supporting characters, including River College instructors and peers helped Nicole feel socially comfortable at River College. Those supporting characters alongside some Lake University peers ultimately improve her sense of belonging at Lake University after some initial discomfort. None of that is explicitly about Nicole's self-efficacy judgments, but beginning in self-efficacy pointed us in those directions. While we were coding for self-efficacy explicit statements, there were many cases where we felt that something Nicole said should be coded as *something*, maybe not SEE but *something* that was similar. On the same lines, we would tag excerpts describing an experience as *something* similar to social persuasion, if she described feeling supported by her instructors, or *something* similar to vicarious learning when she discussed the impact of her peers. By the literature definitions of these source experiences, they were often not aligned enough to be argued as those source experiences. Yet, our self-efficacy framework led us to focus on those scenes, from which we crafted a story telling of the impact of supporting characters on her sense of belonging and feelings of comfort at River College compared to Lake University.

In allowing ourselves to expand beyond self-efficacy, we began to notice constructs like sense of belonging that are plausibly related to self-efficacy, because feeling comfortable in an educational environment could make it more likely to have relationships with peers and professors. That opens the possibility for social persuasion and vicarious learning experiences. Furthermore, if one is comfortable with professors, one is likely more comfortable asking for or applying for things like research opportunities, which could provide mastery experiences. Plus, Nicole discusses her social anxiety as a barrier to socially integrating at Lake University, and that would

fall under a physiological state, which therefore might impact her self-efficacy. Nicole's data had elements around self-efficacy that were not explicitly synonymous, but using self-efficacy as our starting framework pointed us in useful directions.

6.2 Anti-Deficit Framing Informed the Research Approaches

We aimed to support minoritized students' persistence in STEM through supporting the self-efficacy development of TYC and transfer students, since self-efficacy is a predictor of STEM persistence, and TYC students more likely include minoritized students than FYCs. This broad research agenda was both motivated by our anti-deficit framing as researchers but also led us to learn more about anti-deficit framing to approach our research. We were interested in supporting, for example, women and Students of Color to transfer and complete STEM majors, and there were many women and Students of Color in our research population. Thus, we knew we needed to be prepared to handle discussions about microaggressions or systems of oppression that might arise. Equity-oriented frameworks informed both our approaches to data analysis and to data collection, but this was not explicitly stated in the research questions described in the three body chapters of this dissertation.

Particularly, we used counterstorytelling methods in our narrative analysis of Nicole. We presented her story as one about a successful transfer student from a successfully supportive environment at River College; and we framed the TYC setting as the expert setting from which universities should learn to develop educational environments. We saw in Chapter 2 some of the ways storytelling could be used as an anti-deficit research method.

Anti-deficit framing and thinking of systems of oppression as institutional informed our approach of examining environments and the context of self-efficacy. We can see that in Nicole's narrative analysis, but also specifically in Chapter 5. That chapter zoomed out from Nicole's

individual embedded case study to a TYC environment and discussed the components that supported students.

6.3 Despite Anti-Deficit Methods, (In)Equity, and Social Identities are Not Explicitly Discussed in the Body Chapters

Despite caring about supporting equity and being informed in our research by anti-deficit framing, this did not explicitly show up in the analysis and results described in the body chapters of this dissertation. First, this might be because we did not explicitly ask about social identities and the potential impact of systemic inequity in the research questions described in this dissertation. Thinking back to Harper's (2012) critique of higher education research studying race without racism, perhaps in studying students with minoritized identities in STEM we should explicitly ask about systems of oppression in our research questions. This could be considered particularly true in STEM, in which even if researchers aim to learn from and support minoritized students, white men are overrepresented and that can easily, even unintentionally, remain true in a research population. Furthermore, without research questions explicitly about one's social identities and the ways systems of oppression in society then differentially impact one's experiences, some people will be more attuned to or willing to discuss such things than others. Finally, societal inequities might not be relevant or present explicitly in all stories.

The literature in Chapter 1 suggests that such things are implicitly present in all stories because we live in and move through society. For example, there is an interesting moment in our interviews with Nicole where she mentions being told by many professors how hard her chosen academic and career path will be, and we asked her how she was interpreting that, whether encouraging, discouraging, or neutral. She responded that she interpreted it neutrally, that she knew it would be hard and understood her professors reminding her of that. In Chapter 1, we argued and referenced many scholars who argue that few things are actually neutral. Within an

inequitable system, anything neutral actually skews toward the bias of the system in which it is embedded. In order to achieve equity, we need to actively and purposefully dismantle inequitable systems, not just ignore them or avoid them or attempt to not take part in them. In Chapter 4, we argued that compared to explicit positive encouragement from River College instructors, neutral statements from her professors at Lake University were a downgrade and less supportive by comparison. Here, we argue one step further that a neutral statement might always be interpreted in the negative way, particularly for socially anxious women in higher education facing difficulties socially integrating and finding community.

Studies have suggested that women are more prone to anxiety than men (Bahrami and Yousefi, 2011; McLean et al., 2011; Remes et al., 2016). This can similarly be interpreted in deficit or anti-deficit ways, and informed by our framing in Chapter 1, we interpret this in anti-deficit ways. This means considering the ways society is cisheterosexist and may disproportionately prompt anxiety responses and overtime contribute to chronic anxiety in women. Thus, sexism may not have explicitly come up in Nicole's data, but it was almost certainly present through her socially anxious identity.

6.4 Self-Efficacy Alone Cannot Address Everything

Self-efficacy as a theory does not explicitly require or call for anti-deficit or deficit framing. Neither is explicitly embedded. However, as we saw throughout Chapter 1, few things are ever neutral. When we treat an environment, construct, or idea as neutral or objective, within a biased society, they skew towards that systemic bias. Thus, a framework that does not explicitly align with anti-deficit framing will easily lead to deficit framing.

When we think about the many studies that have shown cases in which women have lower self-efficacy towards certain tasks than men, such findings could be interpreted in deficit or anti-

deficit ways. We are interested in studying women's self-efficacy from an anti-deficit and systemic perspective, aiming to learn what support systems work for them and help their self-efficacy increase, in order to design more such environments. We also consider the ways systemic inequities place barriers in women's paths which might be detrimental to their self-efficacy, and that our responsibility as education researchers is to minimize those oppressive systems. We can approach those ideas using self-efficacy, focusing on how we can better support women's self-efficacy as a mediator to their persistence in STEM and how we can dismantle systems impeding their self-efficacy. Alternatively, we can approach those ideas considering other constructs that might work around self-efficacy to support women in persisting *regardless* of their self-efficacy. Maybe, self-efficacy is not the motivational construct that matters to Nicole, and that might be why she did not explicitly discuss it often.

We approached her data collection and analysis through self-efficacy, but ultimately told her story as being about social integration and belonging as bolstered by supporting characters. Perhaps we could support women's self-efficacy through targeting other types of self-belief (e.g., social identities; sense of belonging). If people with different identities interpret self-efficacy in different ways, maybe self-efficacy research has been overlooking sets of data and ways of supporting certain students because of an unacknowledged set of cultural norms within self-efficacy research. We know that women are more likely to have anxiety than men, and we also know that men frequently have higher self-efficacy in STEM than women, and those two things are likely related, since anxiety as a physiological state can impact one's self-efficacy. We should consider, as motivation researchers in higher education, if we are studying those things in the right ways. We have taken an anti-deficit approach to studying self-efficacy in these body chapters, primarily through a systemic perspective. This is a first step to address improving environmental

support for women to overcome barriers and improve their self-efficacy. A good next step suggested by our narrative analysis of Nicole is to learn from the other ways women might be mediating negative societal impacts with constructs other than self-efficacy. This is one of the reasons we hypothesize that we might have needed to broaden from self-efficacy in our story about Nicole.

This means that we caution against using the SEE codebook or generally studying self-efficacy without considering systemic factors. Self-efficacy explicitly involves examining an individual's beliefs about their own self, hence *self*-efficacy. However, the theory of self-efficacy informs us that experiences impact one's self-efficacy, and environments can provide or limit opportunities for these types of experiences. It is in the experiences and development process of self-efficacy where we can take a systemic view. More qualitative work should focus in that area in order to use more anti-deficit framing with self-efficacy.

6.5 Future Work in Self-Efficacy Should Address Higher Education's Responsibility to Dismantle Embedded Inequities

In order to collect data regarding equity and inequity it might be necessary to explicitly address this goal in one's research questions. However, there are also affordances to remaining open, broad, and exploratory. Thus, it is not necessarily an inherent problem that we did not, for example, explicitly focus on race. We aimed to be prepared for such discussions to arise. Then, this dissertation provides examples of orienting toward equity and using anti-deficit framing to approach self-efficacy work, but with open-ended research questions.

This provides a good start, but we also saw in Chapter 1 that it is a duty of higher education practitioners and researchers to address historically and currently embedded inequities. We aim to do and encourage future work expanding on this blueprint and bringing anti-racist, feminist, and accessible frameworks and using them in tandem with self-efficacy.

Among future work we have considered, we think using CRT or other antiracist frameworks could inform the addition of some experiences as potential sources of self-efficacy. Considering that self-efficacy may have historically overlooked cultural ways of thinking outside of white norms, there may be a whole set of additional potential experiences for impacting self-efficacy that have not been considered before.

6.6 Conclusion

This dissertation has introduced a new tool for qualitative study of self-efficacy and described two studies in which the tool initiated analysis focused on self-efficacy and broader constructs. We approached studying self-efficacy by examining the environments in which students exist that provide experiences that can impact their self-efficacy. We intend the codebook from Chapter 3 to be used as a tool to allow qualitative studies focused on environmental level settings and open up the possibility of characterizing additional types of experiences that might impact people's self-efficacy.

Building on the work in this dissertation, we think there needs to be more qualitative research into self-efficacy specifically using anti-deficit framing and bringing in anti-racist, feminist, and accessible theories to use in conjunction with self-efficacy. As motivation researchers in higher education, we need to examine our lenses, methods, and research questions to consider ways we are neglecting or excluding participants in our work. In science education, these research practices can work toward a more equitable learning environment to better support students' enjoyment of science.

APPENDICES

APPENDICES OF CHAPTER 3

Appendix 3A Codebook Short Reference Version

This short reference version is useful for onboarding a new coder to the codebook and directing coders to the relevant sections in the full codebook for greater detail on each step and concept.

Self-Efficacy Definition

For this codebook, we define self-efficacy as one's confidence in one's own ability to perform particular tasks, and we focus on academic tasks in this codebook.

Data Sources and Context

In creating this codebook, we used transcribed interview data and written journal reflections answering open-ended prompts. We specifically focused on self-efficacy towards academic tasks and our research participants were typically all students, so we will often refer to the person who is making Self-Efficacy Explicit statements as a "student." However, this codebook could be generalized to other contexts.

Conceptual Overview for Process of Coding "Self-Efficacy Explicit" (SEE) Statements

Broadly, the coding process for "Self-Efficacy Explicit" statements involves examining each instance of certain key words or "indicator words" that we pulled from self-efficacy survey language and then answering a flowchart of binary yes/ no questions to determine whether the indicator word in context is evidence of a person's self-efficacy judgment or not.

Coding Steps

1. Step 1
    a. Search for Self-Efficacy Explicit indicator words one at a time and address all steps for each instance of the word/ phrase. The indicator words include:
        i. Able (ability)
        ii. Can
        iii. Could
        iv. Capable
        v. Confident (confidence)
        vi. Possible
2. Step 2
    a. Examine the context of each instance of the indicator word and address the following questions:
        i. Check that the phrase is not one of the following three things that look like self-efficacy but are different from self-efficacy:
            1. An outcome expectation
            2. A statement of present confidence about past performance
            3. A simple description of what happened in the past that deceptively uses a SEE indicator word, often “able” or “could”
            4. If the excerpt is none of these three things, continue to Question 2. If the excerpt is one of these three things, it is not a Self-Efficacy Explicit statement, so do not code it.

ii. Is this word being used to describe confidence about a specific task, discipline, or career? If No, do not code the word. If Yes, continue to Question 3.

iii. Is the task about the student's academic or career-related experiences or something plausibly related to that? If No, do not code the word. If Yes, continue to Question 4.

iv. Are you sure that the student is using this word to describe themselves? (e.g., They are not describing someone else, what someone else thinks, or the general "you".) If No, do not code the word. If Yes, continue to Question 5.

v. Is the statement of confidence inside a conditional phrase? If Yes, do not code the word. If No, then select all text from (and including) the indicator word/ phrase to (and including) the task about which the student is discussing their self-efficacy and code that whole excerpt as Self-Efficacy Explicit. Then, move on to Step 3.

3. Step 3

    a. Code the tense of the Self-Efficacy Explicit statement, selecting and coding only the indicator word/ phrase itself.

        i. There are two possible tense tags:

            1. Past Self-Efficacy (Simple, Continuous, Perfect, Perfect Continuous)

                a. The task itself could be in the past, present, or future

2. Present Self-Efficacy (Simple, Continuous, Perfect, Perfect Continuous)
    a. The task itself must be in the present or future and cannot be in the past
3. Note that regardless of the tense of the self-efficacy and the task, the task must always be more in the future than the self-efficacy; in other words, self-efficacy judgments are by definition future-looking. For example, if someone says they presently feel confident about (or because of) something that happened in the past, that would not be a SEE statement but would likely be a statement describing a Mastery Experience.

4. Step 4
    a. Code the indicator word or phrase as synonym or antonym
5. Step 5
    a. Code the phrase describing the task towards which one is judging their self-efficacy

Appendix 3B Rationale for Rules Regarding Amount of Excerpt to Code

Our guidelines for the way to code are influenced by the software we used when developing this codebook. We used MAXQDA. We chose to code the "entire" excerpt entailing the SEE statement, meaning all of the sentence or sentences from (and including) the indicator word/ phrase all the way up to (and including) the task about which the student is discussing their self-efficacy. This is because coders can then export all coded statements but retain enough context to know what the student said about their confidence and the task about which they were

talking. Then, we decided that for the sub-codes of tense and synonym/ antonym, we would only code the indicator word or phrase, and similarly for the optional additional in vivo code of task, to only code the phrase describing the task. We decided this because the relevant information is captured in the highest level parent code SEE and then coders can search the cases of the sub-codes being contained by the parent code to see the full context of the sub-codes.

Furthermore, when multiple indicator words are used in the same statement, we chose to only code one of them, typically the first one we encountered when searching words. This is part of why we recommend searching for confident last, because it is often paired with other indicator words and not used on its own.

Appendix 3C More Information on Methods

What has become two separate codebooks, one for Explicit and one for Experiences, began as one joint codebook. Initially, Abby Green worked on developing the self-efficacy codebook. She had previous experience working on the Mindset codebook (Little et al., 2019). That experience and seeing another project called "Carbon Time" informed how she worked on the self-efficacy codebook. The "Carbon Time" project used a list of indicator words for coding, so Green pursued that route in creating the self-efficacy codebook, particularly making indicator words for the Self-Efficacy Explicit code. The data Green worked with was from the "Vital Signs" project, for which Dr. Vashti Sawtelle had piloted self-efficacy and mindset interview questions. Green particularly focused on data from "Leyla" because that student talked a lot and provided many good example statements for the codebook. Several examples from Leyla above are included in the paper in the indicator words example quotes. Abby primarily worked with three interviews, Leyla, Lian, and Benjamin, and though she focused on Leyla's interview, she also looked through Lian and Benjamin's interviews for ideas.

The version of that codebook that Laura Wood inherited from Abby Green, we call Codebook Version 1.0. Wood began using Codebook 1.0 between 2017 and 2018 (Wood and Sawtelle, 2019). After publishing a PERC paper in 2018 using the codebook, Wood went on to further develop the codebook. By 2019, we had made the decision to split the codebook into two, and Wood presented the codebook using a flowchart similar to the coding steps in the paper and short appendix reference version. Laura was the primary researcher responsible for iteration from Codebook 1.0 to Codebook 2.0, with support from Angela Little, Vashti Sawtelle, and D'Mario Northington. Codebook 2.0 is the intermediate stage between Abby's initial codebook and this final published version Codebook 3.0. In Codebook 2.0, the decision was made to split the codebook into two, and certain intermediate decisions were made on questions raised. Final decisions were made for Codebook 3.0. For codebook 2.0, Laura examined 16 additional interviews as well as written journal reflections from 13 students. Wood and Little had multiple meetings per week for a couple months in 2019 discussing iterations of the codebook. Wood also worked weekly with Northington for a few months later in 2019 both coding and discussing decisions for about four student interviews. Laura and D'Mario focused more on the Experiences codebook, but some decisions impacted the Explicit codebook.

Appendix 3D Iteration and Intermediate Codebook Version Decisions

In the initial version of the codebook, the indicator words were developed from published surveys measuring self-efficacy and listed in the categories of "explicit statement of ability," "confidence," and "synonyms for 'able.'" Explicit statements of ability meant the terms, "able to- positive," "able to- negative," "can- positive," "capable," "could- positive," and "could- negative." Green, an undergraduate who was the initial codebook developer, drew from literature in her theorizing of possible codes but only made codes a posteriori when she actually saw them

in the data. This is why, for example, “can” was only listed as positive, because she never saw an example in her data using “cannot” or some variant of can in a negative sense. Confidence only included the word “confident.” Synonyms for able (or not able) had two indicators, “have no clue,” and “impossible.”

We ultimately collapsed the list of indicator words into able, can, could, capable, confident, and possible, along with antonyms and other conjugations. Thus, any word could be used in the synonym form (what the initial codebook called positive) or antonym form (what the initial codebook called negative). We ultimately decided to remove the indicator phrase “have no clue,” because it and similar phrases indicating knowing or not knowing how to do some task did not seem to clearly enough indicate one’s self-efficacy and could instead indicate other explanations. We also clarified the description of how possible or impossible would need to be used in order to count as an explicit statement of a self-efficacy judgment.

Table 3A. 1 Indicator words and survey items from which they are pulled

INDICATOR WORD	SURVEY ITEMS USING INDICATOR WORD
can	“I **can** complete the physics activities I get in a lab class” (Marshman et al., 2018, p. 4) “I’m not very good at math and I **can’t** really catch onto some of the things we learn” (Usher et al., 2019, p. 10) “I **can** apply the MATLAB tools to actual situations and problems” (Hutchison et al., 2006, p. 43) “I know I **can** …accomplish my goals in physics” (Lindstrom and Sharma, 2011) “The motto, ‘If other people can, I **can** too,’ applies to me when it comes to physics” (Lindstrom and Sharma, 2011) “In general, I think that I **can** obtain outcomes that are important to me” (Chen, Gully, and Eden, 2001) “I am confident that I **can** perform effectively on many different tasks” (Chen, Gully, and Eden, 2001) “Compared to other people, I **can** do most tasks very well” (Chen, Gully, and Eden, 2001) “When I make plans, I am certain I **can** make them work” (Sherer et al., 1982) “One of my problems is that I **cannot** get down to work when I should” (Sherer et al., 1982)
could	“If I went to a museum, I **could** figure out what is being shown about physics…” (Marshman et al., 2018, p. 4) “If I wanted to, I **could** be good at doing physics research” (Marshman et al., 2018, p. 4) “I am confident that I **could** deal efficiently with unexpected events” (Schwarzer and Jerusalem, 1995) “Self-efficacy was assessed by asking subjects to indicate whether they believed they **could** successfully complete the educational requirements” (Brown, Lent, and Larkin, 1986)

	"How confident are you right now that you **could** exercise three times per week for 20 minutes if…" (Resnick and Jenkins, 2000)
able	"I am often **able** to help my classmates with physics in the laboratory or in recitation" (Marshman et al., 2018 p. 4) "I feel insecure about my **ability** to do things" (Sherer et al., 1982) "No matter what comes my way, I'm usually **able** to handle it" (Schwarzer and Jerusalem, 1995) "Has your confidence level in your **ability** to do science changed as a result of taking this course?" (Fencl and Scheel, 2005)
confident	"Describe something that happened that made you feel less or more **confident** in math or science" (Usher et al., 2019, p. 5) "I am **confident** that I can perform effectively on many different tasks" (Chen, Gully, and Eden, 2001) "I am **confident** that I could deal efficiently with unexpected events" (Schwarzer and Jerusalem, 1995) "How **confident** are you right now that you could exercise three times per week for 20 minutes if…" (Resnick and Jenkins, 2000) "Has your **confidence** level in your ability to do science changed as a result of taking this course?" (Fencl and Scheel, 2005)
capable	"I do not seem **capable** of dealing with most problems that come up in life" (Sherer et al., 1982) "I am **capable** of receiving good grades on my assignments in this class" (Fencl and Scheel, 2002)

Appendix 3E Potential Additional Indicator Words

We worked for years with many pieces of data and pulled from literature to develop this codebook's list of indicator words, but we still might not have made an exhaustive list of indicator words. Particularly, in the literature cited above from which we pulled possible indicator words, the phrases "manage/ do not manage" and "I know/ I don't know" show up in the surveys, but not in our indicator list. Many potential other indicator words we considered are often used in conjunction with indicator words that are already on our list, so the question to ask is only about when possible other words might be used on their own, since instances using an existing indicator word would already be captured by the codebook. Instances of participants using the word "know" without being attached to another indicator word in our data are typically just figures of speech or about irrelevant contexts in our research. Students often say things like, "...I [took a class], like I don't know, it really inspired me" (2019). However, an example also

from Allison's interview does use the word know without an attached self-efficacy indicator word and not as a figure of speech:

> "I mean, I was pretty sure I've always wanted to, vet school's always been my end goal for grad school. But I didn't, going into my first semester at [college] *I didn't know at all what I was doing*. So I took random classes that I thought were going to get me somewhere. Turns out …they didn't, like, count for anything here, transferring here."

This could seem like a statement of Allison's self-efficacy given that she "didn't know what she was doing," but we argue that there would be too much inference to assume that the statement is motivated by her self-efficacy and not some other possible explanation.

The quote from Victoria is a great example of the word "know" attached to another indicator word to definitely show that the explanation for the sense of knowledge is self-efficacy: "I'll probably do quite well. It's like I put in the work. I *know* how to do the math. It's that math, I **can** do that math." This example illustrates a clear self-efficacy explanation for Victoria "knowing how to do the math," but also suggests that there are other possible reasons one could know how to do something besides self-efficacy. In short, we were not convinced that "know" reliably indicated explicit self-efficacy so we did not include it as an indicator word.

Apart from a single set of journal entries, the word "manage" was almost never used by participants in interviews. An interesting case is Amani saying that a hard class "was still manageable". This would definitely not count as SEE because the task is in the past, but if we imagine a person saying that a task is currently or currently feels manageable, we could think of that as similar to the use of the indicator word "possible." In that situation, it seems that maybe that word could be added to the indicator list, but it did not show up often enough in our data or in the literature to make our list for this codebook. Similarly, in the examples of the word

manage being used in students' written journals, the three instances also use it in the past tense, so they might indicate potential mastery experiences but not SEE. In short, it is certainly likely that our list of indicator words is not exhaustive for all sets of data, but the list captured most self-efficacy evaluations in our data.

APPENDICES OF CHAPTER 4

Appendix 4A Spring 2019 after Research Methods Course at River College

This first interview conducted with Nicole focused on eliciting self-efficacy experiences and used the LifeGrid format (Rowland et al., 2019).

a. Interview protocol

- Talk about how your group decided to make changes to your initial idea for your project, and also how you felt about changing from your initial interests.
- Can you walk me through how your project evolved over time?
- Just because I didn't get to interact with any of you over your spring break, could you tell me if you did any work on your project over spring break?
- Looking back at the details of each week, is there anything you're surprised by or would do, answer, or describe differently now?
- Can you tell me about previous experiences you have with doing science experiments and how they prepared you or didn't prepare you to complete this project?
- Discuss how you feel now, at the end of your project, about the goal you set for yourself in the first week of journaling. How do you feel about your success accomplishing the goal? How did this goal change throughout the semester?
- How did your overarching goals for what you wanted to take away from this project experience change over the course of doing the project?
- Both now, having finished the project and looking back on the whole experience, as well as thinking about smaller achievements throughout the process, how do you feel you did in achieving your goals?

- Discuss your collaboration each week with other people in the course and your contribution to the project each week.
- Could you describe how you remember feeling each week in terms of your confidence in your progress on your project?

b. Summary of Journal Prompts

The journal prompts to solicit reflections were distributed each week as part of the course activities. These prompts were designed to elicit statements related to academic and scientific self-efficacy experiences. Examples of some of the journal prompts include:

- What did you work on for your project in this past week?
- What were your project goals, and how satisfied do you feel with your progress on these goals? What are your goals for next week, and how confident do you feel about your ability to complete those goals?
- What did you learn this week that helped you move forward in your project?
- Describe an experience from working on your project this week that stands out to you as memorable.
- Discuss any interactions you had with your instructors this week. What went well and what could be improved?

c. Spring 2019 Interview Excerpts

1. Excerpt 1

INTERVIEWER: How was the process of finding a group? Because I feel that one week nobody had groups and then the next week everybody had their groups and their projects. So, how did that happen?

RESPONDENT: Yes. I just remember standing in the hall. I heard [Collette]and I think it was [another student]. We're talking and it sounded like [Collette] also wanted to work with animals so I just asked her if she had a partner yet. I think, at the time, she was thinking about working with [other student] as well. But I asked to join the group and that's kind of how it started.

INTERVIEWER: Cool. Yes, I was wondering too how they all kind of just ended up being partner groups. Were you originally thinking of being a group of more than two people and then it just fell through working with [other student] as well?

RESPONDENT: Originally, I didn't really care how many people were in the group.

INTERVIEWER: So, it just ended up that everyone was in their groups?

RESPONDENT: Yes, and [other student] ended up working with some other group in the end.

INTERVIEWER: You just kind of overheard her and were like, "Hey, I don't have a partner"?

RESPONDENT: Yes, (chuckles) pretty much.

INTERVIEWER: Cool. And then the next week you said that you had joined a group that was interested in that. At that point, you guys were just like, “We want to look at water quality and fish”?

RESPONDENT: Yes.

INTERVIEWER: That was the level of specificity. That probably covers that whole week then. ...Do you remember anything else big that went on in the week where you decided what you wanted to do? It looks like the next week you were discussing ideas. You wanted to look at heavy metals in water and fish. And that changed, right?

RESPONDENT: Yes. For the first couple of weeks of the experiment, actually, we kept talking to all of the professors. None of them even knew if we could do this project. So, we were really worried.

INTERVIEWER: Yes, I was noticing that because there was one week where [professor] had said that you would be able to do it. And then the next week you were talking to [another professor] again and he was still unclear if you would be able to do it or not. So, it sounds like the professors all had different communication with you and different ideas of things to say.

RESPONDENT: Yes.

INTERVIEWER: Did you feel it was not organized or did you feel that that added to your stress some? Or was it useful having all of the different professors able to help in different ways?

RESPONDENT: It was useful for them to help in different ways, but at the same time it did add to the stress. And then not knowing 100 percent if we would be able to do it. A very confusing time as well (chuckles) trying to figure out a different experiment that we could do just as a backup if we weren't able to.

INTERVIEWER: I feel like you guys had a pretty good backup plan all along, though, right? [0:06:19]

RESPONDENT: I think so, yes.

2. Excerpt 2

INTERVIEWER: I also felt like some of the groups worked more specifically with one instructor or the other based on the expertise of the instructor. Do you guys feel like you worked specifically with someone over someone else? I forget what expertise each one has. Were you working with someone specifically more?

RESPONDENT: I would say probably in between [first professor] and [second professor] just because we were looking at the more animal biology and some chemistry...

INTERVIEWER: Right. That's what it is. Thank you. I was like, "I can't remember what they all do." Did you know the instructors before this class?

RESPONDENT: I knew [first professor]. I had him in my very first biology class in my first year here. He probably doesn't remember me (chuckles). So, I had him and then I think that was a semester before I had [second professor] for my chemistry lab. At the time, I was taking Organic-1, which he was also my professor for that as well. I had never actually met [third professor] before that class.

INTERVIEWER: I feel like I've talked to some other people in the interview, and they found it really helpful that they were already comfortable with the instructors. Did you feel like that was helpful? That it was like, "These are people that I know"?

RESPONDENT: Yes, it did. It was very helpful to also get to know [third professor] even more because that was my first time meeting him and I had him for that class, and another class at the same time. Now I have him again.

Table 1A.

Overview of emotion statements in Nicole's journals from River College Scholars methods course

Table 4A. 1 Emotion words in Nicole's journals

WEEK # OF JOURNALS	EMOTIONS DESCRIBED
1	*None*
2	*Passionate*: "the reason being that we both seem very passionate about working with animals."
3	*Proud, worried, encouraged*: "While we are just starting on finalizing our project idea, I'm proud of the fact that we know specifically what we want to do our project on and that we have a back-up idea in case we are unable to do what we initially wanted to do." "I am a little worried about getting the project done on time." "They then went on saying that even if we do not find a heavy metal that we are looking for, then that is still a result. It was encouraging to me to hear that last part as it is easy to forget that."
4	*Proud, frustrated, satisfied*: "I am proud of the fact that we have finally made a decision on what we wanted to do for our research project." "However, I am beginning to be a little frustrated by the fact that we have yet to actually start the project, so I kind of feel a little 'behind schedule.'" "I feel a little satisfied with the progress we have made, but I wish we could have done more."
5	*Proud, frustrated, worried*: "I'm proud of the fact that [Collette] and I have finally found something we really want to do and that at this point we are just waiting for materials." "However, I am very frustrated by the fact that we may not be able to work on this research idea." "He had told me that he was unsure if we would be able to do research involving animals, which is really worrying me."
6	*Happy, frustrated, satisfied, afraid*: "I'm happy that we bought all of the materials that we need." "However, I am very frustrated by the fact that we didn't have enough time to find a place to get the river water." "Unfortunately, during our drive with [professor], we were unable to find a good place to collect the water, so I only feel a little satisfied with our progress." "We are unsure if we should just feed them earthworms, something that they might eat in nature, or if we should give them carnivore pellets, which we are afraid might make the fish more aggressive."
7	*Proud, frustrated, satisfied, excited (x2)*: "I am very proud that we have completely prepared both tanks for the fish and already have the fish in the tanks." "I would normally be frustrated about the feeling of being very behind in our project, however, the professors talked about us being able to continue our research into the next semester. Therefore, at the moment, I do not feel that frustrated about anything." "I feel very satisfied with the progress we have made in our research project." "Additionally, all of the instructors talked about how we may be able to continue our research project into the next semester, which is very exciting to me." "I feel very good about my contribution and I am very excited to learn more about how to take care of fish and how to measure them."
8	*Proud, frustrated, pleased, afraid*: "I am very proud that we have started collecting data on the fish." "However, I am frustrated by the fact that we seem to be losing fish quite frequently." "I am very pleased that we are on our second day of collecting data on how the fish are progressing." "I feel good about what I have been contributing, however, I wish that I could help out more with the fish but I am too afraid of hurting them."
9	*Proud, frustrated, afraid, satisfied, feeling good*:

	“I am proud that we have finished collecting the data that we need.” “However, I'm a little frustrated that we haven't really had time to work on the poster.” “and I'm afraid of not getting it done on time.” “I feel somewhat satisfied with the progress we have made.” “I feel pretty good about my contribution.”
10	*Proud, frustrated, proud, satisfied*: “I am very proud that we have officially completed the experiment and created a decent poster.” “However, I still feel a little frustrated that my partner and I never really had a lot of time to work on it more outside of class.” “I am most proud of the fact that not all of our fish died, as we thought they might have by now.” “I feel pretty satisfied with how we did as I think our poster is decently good.”

Drawings of settings adapted from the observational fieldnotes

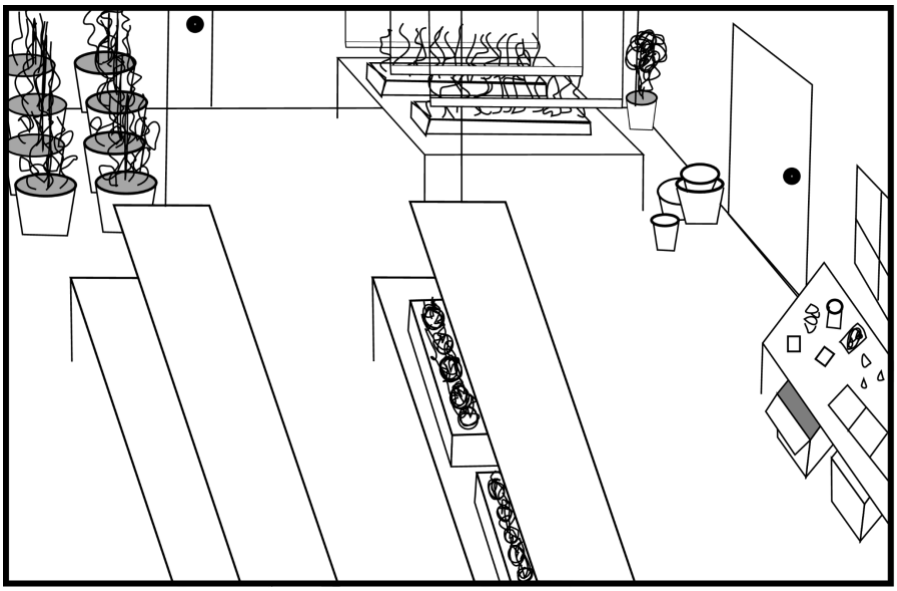


Figure 4A. 1 River College Greenhouse

Appendix 4B Fall 2019 (First semester at Lake University)

The following interviews at Lake University again focused on eliciting self-efficacy and self-efficacy experiences. These interview prompts were largely drawn from published work probing self-efficacy experiences in interviews.

a. Interview Protocol

- Can you tell me a little about yourself?
    - What are you studying in college?

    - Where did you start your college path?
- Did you “graduate” from the community college?
    - In your experience are there differences for students if there is intent on transferring vs. staying at [River College] for a specific program?
    - [If yes], so when you finish [at Lake University] will you have graduated twice?
- Do you have ideas about what you might want to do after college?
- What classes have you been taking this semester?
- What’s your major [at Lake University]?
    - Tell me one memorable story that would help me understand how you came to be pursuing your major. (modified from Zeldin and Pajares, 2000)
    - What do people you know (family/teachers/peers) say to you about your decision to pursue this major plan? (modified from Zeldin and Pajares, 2000)
    - Have you gotten any messages from society about your choice? (modified from Zeldin and Pajares, 2000)
- Looking back at your academic career, is there anything you would do differently if you had the chance? (modified from Zeldin and Pajares, 2000)
- I’m really interested in how students view success in classes. Can you tell me about your thoughts? How do you define success in your science classes? What do you need to do to consider yourself successful? (modified from Hutchison et al., 2006)
    - Anything else?
    - If you had to rank these things, which is most important?

- I'm also interested in how successful you think you will be as a science student. To what degree do you think you will be successful in your science classes? (modified from Hutchison et al., 2006)
    - On what experiences are you basing your judgment?
    - How have other people influenced how you think you will do?
    - How have people (family/teachers/peers) encouraged/discouraged you to succeed?
- Tell me about a time you felt really confident about your performance in a particular science class. It could be a class you're taking now or one you've taken in the past. (modified from Hutchison et al., 2006)
    - What about that experience made you feel confident?
- Finish this statement: When I'm looking back at my college days, I'll think I was successful if _____ (modified from Hutchison et al., 2006)
    - How do you believe your peers would finish this statement?
- Tell me a little bit about your experience of transferring to [Lake University]. What went well? What could have been improved?
- What do you think the main challenges are in completing the requirements for your major? What are you most worried about?
- Have you had much opportunity to interact with the [Lake University Scholars] program yet? What has that looked like?
    - Have you had your meeting with the [Lake University Scholars] Advisor?

    - One thing we've heard happens in meeting with [the Lake University Scholars advisor] is laying out a schedule for the time that you're here - could you tell us more about that?
- Is there anything you would like us to know about how to support students who, like you, transfer to [Lake University] from a two-year college?

b. Fall 2019 Interview Excerpts

1. Excerpt 1

INTERVIEWER: So, first of all, can you just tell me a little about yourself? What are you studying? Where did you start? That kind of thing.

RESPONDENT: Yes, so I've always wanted to be a veterinarian since I was little. Over at [River College] at the beginning of the [River College Scholars] program there, we had to take a course over the summer. I don't quite remember what it was called but it had something to do with figuring out what you wanted to do. And that solidified what I wanted to do, but it also directed me to a specific type of veterinarian. So, I found out that I really want to work with wildlife or a zoo. So, there's that (chuckles).

INTERVIEWER: What kind of specific veterinarian program is that then?

RESPONDENT: I don't think there's a specific program for it, but it just directed me into exactly what animals I want to work with.

INTERVIEWER: You can't be a veterinarian major as an undergrad, right? So, what's your major now?

RESPONDENT: Integrated biology and then I just decided to double major in zoology since there's a lot similar in the two.

INTERVIEWER: I'm also curious what was it about that summer course or program that helped you figure out what kind of veterinarian you wanted to be?

RESPONDENT: There were a couple of programs that we looked at on the computer and I don't know. One of them just talked about zoo veterinarians and I was like, "Yes, I'd really love to work with more exotic animals and stuff like regular cats and dogs."

2. Excerpt 2

INTERVIEWER: Have other people influenced you at all on how successful you think you'll be as a science student?

RESPONDENT: I don't know (chuckles). I don't know if this is really answering your question or not, but I find it helpful to study in groups and stuff. Talk about any problems that do come up and that I don't quite understand. Even talking to the faculty members and the professors. So, I know that stuff helps and even sometimes if I'm really struggling, I'll even go to my brother because sometimes he can help out too (chuckles).

INTERVIEWER: Have you found a study group here?

RESPONDENT: Not yet. It's more like I've been placed in groups inside of classes. So, we have group activities that help me understand things better.

INTERVIEWER: Is that experience, being placed in groups inside of classes, unique to [Lake University] or is that across all of those experiences you were thinking about?

RESPONDENT: I don't think I've ever really dealt with that outside of [Lake University] actually. Not that I can remember at least.

INTERVIEWER: So, the study groups from other courses would've been things that you did for yourself?

RESPONDENT: Mm-hmm.

INTERVIEWER: How did you find those people? How did that work for those other experiences?

RESPONDENT: It was mainly just in chemistry I had to do that with and it was just people that I quickly got along, and people that I just sat next to in class who also felt like they needed help in understanding everything. So, we helped each other and what we learned.

INTERVIEWER: Did you all set up meetings outside of class?

RESPONDENT: Yes.

INTERVIEWER: How did you do it?

RESPONDENT: Just trying to find a time that worked (chuckles) for everyone.

INTERVIEWER: And then you'd all meet together in a place?

RESPONDENT: Yes.

INTERVIEWER: Then what would you do when you met together?

RESPONDENT: Discuss problems that we had and try to figure it out together as a group. I don't know really how else to -

INTERVIEWER: So, you just went through, "I don't quite understand this"?

RESPONDENT: Yes.

INTERVIEWER: But you thought that those things really helped you?

RESPONDENT: Yes.

INTERVIEWER: Helped you with what?

RESPONDENT: Just understanding the material in more depth. Just in general (chuckles).

INTERVIEWER: It sounds to me that you've said that at [River College], maybe also in high school, you found study groups in chemistry specifically by just finding people who also needed help like you did, working with them. And then it sounds like this semester you haven't really found those study groups at [Lake University] yet. Maybe it's just a question of time, but do you have a sense of what's different between the [Lake University] experience and the [River College] experience?

RESPONDENT: I kind of feel like it was easier to find people who you get along with over at [River College] because it is a smaller school. So, it just seemed like - I don't know how to explain it. Here I find it's more difficult to find that sense of belonging and harder to find people that you get along with. That's just my personal experience so far though.

INTERVIEWER: Can I push a little bit and ask you to unpack that a little bit?

RESPONDENT: Yes.

INTERVIEWER: When you say that it's harder to find people you get along with, it's harder to have a sense of belonging, do you have any examples or stories? Can you take me to a moment in your experiences where you really felt that?

RESPONDENT: There have been some times in some of the groups that I was assigned with that I just don't really get along with the people. They don't have the same sense of - They don't really put as much effort into the project sometimes and I can't really see myself as getting in a study with them when they don't seem to care as much as me. (chuckles)

INTERVIEWER: So, it's a sense of, "I really care about doing well here and other folks don't care as much," is that what -?

RESPONDENT: Yes. Some people, at least.

INTERVIEWER: I really resonate with that. I'm trying to connect it, too. So, I think that makes a lot of sense to me for finding a good study group. So, you got assigned to a group in class, these people I don't really fit with. But I think one thing that could've happened, as you would say, is, "I need to find other people to study with." But that isn't something that has happened for you?

RESPONDENT: No. So, I have a lot of social anxiety. It's very hard for me to go up and talk to people.

INTERVIEWER: So, then, can I extrapolate slightly from that to say that at [River College] when you say it was easier, is it also that there are fewer people?

RESPONDENT: Yes.

INTERVIEWER: How big are your classes right now this semester?

RESPONDENT: (chuckles) So, I have some pretty big lectures talking about - Some classes are smaller. I know one of my classes, probably 30 or 40 people, but then there's other classes, ones that I am more struggling with, and there were hundreds of people in there.

INTERVIEWER: Like MicroBio for instance?

RESPONDENT: Yes.

INTERVIEWER: Can you estimate for me? Two hundred people? Four hundred people?

RESPONDENT: Probably between 200 and 400, yes.

3. Excerpt 3

INTERVIEWER: So, beyond your peers, have other people encouraged you or discouraged you to succeed in science specifically?

RESPONDENT: Not so much [at Lake University] because I haven't actually been able to talk to any of the professors, mainly because I really haven't made the time to. I couldn't find the time to. But I know over at [River College] there were some faculty who supported me in what I wanted to do and the same with my family and friends.

INTERVIEWER: What does that support look like?

RESPONDENT: Basically, not so much pushing me to do anything that I don't want to do. Even if with my parents, if I get a bad grade they don't really care as much because they just care that I'm actually going to college and trying this, and doing what I want to do.

INTERVIEWER: How do you know that they don't care about the bad grade but they do care about you doing those other things?

RESPONDENT: They've told me (chuckles). They said pretty much, as I said before, that it's okay if I get a bad grade. Just keep doing what I'm doing. Try as hard as I can and if I don't succeed as much as I'd personally like to, then it's still okay.

INTERVIEWER: Is there a particular memory that you're thinking of when they said those things? Could you share with me that actual memory that you're thinking of?

RESPONDENT: It's been so long (chuckles). Honestly, I can't really remember the memory.

INTERVIEWER: It's just a sense that this happened?

RESPONDENT: Yes.

INTERVIEWER: So, it also hasn't been recent.

RESPONDENT: Yes, it was in high school. Early high school.

INTERVIEWER: So, I'm going to go back a little bit and think you have a very clear path. You want to do this vet Med. You're thinking of wildlife or zoo vet. Can you tell me a story that would help me understand how you came to decide you wanted to be a vet?

RESPONDENT: As I've said, I always wanted to do it when I was little. Ever since I was little.

INTERVIEWER: Did you have pets?

RESPONDENT: I've had pets. I've had cats, dogs, birds. Right now, I have a bearded dragon and I've had scorpions in the past (chuckles).

INTERVIEWER: What is a bearded dragon? I mean, it's not a dragon, right?

RESPONDENT: (chuckles) It's a type of lizard. Do you want to see a picture?

INTERVIEWER: I would love to see a picture.

INTERVIEWER: How did you get into volunteering at the zoo?

RESPONDENT: I really wanted to get some experience in working with zoos. Whether it was volunteering or internships. So, I found the closest zoo to where I was living (chuckles) and I applied and went to the orientation and here I am.

INTERVIEWER: How long have you been volunteering?

RESPONDENT: Since the end of July I believe.

INTERVIEWER: Did you move down here to go to school out here?

RESPONDENT: Yes.

INTERVIEWER: Now you're living in the [Lake University] area?

RESPONDENT: Yes.

INTERVIEWER: I was just curious because you said it's the closest zoo.

INTERVIEWER: Do you think that volunteering at the zoo might open up some opportunities to working there or a summer internship or do you not have any idea yet?

RESPONDENT: I'm hoping so. I actually just applied for an internship there for their animal care. So, I'm hoping that my experience in volunteering there so far will help me get it (chuckles).

INTERVIEWER: Did you just see a flyer up on the wall to apply for that internship or how did you hear about it?

RESPONDENT: I looked at it online. So, I went through their website and everything found that they had an animal care internship, and I applied.

INTERVIEWER: Are you applying to other kinds of internships like that?

RESPONDENT: Not right now. I'm going to see how this one goes first, and then depending on how it goes I might apply for other ones.

INTERVIEWER: So, again, thinking your path is pretty well defined. How do people that you know, your family, teacher peers - what do they say to you about your decision to be a vet?

RESPONDENT: I keep hearing from professors a lot that it's very difficult to get into the vet program. And I know my parents have said it too. But, again, they're pretty happy and proud of me for trying to become a veterinarian (chuckles) in the first place.

INTERVIEWER: Professors [at Lake University]? Professors at [River College]? Teachers? Who are the people?

RESPONDENT: Both (chuckles).

INTERVIEWER: So, I heard you say that you haven't really talked to your professors [at Lake University].

RESPONDENT: There's been a couple of cases where I have. But not in detail on trying to get help for my classes and getting to know them a little on a more personal level.

INTERVIEWER: So, it's just kind of a meet-and-greet conversation?

RESPONDENT: Kind of, yes.

INTERVIEWER: Okay. And so, they hear you want to be a vet and they say that it's hard to get into?

RESPONDENT: Yes (chuckles), pretty much.

INTERVIEWER: I'm curious, if you don't mind me asking, how it makes you feel when people say, "Oh, it's really hard to get into that program"? Do you feel like they're encouraging? Do you feel like they're discouraging? Do you feel like it's a neutral statement?

RESPONDENT: Neutral statement. I know it's going to be hard to get into. I know how competitive it is. So, I don't really see it as being discouraging or encouraging. I just see it as they're stating a fact that I already know (chuckles).

INTERVIEWER: So, you said your teachers, you've heard that a lot, and your parents I think you said also. And then I also hear you had this experience at the zoo. I'm curious. Do you have a sense from broader society about the decision to be a vet? Have you gotten any ideas? That's probably a weird question. Is there anything outside of those specific people that you feel from society that tells you about your choice to be a vet?

RESPONDENT: Not really.

INTERVIEWER: (chuckles) There was no TV show that you watched growing up or other cultural norm kinds of things?

RESPONDENT: No.

INTERVIEWER: How did you even come up with the idea of being a vet?

RESPONDENT: My love for animals and in high school we started dissecting things and I enjoyed being able to learn about the anatomy of different animals.

INTERVIEWER: And you did a Google search, “If I like animals, I’m destined for things”?

RESPONDENT: (chuckles) Pretty much. There was some career, I guess, quizzes that sometimes I had to take for classes and stuff.

4. Excerpt 4

INTERVIEWER: I’m going to switch gears a little bit and I want to learn more about your experience in actually transferring to [Lake University]. Can you tell just what went well, the actual moving and starting [at Lake University]? What went well?

RESPONDENT: I think in general everything went well. Orientation and everything certainly helped and even going around on my time and walking around campus, seeing where my classes are, definitely helped as well. I can’t really think of anything (chuckles) else right now.

INTERVIEWER: Is there anything that could’ve been improved that would have helped you?

RESPONDENT: Yes. So, I think that there definitely - I don’t know exactly how, but definitely a way to better prepare me in terms of difficulty for classes. Because I went from [River College]

where everything basically seemed more like high school and then I came here. I was like, "Wow, this is so much more different. So much more difficult than the classes that I previously took."

INTERVIEWER: Can you help me understand a little more about what feels so different and the difficulty? Is it that you have to cover more content? What are the things that -?

RESPONDENT: I think it partially deals with having to cover more content as well as I felt like over at [River College] it was more like just looking at something, memorizing for the test, and then that's it. But then here, it seems like more understanding in detail, and - I don't know how to phrase it. But if someone were to say from microbiology, if someone were to get this certain virus what happens next, and what can prevent this, and just understanding things in more detail versus on the surface, if that makes sense (chuckles).

INTERVIEWER: So, could you contrast that example? [At Lake University], someone would say, "If you get this virus, what could happen next?" At [River College] what would that question have looked like?

RESPONDENT: It's hard. I don't really know (chuckles) how to describe it actually. I felt like at [River College] it'd be more in terms of, say, showing a picture of a virus and them being like, "What kind of virus is this?" Instead of going more into detail. I don't know if that makes (chuckles) any sense.

INTERVIEWER: Yes, it does. It makes a lot of sense to me. The idea that you just have to do a matching game and, in your brain, is this the thing they want or not or do I have to be able to do more than just matching?

RESPONDENT: Yes.

INTERVIEWER: You said that helping you be prepared for that difference and I know you said I'm sure what. So, I won't (chuckles) necessarily ask to say what you think that could be. But I'm curious about how that felt in that first experience where you were like, "Oh, this is different." What were you feeling? What did that feel like?

RESPONDENT: I was feeling very overwhelmed. I was very far behind in some of my classes in terms of taking notes and everything. And I felt like for some of the exams I wasn't very well prepared because of how far behind I was and how overwhelmed I felt, and the shock (chuckles).

INTERVIEWER: This is probably a little uncomfortable so I apologize but if you situate yourself back into that feeling of overwhelmed you said you were feeling behind. Is it that you physically couldn't keep up with the notetaking? What was contributing to that feeling?

RESPONDENT: I was physically behind in specifically two of my classes. One of them was microbiology, which is why I probably still feel like I'm not (chuckles) doing a very good job in that. As well as my [other class]. Especially with microbiology, it's a hybrid class. So, all the lectures are online and then we come into class on Fridays and just do a group activity pretty

much. So, I always kept trying to print off the lectures and then watch the videos that they gave us, and take additional notes. But I just kept running out of time every single time, and I just kept getting so far behind. I was at a point where I couldn't do it anymore (chuckles) and I just started watching the videos and not so much taking the notes anymore because I just physically couldn't do it.

INTERVIEWER: So, thinking about that physical. I'm curious to know more about - So, you had five courses, which sounds like a lot to me. Were there other commitments on your time that were taking up so that you just physically ran out of time to do things?

RESPONDENT: Yes. So, as I said, I was behind in two classes and one was microbiology. The other one was [a different class], and for that class, we have to read books every week. And so, I felt like that was another very time-consuming commitment. As well as my volunteering over at the zoo, and then being in the [recreational club] as well as the [academically relevant club] here. It's just a lot that I took on all at once that I probably shouldn't have (chuckles) but I did anyway.

INTERVIEWER: Given that statement, is there anything you're planning to change next semester?

RESPONDENT: Probably going to stop being in the [recreational club] for a while. Just be in the [academically relevant club]. Something that is more directed towards what I want to do. Depending on what exactly happens with the internship, right now I only have four classes, I believe, instead of having five and committing to doing more homework I'm doing less now.

And possibly volunteering a little less than I normally would. But other than that, that's pretty much all the changes I might take (chuckles). Considering at least.

5. Excerpt 5

INTERVIEWER: Do you think that there was a difference for students at [River College] who planned to transfer like you versus the students who were planning to just finish up at [River College] and be done? Graduate with the associate's and be done?

RESPONDENT: I haven't really thought about that, actually. I don't think there would be much of a difference between that. None that I can really think of at least.

INTERVIEWER: And then because you did graduate with an associate's, I'm curious just how you think about it. Will you graduate twice then when you get your bachelor's? How are you thinking about that?

RESPONDENT: I guess technically (chuckles) yes.

INTERVIEWER: So, if I asked you something about graduation, what would you be thinking about at this point?

RESPONDENT: Personally, I don't know. So, I have an older brother who is in his pharmacy school right now. His third year, and the way that he's taking it has influenced how I see it as

well. Because I know he didn't really make much of a big deal of graduating. He also went to [River College], so he didn't really make about a big deal about graduating there and he didn't really make a big deal with his bachelor's. So, I don't really see it as a big deal either, but I also see it as graduation because it is something to be celebrated.

INTERVIEWER: Could you tell me a little bit more about what you mean by a big deal? What would that look like?

RESPONDENT: Actually, going to graduation sort of thing and (chuckles) -

INTERVIEWER: Walking with the robes on and everything.

RESPONDENT: Yes.

INTERVIEWER: So, you did not do that for [River College].

RESPONDENT: I actually did. I wasn't really planning for it, but everyone was excited because I was the first [River College Scholar] to graduate from [River College]. So, I felt kind of obligated (chuckles).

INTERVIEWER: So, if you had been following your brother's path, you would have not done it?

RESPONDENT: Yes.

INTERVIEWER: Can you tell me; how did you know people were excited about you walking?

RESPONDENT: Everyone kept talking about it. [Dean of college] over there, he kept showing me the stole and everything for the [River College Scholars] (chuckles) program. So, I was like, "Okay."

INTERVIEWER: It seems like a big deal.

RESPONDENT: I guess, yes.

INTERVIEWER: And are you thinking you will go to the commencement ceremony when you graduate from [Lake University] or are you still like, "I don't know"?

RESPONDENT: Probably not for the bachelors, but when I graduate and get my DVM..., that's probably when I'll walk.

INTERVIEWER: So, you are planning to go to vet school...

RESPONDENT: Yes.

INTERVIEWER: That's your goal. Great. So, my question would've been, plans for after college. But I feel like right now you've told me some of that. I don't know if you want to add anything to what you've told me already.

RESPONDENT: Right now, I'm looking into the next four years pretty much. Four, six years, I guess. Going to vet school ...and hopefully afterward trying to find a career related to zoo animals. Maybe wildlife.

INTERVIEWER: And when you say four to six years, could you break it up for me? How much more time do you think you have for your bachelor's versus how much is vet?

RESPONDENT: Including the semester, two years for my bachelor's and then probably four years for my graduate. I'm not actually sure because it is with zoo animals so I'm not really sure if there's more schooling I need to take for that since it's more diverse.

INTERVIEWER: That makes sense to me. Have you met with an advisor where you know two years is the amount of time it's going to take you [at Lake University]?

RESPONDENT: Yes, I met with the [Lake University Scholars] advisor. She said I should be able to finish my bachelor's in two years.

Appendix 4C Spring 2021 (At the end of 2nd year at Lake University)

a. Interview Protocol

- How has this semester at [Lake University] been?
    - How did it compare to your other semesters?
- What classes did you take this semester?
    - How did you feel those went?
    - Compared to your last two semesters at [Lake University]?
    - Compared to classes at [River College]?
- How much do you feel you've found community at [Lake University]?
    - Have you made any progress with finding a study group or feeling like you belong at [Lake University]?
    - In the past you've also mentioned having social anxiety; how much of a factor has that been in this semester?
- Have you gotten to know your professors [at Lake University]?
    - How do those relationships compare with the ones you had with professors at [River College]?
- Do any people at [Lake University] stand out as helpful for you making connections and finding community at [Lake University?
    - Advisor, teacher, peer, friend, roommate, etc.
- How involved were you with the [Lake University Scholars] program this semester?
    - What did that look like? What did you do?
- What has the [Lake University Scholars] program offered this semester, both in terms of social events and professional events?
- What is your plan for your next step after graduating from [Lake University] with your Bachelor's degree? Has it changed?

- How much longer do you expect to spend at [Lake University] before getting your Bachelor's degree?
- We noticed some big changes in your responses to the self-efficacy survey you filled out a few weeks ago from when you filled it out at [River College]. Do you have any ideas about what contributed to those shifts?
    - For example, while you were at [River College], you answered that you agreed that you were confident you could master the skills being taught in your remaining classes in your major department, but a few weeks ago you answered that you disagreed. Do you have a sense of what might have changed?
- Think of a time you felt really confident about your performance in a particular class—either one you're taking now or one you've taken in the past. What about it made/ makes you feel confident? Take me back to that moment; what were you feeling and experiencing?

b. Spring 2021 Interview Excerpts

1. Excerpt 1

INTERVIEWER: So maybe this is a difficult question because obviously the last semester and then some of the semester before that have been very different just with the pandemic, but have you noticed any interesting differences or similarities or things that have changed between like the first semester that you spent at [Lake University] and you know where you're at now at [Lake University]? What do you think has sort of changed in your time?

RESPONDENT: So definitely like the biggest change is my overall schedule. Obviously being in person, like had me more on track. There was times where I would just be on campus in between classes and I'd spend that time doing my homework and not it's like I'm just sitting at home in my bed and it's like oh, I could do my homework but you know there's some shows I've got to watch now too.

INTERVIEWER: Yes.

RESPONDENT: So it's a lot of it is like procrastination and just like kind of like the idea of like being in a place that I'm not used to doing my homework and I'm used to like sleeping and like watching TV and doing all these other things. Just kind of like that association. And another big difference is like not actually having like in person like being around people.

It's definitely a lot more different and like kind of like harder to, not like talk to people because like a lot of classes still have like discussion boards and everything. But it's definitely harder to kind of like get closer to classmates in terms of like making study groups and everything for me.

INTERVIEWER: Yes for sure, I definitely feel that. So on that topic then of sort of the community and the finding study groups at [Lake University] and stuff, how has that been going? You know have you been able to maintain much community in general? Have you been able to do much class work and studying with other people, what does that look like?

RESPONDENT: Not really. I'm the kind of person that would so much rather prefer to be in person than like video chat like, so like, like right now I'm like generally comfortable with you because I've been around you so often, but with other people and like meeting them for the first time it's definitely like my social anxiety like really kicks in and I just, I can't handle it.

INTERVIEWER: I understand I generally am even more stressed for Zoom interviews and stuff than in person, so I feel that yes. Have you, but you mentioned that you have been able to sort of talk to some people in like class online discussion groups and stuff, so has there been any support or structures in place to keep that class interaction going?

RESPONDENT: Usually the professors will kind of give like an assignment based on like the discussion board.

So like whether it's like you posting a question or like a topic, and other people are supposed to like reply sort of thing, so it's more like a mandatory thing if you want to get a grade more than like, hey, if you have any questions sort of thing, or like just want to talk about the class in general.

INTERVIEWER: Yes that makes sense, and sometimes mandatory discussion I feel like can work but maybe sometimes it's, doesn't go anywhere once you've checked off the box.

RESPONDENT: Yes.

INTERVIEWER: Yes, okay. So does that mean then that you have mostly been doing your class work and homework by yourself for the most part?

RESPONDENT: Yes.

INTERVIEWER: I'm sorry that's frustrating, it can make difficult classes even harder.

RESPONDENT: Yes.

INTERVIEWER: Yes, some especially in the last time that we interviewed you mentioned a difficult time finding community and study groups at [Lake University] and your social anxiety having a big impact on that. It sounds like that's still been a really big factor right now?

RESPONDENT: Yes.

INTERVIEWER: But can you just say more about you know what that's looked like during the last semester?

RESPONDENT: Yes, so during last semester like I kind of said before, like it's mainly just been like me by myself for the most part, just like focusing on my homework. Of course there's like, not so much with like people on [Lake University campus] like community or anything but like I'm lucky enough to be able to like say, come home, spend some time with my family or like even spend some time with my roommates or my boyfriend.

But in terms of like community for [Lake University] there really hasn't been much interaction.

2. Excerpt 2

INTERVIEWER: So next question and you know a lot of these questions are obviously going to be weird during times of COVID and I expect that in the answer, that's totally fine, but have you gotten to know any of your professors [at Lake University] or sort of found any you know professors you're closer to than others, any mentors, anything like that?

RESPONDENT: A little bit, it's just been like basically getting to know them through their classes more so than anything else. But the, my professor for I believe it was [biology class], I got to like kind of know all of the work she does in terms of like she does a lot of like citizen science... Which I think is really cool. ...And then there's been a couple classes where I've had the same professor and I believe it was, I can't think of her last name right now, I think it's [last name].

INTERVIEWER: That's okay I'm not going to know these professors anyway.

RESPONDENT: Yes I think it's [last name].

INTERVIEWER: Do you remember any of the classes that you took from that professor where you got to know them?

RESPONDENT: [Genetics class] and then [biology class].

...

INTERVIEWER: And so you mentioned that the [biology] class was one of the classes this semester you sort of liked more and then also that you've gotten to know that professor. Do you think that that was a big part of why you liked that class more?

RESPONDENT: I'd say that's part of it yes. I think most of it was just really liking the content though.

INTERVIEWER: Okay, so it maybe started with the class content being interesting and then you kind of also grew to like that professor.

RESPONDENT: Yes.

INTERVIEWER: So in terms of the relationships you're able to make with professors at [Lake University] and getting to know professors at [Lake University], how does that compare with the kinds of relationships you had with professors at [River College]?

RESPONDENT: I would say it's definitely harder to get to know professors here compared to over at [River College].

For the simple fact that [River College] is just smaller, less people in the class. You get to know professors more on like a one to one level and they get to know you back too. Because I'm sure it's very difficult when they have a class of like 500 people to even remember your name you know.

INTERVIEWER: Yes for sure, and you think that that's just the biggest reason that getting to know professors is different, is just the size of the school?

RESPONDENT: Yes.

INTERVIEWER: I totally get that. And so maybe other than professors or something, do any people at [Lake University] stand out to you as helpful for making connections and finding community like an adviser, peers, friends, maybe your roommates. I don't know if they're [Lake University] students, anything like that?

RESPONDENT: Yes some of my friends, one of my friends in particular...

And she was like the president of the [animal science club], oh my goodness, and she actually helped me get the, well helped kind of like pushed me a little bit, but in a good way, to get the secretary position for the club.

Drawings of settings adapted from the observational fieldnotes

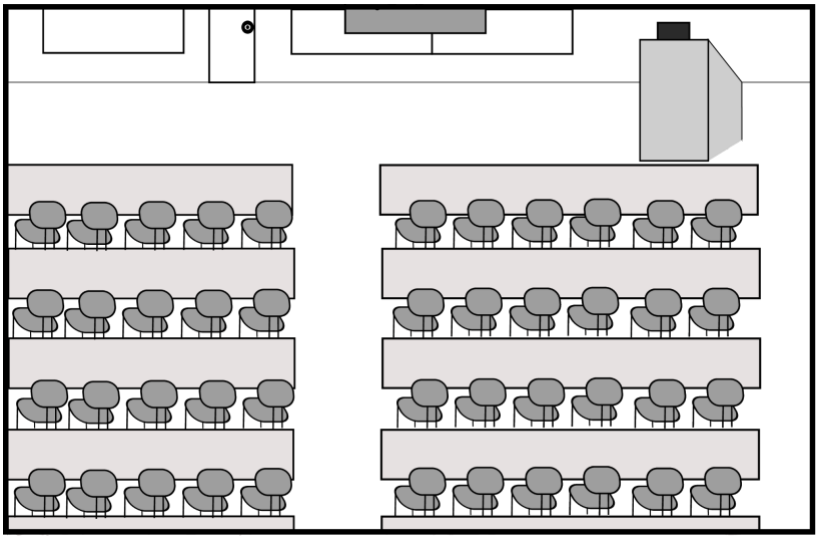


Figure 4A. 2 Lake University Scholars cohort seminar course classroom

This is another example of a classroom and its size and environment at Lake University, specifically the classroom in which the Lake University Scholars seminar course is taught. Although it is not a lecture hall able to seat multiple hundreds of students, it is still larger than the River College Scholars research methods classroom.

Appendix 4D Further Information on Methods of Reconstructing Narrative from Raw Data

a. Collecting Data with an Eye to Self-Efficacy

As described in the main manuscript, the data presented in Nicole's narrative was part of a larger project attending to the development of science self-efficacy for two-year college and transfer students. In this section we provide more detail about how this influenced various decisions about data collection.

b. Fieldnotes from River College Spring 2019

In the fieldnotes Wood collected from River College, she attended to explicit mentions of self-efficacy and interactions that might be opportunities to impact self-efficacy (see Sawtelle et al., 2012). Wood recorded direct quotes about students' confidence in their ability to do tasks as they worked on their research projects, or group work, or homework, etc. Wood also recorded direct quotes from teachers or student peers that were encouraging and seemed like they could provide opportunities for a social persuasion experience. Wood attended to people's body language and physical movements and verbal descriptions of their feelings and emotions to notice the potential physiological state experiences. Wood kept an eye out for moments that students mentioned previous mastery experiences they had that made them feel more confident in their ability to do their current task.

c. Journal Reflections and Interviews

As discussed above, the journal prompts and interview protocols also probed for self-efficacy. As can be seen in Appendices A.a., A.b., and B.a., the journal prompts and interview protocols were written explicitly to elicit self-efficacy.

d. How the Story Changed Over Time

Initially after that second interview with Nicole we noticed that when she spoke about social anxiety, she also described difficulty finding academic peer groups for projects and studying, but this had not seemed like a big challenge for her at River College. We thought early on that the story we would craft would be focused on the differences in Nicole's group work experiences between River College and Lake University. As we did more analysis, this felt like

just one piece of a larger story that was more broadly about supporting characters and their impact in a variety of situations beyond just academic peer group work.

e. Moving Away from Self-Efficacy

As we worked through a deductive coding process of Nicole's primary data (journal responses and interview transcripts) for self-efficacy explicit statements and self-efficacy experience descriptions, we found that we were coding a low percentage of her data (less than a third). While we saw experiences that echoed social persuasion and vicarious learning experiences for self-efficacy, Nicole did not make many clear self-efficacy statements. However, she did speak regularly about the impact of supporting characters, like faculty, cohort staff, family, and friends. Having identified this central theme in Nicole's story, other pieces of Nicole's data started to stand out, like how the cohort faculty and staff influenced Nicole to participate in the graduation ceremony from River College despite her brother not having participated and not thinking graduation was a big deal. We also were seeing significantly less of Nicole describing influential supporting characters in what she told us about her experiences at Lake University.

Appendix 4E Narrative Analysis

a. Summarizing Raw Data to Describe Characters and Settings

In order to reorient to the data with this emerging theme, we decided to take a different analysis approach and re-examine the data through a narrative analysis lens. To organize and slightly reduce the data, we did a rough coding process of Nicole's primary data as it oriented to impactful supporting characters. In this process, we found large chunks of data that were relevant to this story. This coding process captured most of Nicole's data. To continue down this analysis

path, Wood organized these data around the elements of narrative analysis – plot components/ commonplaces. We thought of this as writing a description of the characters (who, part of sociality), the settings (where, place combined with aspects of sociality), and so on. In this early processing of the data, Wood initially copied and pasted pieces of data directly to describe these elements before beginning to summarize the data into her own words.

For example, to describe the main character Nicole, Wood initially compiled excerpts from Nicole's own words (see Table 2A) along with pieces of the fieldnotes and visual observations from recorded interview videos. Most of these excerpts can also be seen in more detail in the sections above. Table 2A shows the process of summarizing primary data interview excerpts into descriptive statements about Nicole. This type of process was then worked into introducing Nicole (see section IV.A.).

b. Triangulating Data to Craft Vignettes

Writing paragraphs for the plot, or problem and resolution, was a longer process than describing the characters and settings. This process began with summarizing excerpts of data in bullet points. Then those summaries were grouped together to tell stories, particularly comparing and contrasting similar experiences at River College with Lake University pre- and post-transfer. After grouping those summarized bullet points, we wrote full paragraphs to tell a story rather than simply listing a series of quotes, but privileging language pulled directly from the excerpts or explicitly quoted. At this point we also pulled in additional description from secondary data (e.g., fieldnotes or Nicole's peers' journals). See Table 3A for the example of how we triangulated data from Nicole's time in the River College research methods course to craft our first vignette (Section IV.C.1.).

Another example of this process of summarizing raw data to craft a vignette would be to summarize Appendix B.b.2. as the following. Nicole "find[s] it helpful to study in groups," and turns to "faculty members and professors" when she doesn't understand problems. "Sometimes," she says, she "even go[es] to [her] brother because sometimes he can help out too." Since transferring to Lake University, Nicole has "not yet" found a study group but has been "placed in groups inside of classes." This is a new experience for her, and in previous courses she found study groups without them being assigned. She describes it very matter-of-factly like it was not a huge hurdle, saying, "it was just people that I quickly got along [with], and people that I just sat next to in class who also felt like they needed help in understanding everything." She says they set up meetings outside of class by "just trying to find a time that worked for everyone." Then they would meet together and "discuss problems that [they] had and try to figure it out together as a group." Even though Nicole has been assigned some study groups in classes, she feels that she does not have useful study groups at Lake University yet, even though she did not have a hard time with that at River College or in high school. She says that she "feel[s] like it was easier to find people who [she got] along with over at [River College] because it is a smaller school." She also attributes her difficulty finding study groups at Lake University or feeling that the assigned groups are successful to her social anxiety, saying, "it's very hard for me to go up and talk to people." This paragraph and the process of making it by summarizing an excerpt of data was used to develop the second vignette (Section IV.C.2.) in the main paper. We then used that kind of writing process to make each of the vignettes.

c. Member Checking Validity

As we crafted the story to tell about Nicole and the impact of supporting characters on scenes in her experience at River College and at Lake University, we thought we could argue that Nicole had more impactful supporting characters who shaped her story at River College than at Lake University. However, we either wanted to make sure that this story was accurate to her continued experience at Lake University or check on how her experience had shifted over time and possibly give more of a resolution at the end of our story. We also know that a lot of transfer research does not follow students for very long at their FYCs post-transfer, and in our broader project as well as specifically this case study, it was our goal to gather more longitudinal data on students throughout their FYC experiences.

To accomplish this goal of checking on the validity of the story we had developed so far and getting a little more information towards a resolution in our story, we interviewed Nicole again in Spring 2021. See Appendix C for this interview protocol. We focused on things like clarifying Nicole's answers to the self-efficacy survey we had given her multiple times, checking on how much of an effect her social anxiety has continued to have on her experiences at the FYC, asking if she has made any connections with professors and peers in her continued time at Lake University, etc. We found out that most of her answers to the self-efficacy survey that changed to lower values were really just because they did not apply to her anymore, for example, because they asked about math classes of which she had none left to take. We also learned that she continued to have difficulties getting to know her peers and professors but she had made some significant connections, particularly with a friend who was in the same club as Nicole and a particular professor who had made an impactful impression. This allowed us to end the story with a happier note and point out the kinds of settings and commonplace conditions that could help students like Nicole form connections and find community after transferring to a FYC.

Table 4A. 2 Summarizing primary data to introduce main character Nicole (used to craft Section IV.A.)

INTERVIEW EXCERPTS	AUTHORS' SUMMARY
"I have a lot of social anxiety. It's very hard for me to go up and talk to people." (Interview 2)	Nicole has social anxiety
"I've always wanted to be a veterinarian since I was little. Over at [River College] we had to take a course … it had something to do with figuring out what you wanted to do. And that solidified what I wanted to do, but it also directed me to a specific type of veterinarian. So, I found out that I really want to work with wildlife or a zoo." (Interview 2)	Nicole wants to be a wildlife or zoo veterinarian
"[My major is] integrated biology and then I just decided to double major in zoology since there's a lot similar in the two." (Interview 2)	Nicole is double majoring in integrating biology and zoology
"I really wanted to get some experience in working with zoos. Whether it was volunteering or internships. So, I found the closest zoo to where I was living and I applied and went to the orientation and here I am." (Interview 2)	Nicole is proactive in pursuing opportunities oriented towards what she wants to do
"I keep hearing from professors a lot that it's very difficult to get into the vet program. And I know my parents have said it too. But, again, they're pretty happy and proud of me for trying to become a veterinarian in the first place." (Interview 2)	Nicole has heard from professors and family that her path is difficult, but her family is proud of her
"[at Lake University] I haven't actually been able to talk to any of the professors, mainly because I really haven't made the time to. I couldn't find the time to. But I know over at [River College] there were some faculty who supported me in what I wanted to do and the same with my family and friends." (Interview 2)	Nicole has not gotten to know her FYC professors but was supported by faculty at River College and her family and friends
"It's mainly just been like me by myself for the most part, just like focusing on my homework. … I'm lucky enough to be able to come home, spend some time with my family or like even spend some time with my roommates or my boyfriend. But in terms of community for [Lake University] there really hasn't been much interaction." (Interview 3)	Nicole does not feel she has significant community at Lake University
"I find it helpful to study in groups and stuff. Talk about any problems that do come up and that I don't quite understand. Even talking to the faculty members and the professors. So, I know that stuff helps and even sometimes if I'm really struggling, I'll even go to my brother because sometimes he can help out too." (Interview 2)	Nicole likes to study in groups and seek help from faculty when needed, and she sometimes goes to her brother for academic help

"I have an older brother and the way that he's taking it has influenced how I see it as well. Because I know he didn't really make much of a big deal of graduating. He also went to [River College], so he didn't really make a big deal about graduating there and he didn't really make a big deal with his bachelor's. So, I don't really see it as a big deal either, but I also see it as graduation because it is something to be celebrated." (Interview 2)	Nicole's brother is influential to her decisions
"I would do summer [internships], but my family lives in [state] so we go there every year in the summer, and that's really the only time we can [so I'm only applying for spring internships.]" (Interview 2)	Nicole has family obligations that she prioritizes
"No[thing I would have done differently]. Maybe looked further into my other interests because I do feel pretty confident in wanting to be a veterinarian but sometimes, I do have my doubts. Because I also really love art, and drawing, and painting." (Interview 2)	Nicole also likes creative pursuits but is fairly confident in her academic decisions

Table 4A. 3 Example of triangulating data sources to develop first narrative vignette (Section IV.C.1.)

Colette's reflective weekly journals	**Nicole's reflective post-semester interview Spring 2019**
" I feel extremely confident. I like to fish …I also manage my own fish tank and know the ideal conditions for fish." (Wk 4) " We can get our fish easily by going to the [store] and buying them, as they are cheap." (Wk 4)	" I just remember standing in the hall. ...[I]t sounded like [Colette] also wanted to work with animals so I just asked her if she had a partner yet. I think, at the time, she was thinking about working with [another student] as well. But I asked to join the group and that's kind of how it started."

Nicole’ s reflective post-semester interview Spring 2019
“ [We] had a specific place we had in mind. They had a completely different place that they had in mind. (chuckles) We probably really should’ ve, in our own time, went to our spots and see if we were able to get water. …We didn’ t (chuckles) so we were just driving around [river] trying to find spots. We actually drove past an area for docking boats. We didn’ t see it though because it was down a hill. Because we didn’ t find anything that day, we didn’ t know it was there. We came back. We didn’ t have anything”

Narrative summary	Daily in-the-moment fieldnotes	Nicole’ s reflective weekly journals
Nicole had an easy time finding a project partner, despite her social anxiety. Her partner Colette is very confident in working with fish.	“ [Colette] supplying terminology like “ bubbler” → very confident person, seems to have background working in aquariums or zoos or with fish that leads to mastery self-efficacy experiences” (3/21)	“ I'm hoping to work with a group that has a similar interest… I believe that agreeing on a project will go smoothly as I am still open to ideas.” (Wk 3) “ I plan on doing a research project on how water quality affects fish. …also because someone else in the group is interested in doing this research.” (Wk 4)

Narrative summary	Daily in-the-moment fieldnotes	Nicole's reflective weekly journals	Colette's reflective weekly journals
Colette tried to get young perch but instead got minnow baitfish, so Nicole and Colette had less information on their fish than they expected. They also faced a difficulty gathering water for their fish tanks, but Nicole framed it as a learning experience.	" there were two large tanks of distilled and of creek water with the fish (about 5 each) and also two smaller tanks with distilled and creek water respectively with the frogs (3 each) The fish project team could only get perch minnows instead of perch There is little info, no growth charts, etc. Don't even know their age or if they'll grow more etc" (4/11)	" Unfortunately, during our drive with [professor], we were unable to find a good place to collect the water, so I only feel a little satisfied with our progress. On Thursday, we will be going out again to try and get all of the water that we need water to do anything else with our project, I feel pretty confident with our ability of getting it and preparing it for the fish." (Wk 6) " On Monday, I learned a new research skill, not only for this project, but also for future projects I may do. …[professor] told us how this was a learning experience: make sure you know exactly where you are getting your materials from and make sure you have enough time to do it." (Wk 6)	" They are perch minnows, and the man who gave them to me at the bait shop had no idea what I was saying when I asked for " Perch fry." So now our goal is to measure their growth, if any." (Wk 5) " I went to pick up the fish at the bait shop …Turns out they're just Perch minnows meant for catching perch." (Wk 5)

Narrative summary	Daily in-the-moment fieldnotes	Nicole' s reflective weekly journals	Colette' s reflective weekly journals
To add to their challenges, many of their fish also got a disease and started dying.	" [Colette] just said " I' m so glad I worked where I worked because otherwise I' d be like ' what is happening?' " (Worked at aquarium; talking about white cysts- she asked her friend for help when it originally happened to her personal betta fish)" (4/18) " trying to get pic of fish white spots Partner pulled dead fish out of trash to get pic of it using gloves Difficulty seeing spots with white background Tried putting black spiral notebook behind fish tank" (4/18) " The fish have all developed itchy white cysts so they' re discussing with Ron how to address it Could be why they' ve died not sure Treatment is a fizzy tablet in the water" (4/18)	" I would normally be frustrated about the feeling of being very behind in our project, however, the professors talked about us being able to continue our research into the next semester. Therefore, at the moment, I do not feel that frustrated about anything." (Wk 7)	" ...Also, two distilled tank fish, out of six total, have died." (Wk 7) " I am very proud that we have started collecting data on the fish. However, I am frustrated by the fact that we seem to be losing fish quite frequently. We started out with six fish per tank and are now down to three fish per tank." (Wk 7) " We found that in both tanks, the fish showed early signs of ich. We properly treated them by placing 3 ich guard tablets in each tank." (Wk 7)

Narrative summary	Daily in-the-moment fieldnotes	Nicole's reflective weekly journals	Colette's reflective weekly journals	Nicole's reflective post-semester interview Spring 2019
Despite these difficulties, the students persevered in completing a project, learning other skills like testing the water pH in their fish tanks, and made and presented a poster. Even though it was stressful having difficulty getting water, Nicole says she found it fun.	" [professor] showing [Nicole] and partner calibration liquids and tool for measuring properties of water [Nicole] is testing water in tank now Testing pH [professor] told them how to do everything" (4/18) " [Colette] and [Nicole] said they're still working on their poster " It's rough" [professor]: " when is this due?" Students: " today" [Colette] said we were still getting data earlier this week [professor] said " you could have started with intro and all that good stuff" etc" (4/25)	" I am most proud of the fact that not all of our fish died, as we thought they might have by now. …The main thing that I would change would be the type of fish we use in our experiment. If I were the one picking up the fish, I would have taken a little more time to find the yellow perch." (Wk 10) " I think that the most memorable experience from the entire experiment was receiving the water from the [river]. I found it to be very fun" (Wk 10)	" I am proud that we even got the project to work out. We didn't get the fish we wanted and it wasn't easy to get the water, but we managed to finish it all. …If I could change what has happened, I would go back and order perch fry from a supplier and pick a known boat launch for water collection in the first place." (Wk 10)	" Yes, [the instructors] were very lenient especially because it was the first time. They said that they didn't even know how to teach this sort of thing, too. So, they weren't very hard on us for anything."

Table 4A. 4 Definitions of narrative inquiry terms

COMMONPLACES	DEFINITIONS	OVERLAP WITH PLOT COMPONENTS
Place	Physical location in space	Where
Temporality	Time, not necessarily chronological or linear, depends on the story/ characters and can include flashbacks	When
Sociality	Internal and external/ environmental conditions and the interactions between those	Who, why, how

APPENDICES OF CHAPTER 5

The days of class marked in the table below are the days on which Wood took fieldnotes and not the corresponding week of the course by the semester calendar, because there were days of class canceled due to inclement weather and days on which Wood did not attend due to sickness, and spring break is not counted in these days of class meetings.

Appendix 5A Data Tables by Themes

Table 5A. 1 STEM-199 teaches students authentic science skills

THEME	OBSERVATIONAL FIELD NOTES	STUDENT JOURNALS
Teaching students that science is about asking questions	Ended [American] coot [experiment] discussion with "what new questions do you have?" love that … (I think was an awesome way to teach the scientific method) (First day)	

Teaching students important research skills early	Slide just says in big black font on a white background "carefully proofread your work" [instructor]: "It's hard for us to proofread our own work because we know what we're trying to say and we will mentally put in the missing words or an s so we need to proofread very carefully; hopefully you guys know what that means for you, you get someone else, etc." [instructor]: rather than penultimate, "just say second to last!" … (He really seems to be saying a lot of things no one told me explicitly…) … "Whenever possible, represent your materials graphically rather than in text" … Did emphasize though this is a poster and you may not be there to explain the poster to people reading it … (No one ever taught me how to make good posters until after junior year in my REU) (Seventh day)	"[Student] and I have already started to do a literature review and what we have found helps us to shape what we are interested in and what we want to research specifically. My professors have already taught us a lot of the fundamentals like the scientific method, how to conduct literature review, how to unbiasly analyze data and they will be teaching us research ethics." (3/1) "[Professor] help[ed] my group set up our experiment and assisted us along the way by providing us the tools necessary." (4/4) "I wrote the abstract this week while my partners finished up the rest of the poster. I believe I did well doing this because I also had [professor's] help." (5/2) "I talked with [professor] about looking into the water quality. He provided us with an instrument to accurately check the pH for each water. Additionally, he said that he was looking into finding something to test for the oxygen levels." (4/25) "This week our main goal was to collect our samples. Our instructors have been guiding us on literature reviews and overall prep. We made an itemized list of everything we needed. Today we hope to go get the samples." (3/28) "My instructor informed [us of] some locations where I can do my soil test. It was a big help because that was my final step until I can physically go out and find my final products." (3/28) "This week we are working with our instructors to tray our samples. Our goal is to learn how to put them on the trays and how to log our samples." (4/4) "One of our instructors helped us figure out a recipe to use/purchase to detect Legionella, which requires very specific media." (4/11) "Our instructor helped me write our abstract by telling me what needs to be included." (5/2) "Worked with our instructor to get the data we needed to complete the poster. It went well because we received everything we needed to finish it all." (5/2) "An interaction I had with one of the professors this week is deciding what graph is best for our data results. Something that went to well is that we chose a graph that worked for our results and theme." (5/2) "Getting our poster started and at least finished before the end of the semester. I am confident that we can get a decent poster done by the end of this week to show to the professors by next class and see what we can work on or add to it." (4/18)

Table #A. *Evidence of instructors bringing in external support*

Theme	**Observational fieldnotes**
Social persuasion and messaging about potential student mastery experiences	[There was a presentation from folks at a local FYC about an REU opportunity during class on this day] Woman from [local FYC] pointing out that even if you're a younger student if you have research experience, like this class will give, you should still apply for things earlier than you might feel qualified … They're talking about how the most important parts of apps are personal letters and letters of rec, which has been covered a bit upstairs but seems like some new info and perspectives … [instructor] pointed out that another question from upstairs/ earlier was who is appropriate for recommenders They said professors, employers, high school teachers "More important to have someone that is familiar with you who is not a relative than someone" you had in class and never really talked to (I assume he means like a lower-profile high school teacher who knows you would be preferable to a high-profile professor who doesn't know you) …

	Question from student about if he does stuff at home working on micology trying to culture fungus and hasn't gotten very far should he talk about this? She said yes absolutely And that someone at [local FYC] will love you some day (Second day)

Appendix 5B Describing Student Projects and Products

Table 5A. 2 Student project topics and weekly work

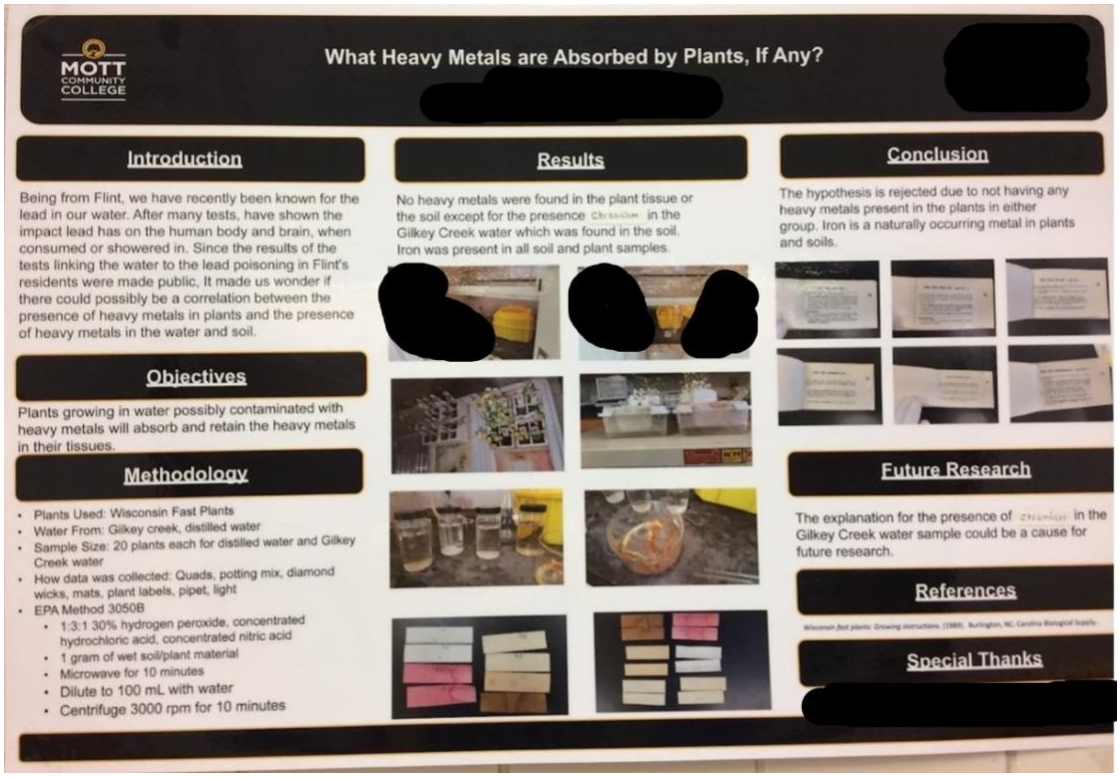
THEME	OBSERVATIONAL FIELD NOTES	STUDENT JOURNALS

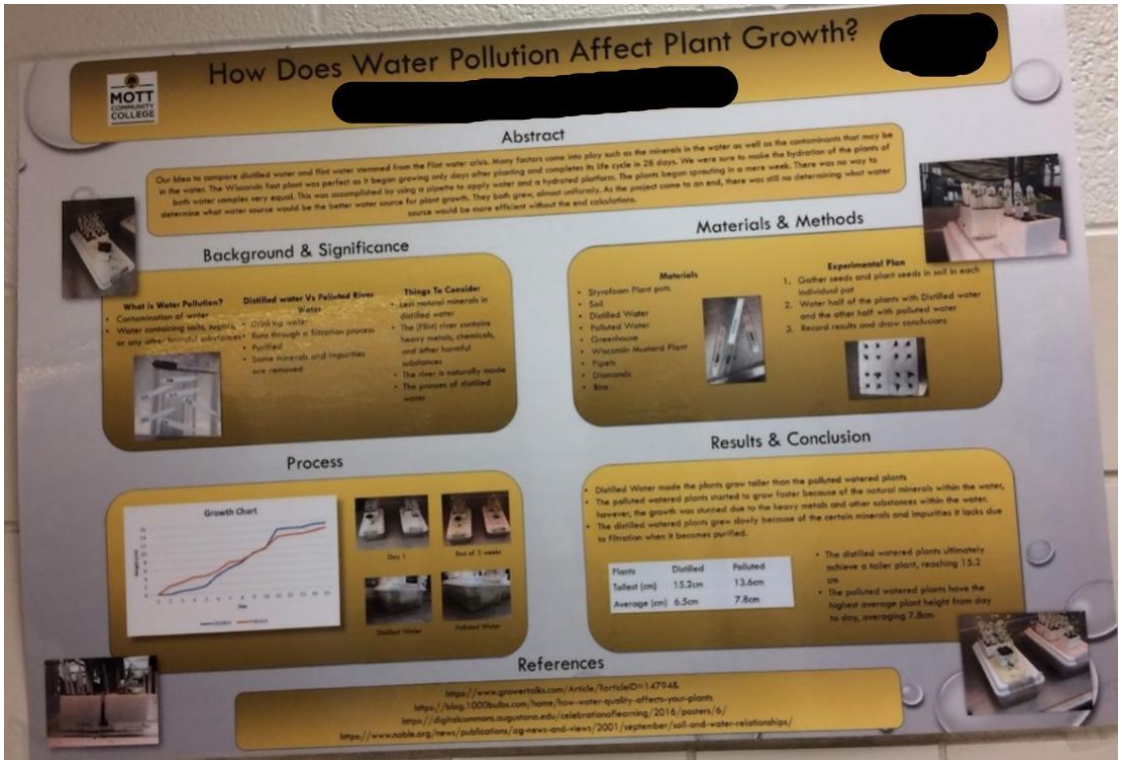
Student project topic ideas initially	[student] and partner who's not here- soil contamination [student]- bio-remediation according to [student] who's not here but [student] doesn't know what that means, [student] thinks micro-organisms, so [instructor] said they gotta make a decision [student] and [student]- contaminants in creek and where they are [student] and [student]- oxygen and heavy metals at different locations in creek- looking at heavy metal kits [student] and [student]- how pollution affects plant/tree/mustard plant growth [student] and missed her name- creek water effect on frogs (Fourth day)	"For my project I am thinking about researching something to do with how the chemicals (that are not naturally occurring) in the Flint river and the creek at Mott [a]ffect the organisms that live in the water. I will take water samples to look at what chemicals are in the water and take samples of the organisms, grow them in the lab with and without different chemicals found in the water and measure growth. I chose this idea by discussing what to do with other students. I am thinking about comparing water samples from parts of the flint river with Bluebell beach that connects to the Flint River, which was shut down because of E. coli. I want to observe if there is as much E.coli in the flint river samples taken as there is in Bluebell beach, and why Flint residents are still "allowed" to drink from the water." (3/1) "[I'm thinking about researching] Gas Exchange in Ectotherms. [I came up with this idea by] Going through the list and discussing it with my partner." (3/1) "[I'm thinking about researching] how pollution affects trees, this is one of the ideas I came up with when working with my partner." (3/1) "I am thinking about researching gas exchange in ectotherms (frogs maybe). I came up with this idea from having an interest in the way cold mammals are different from warm blooded animals." (3/1) "Me and my group's current project idea is to investigate how water and soil pollution affects plants. What we plan to do is have four test subjects using mustard plants to see their growth overtime. We plan to have one plant that has clean water and clean soil, another with clean water dirty soil, another with dirty water and dirty soil, and another with dirty water and clean soil. We will then conduct an observation over a period of time to compare their growth." (3/12) "My current project idea is to examine the E.coli content and L. pneumophila in the Flint river near the pipes and calmer parts of the river where these would be growing. Why do they grow here in the Flint River, are they still there after water filtration, and what happens

		when we consume them from the drinking water?" (3/12)

Final student project topics	(Pulled from redacted pictures of student posters below) (Tenth day) Heavy metals in plants grown in Gilkey Creek water compared to purified water Plant growth in plants grown in Gilkey Creek water compared to purified water Legionella, Salmonella, and E. Coli in water samples from three different test locations in the Flint River Frog growth in Flint River water compared to purified water Fish growth in Flint River water compared to purified water	"My standards were pretty low since this whole endeavor was very new to me. However I exceeded every goal I had. Our poster looks very neat, nice and informative. We are excited to present because we are very proud of our research and poster overall. The class was not what I envisioned it would be but it is so much more!" (5/2) "I feel that this was helpful for me because I learned how to collect data. I am most proud of being able to have the experience of doing a research project. The most enjoyable part was hearing peers speak about the projects. If there was anything I would change it would be having more time to get all objectives completed." (5/2) "I think I am the most proud of finishing something. I know that sounds silly but we were actually able to answer the questions we posed. I think the most fun part of the whole project was probably that is was applicable to our every day lives and our peers. I wouldn't change anything from this semester." (5/2)

Final project products	(See below table for redacted pictures of student posters) (Tenth day) An interesting thing that I noticed in talking to students about their posters is that they seem to assume people's awareness of local Flint locations- particularly [student] and [student] talked about the areas of the Flint creek or river- I'm honestly not even sure which one ironically- as though I knew what they were talking about, saying things like if you go down this road and you'll see this water treatment place and behind that is where we got a water sample and it's so close to the walking path that it might be why there was a higher level of bacteria from dog poop and stuff … Just heard [student] ask the person at their poster if she "did something wrong" because they got a positive result for something that they had thought might be cholera but cholera needs to be negative (Tenth day)	


MOTT COMMUNITY COLLEGE
What Heavy Metals are Absorbed by Plants, If Any?
[redacted]
Introduction
Being from Flint, we have recently been known for the lead in our water. After many tests, have shown the impact lead has on the human body and brain, when consumed or showered in. Since the results of the tests linking the water to the lead poisoning in Flint's residents were made public, It made us wonder if there could possibly be a correlation between the presence of heavy metals in plants and the presence of heavy metals in the water and soil.
Objectives
Plants growing in water possibly contaminated with heavy metals will absorb and retain the heavy metals in their tissues.
Methodology
Plants Used: Wisconsin Fast Plants
Water From: Gilkey creek, distilled water
Sample Size: 20 plants each for distilled water and Gilkey Creek water
How data was collected: Quads, potting mix, diamond wicks, mats, plant labels, pipet, light
EPA Method 3050B
1:3:1 30% hydrogen peroxide, concentrated hydrochloric acid, concentrated nitric acid
1 gram of wet soil/plant material
Microwave for 10 minutes
Dilute to 100 mL with water
Centrifuge 3000 rpm for 10 minutes
Results
No heavy metals were found in the plant tissue or the soil except for the presence [redacted] in the Gilkey Creek water which was found in the soil. Iron was present in all soil and plant samples.
[redacted]
Conclusion
The hypothesis is rejected due to not having any heavy metals present in the plants in either group. Iron is a naturally occurring metal in plants and soils.
Future Research
The explanation for the presence of [redacted] in the Gilkey Creek water sample could be a cause for future research.
References
Wisconsin fast plants: Growing instructions. (1988). Burlington, NC: Carolina Biological Supply.
Special Thanks
[redacted]


How Does Water Pollution Affect Plant Growth?
[redacted]
MOTT COMMUNITY COLLEGE
Abstract
Our idea to compare distilled water and flint water stemmed from the Flint water crisis. Many factors come into play such as the minerals in the water as well as the contaminants that may be in the water. The Wisconsin fast plant was perfect as it began growing only days after planting and completes its life cycle in 28 days. We were sure to make the hydration of the plants of both water samples very equal. This was accomplished by using a pipette to apply water and a hydrated platform. The plants began sprouting in a mere week. There was no way to determine what water source would be the better water source for plant growth. They both grew, almost uniformly. As the project came to an end, there was still no determining what water source would be more efficient without the end calculations.
Background & Significance
What is Water Pollution?
Contamination of water
Water containing soils, liquids, or any other harmful substances
Distilled water Vs Polluted River Water
Distilled water
Runs through a filtration process
Purified
Some minerals and impurities are removed
Things To Consider
Less natural minerals in distilled water
The (Flint) river contains heavy metals, chemicals, and other harmful substances
The river is naturally made
The process of distilled water
Materials & Methods
Materials
Styrofoam Plant pots
Soil
Distilled Water
Polluted Water
Greenhouse
Wisconsin Mustard Plant
Pipets
Diamonds
Bins
Experimental Plan
1. Gather seeds and plant seeds in soil in each individual pot
2. Water half of the plants with Distilled water and the other half with polluted water
3. Record results and draw conclusions
Process
Growth Chart
Day 1
End of 3 weeks
Distilled Water
Polluted Water
Results & Conclusion
Distilled Water made the plants grow taller than the polluted watered plants
The polluted watered plants started to grow faster because of the natural minerals within the water, however, the growth was stunted due to the heavy metals and other substances within the water.
The distilled watered plants grew slowly because of the certain minerals and impurities it lacks due to filtration when it becomes purified.
Plants | Distilled | Polluted
Tallest (cm) | 15.2cm | 13.6cm
Average (cm) | 6.5cm | 7.8cm
The distilled watered plants ultimately achieve a taller plant, reaching 15.2 cm
The polluted watered plants have the highest average plant height from day to day, averaging 7.8cm
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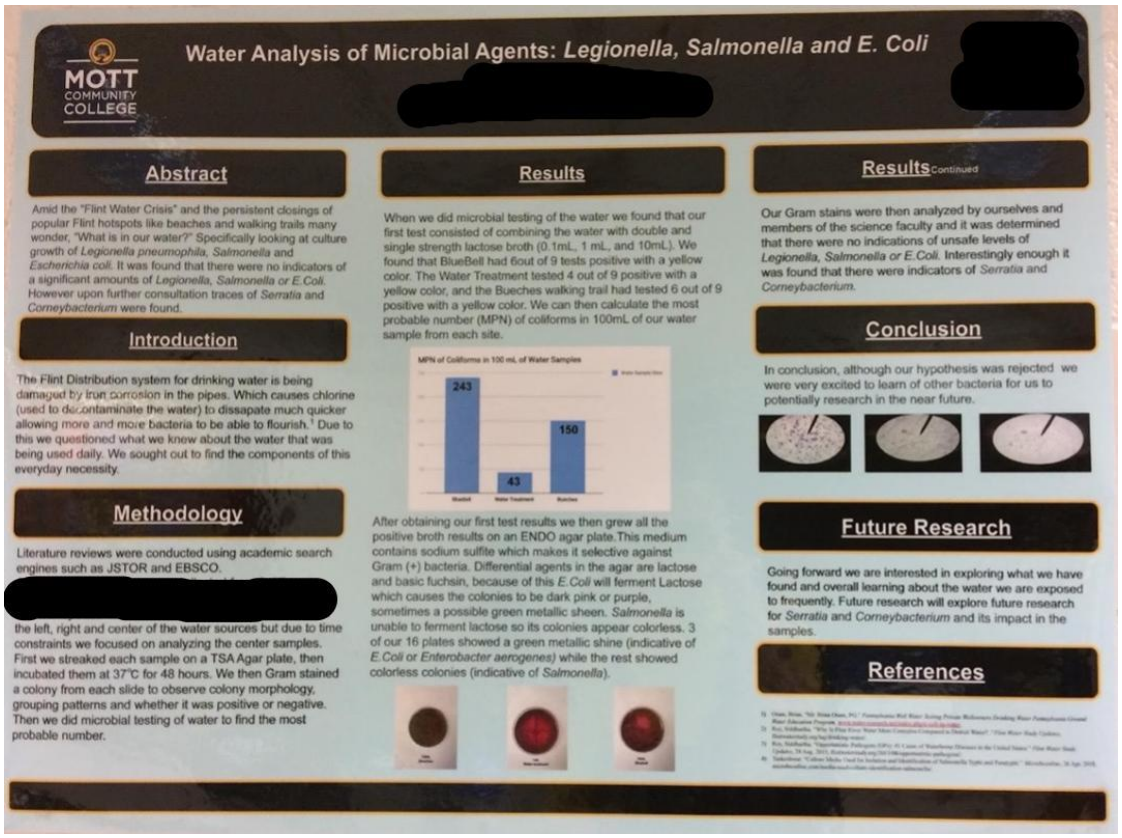

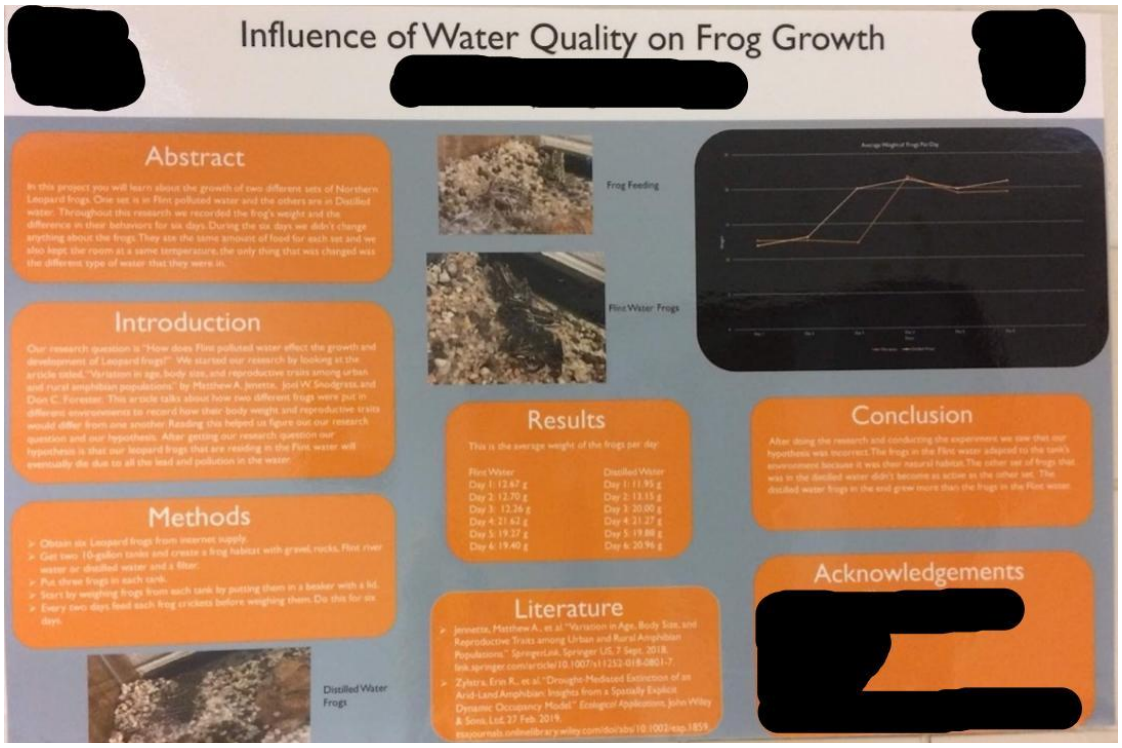

Figure 5A. 1-4 Photographs of student project posters. These photographs (redacted for anonymity) show some of the students' final posters from their project in the 2019 offering of STEM-199.

Appendix 5C More Information on Methods and Coding

The following are our code definitions. The first four are Bandura's proposed sources of self-efficacy, and you see them discussed in the tables above where we point out the opportunities the STEM-199 professors provided with their actions for students to potentially have an experience like one of the following four types and thereby possibly influence their self-efficacy judgements of their ability to perform scientific research tasks. The other codes on which we focused were "student-driven" and "tolerance for obstacles."

Mastery experience

Previous experiences one has doing a similar task to a current task at hand that influence how one feels about their ability to do the current task at hand.

Vicarious learning

Experiences one has observing another person doing a similar task or talking to someone about doing a similar task to a current task at hand that influences how one feels about their ability to do the current task at hand.

Social persuasion

Messages, encouragement, and influential statements from another person about one's ability to do a certain task, usually a person one respects and looks up to (e.g., a teacher, family member, etc.) that influence how one feels about their ability to perform a similar task.

Physiological state

One's physical, emotional, and physiological state of being that influences how one feels about their ability to perform a certain task.

Student-driven

Evidence of students taking control of their experience/ project direction and making decisions on project steps, rather instructors prescribing steps.

We think of this evidence as including things like students designing their own research questions from their own interests and academic experience or desired education, students making independent decisions on the progress and steps of their projects, and students trying to address obstacles on their own before consulting instructors. You can see examples of such student actions and experiences above in Appendix A.

Tolerance for Obstacles

Evidence that students have learned to work through, address, and solve research project difficulties, or they are actively trying to find ways to alleviate their struggles.

We think of this evidence as including things like students stating that their emotional state is better than it otherwise might have been when thinking about the project difficulties, students solving problems on their own or with instructor support, and students describing the skills they've learned that help them feel prepared for their projects. You can see examples of such student actions and experiences above in Table 5A in Appendix A.

Table 5A. 3 Selected excerpts from journals as categorized in an early report to instructors

Choosing and working with project group	"I'm hoping to work with a group that has a similar interest in research topics. While I have not actually discussed the possibility with anyone else yet, I believe that agreeing on a project will go smoothly as I am still open to ideas." "I do plan to work in a group of at least 2 people. Working in a group will allow more ideas to wonder which is why we haven't yet decided on a concrete topic. Finding a group with a game-plan is a little hard right now because it's hard to join ideas together to come up with a topic that fits what everyone wants to do. As of right now, I will continue to work on forming a group and joining ideas together to come up with a fit topic." "I would like to work with a group and or partner, but it is all about if anyone else is interested in [the topic I'm interested in.] If no one else seems interested, I will plan on pursuing this research topic on my own. I have not yet discussed or reached out to anyone about being in a group researching this topic." "Yes it was a decision made for the class that we had to work as a group" "I am willing to work in a group, however I'm not planning to be in a group at this time. With how broad the field of [my research interest is], it can fit into numerous project ideas easily." "We didn't have much contact, but we both collected some more literature review which is what we needed right now." "In person my partner and I are great, very vocal and collaborative and we help each other out when we need it. We definitely prefer to work face to face, because we aren't very good at communicating outside of class. We text here and there but it isn't as helpful of a communication as it would be face to face. I envision us having to work together rather than delegating bits and pieces of the research to each other."

Student goals for the course	Learn research skills ● "I hope to gain research skills, how to create a poster, different databases, scientific methods, proper data recording skills, graphs, etc doing this research project." Gain confidence in presentation skills ● "I am hoping to be more confident in my presentations, and obtain more knowledge on poster presentations and what methods go in to obtaining all of the information for a research project." Learn how to conduct research with animals Learn about their specific research topics Practice and improve teamwork skills ● "I hope to leave this project having gained communication skills and more knowledge on how to collaboratively work in a group with the same goal." Have an experience that looks good on a resume ● "I'm not sure what skills or knowledge I hope to gain. Hopefully, this class 'looks good' on my resume." Learn how to conduct a science project Get comfortable in a lab setting to prepare for future lab research opportunities ● "I also want to be more comfortable in the lab and knowledgeable about the research process. I would also like to be more confident in pursuing future lab/ research opportunities." ● "At the end of this project I hope that I am confident with using the scientific method to conduct research. I mainly hope to learn something applicable out of this research. I really hope to find something in my research that opens the door to more research. As long as I learn something I will be happy." Gain experience useful to future education ● "I am hoping to receive experience I can utilize in my future education." There were also a few student responses about their specific research topics relating to their intended majors and desired future careers or further education paths.
Impacting confidence in completing research	"I'm nervous because I've always been the student and not the researcher. But I'm confident in myself and my work ethic. I also feel more at ease knowing that I have such approachable professors to ask questions and they're knowledgeable enough to supply me with accurate and relevant advice and information." "With adequate help from our professors, I feel very confident that we can achieve these tasks." "My professors have already taught us a lot of the fundamentals like the scientific method, how to conduct literature review, how to unbiasly analyze data and they will be teaching us research ethics." "We are fairly confident that as a pair we could complete a research project of this size." "Me and my partner are both eager to research this topic."

Student interactions with instructors	The instructors being helpful on things like working on the poster, getting the equipment and materials needed for projects, helping with questions on the research projects ● "An interaction we had with our professor was that Professor Wade showed us someone's poster that used to attend Mott and that was pretty cool because we got a general idea on what to do for our poster." The instructors not being judgmental on any questions students had ● "[Professor 1] and [Professor 2] have been very helpful, and not judgmental about any of the questions I have had even if I felt like they were "dumb" questions at the time. [Professor 3] was also very helpful when he assisted us in narrowing down our focus for the research project." Most often what students said they needed from instructors were materials and equipment and help using equipment Next most often many students discussed not being sure if they would be allowed or able to do their research projects and wanting confirmation from the instructors ● "At the moment, I'm not feeling very confident for the simple fact that we may not be able to perform this research project. Should the project be approved, then I would feel much more confident about my ability to help complete the project."
Student difficulties	Difficulty finding articles relating to project topic ● "My goals this week were to find articles related to my project, and so far I haven't really been able to find anything useful. I feel that it is hard to find any source related to my topic. Next week I plan to get help towards finding resources." Feeling behind because of snow days and canceled classes ● "I feel a little behind because of all the snow days and canceled classes we have had." Dislike of doing research ● "[My goals were t]o understand more about my research and get better acquainted with it. I'm not very confident about my ability on this project because I dislike doing research. I feel as though I can do better and I should be further ahead with my project." Frustrated by feeling behind on getting materials needed to do research project Feeling like they should be further along on their projects Unsure if they would be able to do their project ideas and worried about needing back-up plans

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