The Journey of Becoming and Belonging:
A Longitudinal Exploration of Socialization's Impact on STEM Students' Sense of Belonging

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ABSTRACT

Persistently high attrition rates from STEM majors present a stubborn challenge for researchers, administrators, and faculty alike. To approach this problem, my dissertation examined the socialization processes by which students develop a sense of belonging to both their institution and their discipline. Previously identified as an important factor in students' persistence and overall satisfaction with their undergraduate experience, belonging is a critical piece of the retention puzzle. However, not every student experiences or develops belonging in the same way. This dissertation applied the theoretical lens of socialization to deepen the understanding of how social interactions help or hinder students' belonging to their university and chosen major alike.

My dissertation work was grounded in the synthesis of two theoretical frameworks: Conrad et al.'s (2006) model of socialization and Strayhorn's (2018e) conceptualization of sense of belonging. The study took the form of an embedded case study of two similar disciplinary contexts within a large public land-grant Research 1 institution, with four students from each context for a total of eight participants. By leveraging four years of interview data from each participant, supported by institutional documentation, I addressed the question: In what ways does a student's socialization experience influence, if at all, their sense of belonging to both their chosen discipline and their university? Data analysis included qualitative coding, trajectory mapping, and

thematic analysis. Trajectories were produced for each participant before expanding the analysis to examine patterns across and between the contexts.

My findings addressed the mechanisms of socialization at the undergraduate level and how they evolved over time. The primary outcome of my work was a set of three distinct socialization trajectories, named the Anchored, who built strong socializing relationships early and maintained them throughout their undergraduate years; Independents, who neither sought nor wanted such relationships; and Wanderers, whose socializing relationships tended to be short-lived and inconsistent, although desired. Fourteen unique groups of socializing agents were identified, along with five common drivers for intentionally engaging with specific agents: personal and academic support, research and industry aspirations, and finding a path. Pre-college socialization experiences were salient for developing anticipatory belonging, as students who were exposed to their discipline or institution prior to arriving as students had an easier time becoming integrated to their communities. Once students arrived, their socialization trajectories tended to shape their feelings of belonging to the institution, with close ties forming for the Anchored, appreciation for general support among the Independents, and a mix of happiness and frustration for the Wanderers. By contrast, disciplinary belonging was more reliant on the individual participant's goals and interests. Disciplinary differences between the two contexts were identified but were limited in scope and generally linked to the career outcomes students associated with their chosen major rather than their experiences in the major. Finally, my research revealed that a strong sense of belonging in one domain of undergraduate life could be sufficient for a student to persist to degree completion despite weak or absent feelings of belonging in other areas.

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GENERAL AUDIENCE ABSTRACT

For decades, students have been leaving STEM majors at alarmingly high rates despite the efforts of researchers, administrators, and faculty. To approach this problem, my dissertation examined how social interactions and relationships can help students feel like they belong in their chosen major and university. Previous research identified such feelings of belonging as an important factor in helping students persist to the completion of their degrees, and my work added onto this body of work by specifically examining the role of students' social connections.

My dissertation utilized data from eight total students. Four of the students were chemical engineering students, with the remaining four from chemistry and biochemistry, together called the "chemical sciences." The data for this work included four years of interview data supported by institutional documents. Such documents provided information like curricular requirements, demographic and population information, and course information, which helped provide background for the students' interviews. Leveraging these data, I addressed the aforementioned interaction of students' social interactions and their feelings of belonging on campus and in their major. My data analysis was based around the creation of trajectories that would capture the evolution of a student's experiences over the course of their undergraduate career. Once trajectories were generated for each student, I was then able to look across the trajectories and identify patterns between and within them.

The primary finding of my dissertation work was the emergence of three distinct patterns of how students' social interactions evolved over time, labeled the Anchored, who built strong and consistent networks that they maintained over two or more years; the Independents, who neither sought nor wanted such relationships; and the Wanderers, who had relationships and interactions that were often short-lived or inconsistent, but wanted more. Fourteen unique groups with whom students interacted were identified, along with the respective impacts said groups could have on students' feelings of belonging. Additionally, five drivers for seeking out interaction with these groups were identified: personal and academic support, research and industry aspirations, and finding a path. The experiences students had with their university or major prior to enrolling were found to be important for shaping the way students perceived their future, and those with greater exposure to their institution or discipline had an easier time seeing themselves fitting in and finding a place for themselves on campus once they enrolled. Once students arrived, their trajectory of interaction tended to shape how they felt about their institution, with close ties forming for the Anchored, appreciation for general support among the Independents, and a mix of satisfaction and frustration for the Wanderers. By contrast, belonging within the discipline was more reliant on the individual participant's goals and interests. Disciplinary differences between the two contexts were identified but were limited generally linked to the career outcomes students associated with their chosen major rather than their experiences in the major. Finally, my work revealed that when students felt like they belonged in one area of their undergraduate life, those feelings could support lacking feelings in other areas, helping them to persist to graduation.

Dedication

To my mom and dad, and all of the people who helped me get to this point.
I would not be here without all of you.

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Thank you for supporting me throughout this process and enduring it with me. I love you.

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Chapter 1 - Study Overview

1.1 Problem Statement and Research Purpose

For decades, researchers have tried to understand why students depart higher education (Astin & Astin, 1992; Tinto, 1975, 1987, 1993), particularly in Science, Technology, Engineering, and Mathematics (STEM) programs where attrition rates remain alarmingly high (Yoder, 2016). The stubborn problem of persistence has remained despite efforts from researchers and policymakers. Numerous factors have been identified in the puzzle of retention, including academic difficulty (Anderson-Rowland, 1997; Henry et al., 2019; Wallwey et al., 2022), non-cognitive factors like grit (Choi et al., 2017; Ibarra, 2022), career uncertainty (Belser et al., 2017; Mau & Li, 2018), and prejudiced culture and stereotypes (Deiglmayr et al., 2019; Šaras et al., 2018; Thébaud & Charles, 2018; Wilkins-Yel et al., 2022). I have chosen to pursue further study of one such factor in this dissertation: sense of belonging (SoB).

An individual's SoB is derived from the degree to which they feel supported, welcomed, cared about, and valued within a specific environment (Strayhorn, 2018e). Belonging has been noted as a fundamental human need (Maslow, 1954) and sufficient to motivate behavior (McCabe et al., 2005; Strayhorn, 2018c). Strong feelings of belonging have also been linked to improved academic outcomes (Abbott-Chapman et al., 2014; Barth et al., 2021), emotional well-being (Ibarra, 2022; Luque-Suárez et al., 2021), and most relevantly, persistence to degree completion (Davis et al., 2019; Lewis et al., 2016; Stoddard, 2022). The process of fostering students' belonging has also been studied previously (e.g., Beckett et al., 2022; Blignaut et al., 2021; van Zyl, 2022; Wilson & VanAntwerp, 2021), but a gap remains in our understanding of the specific types of interactions and interventions that produce desirable belonging outcomes

(Strayhorn, 2018c). In this work, the lens of socialization theory was employed as a means of addressing this gap.

Throughout a student's academic career, there are countless interactions with peers, instructors, administrators, family members, and a plethora of other individuals. Socialization refers to the way social interactions and relationships combine to provide students the knowledge, skills, and values required to be successful in their multiple roles both on and off campus (Conrad et al., 2006; Weidman, 1989). These interactions, while potentially inconsequential individually, can combine to influence students' identities, engagement with the university and discipline, and post-graduation aspirations (Ahmad et al., 2012; Weidman, 1989; Winkle-Wagner & McCoy, 2016). Most pressingly for this work, however, socialization also has been demonstrated to develop students' SoB (Chen & Yao, 2015; Strayhorn, 2018b; Weidman et al., 2014). Socialization has also been linked to the development of disciplinary identity (Austin et al., 2012; Rodriguez et al., 2018; Weidman et al., 2014) which in turn supports feelings of belonging (Jaiswal et al., 2022; Seyranian et al., 2018). Throughout this dissertation, I applied socialization as a tool to understand the development of students' belonging to their disciplinary and university communities, with a simultaneous emphasis on understanding the specific socializing interactions and relationships that promote belonging.

Despite the emphasis on the relationship between socialization, belonging, and retention in STEM, I do not believe the role of socialization—or belonging, for that matter—to specifically be making every student with an interest in STEM pursue it to degree completion. Socialization is a powerful tool for informing students what the discipline is and what being a member of the discipline would entail, something that students have been found to struggle with even towards the end of their undergraduate careers (Matusovich et al., 2009). Building upon

this, my dissertation investigated the kinds of pre-college and early-career socialization experiences that are most formative in helping students understand their disciplinary undertaking and how that understanding can be developed when students are still most flexible in their academic and postgraduate plans.

The issues of recruitment and retention in STEM are front and center in many circles, including both research (Beddoes, 2021; Kuh & Love, 2000; Meyer & Marx, 2014; Tinto, 1987; Yoder, 2016) and policymaking (National Academy of Sciences, 2007, 2011). As these are complex challenges to address, all possible approaches for investigating them are valuable. My dissertation utilized socialization as a means to understand the development of belonging, which in turn supports students to persist in their degrees (Davis et al., 2019; Seyranian et al., 2018). There is likely no "one-size-fits-all" solution to improve student experiences. Instead, I geared this study to examine the individual experiences of eight STEM students in pursuits of understanding how and why they engage with socializing agents and subsequently how they come to feel like they do or do not belong in their disciplinary and university communities. My work addressed several gaps in engineering education research on socialization and belonging, including adding to a limited number of longitudinal studies utilizing either theory, providing a holistic view of the socialization process for undergraduate students, and delving into how specific attributes—both institutional and personal—and experiences contribute to feelings of belonging. The findings of this dissertation also hold implications for future research and practice, detailed in Chapter 5.

In light of this research purpose, I designed and conducted a single embedded case study of two disciplinary contexts within one large public mid-Atlantic research-focused (R1) institution, based on Yin's (2018) approach to case study methodologies. I utilized a conceptual

framework that synthesizes Conrad et al.'s (2006) model of undergraduate socialization and Strayhorn's (2018e) theory of SoB to connect the two frameworks and provide a more complete understanding of their interplay. Using a combination of semi-structured interviews collected in the spring or summer of each of the four years of eight participants' undergraduate careers and supporting institutional documents, I produced trajectories of socialization and belonging that identify the interactions, relationships, and experiences that were most salient in fostering students' SoB. The outcomes of this dissertation addressed the four identified research gaps while also providing implications for future research and practice. My dissertation deepened the understanding of how we can support our students to their academic and professional goals but has also identified areas in which more work is still needed.

1.2 Definitions

In this section, I will provide definitions for terms that I use throughout the rest of the dissertation. These definitions are grounded in existing literature, but I provide my own interpretation of them as well within the context of this work.

1. **Socialization** is broadly defined as "the process by which an individual acquires the beliefs, values, skills, and resources needed to live and participate in society" (Weidman et al., 2014, p. 67). The "society" being referenced can be any group, organization, or context in which and individual is a newcomer (Conrad et al., 2006). In this study, I define two connected contexts students are socialized into: their major and the broader university. While the major context exists within the university context, there are unique skills and resources required (e.g., academic knowledge) to succeed in the major, and the roles that students hold in each can vary significantly (Reason et al., 2007). The socialization process itself is specifically focused on the social interactions and

relationships that shape students' understanding of their newfound roles (Conrad et al., 2006). Such interactions take place on the backdrop of a normative context (Weidman, 1989), defined next.

2. A **Normative Context** is a space in which the policies, rules, and culture exert pressure on interactions and values to align with accepted norms (Korte, 2009; Weidman, 1989). For example, on a university campus, the rules that all students must follow establish some expectation of how they conduct themselves, with punishments for not adhering to the expectations. As another example, in STEM—engineering particularly—established masculine norms produce a more challenging environment for women to work in (Akpanudo et al., 2017; Simon et al., 2017). The normative context in which socialization occurs characterizes the interactions, so understanding the established norms in the context(s) of interest is a crucial part of socialization research. In this dissertation, two normative contexts are simultaneously examined: the major and the university. As noted above, the two share many similarities, with many of the university's norms also applying at the disciplinary level, but additional norms in STEM majors must also be considered for socialization into the major.
3. **Socializing Agents** and **Reference Groups** are two terms used to refer to individuals and groups that have direct influences on students' socialization. Reference groups sometimes take a more passive role in socialization when an individual takes the group's hypothetical perspective or response into account when making a decision or judgement (Weidman, 1989). Throughout this dissertation I use the two terms interchangeably when referring to individuals, groups, and organizations that influenced participants' socialization.

I also defined a separate influence that I referred to as a **resource** in my findings. Resources are groups, offices, or individuals on campus that students described as being in place to support them. Examples included career service offices, mental health resources, or advisors. Resources were separate from socializing agents because the former were referred to in an abstract sense, with students noting their presence on campus but not directly interacting with them or individuals associated with them. Once a student interacted with one or more people associated with the resource, it became a socializing agent for the purposes of this dissertation.

4. I choose to define **Sense of Belonging** or **Belonging** in line with Strayhorn (2018e) as "a basic human need and motivation, sufficient to influence behavior" that encompasses "students' perceived social support on campus, a feeling or sensation of connectedness, the experience of mattering or feeling cared about, accepted, respected, valued by, and important to the group" (pp. 28–29). I use several terms to refer to this phenomenon, including "feelings of belonging," "sense of belonging (SoB)," and "belonging," interchangeably throughout this work. The specific dimensions of Strayhorn's model of belonging are outlined further in Chapter 2.
5. I use **Alienation** in this dissertation as the antithesis of belonging. When a student feels that they have no place in a given community, or that they are being expected to change in ways that do not align with their personal values and identities, they are alienated from said community (Strayhorn, 2018c). Alienation is particularly strong when a student feels outcast or isolated from a group to which they once belonged (Strayhorn, 2018e). I use the term sparingly, preferring to emphasize belonging in line with Strayhorn's anti-deficit perspective that focuses on positive outcomes for students and collegiate programs alike.

6. **First-Year Engineering (FYE)** is a term I use to refer to the sequence of classes all engineering students at the study institution must take in their first year regardless of intended major. The pair of courses cover a range of introductory engineering topics including teamwork, basic programming, ethics, and the design process. Students must complete these courses with satisfactory grades to transition into their sub-discipline of engineering. FYE courses are not restricted to the study institution, being a common way to introduce engineering to new students (Bucks et al., 2015; Choi et al., 2017; Cruz & Kellam, 2018). There is no such equivalent for chemistry and biochemistry students at the study institution, though there are a set of common classes that most students have to take, which includes introductory chemistry, calculus, physics, and English courses.
7. The **COVID-19 pandemic** was a global health crisis event that began in late 2019 but reached the United States (US) in full in early 2020. March 2020 marked a shift for universities in the US as they transitioned to online learning in response to lockdown and quarantine requirements (Aristovnik et al., 2020). This dissertation spans four years of data collection, with Years 3 and 4 being affected by the policy changes, as in-person interviews were no longer feasible. The majority of interviews in Year 3 and all interviews in Year 4 were conducted via telephone or video conferencing software. The limitations the COVID-19 pandemic imposed on this study are discussed more in-depth in Chapter 3.
8. The **Understanding Knowledge and Student Agency (UKSA) Project** is a multi-year, multinational research collaboration between six institutions in the US, United Kingdom (UK), and South Africa. The project involved data collection for four years at each university from the chemical engineering (ChE), chemistry, and biochemistry

departments. I was involved from the second year of data collection onward, collecting interviews in the third and fourth years. The data used in my analysis is derived from this project, with some being generated prior to my involvement. Additional detail about the UKSA project is provided in Chapter 3.

1.3 Research Questions and Study Design

This dissertation will address the research question and sub-questions provided below:

Overarching Research Question (RQ): In what ways does a student's socialization experience influence, if at all, their sense of belonging to both their chosen discipline and their university?

Sub-question 1 (SQ1): How do students' disciplinary socialization experiences evolve from pre-college engineering or science to degree completion?

Sub-question 2 (SQ2): What types of socialization do students engage in at their university, and why do they choose the specific types of socialization they have control over?

To address these research questions, I employed Yin's (2018) embedded case study design making use of qualitative, semi-structured interviews with additional support from existing documents. I structured my study around a single institutional case with two embedded disciplinary contexts, each containing four individual participants. A conceptual framework synthesizing theoretical models of socialization (Conrad et al., 2006) and belonging (Strayhorn, 2018e) guided my dissertation. My data analysis methods revolved around the coding of individual interviews, supported by institutional documents for additional context. I then built individual trajectories of socialization and belonging for each participant before looking across the trajectories for themes that could address the research question and sub-questions. The data collection and analysis processes are outlined further in Chapter 3. A summary of the structure of my study and how it addressed my research questions can be found below in Table 1.1.

Table 1.1 Summary of Study Structure and Outcomes

Research Question	Data Collection Method	Data Analysis Method	Findings
RQ: In what ways does a student's socialization experience influence, if at all, their sense of belonging to both their chosen discipline and their university?	1. Four qualitative interviews (Spring/Summer of each academic year) 2. Project summary documents of curricula 3. Public institution and department websites	1. Descriptive and In Vivo coding 2. Trajectory mapping 3. Thematic analysis 4. Reflective memos and participant summary documents	• Consistent communities were most valuable • SoB to discipline could cover for weak SoB to university and vice versa • Non-socializing influences present, impactful
SQ1: How do students' disciplinary socialization experiences evolve from pre-college engineering or science to degree completion?	1. Four qualitative interviews (Spring/Summer of each academic year) 2. Project summary documents of curricula 3. Public institution and department websites	1. Descriptive and In Vivo coding 2. Trajectory mapping 3. Thematic Analysis	• Three trajectories: Anchored, Independents, Wanderers
SQ2: What types of socialization do students engage in at their university, and why choose the specific types of socialization they have control over?	1. Four qualitative interviews (Spring/Summer of each academic year) 2. Project summary documents of curricula 3. Public institution and department websites	1. Descriptive and In Vivo coding 2. Trajectory Mapping 3. Thematic analysis 4. A Priori coding of drivers for socialization	• Wide range of socializing agents sought out, depending on goals • Five categories of drivers for engaging: academic & personal support, industry and research aspirations, finding a path

1.4 Significance of the Research

My dissertation produced outcomes that serve to benefit the engineering education community. The primary product of the study was the beginnings of a set of categories of socialization. Labeled the Anchored, the Independents, and the Wanderers, the three groups represent distinct patterns of socialization that students followed through the duration of their undergraduate careers. These trajectories also carry implications for how SoB can be fostered for

students with differing needs and goals, as participants across all of the trajectories completed their degrees. The organized trajectories provide a means for faculty, administrators, and advisors to identify what kind of socializing interventions might most benefit their SoB and in turn their aspirations to persist to graduation. This finding is incomplete, as there are other trajectories that were not present in the study's population, as in the case of students who fail early classes, choose to leave STEM, or drop out of the university. Consequently, a promising route forward for future research and investigation to further develop the model emerged.

Building upon these trajectories, my analysis demonstrated the existence of a significant disparity in anticipatory socialization and belonging for students who were able to physically visit campus versus those who were not. The participants who visited campus were able to make their enrollment decisions based on a more robust set of factors than their peers who did not, factoring in the physical environment, subjective "feel" of campus, and interpersonal interactions that occurred during the visit. This disparity in decision making rationale holds significant implications for recruitment and retention efforts, as my work also showed that the students who found meaningful connections early were the most successful in maintaining strong networks on campus and achieving their academic and personal goals. Similarly, exposure to disciplinary experiences and professionals was shown to increase student comfort with their major selection and allow them to have more clear notions of what they wish to achieve with their studies. I explore several approaches to improving the onboarding process for prospective and early-career students in Chapter 5.

This dissertation also contributes to existing literature on belonging by identifying in several participants that strong SoB in one domain of life was sufficient to compensate for weak SoB elsewhere. For example, strong feelings of belonging to one's discipline was enough to

support students through difficulties in broader university and social relations. The compensatory potential of SoB in a single domain holds potential for interventions to support students who are lacking connection to their institution in one way or another, as in combination with the trajectories noted above, it allows for the identification and specific targeting of the most important relationship and support structures for an individual student's needs. Rather than trying to find networks in all aspects of the student's personal, academic, and professional life, efforts can instead be concentrated on the most pressing areas.

Finally, my findings contribute to several notable research gaps identified earlier in this chapter and expanded upon in Chapter 2. My work with a longitudinal dataset has provided a deeper understanding of the processes of socialization and belonging development over time. This understanding is summarized and presented in the form of the trajectories mentioned earlier. Through my analysis, I have identified fourteen unique groups of socializing agents and some insight into how they interact with one another, providing a more holistic view of the socialization process than is available in most current literature. My examination of belonging development through the lens of socialization has bolstered the knowledge of how interactions with specific individuals and groups can foster desirable belonging outcomes. The study has also contributed some understanding of how institutional characteristics contribute to belonging, though such findings still prompt further work to broaden our understanding beyond the single context present in my study.

1.5 Scope of the Study

In designing my dissertation study to focus on socialization's role in developing students' SoB, there were certain aspects I could not address, or chose not to address in order to keep the study focused. Where possible, I tried to include acknowledgement of these in the literature

review or my analysis even if I could not address them in-depth as part of the results. First, and most importantly, my study was not able to go in-depth about the differential experiences of students from historically minoritized backgrounds including women, Black, LatinX, and Indigenous students, as well as students at the intersections of these identities. There is ample literature indicating that both socialization (e.g., Beddoes, 2021; Riney & Froeschie, 2012; Twale et al., 2016) and belonging (e.g., Aerts et al., 2012; Cheryan et al., 2015; Strayhorn, 2018d) are experienced differently by minoritized students. The differential experience, however, was not a targeted outcome of my study, which was geared towards a broader understanding of socialization and belonging as they evolved over time. I also could not have provided a detailed exploration of the comparative experiences due to the structure of the interview protocols in the UKSA project. Limited demographic information was collected from participants, with certain aspects like socioeconomic status being only indirectly addressed and the participants having to choose to volunteer certain information around neurotypicality and sexual orientation. Furthermore, among the participants, only two of the eight could be considered in overrepresented populations: Anthony, a white man, and Arun, who identified as an Indian man. Nonetheless, I made efforts in my analysis and the presentation of my findings to consider the participants' self-reported identities and how they informed their experiences.

Second, my study does not account for the socialization experiences or SoB of any students who left STEM or their university. This is a common thread of research using both theories, particularly given their connection to the issues of recruitment and retention. However, due to the structure of the UKSA project, students who left their majors of interest or study institutions were not interviewed further. No exit interviews were conducted with these students either, so there was no means to understand their decisions. There are two niche cases present in

this study where a student either transferred from one major to another within the bounds of the study—from chemistry to ChE—or from one of the UKSA study's US institutions to the other, so the reasons for these specific transitions will be accounted for and investigated.

Finally, as noted by Pascarella and Terenzini (2005), research on change in college students is split into two distinct streams: college impact theories and development models. The former focuses on the institution's influence on student growth, whereas the latter emphasizes intrapersonal development as the student learns and grows. This study makes use of Conrad et al.'s (2006) framing of socialization, which is a college impact model. As a result, this dissertation does not provide any deep insight into the participants' internal development, instead favoring the impact of social interactions and relationships. This is not a limitation of the study in any way, but I wanted to clearly situate my work as fitting into the college impact stream of research. Some intrapersonal development is still present in my findings, as the two are not mutually exclusive. Weidman's (1989) original framing of socialization includes individual cognitive development as a facet of the process, which remains true for my study. However, I have chosen to place the emphasis on the interpersonal and organization elements of the process in alignment with Conrad et al.'s (2006) assertion that these elements are more policy relevant and easier for educational faculty and institutions to work with for reform.

1.6 Researcher Positionality

The topic for my dissertation was partially inspired by my own experiences as an undergraduate studying industrial engineering. The ups and downs of my own journey as an engineering student informed my research interests and helped to shape the direction of this work. I struggled to make connections with peers and faculty during my undergraduate degree, putting me off from my initial career path and turning my attention towards engineering

education. The core of my research interests has always been finding ways to ensure that students can have better undergraduate experiences than I did, though my approach to promoting that outcome has shifted over time. As a result, I must be open about my own biases stemming from past experiences and be cognizant of their influence on how I collect, interpret, and present data.

First, I recognize that my own past experiences have influenced my choice of theoretical framing. There are numerous college impact models in current literature, but I was drawn to socialization due to its resonance with my own experiences on the fringes of my major's community. Its explicit focus on social interactions and relationships—or lack thereof—and their influence on personal values aligned with my undergraduate journey. My decision to use SoB as my outcome space evolved in a similar way. In my pilot analysis, which is further described in Chapter 3, I found myself reflecting on my own experiences as they compared to the participant's. Anthony's descriptions of feeling like he fit into his university but not his discipline aligned with my own past. This facet of the participant's experience was something that I wanted to maintain in my findings, which among other reasons—also described in Chapter 3—was motivation enough to begin exploring SoB. Throughout the process I was careful to not let my own personal interests outweigh the need for validating the use of my theories. I read widely on both socialization and belonging and provided rationales for the use of both approaches, which can be found in Chapter 2.

Second, having been a part of the UKSA project for three years at the time of completion of this dissertation, I have had ample opportunity to connect with the dataset I drew this study's population from. I conducted interviews with some participants, but not others, and have analyzed various parts of the dataset for previous studies (Goldschneider, 2021; Goldschneider et

al., 2020; Pitterson et al., 2022). Through the interviews and prior research work, I have established greater or lesser amounts of rapport with both the individuals and accounts present in this study, depending on the degree to which I had engaged with them in the past. To account for this in the analytical process, at the outset of working with a participant's data, I first made notes as to whether I had A) interviewed them in either the third or fourth year or B) any preconceived notions of their experiences. By writing these out at the start, I made myself aware of any preexisting memories I had of them that could bias my interaction with their transcripts and was careful to set them aside during the analysis.

Finally, as a cisgender heterosexual white male, I recognize the privilege I have, particularly in STEM. This privilege influences the lens through which I view both my own past experiences and the experiences of my participants. I tried to remain aware that my own privilege rendered my own experiences different from those of my participants. Throughout the process of this study, I tried to remain cognizant of the influence of my privilege via self-reflection and memoing. Socialization and belonging are experienced differently by every individual, and I made sure that my own perceptions did not influence participants' accounts throughout the data collection and analysis processes.

1.7 Personal Research Paradigm

As a researcher, I align myself with the constructivist paradigm. Constructivism is a research paradigm that emphasizes the individual experience, arguing that there are multiple equally valid realities that emerge as a product of an individual's reception of their lived experience (Ponterotto, 2005). In concurrence with the paradigm, I believe that every individual constructs their own reality based on the synthesis of their values, beliefs, and lived experiences(Ponterotto, 2005). As a result, when I review a participant's response, I view it less

as a strictly factual account of the occurrence and more of a personal reflection on how the individual experienced and made sense of a specific event or relationship. Multiple perspectives of the same occurrence can be, and often are, different without reducing the validity of any individual's account. Furthermore, these accounts are influenced during the process of co-creation, as a shared account perspective generated by the interaction of the participant and the researcher (Guba & Lincoln, 1994).

My personal paradigm has influenced the design of this dissertation in several ways. First, while constructivist thought does not strictly bind itself to any set of methods or methodologies, it does lend itself to qualitative research due to the weight qualitative methods give to the individual account (Guba & Lincoln, 1994). I have been drawn to qualitative research for this reason, though I will never diminish the value, usefulness, and validity of quantitative or mixed-methods research. I believe personal stories are some of the most powerful tools researchers have when examining social, cognitive, and affective phenomena in higher education settings. To this end, I chose to center my dissertation study around long-form interviews with support from existing university documentation.

Constructivism helped to inform the construction of my conceptual framework for this study as well. Both of the theoretical frameworks I chose to connect are specifically conscious of the individual nature of the phenomena of interest. Conrad et al. (2006)'s approach to socialization takes careful consideration for students' individual beliefs, values, and backgrounds when conceptualizing how the socialization process affects them. Similarly, Strayhorn (2018e) posits, "To help someone achieve a sense of belonging, one needs to know something about their expectations, values, attitudes, interests, goals, and so on" (p. 35). By placing such emphasis on the individual's characteristics and the way they interact with how the individual experiences

socialization and belonging—effectively stating that an individual's traits and characteristics result in them constructing their experiences of the same broad phenomena in different ways—I believe they align well with the constructivist paradigm.

1.8 Summary

The purpose of my dissertation study is to explore students' socialization experiences throughout their undergraduate careers in pursuit of furthering the understanding of how social interactions and relationships influence students' SoB in their discipline and in their university. This knowledge would provide a basis for improvements to existing university structures, policies, and interventions that would support students at risk of leaving STEM or their university altogether. Reducing attrition due to lack of belonging provides an avenue for future research and practice in an effort to reduce the concerningly high percentage of students who do not complete their degrees.

Chapter 2 will provide a broader overview of existing literature in the higher education space addressing recruitment and retention issues, student exposure to STEM, and elements of the culture in STEM that contribute to attrition. It will subsequently delve into the current body of research on both socialization and belonging in an effort to ground my study in existing theory. Conrad et al.'s (2006) framework of undergraduate socialization will be introduced, followed by Strayhorn's (2018e) theory of SoB. The justification for combining them into the conceptual framework that undergirds my work will then be provided, along with alternative theories that were considered during the formation of the study. I close the chapter by identifying the gaps in current literature that my study will address.

Chapter 3 describes the methodology and methods employed in this dissertation in more detail, providing further justification for the fit of Yin's (2018) embedded case study approach.

Participant recruitment, selection, and demographics will be provided, followed by the methods employed in both data collection and analysis. Measures of research quality and the steps taken to ensure the study was performed in an ethical manner will be summarized. Finally, limitations of the study will be addressed.

Chapter 4 provides a summary of the results of my analysis. Individual participants will be introduced via short trajectories of their socialization and belonging before patterns are established across the full study population. Each of the research questions will be explored in-depth with examples and direct quotations from the participants to illustrate the themes that emerged from the data. Three distinct trajectories of socialization are identified and discussed with consideration for intra-category differences. Some additional findings outside of the scope of the specific research questions will also be covered.

Chapter 5 will connect all of the previous chapters together, outlining the primary contributions of my study and how they build upon existing research. I will explain how my work begins to address some of the research gaps identified in Chapter 2. Subsequently, I will address how my findings can be used by the broader engineering education community going forward for both additional research and practice.

Chapter 2 - Literature Review

2.1 Introduction

Set against the backdrop of sustained cries for increasing the number of STEM graduates in the United States (U.S.; National Academy of Sciences, 2007, 2011), my study was geared towards addressing recruitment and retention concerns. The significant number of students leaving STEM can be attributed to a number of factors, including but not limited to academic difficulty (Sanabria & Penner, 2017; Solomon & Croft, 2015), misalignment of expectations and reality (Bush et al., 2014; Godwin & Potvin, 2017), unwelcoming culture (Canning et al., 2020; Thébaud & Charles, 2018) and low self-efficacy and self-confidence (Geisinger & Raman, 2013). To address the matter of persistence and degree completion, I chose to employ students' sense of belonging (SoB) as the outcome of my work. SoB has been previously linked to persistence and positive academic outcomes like increased self-efficacy and engagement (Barth et al., 2021; Pendergast et al., 2018). It has also been identified as a positive influence on students' overall well-being (Luque-Suárez et al., 2021; Morinaj & Hascher, 2019). When students feel like they belong on campus and in their chosen discipline, they are more likely to stay (Davis et al., 2019). Numerous factors have been related to the development of belonging (Lewis et al., 2016; Sprowls, 2020), but I have chosen to focus on students' socialization experiences as undergraduate students (Chen & Yao, 2015). Students' socialization experiences revolve around the various individuals, organizations, and structures—all contained under the umbrella terms "reference groups" or "socializing agents" (Weidman, 1989)—students interact with during their time on and off campus. As students interact with these socializing agents, they gain knowledge and experience that they then integrate into their existing system of personal

beliefs, values, knowledge, and skills (Conrad et al., 2006). I argue later in this chapter that by using the lens of socialization, this work has uncovered ways that specific interactions and relationships influence students' belonging within their specific institutional context, addressing existing research gaps (Strayhorn, 2018c).

In this chapter, I will first introduce the background of my study, exploring the current issues with persistence and recruitment in STEM education (Section 2.2). I will then explore literature on socialization, one of the guiding theories for my dissertation work (Section 2.3). Following that will be a similar exploration of the theory of belonging and how it has been applied to higher education (Section 2.4). Subsequently I will introduce the specific theories that guide my dissertation: Conrad et al.'s (2006) framework of undergraduate socialization and Strayhorn's (2018e) framework of belonging (Section 2.5). The connection between the two will be established, and I will present the conceptual framework guiding my dissertation work. Alternative theories will briefly be addressed (Section 2.6) before I present the research gaps my dissertation seeks to address to close the literature review (Section 2.7).

2.2 The Ecosystem of Recruitment and Retention in STEM

Over the past several decades, calls have come for US institutions to increase the number of STEM students being recruited and retained through graduation (National Academy of Sciences, 2007; U.S. Department of Education, 2022). Attrition numbers are high for engineering in particular, with up to 30% of students leaving the field by the second year, and some estimates of the national average of four-year graduation rates hovering around 35% (Yoder, 2016). Completion rates are even lower for historically minoritized populations as well (Lisberg & Woods, 2018; Yoder, 2016). Such high attrition rates have endured, as they were a concern for researchers prior to the turn of the 21st century as well (e.g., Astin & Astin, 1992;

Tinto, 1975, 1987, 1993). Nonetheless, the statistics presented in reports and government initiatives (National Academy of Sciences, 2007; U.S. Department of Education, 2022; Yoder, 2016) placed pressure on and provided incentives for primary, secondary, and post-secondary educational institutions alike to foster student interests in STEM and create an environment in which all students could thrive. The success of such recruitment and retention efforts have been mixed. This section of the literature review will begin with an overview of how STEM is presented to students in the K-12 educational space, followed by an examination of how colleges and universities recruit students and support them prior to the beginning of their first semester of undergraduate study. Subsequently, topics related to retention will be addressed, including the overarching culture in both engineering and STEM more broadly, and the academic hurdles students must overcome to pursue their degrees.

2.2.1 K-12 Introductions to STEM

Shortly after the aforementioned round of calls for increased STEM participation in the US began to emerge in the early 21st century, another report was published detailing the status of engineering education at the K-12 level. This report outlined the scope of engineering's inclusion in K-12 curricula, a summary of the tools being used, and some aspirational goals for future development (Committee on Understanidng and Improving K-12 Engineering Education in the United States, 2009). In short, there were numerous questions about if and how engineering would be woven into existing science and technology programs, what kinds of programs and tools would need to be developed, and how research could help address these questions. Outside of purely academic spaces, students could still be introduced to STEM, most commonly through familial influences (Matusovich et al., 2011). Familial exposure to engineering was particularly salient for women, who were more likely to pursue STEM if someone in their family did so first

(Schreuders & Mannon, 2007). I have included this discussion of pre-college experiences as they are a critical component of developing students' perceptions of engineering (Hammack et al., 2015; Madara & Namango, 2016). These perceptions then allowed students to make judgements of whether their own ideals, skills, and values align with what they have seen of the field, which in turn influenced their enrollment decisions (Strayhorn, 2018e). Pre-college experiences will be examined further in the context of this study's participants in Chapter 4, but for now I focused on the existing literature.

Introductions to STEM in the K-12 space take two primary forms: direct integration into the curricula, and extracurricular programs. Engineering concepts have been increasingly present in K-12 curricula, with the Next Generation Science Standards (NGSS) declaring the end goal to be engineering design taking equivalent priority to the physical, life, earth, and space sciences (NGSS Lead States, 2013). Despite some guidance, the way these concepts have been introduced varied widely. Some programs used introductory programming software to introduce algorithmic thinking and computer science topics to students (Noak et al., 2022), while others focused on hands-on activities to bring STEM topics into the physical world (English & King, 2019; Ryder et al., 2012; Terry et al., 2011). Efforts have been made to combine traditional K-12 life science principles with engineering design, moving towards a fully combined approach to STEM topics (Guzey et al., 2016). Finally, some programs have experimented with outreach to professional organizations to introduce topics and specialized fields of engineering to their students, as in Dick et al.'s (2019) experiment with railway engineering. The outcomes of such curricular reforms have been noted, as in the case of statistically significant increases in standardized test scores following the introduction of engineering concepts as part of Project Lead the Way in Iowa (Rethwisch et al., 2012), though others did not have such positive outcomes (Guzey et al.,

2016). Furthermore, participation in engineering-specific courses in high school has been linked to increased likelihood of pursuit of a STEM degree in college (Phelps et al., 2018). More work is still needed to fully understand the best practices for the introduction of an integrated STEM curriculum, but in the meantime, many schools have turned to extracurricular activities to provide early introductions to hands-on science and engineering.

The most commonly studied form of extracurricular exposure to engineering is the plethora of summer programs available to middle and high school students, though after school programs have begun to be recognized as a valuable space for informal STEM learning (Schnittka et al., 2016; Vallett et al., 2018; H. Wang et al., 2018). Like their curricular counterparts, summer programs have tried to approach STEM content in a variety of different ways, ranging from research-focused experiences (Kittur et al., 2017) to hands-on projects (Cui et al., 2011; Goonatilake & Bachnak, 2012; Yilmaz et al., 2010) and industry site visits (Goonatilake & Bachnak, 2012; Hirsch et al., 2017). Through these introductions, students had the opportunity to learn more about engineering as a discipline and their prospects for further study as well. In general, summer programs resulted in increased interest in pursuing STEM, particularly among participants from historically minoritized backgrounds (Hammack et al., 2015; Hart & McAnulty, 2014). Whether in class or out of school, introductions to STEM during primary and secondary schooling had strong implications for fostering student interest in pursuing STEM further.

Finally, I would like to provide a brief nod to the body of research that exists to understand the factors that influence students' perceptions of STEM. Numerous instruments have been developed to measure student affinity for STEM and the factors that influence it (Capobianco et al., 2012; Madara & Namango, 2016; Mahoney, 2007; Mau & Li, 2018;

Pierrakos et al., 2016; Wright, 2018). My dissertation work was primarily focused on the experiences and social connections most influential to students and seeing as these authors primarily describe their instruments' design and validation, I chose not to cover them in-depth here. Nonetheless, I would have been remiss to not mention their work in the K-12 engineering education space.

2.2.2 Easing the Transition: Post-High School, Pre-College

The time between graduating high school and starting college is a simultaneously exciting and nerve-wracking period for many students. Many are leaving home, family, and friends. Graduating seniors can face anxiety over standardized test scores, familial pressures, and more (Çirak, 2016). Some are setting out on an academic journey without being certain about their decision of major (Pinxten et al., 2014). Others are the first in their families to pursue higher education, with little familial guidance to ease their transition (Gist-Mackey et al., 2018). Some have tried to ease this transition by approaching it from a mental and physical wellness perspective (Jellinek, 2006). One common way that universities have tried to aid students in their introduction to university life is through preparatory bridge programs.

Bridge programs are typically designed to do two things: support academic competencies and help students adjust to college life (Tomasko et al., 2016), though some are also designed towards other outcomes (Baker et al., 2009; Barth et al., 2021). Oftentimes the academic competencies being targeted—particularly at engineering- and STEM-focused universities—are related to mathematics, often specifically calculus (Cançado et al., 2018; Grimm, 2005). Addressing the mathematics students will need in their first year is a crucial step in helping them succeed early in their career. In the past, bridge programs have been found to be beneficial for the retention and graduation rates of students in STEM, particularly for historically minoritized

groups and students that were identified as “academically at-risk” (Gleason et al., 2010; Grimm, 2005; Tomasko et al., 2016). Furthermore, the introduction to on-campus resources, the physical environment of the university, and a small group of peers has been found to be beneficial for students, particularly at the beginning of their first year (Barth et al., 2021). Bridge programs are a powerful tool in easing the transition from high school to college, giving students a chance to begin to develop feelings of belonging at their university before many of the peers (Strayhorn, 2018a).

2.2.3 Engineering and STEM Culture

The culture of STEM, and particularly engineering, has long been under scrutiny for being male-dominated and unwelcoming to women and historically minoritized populations (Douglas et al., 2020; M.-T. Wang & Degol, 2017). This “chilly climate,” wherein those in the minority are made to feel cast out, ignored, or isolated, has contributed heavily to the persistence of race and gender disparities in STEM fields (Cosentino de Cohen & Deterding, 2009; Šaras et al., 2018; Simon et al., 2017). All levels of STEM are affected by such discrimination, from the stereotypes that make middle and high school girls turn away from STEM (Cheryan et al., 2015; Madara & Namango, 2016; Starr & Simpkins, 2021) to community college campuses (Jorstad et al., 2017), undergraduate (Jensen & Deemer, 2019) and graduate students (Wilkins-Yel et al., 2022), STEM faculty (Griffith et al., 2022), and engineering industry (Ettinger et al., 2019; Ross & Godwin, 2015). Further complicating the matter of discrimination in STEM is that it is not always active, but rather takes the form of a pervasive set of social norms that have evolved to support masculinity and whiteness.

Beginning even in elementary school, both students and instructors have been shown to harbor the belief that men are better at mathematics and science, even to the point of

overestimating the male students' potential while underestimating that of women (Hand et al., 2017). The undercurrent of male dominance in STEM is present in university-level classes as well. Deiglmayr et al. (2019) found that many women across five STEM disciplines felt that they were lacking the "brilliance" required to succeed in STEM, a trait recognized by men and women alike, but much more commonly claimed by the former. This notion aligns with extant literature in arguing that even as ideals of what is valuable or preferable evolve, they are often deemed masculine (Akpanudo et al., 2017). Even in industry, women often feel pressured to overperform in their roles so that their presence will be recognized and considered valid by their peers, despite being passed over for promotions and awards (Ettinger et al., 2019). In recent decades however, it has become apparent that not all STEM fields are equally dominated by males. While women still only make up only about twenty percent of the student populations in engineering and physics (Yoder, 2016), they have become the majority in the fields of chemistry and biology, and are nearly half of the population in mathematics (Snyder & Dillow, 2015). Progress towards equal presence and treatment is being made, but the problematic culture of STEM remains intact. Unfortunately, that very same culture affects not just women, but other historically minoritized populations as well.

The demographics of the engineering populations in both industry and academia are far from representative of the U.S. population as a whole (Lichtenstein et al., 2015; National Center for Science and Engineering Statistics, 2017). Some have attributed this to a range of factors, including college affordability, social support, role models, access, and preparation (National Academy of Sciences, 2011). Interactions with faculty (Newman et al., 2015; Strayhorn, 2018d), microaggressions (Dupuy et al., 2018), discriminatory hiring practices and office environments (Douglas et al., 2020), and poor research collaboration experiences (Griffith et al., 2022;

Wilkins-Yel et al., 2022) have also been noted in prior research. Many have attempted to address the challenges head on, designing programs and interventions meant to recruit and retain minoritized students. Extracurricular programs have been specifically designed to be accessible to minoritized and underserved populations, fostering STEM identities from an early age (H. Wang et al., 2018). Interventions and support structures have been designed to aid minoritized students in their undergraduate pursuits including connecting them with mentors (Lisberg & Woods, 2018), fostering STEM identities (Hazari et al., 2013), and building community and feelings of belonging (Barth et al., 2021; Maestas et al., 2007; Strayhorn, 2018a). There is much more that has been done in this research space, and I regret that I could only present a small portion of it in my exploration of the influence of the underlying culture in STEM. Nonetheless, the disparities in how culture affects minoritized populations is an important consideration when linking culture to recruitment and persistence. Before moving on from STEM culture in this chapter, however, there is an additional aspect of this topic I have yet to cover: competition.

The final element of STEM culture I would like to address in this section is its historically competitive and sometimes cutthroat nature. STEM degrees are difficult, a key contributor to the high attrition rates (Whalen & Shelley, 2010). However, the culture that surrounds this difficulty perpetuates the stance that STEM is difficult, it should be difficult, and not everyone should be able to complete a STEM degree (Riney & Froeschie, 2012). The culture of challenge can be seen in the aforementioned beliefs in the necessary "brilliance," or innate talent required to achieve success in engineering (Cheryan et al., 2015; Deiglmayr et al., 2019). Furthermore, early career STEM classes are often presented in such a way that students and faculty alike approach them with the expectation that many will not pass, creating an air of competition that alienates students (Canning et al., 2020). This exclusionary approach—

sometimes viewed as “weeding out” students—disproportionately affects minoritized student populations and results in greater rates of attrition (Wallwey et al., 2022). When students feel excluded or threatened by their academic workload, overcoming the challenges presented by their early-career classes becomes an even more daunting task.

2.2.4 Academic Hurdles

As students begin their undergraduate careers in STEM, they are often met with a number of academic hurdles, particularly in mathematics (Solomon et al., 2010). The required courses, generally beginning with pre-calculus or calculus, are a roadblock for many students. Once they begin to struggle, they often disengage from the course content, worsening their performance even further (Solomon & Croft, 2015). Without being able to complete their prerequisite courses, many students never make it to their major-specific content, leaving STEM altogether. Chemistry, physics, and calculus grades have all been identified as good predictors of student persistence, further underlining the importance of overcoming early academic challenges (Geisinger & Raman, 2013). Some students also chose to move away from what they perceive to be a fully abstract first-year curriculum, a far cry from the hands-on experience they expected in engineering (Bucks et al., 2015). Others struggled under the pressure of the cutthroat culture presented in many STEM classes (Canning et al., 2020). In combination, the academic load and the other adjustments that are needed for university life can pile up on students, placing them in a position where they feel like they cannot recover (Meyer & Marx, 2014). Given the significant impact academic hurdles have on students’ persistence, researchers have put great effort into trying to find ways to mitigate their influence.

As previously noted in section 2.2.2, bridge programs are one area that has already been explored with regards to mathematics preparation (Cançado et al., 2018; Gleason et al., 2010).

By addressing students' uncertainties about the prerequisite concepts early, students performed better in their mathematics classes and were more likely to persist. Other researchers have explored the value of mathematics support centers as a means of providing comfortable and supportive learning environments (Solomon et al., 2010). Significant attention has also been paid to how rising class sizes have affected students and how to mitigate their impact on student performance (Beattie & Thiele, 2016; Gleason, 2012). Taking a different angle on the issue of students' performance and persistence, Henry et al. (2019) call out a lack of acceptance of failure in STEM, despite the intrinsic value of failure to the advancement of science. They argue that students are ill-equipped to handle failure when they arrive to the university, often leading to their decision to change majors. Their solution, in turn, is to foster a growth-oriented mindset in students and help them attribute their failings to factors that are within their control, an approach supported by other researchers as well (Lisberg & Woods, 2018; Sriram, 2014). Providing examples of failure from senior members of a community has also previously been found an effective tool in helping new students accept their own failures in a lab environment (Wylie, 2019). Regardless of whether they are being supported so as to not fail, or taught how to do so with resilience, further work is necessary to understand how students can be aided in overcoming the challenges of early STEM coursework.

2.3 Socialization in Educational Spaces

Socialization emerged alongside a growing number of theories that examined the collegiate institution's effect on students, opting not to share the focus on the intrapersonal development of students that had previously dominated the literature (Pascarella & Terenzini, 2005). Socialization had also been a theoretical approach previously employed in sociology and psychology (Brim & Wheeler, 1976), but Weidman (1989) tailored it to specifically focus on

undergraduate students. What set socialization apart from other college impact models was its granular focus on the role of social relationships and interactions. The framework took into consideration both internal characteristics and identities and external factors like organizational structures and policies—common threads in a number of college impact models (e.g., Astin & Astin, 1992; Terenzini & Reason, 2005)—but used them to characterize the aforementioned social interactions, rather than examining their individual influence on student outcomes. Weidman's (1989) framework evolved over time, taking more into account the influence of organizational structures in the version that I adopted for this study (Conrad et al., 2006). A more in-depth explanation of Conrad et al.'s framework and my rationale for selecting it for this study are provided later in this chapter in section 2.5. This portion of the literature review provides a broader overview of socialization's application in higher education spaces. I will begin with an exploration of the avenues for and impacts of socialization for undergraduate students, followed by brief nods to socialization in both graduate school and professional contexts.

2.3.1 Socialization of Undergraduate Students

Socialization research provided a means to understand how new students are introduced to their majors and taught the fundamentals. In their newly acquired roles, students must learn to navigate the social, academic, and institutional ecosystems in their university, adapting to norms, rules, and expectations (Terenzini & Reason, 2005; Weidman et al., 2014). Through the lens of socialization, the most salient means for students to learn these expectations and skills is through social relationships (Korte, 2009). As a result, much of the current socialization literature focused on these relationships, their impacts, how they can be best fostered and maintained, and where they break down. Several authors have examined the role of social connections and support in students' choice of major, finding that existing interpersonal links to a discipline (e.g.,

family and friends) are an important factor (Schreuders & Mannon, 2007; Vulperhorst et al., 2020). Part of the contribution of this precollege socialization is that it helps students conceptualize what studying in their chosen discipline will be like. This introduction allows students to determine whether their own values and beliefs align with the expectations of the discipline, establishing congruence (Bush et al., 2014). The process of negotiating congruence continues during students' time on campus as well. For example, Lindberg (2009) studied the interactions and relationships that develop Swedish medical students' understanding of what an "ideal physician" is and the subsequent impact of these beliefs. While Godwin and Potvin's (2017) case study of a woman engineering student was originally examined through the lens of critical engineering agency, the findings therein are reminiscent of the issues mentioned here. The student, Sara, found herself feeling distant from engineering due to how she had constructed what engineering entailed and she ultimately departed from the major altogether. Several studies have also documented how socialization during the undergraduate years can in turn inform students' understanding of what possible careers in their majors look like, spanning a range of disciplines including engineering (Keltikangas & Martinsuo, 2009), public relations (Waymer et al., 2018), sales, (Bush et al., 2014), and even in assistance of undecided students (Platt, 2020). The impacts of socialization go well beyond perceptions of the discipline, however.

Socialization research has also contributed to the understanding of the way that student-instructor relationships and classroom environments contribute to the fulfillment of learning objectives. Researchers have been interested in student-faculty interactions as a means for introducing students to the disciplinary norms for feedback and discussion, providing cause for changes to how these interactions can be facilitated both inside and outside of the classroom (Weaver & Qi, 2019). This work also helped to demystify how students come to view their

professors as authorities, mentors, or numerous other relationships. Early connections with faculty have been shown to make students more comfortable asking for help and seeking mentorship from faculty, resulting in more meaningful relationships later in their careers (Fuentes et al., 2014). Beattie and Thiele (2016) cited a host of other socialization literature as a basis for their investigation of various peer-peer and student-faculty interactions in the classroom. Their interest extended beyond the walls of the classroom to include interactions with both peers and faculty conducted outside of structured class time. Their work also captured an important consideration in conducting socialization research by highlighting the varied effects that background and demographic characteristics can have for student experiences of socialization.

Other researchers have also made note of these impacts. Ellis' (2001) exploration of racial and gender influence on socialization experiences revealed that both played a role, even more so for Black women than for Black men. Uneven experiences in engaging with faculty hampered feelings of belonging for Black men as well in studies of community colleges (Newman et al., 2015) and four-year universities alike (Strayhorn, 2018d). Similarly, faculty-student interactions were found to be encouraging and supportive for some international students and dismissive and detrimental to others; the difference often stemmed from the individual student's level of academic and financial preparedness (Glass et al., 2015). First-generation students were also identified as being less likely to engage with their professors or teaching assistants in large (>100 students) classes and more likely in small classes (Beattie & Thiele, 2016). Gist-Mackey et al. (2018) examined the socialization experiences of first-generation students, identifying that their anticipatory socialization prior to arrival was experienced differently, as they had no family members to look to for guidance. Furthermore, supportive

interactions and early-career socialization proved critical in helping them feel like they belonged in the university environment. Finally, I would like to note some of the forays into exploring the socialization experiences of women in STEM. Familial influences were shown to be paramount, as women engineering students were much more likely to have at least one parent who was an engineer than their men counterparts (Schreuders & Mannon, 2007). Women engineering students were also found to have significantly more gender-related negative experiences with their peers and instructors, particularly in group project work and from a small sample of their men professors, particularly at Division 1, research focused universities (Riney & Froeschie, 2012). Being that group work is a core part of many STEM curricula, these findings are particularly concerning, but not surprising given the existing culture described earlier in the chapter.

Some researchers crossed theoretical lines and link socialization and disciplinary identity, typically with the latter as an outcome of the former (Rodriguez et al., 2018; Weidman et al., 2014). Parental and teacher stereotypes about mathematics and science proficiency had noticeable impacts on high school students' self-perceptions of their proficiency and STEM identities (Starr & Simpkins, 2021). Another study linked music students who had more positive experiences with performance, studio time, and classes to stronger teacher identities than their peers at another institution with less favorable experiences (Austin et al., 2012). Though these differences may be attributable to either the institution, program, or individual, the findings were noteworthy, nonetheless. Specific types of socialization have also been highlighted for the role that they can play in helping students develop opinions of their discipline. Stories of failure and fallibility among senior students in research labs have been used to make younger students feel more comfortable with their own capabilities (Wylie, 2019). Exposing early-career students to

senior peers who are open about their own failures helped adjust the students' perceptions of failure, a common pitfall for many STEM students (Henry et al., 2019). While this narrow focus on single socializing agents or experiences helped to identify specific beneficial interactions, it did underline one of the research gaps this dissertation sought to address: the lack of a holistic view of the socialization process. This gap and the others I have identified are covered in more detail towards the end of the chapter.

2.3.2 Socialization of Graduate Students

Much like their undergraduate counterparts, graduate students must learn the expectations and skills necessary to succeed in their endeavors. Weidman et al. (2001) built upon Weidman's (1989) original undergraduate framework to provide an adapted version for graduate contexts. The primary change is the inclusion of an external professional community in the socializing of graduate students, as compared to the greater focus on the university community for undergraduates. External socializing agents like employers were still relevant, but less central and less universally present when compared to graduate students' professional peers (Weidman et al., 2001). Graduate students were also connected much more closely with a smaller subset of faculty, and success in such relationships was often a key contributor to academic and professional accomplishment (Feldon et al., 2016). Further complicating the navigation of graduate school was the unspoken and often untaught assumptions of prestige given to specific universities, programs, conferences, and journals (Fogarty & Jonas, 2010). On top of all of the aforementioned challenges, graduate socialization was also heavily dependent on the specific disciplinary and departmental context in which it occured (Gardner, 2010).

Numerous factors can set one graduate department apart from another, and in turn change the normative culture in which socialization occurs (Gardner, 2010). Research facilities and the

types of research work being done, graduate working space, funding opportunities, and more can all feed into students' socialization experiences (Gardner, 2007). The level of competition within and across departments can also influence socialization as faculty and graduate students must go against one another for limited resources (Gardner, 2010). It is no surprise, given the challenges presented here, that some research has been devoted to finding ways to ease the transition into graduate education by making expectations and available resources clear to incoming students (Benavides & Keyes, 2016). Much like in undergraduate study, knowledge of resources is a significant boon to incoming students (Cançado et al., 2018; Oliveira, 2017).

Unfortunately, another similarity shared between undergraduate and graduate socialization is that it is experienced differently by students from historically minoritized groups. Twale et al. (2016) revisited the original graduate socialization framework (Weidman et al., 2001) with a specific focus on students from minoritized populations. They argued that historic patterns of faculty choosing to admit and advise students like themselves (Garces, 2012), a lack of multicultural curricula (Griffin et al., 2016; Winkle-Wagner & McCoy, 2016), and sociopolitical challenges around race within departments (McGaskey, 2015) posed undue challenges on minoritized students. Such challenges have been echoed in more recent literature as well, but also expand to include the existing culture of masculinity in STEM as a deterrent for women graduate students on top of racial and ethnic discrimination (Wilkins-Yel et al., 2022). Finally, some research has also been focused on first-generation students, though the findings of Roksa et al. (2018) did not indicate significant differences in the socialization experiences of first- and continuing-generation PhD students. Subtle differences emerged around publication rates in early years, but they tended to even out over time.

2.3.3 Socialization in the STEM Workplace

Though not the focus of this study, it is still worth mentioning the research that has been done to investigate students' socialization after college as they begin work in industry (Beddoes, 2021; Korte & Li, 2015) and as faculty in academia (Stewart et al., 2021). As with any transition, there were often feelings of anxiety, uncertainty, and confusion that inhibited an individual student's ability to perform well as they first begin their work. While historically the burden of responsibility for learning the roles and responsibilities of a new position has fallen to the newcomer, companies have substantial capabilities to ease these transitions (Korte, 2009). Given that the assumptions, norms, and roles of professional engineering are different from that of engineering scholarship, it can be a difficult process. New hires must unlearn many of the things that they came to know during college to account for the new culture, rules, and limitations of their new organization (Kowtha, 2008). Some have also tried to address the question of whether the socialization experiences that universities provide are authentic to engineering industry, or if there is a disconnect that must be addressed if students are to graduate prepared for their next steps (Keltikangas & Martinsuo, 2009).

2.4 Belonging in Higher Education

Belonging has long been recognized as an important facet in human development, often being considered a fundamental need to attain the highest levels of self-actualization (Maslow, 1954; Strayhorn, 2018e). SoB within a specific context stems from a combination of factors, including feeling accepted, valued, supported, and welcomed into a group or environment (Strayhorn, 2018c). Though this section of my dissertation will focus on belonging within education contexts, the theory has been applied across a wide variety of domains. Belonging has been a phenomenon of interest among migrant, refugee, and otherwise displaced populations as

they make efforts to adapt to a new environment (Bielenin-Lenczowska, 2014; Osman et al., 2020; Van Eldik et al., 2019). Medical institutions have used the lens of belonging to understand the journeys of medical students (Baixinho et al., 2022; Blanchard et al., 2021; Puranitee et al., 2022) and professionals alike (Diaz-Berenstain, 2021). Other industries have also taken note, including social work (van Zyl, 2022) and agriculture (Sáanchez et al., 2019). The topic of this dissertation, however, remained squarely bounded to a higher education context. I will focus first on the efforts that have been made to help support students in developing their SoB before then delving into the subsequent impacts that SoB can have on students' academic and professional outcomes.

2.4.1 Developing Belonging

To begin this foray into existing literature on the development of belonging, I will revisit the social interactions that dominated the previous section of my literature review, highlighting the relationships that have been identified as important in fostering SoB. Positive interactions with faculty have frequently been studied for their contribution to belonging, but these findings are nuanced. The most beneficial interactions were those in which faculty showed interest and support for student development (Lewis et al., 2016; Maestas et al., 2007; Santa-Ramirez, 2022; Stachl & Baranger, 2020) and respected students for their authentic selves (Strayhorn, 2018e; Vaccaro & Newman, 2016). The latter was particularly important for historically minoritized students, as illustrated by the inconsistent relationships with faculty described by Black men in the work of Newman et al. (2015). Some students were able to foster meaningful connections, but others were dissuaded by persistent racial stereotypes being perpetuated by their instructors. Similarly uneven interactions were described amongst international students, wherein faculty

could either be encouraging role models, or dismissive agents that alienated students in an already unfamiliar environment (Glass et al., 2015).

Though student-professor interactions were among the most studied, students interacted with a host of other groups and individuals that influenced their belonging. Peer groups were a common source of belonging (Antonio, 2004; Jaiswal et al., 2022), particularly for minoritized students, for whom relationships with peers who shared racial or ethnic backgrounds were especially important (Santa-Ramirez, 2022). For students on the Autism spectrum, it was relationships with neurotypical peers that most helped them feel like they belonged (McLeod et al., 2019), a pattern reflected in students with learning disabilities as well (Hadley, 2014). Advisors played a key role in clarifying students' paths forward and helping them see themselves succeeding at the university and in their chosen major (Meyer & Marx, 2014; Strayhorn, 2018e). Familial expectations and views on science abilities could intensify student anxieties around poor academic performance, amplifying doubts of belonging in turn (Hadley, 2014; Starr & Simpkins, 2021). Finally, the very culture that permeates STEM was something many students—particularly women and other minoritized populations—had to wrestle with to feel like they belong. Stereotypes about STEM capabilities (Starr & Simpkins, 2021), beliefs about innate STEM talent (Cheryan et al., 2015; Deiglmayr et al., 2019), gender imbalances among peers and faculty resulting in a lack of role models (Lewis et al., 2016), and generally unwelcoming environments and interactions (Wilson & VanAntwerp, 2021) all contributed. Given the plethora of factors and interactions that can support or detract from belonging, the logical next step is to investigate what work has been done to improve the potential for belonging on college campuses.

Many efforts to foster feelings of belonging in students began in the classroom, a crossroads of sorts for engagement with peers, professors, and course material (Case, 2007). All three facets of the classroom environment have been the subject of further study. Hamm and Faircloth (2005) found that when paired with peers with similar feelings of belonging, those with poor belonging tended to become more alienated from their classroom environment over time, whereas those with stronger belonging tended to remain comfortable in their position, indicating that the peer context has a significant impact. Other authors have found similar impacts of peers in providing feelings of validation, support, and psychological safety in the classroom (Jaiswal et al., 2022; Puranitee et al., 2022). Some interventions have instead focused solely on the role of the instructor in the classroom, though often with interest in similar outcomes. Ibarra (2022) emphasized the use of socio-emotional learning in developing a supportive classroom environments that in turn fostered belonging among the students. Classroom environments and instructor supportiveness have been identified as particularly important for students who were deemed to be at higher risk of disengaging from their school environments (Pendergast et al., 2018). Finally, there have been several efforts to bolster belonging in classroom environments through supportive pedagogy. Stoddard (2022) trialed a collaborative research project on professional chemists that placed an emphasis on recognizing the contributions of historically minoritized populations to the field of chemistry. Her findings indicated that both majority and minoritized students' belonging in STEM were positively affected, though more consistently and more strongly for the minoritized populations. Other efforts have included connecting students to professional mentors in their field of interest (Sprowls, 2020) and networked learning approaches that connect students to their peers, instructors, and professionals (Levin et al., 2019). Moving

beyond the classroom, I now shift the focus onto campus-wide efforts to support students' belonging.

Strayhorn (2018d) described the most important on-campus contributors to belonging as "educationally purposeful activities that foster a sense of mattering" (p. 121). This description placed heavy emphasis on the importance of campus activities that make students feel valued, needed, and welcomed. Students often found such support with on-campus organizations and clubs where they could meet other students like themselves (McCabe et al., 2005; Strayhorn, 2018b). Disciplinary professional societies have been shown to be a powerful tool in developing belonging to students' majors (L. Wang, 2016). Culturally-based student organizations provided a community of supportive peers, often providing the greatest benefit for students of historically minoritized backgrounds (Santa-Ramirez, 2022; Strayhorn, 2018h). Some researchers have also tried to identify the impact of broader community participation activities like volunteering, often to mixed results in terms of belonging outcomes (Luque-Suárez et al., 2021). Greek life organizations have been identified as a strong influence on belonging, with members of sororities and fraternities often surpassing their non-member peers in terms of university belonging as well (Strayhorn, 2018b). Institution type is a final variable to consider, with Smith et al. (2012) having explored quantitative measures of belonging longitudinally at a research institution, a Historically Black College/University (HBCU), a women's college, a faith-based institution, and a teaching-focused institution, though they did not do cross-contextual analysis in their study, and no information about the development of the belonging they measured was provided.

As a final note on supporting belonging, I would like to briefly explore some of the literature that emerged on belonging in online environments, a topic that became increasingly prevalent to researchers during the COVID-19 pandemic. Prior to the pandemic, researchers had

juxtaposed the experiences of online and in-person learners, finding that their SoB was heavily dependent on their experiences in the respective learning medium, rather than the medium itself (Thomas et al., 2014). The pandemic shut down university campuses and classrooms across the world, forcing them to transition on online environments, cancel student clubs and organizations, and close down the vast majority of in-person operations (Aristovnik et al., 2020). To counteract the decreased face-to-face exposure students were getting, research began to focus on how online learning environments could best be designed to support students' belonging (Blignaut et al., 2021). Incorporation of collaborative project-based learning projects helped to mitigate the lack of interpersonal interaction while supporting learning objectives and connecting students to their disciplinary community in one Hong Kong institution (Liu et al., 2022). The themes of connection and support were also echoed among online learners as a means to diffuse feelings of isolation and foster belonging in their academic communities as well (Peacock et al., 2020). Altogether, research has spanned a wide variety of domains in which improvements can be made for the support of student belonging. The importance of these SoBs is presented next.

2.4.2 Outcomes of Belonging

At its core, my dissertation primarily examined the development of belonging, which was addressed in the previous section. This emphasis, in combination with the literature on belonging often converging on a number of similar outcomes, resulted in this section being a bit shorter than the previous. Nonetheless, I felt it important to justify its focus on belonging as an outcome by examining the subsequent impacts belonging could have for students. In general, the literature on belonging tended to link it to two distinct sets of outcomes. The first related to students' academic achievement, the second their psychological and physical well-being. I will address each grouping in turn. Commonly on the academic side, feelings of belonging have been

linked to persistence (Booker, 2016; Hausmann et al., 2009; Lewis et al., 2016; Master & Meltzoff, 2020; Pendergast et al., 2018), with stronger SoB generally indicating greater likelihood of persistence. Belonging has also been linked to STEM identity (Master & Meltzoff, 2020) and self-efficacy (Barth et al., 2021), which subsequently have been shown to improve academic performance (Seyranian et al., 2018). Students with strong academic SoBs have been noted to engage more with their studies (Wilson et al., 2015), with the weaker belonging leading to disengagement as well (Pendergast et al., 2018; Solomon & Croft, 2015; Wilson & VanAntwerp, 2021). There was overwhelming evidence on a variety of fronts that fostering belonging leads to positive academic outcomes, but it held potential benefits for students psychological, physical, and emotional well-being too.

One of the primary ways in which belonging bolsters students' mental and physical well-being is simply in its presence; alienation carried with it a host of psychological and physical health risks (Morinaj & Hascher, 2019). When students feel as if they are isolated or being burdensome to those around them, suicidal thoughts and behavior have been shown to increase (Van Orden et al., 2010). Bolstered belonging, in the case of Walton and Cohen (2011), however, was linked with improved self-reported health and a decrease in the number of doctors office visits in years following an intervention geared towards supporting the students. SoB has also been specifically targeted as a means of increasing students emotional well-being, in and out of the classroom (Ibarra, 2022; Luque-Suárez et al., 2021). It is worth noting, however, that not all actions surrounding belonging foster healthy outcomes. The desire to belong has motivated students to engage in unhealthy patterns of alcohol and drug consumption (McCabe et al., 2005) or unsafe or reckless sexual practices (Strayhorn, 2018f).

2.5 Development of the Conceptual Framework for this Study

My dissertation work had two interwoven theoretical foci: the mechanisms of socialization and the development of disciplinary and university SoB. To encompass and connect both and effectively address the research questions posed in Chapter 1, I elected to use two existing theoretical frameworks. My understanding of the processes of socialization was undergirded by Conrad et al.'s (2006) model of undergraduate socialization from an organizational perspective. Correspondingly, Strayhorn's (2018e) theory of belonging guided its respective portion of my study. This section addresses each framework before explaining how I chose to interweave the two into the conceptual framework that framed my analysis.

2.5.1 Conrad et al.'s (2006) Theory of Undergraduate Socialization

The socialization portion of this study was guided by Conrad et al.'s (2006) model of socialization. This particular conceptualization of socialization was an expanded and reworked version of Weidman's (1989) framework, drawing upon other socialization research in the gap between publications to update and modernize the model. Perhaps the most significant change from Weidman's original framework of undergraduate socialization to the chosen model came in an updated approach to the outcomes of the socialization process. Previously, Weidman had explored tangible outcomes like students' job choices, lifestyle preferences, and aspirations. The original framework did include the abstract outcome of students' values, which was comparable to the updated model's dispositions, particularly given the emphasis placed on the evolution of each from the stage of being a prospective student to being a graduate of the institution. Nonetheless, Conrad et al. (2006) focused more on intangible products of the socialization process, exploring the knowledge and proficiencies students gain, but also their commitment to the discipline or institution and how they identify with their chosen communities.

Conrad et al.'s (2006) approach divided socialization into four phases in a rough chronology, though there is no strict order in which the four must occur. The first was anticipatory socialization, which typically occurs prior to and in the earliest stages of a student's arrival to their university and introduction to their discipline. The student begins to form preconceptions of what will happen as they join their chosen communities. These notions can be heavily influenced by the individual's background and predispositions towards the community, as well as their previous experiences interacting with existing members of said community. Anticipatory socialization can also occur any time the student is preparing for a change in their status as a member of their institution or discipline, whatever form that might take.

The second and third stages of this framework were the most interchangeable and often occur concurrently, rather than in sequence. In turn, these phases covered socialization interactions that occur in formal and informal environments respectively. Formal environments include spaces wherein the university as an institution has some degree of influence, including classrooms, laboratory spaces, orientation programs, and the like. Conversely, informal environments can range from private living spaces to restaurants, dining halls, and all manner of spaces on campus that are not directly controlled by the university. It is during these two stages that the model focused on how students engage with, become involved in, and potentially become embedded into their new communities. While these terms will be used more-or-less interchangeably throughout this dissertation, there are subtle distinctions that separate them, as laid out in the work of Wolf-Wendel, Ward, and Kinzie (2009), which is important to recognize when reading existing literature. The final stage in Conrad et al.'s (2006) framework was the integration step, wherein students take their experiences and incorporate them into their existing beliefs. Through this integration process, students can identify what elements of their pre-

existing ideologies and beliefs they wish to maintain, which to change, and which to discard altogether as their position within their institutional and disciplinary community evolves.

Conrad et al.'s (2006) model also included a vertical dimension to capture the role of socializing agents that the student may be involved with external to the sphere of the institution itself. While the combination of formal and informal spaces in the second and third phases listed above encapsulated the variety of contexts in which socialization might occur at a university, there are a wide range of other socializing agents external to the university that must be noted as well. These might include family groups, friends, employers, and other kinds of professional colleagues. Engineering is a discipline that often has family ties, meaning that having a parent, sibling, or extended family member that practices and discusses the discipline can be particularly impactful (Schreuders & Mannon, 2007). The inclusion of these external groups is important as college campuses are generally not a closed system. Students rarely spend all their time on campus, returning home or visiting friends for holidays and breaks, or having work experiences in the summers. This constant back-and-forth from the university campus means that students pick up ideas or beliefs that they bring back and can share with their peers and other members of the community. Familial pressures were commonly cited with respect to choice of discipline for early-career undergraduate students (Shaaban, 2016). Even beyond the family sphere, social connections external to the university have been determined to have noticeable impacts on students' dispositions towards higher education and engagement with their studies (Trowler et al., 2019). Both the horizontal and vertical dimensions of Conrad et al.'s (2006) framework are visible below in Figure 2.1.

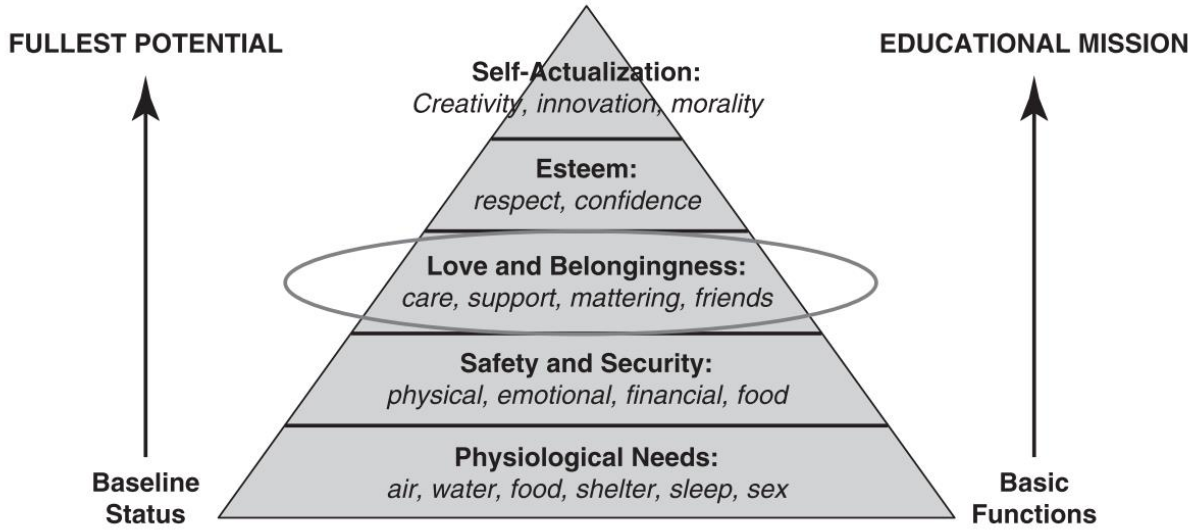
Figure 2.1: Conrad et al.'s (2006, p. 257) Model of Socialization

2.5.2 Strayhorn's (2018e) *Theory of Sense of Belonging*

At its core, Strayhorn's (2018e) theory of belonging evolved from Maslow's (1954) hierarchy of needs. Belonging is presented as a fundamental human need that is sufficient to drive behavior and is pursued only when lower-level, base physiological needs are being met. This hierarchy can be seen in Strayhorn's (2018e) visualization of this theoretical framing in Figure 2.2 below. The feeling of belonging itself stems from perceptions of social support, connectedness, and importance to peers. Belonging has cognitive, affective, and behavioral dimensions. Students often internally analyze or rationalize their membership within a group (cognitive), which in turn leads to emotional (affective) or behavioral responses. This constant renegotiation is central to the process of developing feelings of belonging. Strayhorn's (2018e) model outlined seven key elements in defining SoB. I will address each briefly before linking them to my dissertation work. Following the exploration of Strayhorn's model, I will provide the

rationale for why I chose to implement the theory with a dual focus on disciplinary and university belonging separately.

Figure 2.2: Strayhorn's (2018b) Model of College Students' Sense of Belonging



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1. **Sense of belonging is a basic human need**

Strayhorn (2018e) argued that feelings of belonging are necessary for humans to progress up the hierarchy and achieve esteem and self-actualization needs. Within the collegiate context, students must belong in order to achieve their highest potential and the institution must ensure that students are able to belong in order to accomplish its educational mission. While initially taken aback by the gravity of this statement—it seemed self-aggrandizing, in a sense, to say that this concept being studied was a need for every person—I came to accept it after reading more broadly on belonging. Particularly in the context of college, belonging is an important part of the student experience, and while every student will experience it differently, its significance remains.

2. **Sense of belonging is a fundamental motive, sufficient to drive human behavior**

As noted earlier in the chapter, the need to belong often moves individuals to action. The second element of Strayhorn's (2018e) model asserted the same, underlining that belonging is a fundamental motive, sufficient to drive behavior. This behavior is not always beneficial to the individual (McCabe et al., 2005; Strayhorn, 2018c), but it is driven by a need to feel supported all the same. Within the scope of my study, this was one of the key phenomena of interest. I sought to understand how belongingness and socialization interacted with one another, in this case examining how the desire for support, membership, and care drove students to engage with their campus communities.

3. **Sense of belonging takes on heighted importance in certain contexts, at certain times, and among certain populations**

At formative and uncertain times in an individual's life, belonging to something becomes more important. This importance is similarly true in unfamiliar contexts and among populations where an individual feels marginalized (Strayhorn, 2018e). For many students, arriving to college is an intersection of at least two, and often all three of these conditions. Most undergraduate students are in the later years of adolescence, an important developmental period wherein they are making discoveries about themselves, their interests, and their identities (Pascarella & Terenzini, 2005; Weidman, 1989). In college, they are embedded in an unfamiliar setting, often far-removed from past friends and family, and faced with the challenge of finding their place in an already established social ecosystem. This period is a crucial time to examine SoB.

4. **Sense of belonging is related to, and seemingly a consequence of, mattering**

One of the key parts of belonging is feeling cared about, that one matters to another person or group and that their absence would be missed. Mattering, at its core, is the relational dimension of belonging. A student could believe that they belong to a group, but if their contributions, presence, or absence are not acknowledged, these beliefs become shaded in doubt. Whether in a design team, in the classroom, or a social group, students need to feel that they matter to the contexts that they strive to be a part of.

5. Social identities intersect and affect college students' sense of belonging

Strayhorn (2018e) outlined a number of identities that are salient to the development of belonging, including race and ethnicity, gender, socioeconomic class, sexual orientation, and religion. I posit that others like being a first-generation (Beattie & Thiele, 2016) or international student (Glass et al., 2015), and neurotypicality (McLeod et al., 2019) are also salient within a university context. It is not merely the presence of these identities, but also the intersection of them that influence belonging. One identity might be welcomed in a context while another is simultaneously shunned, resulting is mixed feelings and internal conflict. This intersection of identities complicates the process of finding communities in which a student feels they can belong, as belonging in one space may require the suppression of another personal identity. Though the structure of the interview protocols for this dissertation did not allow for significant findings with respect to this element of Strayhorn's (2018e) theory, one such internal struggle did emerge, further detailed in Chapter 4.

6. Sense of belonging engenders other positive outcomes

Outlined in-depth earlier in the chapter, feelings of belonging have the potential to produce a plethora of other desired outcomes for students and researchers alike. Belonging has been connected to retention and persistence (Hausmann et al., 2009), social involvement on campus

(Vaccaro & Newman, 2016), and academic performance (Wilson et al., 2015), to revisit a few. While belonging was the outcome in this dissertation study, it was an intermediate product of sorts, in that understanding the development of belonging in turn supports all of the benefits that strong belonging promotes.

7. **Sense of belonging must be satisfied on a continual basis and likely changes as circumstances, conditions, and contexts change**

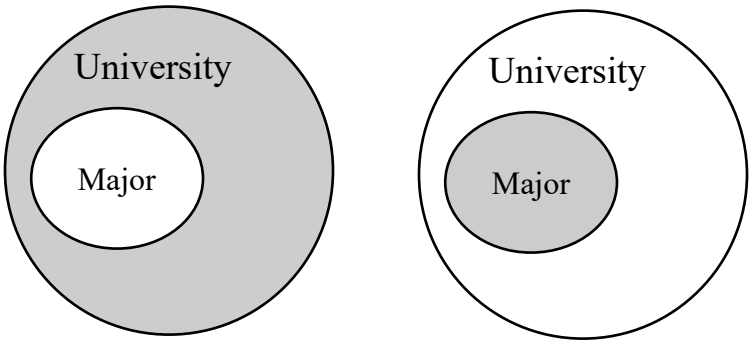
Herein was the importance of the longitudinal dimension of my study. As undergraduate students progress through their academic careers, they change, but so does their environment. They begin to focus more into their domain-specific courses, narrowing their contact with students from other majors in the academic setting. They might leave and join campus organizations as they see fit for themselves. Part time jobs, internships, co-operative work opportunities, and volunteering all expose students to a variety of on- and off-campus communities. Throughout all the shifting circumstances of an undergraduate experience, belonging must continually be maintained or re-established, as even temporary lapses can begin to undermine established SoBs (Walton & Cohen, 2011).

2.5.2.1 A Dual Examination of Disciplinary and University SoB

For this dissertation, I have chosen to apply Strayhorn's (2018e) theory of SoB to two distinct areas within the university context: students' discipline, and the university as a whole. As Strayhorn (2018e) explained, "the experience of belonging is context-dependent, such that sense of belonging in a particular context has the greatest influence on outcomes in that area" (p. 34). Building on this notion, I felt that to fully capture students' lived experiences throughout their undergraduate studies, both contexts had to be analyzed. While I recognize that disciplinary experiences occur within the context of the broader university, they are also distinct from the

broader university, as they are not shared by anyone outside of the major. Similarly, disciplinary experiences form an important part of the overall university experience, but for the sake of this study, I separated the two. A visual representation of the two types of belonging can be found below in Figure 2.3. The decision to use both together stemmed partially from my pilot analysis of a single participant, as outlined in Chapter 3, and partially from a conversation with a colleague from the UKSA project[1]. In tandem, I believe the two facets of belonging combined to produce a more complete picture of the socialization and belonging my participants experienced in their studies while also allowing for a greater application of context-specific findings to improvements in their respective domains.

Figure 2.3: Visualizing University (left) and Disciplinary (right) Belonging



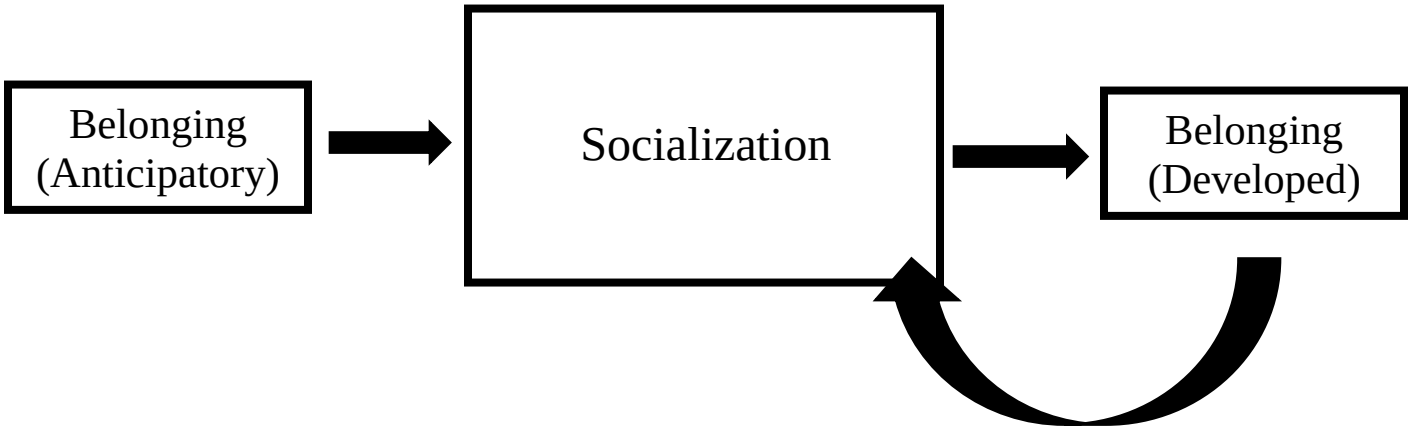
2.5.3 Synthesizing the Conceptual Framework

A student's SoB functions in a similar way as the values and beliefs that Conrad et al. (2006) define as inputs and outputs of the socialization process. Students arrive with some degree of belonging to their institution and chosen major as influenced by their pre-college experiences with both. It is subsequently shaped by their socialization with various reference groups throughout the duration of their undergraduate study, resulting in a multidimensional SoB

[1] Thank you to Dr. Margaret "Mags" Blackie for the inspiration to stop wavering between the two and simply use both in combination.

that is interwoven with their commitment to, identity with, and disposition towards their institution or discipline. As such, SoB is woven throughout the longitudinal dimensions of the model as both a sufficient driver for engagement (Strayhorn, 2018e) and the product of said engagement. This back-and-forth constantly evolves as students negotiate their institutional and disciplinary environments. A simplified "black box" representation of this conceptual framework is provided below in Figure 2.4.

Figure 2.4: Simplified Visualization of the Conceptual Framework



2.6 Alternative Theories Considered

Throughout the process of reading for and structuring this dissertation, I came across a few alternative theoretical frameworks of socialization and belonging before ultimately settling on those discussed above. In this section I will note some of the theories that had been considered and will briefly address why I chose to put them to the side for this study. I will also address the original outcome space that was considered for this study, Communities of Practice (CoP), and why I decided to pursue SoB instead.

2.6.1 Alternative Theories of Socialization

I considered two alternative approaches to socialization throughout the research process. At first, I considered Weidman's (1989) original framework as it seemed like a perfect fit for my

study, given that it was a model of socialization specifically conceived around undergraduate students. However, I chose the revised version of the framework for two primary reasons: its emphasis on non-tangible outcomes, and its greater recognition of variance in socialization experience based on individual characteristics and identities. The former was addressed previously in the description of Conrad et al.'s (2006) revised framework, but in short, the updated model places greater focus on students' identities, values, and dispositions at the end of their undergraduate careers, as opposed to concrete outcomes like job placement. This better suited my study, which has remained focused on students' values and beliefs in the outcome space even as the specific outputs evolved as described in section 2.6.3 below. The latter inclusion was particularly important to me as it aligned with emerging literature on the socialization of historically minoritized populations (e.g., Beattie & Thiele, 2016; Riney & Froeschie, 2012; Roksa et al., 2018), including some of Weidman's own (Twale et al., 2016). By including a greater acknowledgement of how individual characteristics and identities shape the impact of socialization experiences, Conrad et al.'s (2006) framework also better aligned with Strayhorn's (2018e) theory of SoB, which placed a heavy emphasis on how similar experiences could result in widely disparate feelings of belonging for students based on their identities and the intersections thereof (Strayhorn, 2018c).

I also gave brief consideration to the college impact model proposed by Terenzini and Reason (2005), as it has many similarities to Conrad et al.'s (2006) approach. Terenzini and Reason (2005) proposed four key constructs that shape first-year students' development: Precollege characteristics and experiences, the organizational context, the peer environment, and individual experiences. Though it was designed to focus on the impact of the first year of study, the authors argued that it could reasonably be extended to later years as well with modifications

shifting the focus off of the first-year curriculum and taking a broader look at students' socialization into their major over time. Ultimately, I believe that Terenzini and Reason's framework could reasonably have guided a study very similar to mine. The decision to use Conrad et al.'s (2006) was made for two reasons. First, I was more familiar with it at the time of planning my dissertation study and subsequently more comfortable applying it to my analysis. Second, and more importantly, it brought students' socialization experiences to the forefront, placing them against the normative backdrop of the university environment and peer culture that Terenzini and Reason (2005) described. The narrower focus placed additional emphasis on the specific mechanism of socialization, one of the desired outcomes of my study.

2.6.2 Alternative Theories of Belonging

As part of a broader examination of attrition among undergraduate students, Tinto (1993) presented an argument that students often left their institutions because were never able to integrate themselves into their academic environment, subsequently leaving them feeling isolated and lacking any SoB. Tinto asserted at the time that students should willingly separate themselves from their previous culture and values to align themselves with the institutional context, easing their process of assimilation. This theory has come under critique since its original proposal for shifting the burden of responsibility onto students to changes themselves, rather than asking the institution to create an environment in which students from diverse backgrounds could all thrive (Kuh & Love, 2000; Tierney, 2000). Other critiques attacked the theory even more aggressively, stating that it required students to commit "cultural suicide" in order to integrate themselves (Tierney, 1999, p. 82). More recent literature has also presented arguments in favor of moving away from the notion of integration as defined by Tinto (1993)

altogether, as it discriminates against those students who are not part of the "dominant campus culture," particularly international students (Yao, 2015, p. 8).

With these critiques in mind, there was also a distinct disconnect between Tinto's (1993) model of integration and belonging and Conrad et al.'s (2006) conceptualization of socialization. Tinto (1993) argued that students should shed their pre-existing characteristics in favor of aligning themselves with the normative context of the university, where as Conrad et al. (2006) viewed the pre-existing characteristics as factors that define the manners in which socialization occurs in various normative contexts within a university. Conrad et al. viewed the normative contexts as a backdrop for socialization, rather than the desired outcome of it. Students did not need to strive to assimilate themselves to the norms of the institution, but instead their social interactions were shaped by the combination of their own prior experiences, values, and beliefs in addition to their institutional contexts. I instead chose to pursue Strayhorn's (2018e) model of SoB due to its assertion that belonging, like socialization, was a product of the intersection of an individual's identities, beliefs, and institutional environment.

2.6.3 Wenger's (1998) Theory of Communities of Practice

Initially, my dissertation study did not use belonging as its outcome space. At the proposal stage, I instead intended to use Wenger's (1998) theory of CoP. The viability of the framework stemmed from its assertion that as individuals congregate around a specific set of activities like hobbies, academic study, and work, they form niche communities around their practice of said activities. Their membership in a community define their practice, and their practice in turn informs their membership in the community. This reciprocal relationship separated a CoP from a community defined solely by something like geographical boundaries, as well as distinguishing it from a group of individuals who engaged in the same practice—say,

playing an instrument or creating art—individually and separately from one another. I argued at first that a disciplinary community was suitably defined as a CoP, but as I began to delve into analysis further, quickly realized that there were issues I would have to address if I were to proceed with the theory.

My pilot run of analysis revealed several issues when applying specific facets of Wenger's (1998) framework to the interview data, detailed more thoroughly in section 3.4.4.6. The sole focus on disciplinary CoP missed out on a significant part of the pilot analysis subject's experience with the broader university, which foreshadowed the later division of belonging into disciplinary and university dimensions. Identifying the specific CoP membership behaviors described by Wenger did not align with the interview data. At the same time, there was also the broader issue of defining both the community and the practice I examined. To define the practice as "getting a ChE or chemistry degree" was far too broad; there was too much divergence between individual experiences in higher education to consider this a fully shared experience. Bounding the community at the institutional level also nullified the vertical dimension of Conrad et al.'s (2006) conceptualization of socialization, as it removed the influence of family, friends, and employers altogether. I also became bogged down in existing CoP literature due to the plethora of ways that the framework has been re-defined and applied in completely different ways, which made it difficult to extract the value it held for my study (Li et al., 2009). After the frustration of the pilot analysis and a conversation with my dissertation committee, I decided to forego the amount of effort it would take to force CoP to function in the context of my dissertation and instead began the search for a new outcome space that better suited my desired outcomes and my data, ultimately landing on Strayhorn's (2018e) theory of SoB.

2.7 Identified Research Gaps

Through the completion of this literature review and the preparation of this dissertation, I have identified four research gaps this study seeks to address. They are listed below, along with brief descriptions and relevant literature. The ways in which my study begins to address these gaps are provided in Chapter 5.

Research Gap 1: Longitudinal Research on Socialization and SoB

The first research gap related to the limited number of studies that have been done either socialization or SoB. Such studies exist (e.g., Ashforth & Saks, 1996; Hughes, 2022; Maestas et al., 2007; Phoenix, 2019), but my study provided a unique contribution by examining the processes of socialization and belonging development over time for STEM students. The two theories have been linked before (Weidman et al., 2014), but this work served to add to the fairly sparse body of literature.

Research Gap 2: Holistic Views of Socialization in Existing Literature

As noted previously, most studies of socialization focused on a one to two reference groups like parents (Starr & Simpkins, 2021), professors (Beattie & Thiele, 2016), or peers (Riney & Froeschie, 2012). Existing literature has rarely taken a broad view of socialization, accounting for all of the different dimensions of formal, informal, personal, and professional socialization described in Conrad et al.'s (2006) conceptual framework.

Research Gap 3: How Specific Attributes and Experiences Produce Desirable Belonging Outcomes

Directly noted by Strayhorn (2018c) as an area in need of additional research, most literature on belonging to date takes a high level view of the development of belonging, not

identifying the specific mechanisms by which it is developed. Once again, there is existing literature that takes a sufficiently narrow view (e.g., Newman et al., 2015), but my work sought to add to the limited body of research. My dissertation utilized socialization theory as a means to examine the specific social interactions and relationships students form influence their belonging. While not a complete picture of the participants' attributes and experiences, it is a level of detail that has not previously been present in many publications.

Research Gap 4: Understanding of How Institutional Attributes Influence Belonging

Like Research Gap 3, one of the missing pieces in the belonging puzzle is consideration for institutional attributes. Some work has emerged in the space, examining belonging development at a variety of institutional types (T. Smith et al., 2012), but it lacks granularity on how the institutions' characteristics influenced their students. My dissertation sought to bolster this body of work by taking the institution's characteristics into account as part of its analytical process, outlined further in the next chapter.

2.8 Summary

Throughout this chapter I have introduced relevant literature that grounds the need for my study and the theories I have chosen to use in addressing my research questions. With the considerations I provided for why students leave STEM, I contextualized why this study is necessary. By addressing the earliest introductions students have to STEM, their transition into undergraduate study, STEM culture, and the academic hurdles students face, I laid the groundwork for understanding my participants' experiences. The prior presentation of socialization literature provided an understanding of where, why, and how students engage with reference groups in their campus communities and what the implications of those interactions can be. Finally, I detailed both how belonging can be developed in undergraduate students and

how it can subsequently lead to positive academic and wellness outcomes. I have argued that socialization and belonging—and particularly the interplay of the two—provide a suitable theoretical foundation for understanding students' undergraduate experiences and making salient recommendations for improvement in higher education. Several alternative theories were presented, including an altogether separate framework in Wenger's (1998) CoP, all of which would likely prove useful in future work in the same space, but were not the best choice for my dissertation. My work in this chapter has also laid out four key research gaps which the rest of the study addresses. The next chapter introduces the specific methodology and methods I used to address my research questions.

Chapter 3 – Methods

3.1 Introduction

The purpose of my dissertation study was to map the longitudinal socialization journeys of undergraduate STEM students and deepen our understanding of how their socialization experiences influence their sense of belonging (SoB) in their discipline and university. The study was anchored in Conrad et al.'s (2006) theory of undergraduate socialization, with Strayhorn's (2018e) framework for SoB guiding the outcome space. The synthesis of the two as the conceptual framework for my work was addressed in-depth in Chapter 2. This chapter in turn builds upon the theoretical underpinnings to detail the methods and methodology employed in the study. It will cover the broader study from which I drew my data, followed by the rationale for and application of embedded case study methodology. Following on, the chapter will cover participant selection, data collection methods, the analytical approach employed, and the measures taken to ensure research quality and ethical practice. Finally, several limitations of the study will be addressed.

The research questions addressed in this dissertation are as follows:

Overarching Research Question (RQ): In what ways does a student's socialization experience influence, if at all, their sense of belonging to both their chosen discipline and their university?

Sub-question 1 (SQ1): How do students' disciplinary socialization experiences evolve from pre-college engineering or science to degree completion?

Sub-question 2 (SQ2): What types of socialization do students engage in at their university, and why do they choose the specific types of socialization they have control over?

The RQ was developed to capture the interplay of socialization and belonging, whereas the two sub-questions were positioned to capture different elements of the mechanism of socialization. SQ1 focused specifically on the longitudinal aspect of socialization and how it develops over a student's undergraduate career. SQ2 focused on the types of socializing agents with whom students interact, as well as the choices they make about the agents that they intentionally seek out. In turn, SQ2 also provided some insight into when and how a need to belong plays its part as the impetus for engagement—a core part of Strayhorn's (2018e) framing of the theory. These two sub-questions helped to inform the mechanisms by which socialization occurs and subsequently shaped belonging to the institution and to the discipline.

3.2 Study Context

This dissertation was situated as a product of the Understanding Knowledge and Student Agency (UKSA) project. The UKSA project was a multinational collaborative research project supported by the Center for Global Higher Education (CGHE). Spanning six higher education institutions across the United States, England, and South Africa, the UKSA project aimed to further the understanding of student development over the course of their undergraduate study. This interest in longitudinal changes included a variety of topics, ranging from student descriptions of preferred course structure and assessment styles to their perceptions of their roles within the university structure. The project included two institutions in each participating nation, each of which varied from their national counterpart in some way (e.g., residential versus commuter, teaching-focused versus research-focused, etc.). Participants were drawn from two primary disciplines: chemistry and chemical engineering. However, at both U.S. based institutions, biochemistry was included as well to bolster the number of participants, as it was difficult to recruit the targeted number of students from chemistry. These three disciplines were

linked by their foundation in chemistry but retained unique identities that allowed for some comparison of student experiences between them. As addressed in the literature review, there were some cultural differences between these disciplines that affected how students engaged and participated. Furthermore, despite the shared basis in chemistry, required curricula diverged in later years. Disciplinary differences in socialization and the resultant belonging will be addressed in Chapter 4. In the case that a student transferred from one of these disciplines to another, they would still be interviewed, with suitable adjustments to the interview protocol. Similarly, if a participant moved from one institution included in the study to another, they were still interviewed. Students were interviewed in the spring semester of each year of their undergraduate study, though some were conducted in the summer based on participant availability. While this longitudinal participation is the foundation of the research project, some attrition was unavoidable and led to some reduction in the study's population over the course of its duration. As such, the original population of approximately twenty students at each institutional context declined, albeit to different degrees at different universities.

To keep the scope of this study manageable, only one institution from the broader UKSA project was considered. This project focused on a large, public, research-focused university in the Mid-Atlantic region of the United States. The university was a residential college, where the vast majority of students lived on campus in the early years and either on or in the immediate vicinity of campus for the others. Being a U.S. institution, students from all three majors listed above were included in the recruitment process. The research team from this institution included two faculty and two graduate students, as well as one graduate student who left the project after one year of involvement and another who graduated and maintained their participation in a

faculty role at a different institution. Data collection for undergraduate students at this institution began in the spring semester of 2018 and was completed in the summer of 2021.

3.2.1 Site Description

As noted in the previous section, the institution of focus for my dissertation was a large public research-focused university in the Mid-Atlantic United States. Its undergraduate enrollment was roughly 30,000 students by the end of the duration of data collection, of whom approximately 60% were enrolled in a STEM or health science major. The number of engineering degrees awarded is also among the top ten for U.S. institutions (American Society for Engineering Education, 2021). The ChE and chemistry were relatively small programs, each made up roughly 1% of the overall undergraduate population, with biochemistry being smaller than both. It was classified as a Predominantly White Institution (PWI), with roughly 60% of its population identifying as white. As noted in previous research, institution size and type can influence the development of belonging (T. Smith et al., 2012). Subsequently, my findings are most transferable to other large, public, research-focused institutions with a similar focus on STEM. Additionally, the findings are most pertinent to the specific disciplines included in my study. The rationale for their selection is provided below.

3.2.2 Rationale for Chosen Disciplines

Chemistry and ChE were the two primary majors on which the overarching UKSA project placed its focus. At the two U.S. institutions, however, biochemistry was added in the first year of data collection due to low recruitment success among chemistry students. The two original disciplines were chosen for several reasons. First, from a disciplinary knowledge perspective, chemistry and ChE are very similar, with ChE being the engineering discipline most closely linked to a distinct field of science. That is to say, while many engineering majors draw

upon topics like physics and thermodynamics, ChE is inseparable from the chemical science on which it is built. Both majors' curricula have a large number of lab courses, something that is particularly distinctive for ChE in comparison to other engineering majors. In the original framing of the UKSA project, these similarities provided the desired outcome of being able to clearly explore the differences between science and engineering programs. ChE was also chosen due to its centrality to the history of engineering, often being cited as one of the "Big Four" engineering majors alongside civil, mechanical, and electrical engineering (Cote, 2022). As one of the "Big Four," however, ChE is not as male-dominated as the other three of its oldest companions, mirroring chemistry among the sciences (American Society for Engineering Education, 2021; Yoder, 2016). The higher levels of recruitment and retention among women is a phenomenon that bears further study in modern STEM environments, as outlined in Chapter 1. Finally, the singular focus on one branch of engineering pushes forward the case for discipline-specific research that does not group all engineering majors together (National Research Council, 2012). As noted above, ChE has a science- and lab-heavy curriculum that distinguishes it from other majors. Biochemistry's addition at the U.S. institutions was justified on grounds of curricular similarity to the companion chemistry programs, in addition to its contributions to getting the study population to desired levels.

3.3 Methodology

The methodology I chose to employ for this study was a single embedded case study with two distinct contexts and multiple embedded units of analysis within each context. The rationale for this structure is detailed in section 3.4.1 below, as this section is tailored primarily to discussing the suitability of the case study methodology as a whole. I aligned my application with the case study tradition of Yin (2018) due to its foundation in addressing "how" and "why"

research questions in an environment where the phenomenon of interest cannot be separated from the context it occurs in. Additionally, Yin's tradition encourages drawing upon existing literature to direct the research questions that the study seeks to address. As discussed in Chapter 2, this dissertation's inquiries were guided by the synthesis of Conrad et al.'s (2006) model of socialization and Strayhorn's (2018e) conceptualization of belonging. Yin (2018) also provided clear direction for the core components of a case study and some approaches to considering them, which were of benefit to an early career researcher like me. Finally, Yin's tradition of case study research aligned with my personal research paradigm of constructivism, allowing me as a researcher to delve into how my participants constructed their realities as undergraduate students and subsequently how this informed their actions (Baxter & Jack, 2008). Case and Light (2011) argued that one of the strengths of the case study methodology lies in this acceptance of variable realities, as they are most appropriate in studies that seek to answer questions that take into consideration the institutional and individual context of the experiences participants shared.

In line with Yin's (2018) case study design, my study made use of multiple sources of data for the purpose of triangulation. Triangulation allows for the verification of accounts or events, contributing to the validity of the study (Yin, 2012). In my study, the primary data came in the form of semi-structured interviews with the participants. The secondary data was a collection of curriculum and university summary documents compiled as part of the UKSA project for the purposes of contextual comparison. The curriculum documents contained breakdowns of credit requirements, required course lists, and the percentage of lab courses in the overall curriculum. The university documents contained institutional policies, demographic breakdowns, and rankings for the chemistry and ChE departments, as well as the institution as a whole. These documents were reviewed throughout the analysis process to contextualize student

experiences against what was known about their institutional and departmental settings. Most commonly these documents were used to corroborate claims students made about their course requirements, choice of electives, and to provide a foundation for understanding students' perspectives on the institution's diversity.

3.4 Research Design

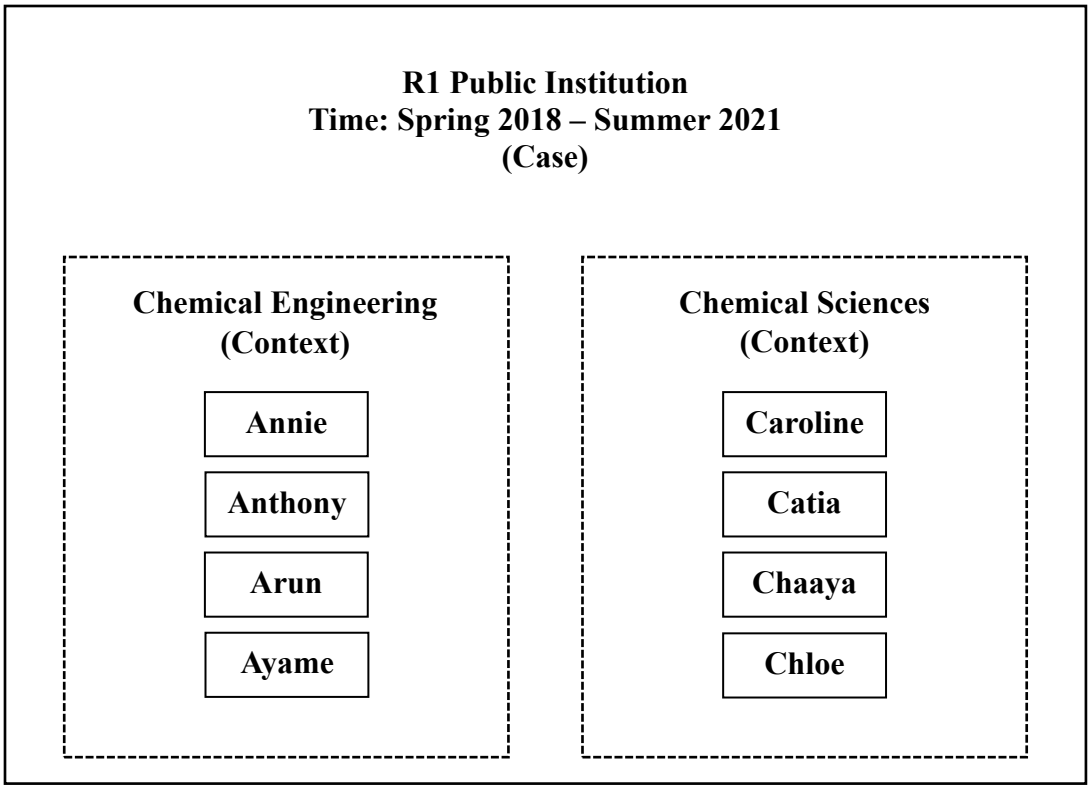
This section will delve into the specifics of how my dissertation study was designed and implemented. I will begin by describing the structure of my embedded case study and providing the bounding and definition of the case. I will then address the other core components of the research methods, beginning with the selection of participants and following with the approach for data collection and strategy for data analysis. Finally, I will address how I ensured the quality of my research, ethical considerations for my work, and the limitations of the study.

3.4.1 Definition of a Case and Structure of the Study

I employed a singular exploratory case study for this work with two sub-contexts and eight total units of analysis equally split between the sub-contexts. Figure 3.1 below illustrates this structure. In this section, I will define and provide rationale for a case—a key part of any case study design (Yin, 2018)—as well as justifying the overarching structure of the study. For my work, the overarching case was the single large, public R1 institution in the Mid-Atlantic United States, with the time boundaries set between the 2017-2018 and 2020-2021 academic years. The particular institution was chosen for two reasons: 1) it was one of the six universities present in the UKSA study and 2) it was the closest institution to me, so I was most familiar with the university and national context of the institution itself (Hatch, 2002). It is worth noting that these time boundaries included the COVID-19 pandemic, which had significant impacts on higher education institutions and the students they serve (Aristovnik et al., 2020), meaning that it

had effects on my study. These effects were explored more in-depth in section 3.4.7.3 below, but in short, the shelter-in-place and quarantine policies that went into effect not only cut students off from most of their in-person classes, but many of their other on-campus activities and resources as well. The two contexts within said case were labeled chemical engineering and chemical science. The latter contained both chemistry and biochemistry, which were combined due to curricular and cultural similarities, as well as the number of participants in each. The units of analysis were the individual participants within their respective contexts. Justification for these is provided below.

Figure 3.1: Summary of Case Study Structure



I chose to define the institution as my case due to the structural alignment with Conrad et al.'s (2006) theoretical framing of socialization. Though the actual socialization process is highly individual, it occurs within a normative context, as discussed in Chapter 2. Across all eight of the

participants, a range of factors like university-level policies, the overall institutional population, on-campus resources like dining halls and career centers, and more provided a consistent backdrop for socialization. Even when delving into context- or participant-specific resources, they were still contained within the same university environment. The chosen contexts provided specific resources to the participants within them like discipline-specific faculty and staff, research opportunities, and disciplinary peers. These provided further opportunities for socialization and were a narrower normative context in which socialization occurs, but nonetheless were contained within the overarching case.

The two contexts for this study, ChE and chemical sciences, were selected due to three primary factors. The first was that they were the disciplines present in the overarching UKSA study population. The second is a bit more complex and has to do with the relative similarity of chemistry to biochemistry when compared to ChE. The curriculum requirements for chemistry and biochemistry were very similar, with many of the same core courses. The ChE curriculum diverged from the other two early on following the common first-year engineering curriculum before developing a focus on technical classes like Fluid Dynamics and Heat Transfer. Finally, the third selection criterion stemmed from the broad cultural differences between engineering and science programs that were addressed in the literature review. Though chemistry and biochemistry are distinct disciplines and do have some curricular differences, I deemed them similar enough to be grouped together as a singular context for the purpose of this study.

3.4.2 Participants

The recruitment of participants for this study began as the broad invitation for students to participate in the UKSA project. There was no distinct recruitment strategy in the first year, instead casting the net as broadly as possible to collect a large initial population. Once all of the

first-year interviews had been conducted and the participants' self-reported demographic information had been documented, the research team began the process of selecting participants for the second year. Given the broad range of students who had been involved in the first year, the research team had the opportunity to select participants with the objective of purposefully diversifying the sample by gender, race, and ethnicity. Following this intentional selection of some participants, the only other changes to the study's population occurred naturally through attrition between each year of data collection. The population declined from twenty purposely selected participants in Year 2 to 11 in Year 3, before finally reaching 8 in Year 4. Given the longitudinal focus of this study, the only participants included in this dissertation were those who completed an interview in each of the four years of their undergraduate study.

The participants in this study were eight students spread across Biochemistry, Chemistry, and Chemical Engineering at the previously mentioned Mid-Atlantic U.S. institution. From the original thirty-seven students at this university who were interviewed in their first year, seven of the eight were enrolled in the institution and interviewed in each of their four years of undergraduate study. The eighth student began her undergraduate career at the other U.S. institution included in the UKSA study but transferred after the second year. Self-reported demographic information for each participant is included below in Table 3.1. The students have each been given a pseudonym beginning with the same letter based on their discipline, per the naming scheme used in the broader UKSA project. Chemical engineering students have pseudonyms beginning with A, whereas chemistry and biochemistry students' names begin with C. For the sake of this project's analysis, the students who transferred either between institutions or between disciplines used the pseudonym that aligns to their status in the first year in later

discussion. Any transfers will be highlighted below in Table 3.1 and any experiences that are distinctly linked to a student's prior institution or major will be noted as such in the analysis.

Table 3.1 Self-Identified Participant Demographic Information

Pseudonym	Discipline	Race	Gender	Transfers
Annie	Chemical Engineering	White	Woman	N/A
Anthony	Chemical Engineering	White	Man	N/A
Arun	Chemical Engineering	Indian	Man	N/A
Ayame	Chemical Engineering	Asian	Woman	N/A
Caroline	Biochemistry	White	Woman	N/A
Catia	Biochemistry	White	Woman	University – Arrived at Study University in Year 3
Chaaya	Chemistry	Indian	Woman	Discipline – Chemistry to Chemical Engineering
Chloe	Chemistry	White	Woman	N/A

3.4.3 Data Collection

The main data for this study took the form of semi-structured interviews, completed in the spring semester of or summer between each academic year. These interviews lasted generally between forty-five minutes and one hour. The data were split into two halves. The first was the two years of interviews that were conducted prior to my involvement with the overarching study. The second was the third- and fourth-year data, for which I conducted many of the interviews. In total, there were four years of interviews from the eight students. Interviews in the first and second years were conducted in-person. Two of the third-year interviews—Ayame and Anthony—were also conducted face-to-face. Due to the COVID-19 pandemic, however, the remaining third-year interviews and all of the fourth-year interviews were conducted via phone call or video conferencing software.

Each interview, whether in-person or online, began with a review of the consent forms that the participants had been asked to fill out and send to the interviewer. The participants were

asked if they had any questions about the form, then if they had any questions about the research project or interview. In the video conferencing interviews, participants were not required to use their video functionality, but could if they wished. All interviews were recorded with the consent of the participants. In-person and phone interviews were recorded with digital audio recorders, the latter making use of the cell phone's speakerphone functionality. Video conferencing interviews were recorded using the software's built in recording tools. All video files were deleted following recording, with only the audio files being retained. The audio files were then sent to a professional transcription service and returned for analysis.

3.4.3.1 Most Relevant Interview Protocol Questions

A selection of the questions from the interview protocols that were most relevant to the analytical lenses described in Chapter 2 are included below in Table 3.2. The protocols evolved year to year, so each question will be listed beside the year(s) it was included in the protocol. The exact wording of the question might have varied between years, but if the spirit of the question was maintained, it was included. Given the semi-structured nature of the interviews, it would have been impossible to list every follow-up question that contributed to the study. However, the protocols did include a number of suggested probing questions. This list is not exhaustive, as many questions that are less directly focused on socialization and belonging might prompt responses that are still relevant. For example, many of the questions about class experiences prompted students to talk about their experiences with professors. The full protocols can be found in Appendix A.

Table 3.2: Selected Interview Questions Relevant to Socialization and Belonging

Question	Protocol Year(s)
If you imagine someone who is a chemist / chemical engineer, that is older, graduated, professional. What is this person like? Or in other words, how would you describe a chemist / a chemical engineer? / What is specific to a chemist / chemical engineer?	1-4
Are there any societies or student associations specific to your study (e.g. association of chemistry students)? (If yes, are you active in it? Why / why not?)	1-4
Do you know if there are professional associations of chemistry/chemical engineering? Would you like to become part of it?	1-4
How are students of chemistry / chemical engineering here connected?	1-4
Do you mostly have friends from this department or students from other departments at this university / somewhere else?	1-4
What do you think of the quality of the study and lecturers this year? How does this compare to last year?	2-4
Are you part of any other university societies or associations [these are general societies – like swimming]? Why/why not?	1-4
Did you have any kind of summer placement/internship/research opportunity/summer job/summer classes?	2-4
Do you have a [final chemistry/chemical engineering project] supervisor? How does that work? How does your supervisor support you?	4
On a scale from 1-10 to what extent are you satisfied with the study course/program/major in general? Why?	1-4
On a scale from 1-10 to what extent are you satisfied with university life in general? Why?	1-4
If you were to choose your study course/program/major again, would you choose the same? Why?	1-4
If you were to choose your university again, would you choose the same? Why?	1-4
Do you think you've changed as a person since coming to university? How?	1-4

3.4.4 Data Analysis

Before employing the analytical process that would ultimately produce the results presented in my dissertation, I first ran a pilot analysis of a single participant, Anthony. The pilot run used an alternative theory as its outcome space, Wenger's (1998) Communities of Practice (CoP), as noted in section 2.6.3. During the planning phase of the dissertation, there were concerns about how well CoP would map onto the dataset I was using. I completed analysis of only Anthony's interviews as a test of the utility of this framework. Ultimately, I learned that CoP was difficult to apply to the context of my study. The mixed success of the pilot analysis is detailed below in section 3.4.4.1, but in short led to the restructuring of my theoretical approach while also demonstrating that the analytical tools and methods I had selected could work with some adaptation for the new outcome space.

The final analysis process for my dissertation work was broken into several stages. The first stage, once all of the interviews had been collected, was to familiarize—or, for the interviews from the third and fourth years, refamiliarize—myself with the content of the interviews. Next, I worked through a first cycle of coding, supported by the writing of reflective memos. As the second cycle coding approach, I employed thematic analysis to find patterns across the emerging codes (Braun & Clarke, 2012; Nowell et al., 2017). Finally, I produced several summary documents to condense the themes and findings into a quickly referenceable format. Each of these steps will be further explained below.

3.4.4.1 Pilot Data Analysis

The pilot data analysis for my dissertation involved the data for a single participant and utilized a different outcome theory. As noted in Chapter 2, this study originally used Wenger's (1998) theory of CoP as its outcome space, determining how students' socialization did or did

not contribute to the level of their membership in their disciplinary CoP. The pilot analysis focused solely on Anthony, a participant I chose because I had interviewed him in the third and fourth years of data collection, making me more familiar with his trajectory from the start. I had also included his first- and second-year interviews in a study on early-career socialization prior to doing the analysis for this dissertation (Goldschneider et al., 2020).

The analytical process for the pilot run was the same as what I ultimately used for the rest of the participants with one distinct change: categories of CoP membership behaviors replaced university and disciplinary SoB in the matrix. Details about the specific analytical procedures are included in later sections, but in short, I familiarized myself with the participant, coded their interviews descriptively, used trajectory mapping to identify longitudinal changes, and conducted thematic analysis. The coding process entailed first filling in a matrix before looking at trends across and within the columns. The socialization codes worked well, serving as my first introduction to cases where personal and informal university socialization could seemingly overlap, which spurred me to define where I separated them for this study.

Challenges arose, however, when trying to label CoP membership behaviors. While I could occasionally label such behaviors from the data in Anthony's interviews, I was often puzzled by which of the categories best fit and often felt as if they were being forced into a box in which they did not quite fit. This, in combination with the difficulty of defining both the community and the practice being examined in the study, was the motivation for pursuing a different outcome space in the form of SoB. The solitary focus of this pilot analysis on his disciplinary community was also the catalyst for the division of belonging into its disciplinary and university dimensions, as I did not feel the original approach had captured Anthony's complete experiences. Anthony's data was re-analyzed using the new framework and a new

matrix, though many of his socialization experiences were carried over due to the success of that part of the theoretical framing. In the end, the pilot analysis was valuable in redirecting my study. While the methods themselves—described in depth in the following sections—were effective, as demonstrated by their success in mapping Anthony's socialization experiences, it was clear that CoP was not a suitable theory for the data I had access to and the questions I posed.

3.4.4.2 Familiarization and Refamiliarization

The first step in my analytical process was to read each of the transcripts several times to familiarize myself with the content and begin to establish an understanding of each individual participant. This was done by reading each of a single participant's transcripts in chronological order before moving on to the next participant. Reading all the interviews provided me with a sense of perspective on each of the participants' accounts, as well as providing me with a broader overview of the content of the entire dataset. This helped to ground me in the data I would subsequently be analyzing, an important first step towards ensuring that I was accurately reflecting the participants' accounts in my analysis (Walther et al., 2013). This step was particularly important given the secondary nature of the data that was used. I made sure during this step to familiarize myself with the context of the data via the supporting curricular and institutional documents. I also reviewed the purpose of the overarching UKSA project to understand the purpose of the original data collection. This particular action revealed that the interviews collected for the overarching project were conducted in a manner that intentionally left them open for analysis through a wide range of analytical lenses. The protocols were designed to cover a broad set of topics and no single theoretical framing was used in the creation of the questions. In short, the original dataset was not created to answer a narrow set of

questions, leaving it more open to secondary analysis. By taking the time to establish rapport with the participants' data and the context in which it was gathered, I set myself up for a more meaningful analysis despite using shared data (Walther et al., 2016)

3.4.4.3 First-cycle Coding, Trajectory Mapping, and Analytical Memos

Once I had established a familiarity with my data, I moved on to coding each interview. I went chronologically through a single participant's interviews before moving to the next participant. I used a combination of In Vivo coding to capture the inherently individual nature of socialization and feelings of belonging and Descriptive coding to more clearly emerge broad themes from the data (Miles et al., 2013). Data analysis for this study was guided by the respective research questions and sub-questions of the analysis. The conceptual framework developed for this work provided overarching categories for analysis, but it did not delve into the specifics of any of them. This high-level view left room for patterns to emerge during the analysis process. The categories derived from my conceptual framework provided the basis for the codebook used in the first-cycle analysis. Codes focused on the different types of socialization Conrad et al. (2006) outlined, as well as the disciplinary and university dimensions of belonging that emerged from my pilot analysis. As the interview protocols did not specifically ask students to describe feelings of belonging, I instead drew upon Strayhorn's (2018e) description of feelings and experiences that contributed to or detracted from belonging. As such, coding for belonging often relied on student descriptions of feelings of validation, mattering, physical and emotional security, and commitment to the discipline or university. These descriptions were readily available in the participants' accounts, allowing me to construct an overview of belonging even when the participants were not directly asked about it. The

codebook can be found in Appendix B with examples of each code and sub-code drawn from the participants' interviews.

The guiding method for my analysis was trajectory mapping, an approach that focuses on exploring changes over time and the cause for said changes within a consistent group of participants. I chose this approach over a recurrent cross-sectional approach as the latter explores changes between discrete points of time, which was not well suited for the fluid evolution this study sought to investigate (Caruana et al., 2015). Using the categories from the codebook as a guide, I began to build a matrix for each participant. This approach allowed for the mapping of their journey over four years of their experiences. These matrices were constructed with separate rows for pre-college, Year 1, Year 2, Year 3, and Year 4. The columns were directly influenced by Conrad et al.'s (2006) theory and my conceptualization of disciplinary and university SoB adapted from Strayhorn (2018e). Column headings divided students' socialization experiences into three categories: 1) University socialization, which entailed experiences in both formal (classrooms, labs, etc.) and informal (residence halls, dining courts, etc.) contexts within their educational institution (Weidman, 1989); 2) Professional socialization, capturing experiences with career support services, employers, and coworkers; and 3) Personal socialization, which included friends, families, and extracurricular organizations. The line between informal university socialization and personal socialization sometimes became unclear, but I chose to group organizations that were not specifically related to the university itself (e.g., student governance) in the personal category. While each of these categories was broad, they were only guides for initial groupings that would be further divided and bounded in the second phase of analysis.

The next column in the matrix captured the way that students described their perception of their discipline. Perspectives captured in this column included how much they enjoyed their coursework, whether they saw a future for themselves in the field, and how well they were able to conceptualize their major as a whole. The pre-college period was particularly salient for this finding, as it served to establish how much the participants knew about their majors prior to enrolling in them, as well as what kinds of experiences they had with it. The knowledge and perceptions they brought into the first year were crucial, as the first few semesters of undergraduate study are a particularly formative period for many students (Cruz & Kellam, 2018).

Finally, two separate columns sought to catch students' experiences, thoughts, and feelings that reflected their SoB to their university and their discipline. These columns captured whether students described themselves as part of the respective communities, how committed they were to persist in their major professionally, how supported they felt in their major and university, and whether they would have chosen the same institution and discipline were they given the opportunity to do so again. Students were never directly asked in the interview protocols whether they felt like they belonged at their university or in their major, but as Strayhorn (2018e) noted, belonging is a multifaceted construct. These columns served as the synthesis of the various experiences and emotions that together gave me a view of their SoB. An additional column—purely for my use in the analysis process—was added to document changes in belonging between years. The notes contained in that column also served to bolster the longitudinal nature of my analysis, as they established a clear continuity between data collection events (Grossoehme & Lipstein, 2016). A sample matrix for Chloe can be found in Appendix C.

Throughout this coding process, I produced memos for each participant. After reading and coding a single year's interview, I would update my memo for that participant with my thoughts on what that year had contributed to their individual journey. As most participants said the most about their pre-college experiences in the first-year interview, I wrote both the pre-college and first-year memos at the same time but divided them in the document to keep them distinct. As I began to work through more participants, the memos began to include the beginnings of trends that I saw emerge. In the case that a student described an important experience from a previous year in a later interview, I would append thoughts into the previous memo with notes of where the new information had come from. This was also the approach I employed in working with the matrices when additional information came in later years. These memos provide a detailed track record of my personal reflections on the participants' experiences and my own approach to the analysis process (Daniel, 2019). Each memo began with my recollections of whether I had personally interviewed the students in either the third or fourth year of data collection, along with my memories of the interviews themselves. Noting my history with the individual participants helped to keep my memory of interacting with them separate from the information contained strictly within the interviews. Given the personal experience the idea for this dissertation stemmed from, I often compared my own experiences with those of the participants. I was careful not to inject my own feelings or opinions into the summaries, instead keeping them separate. The memos allowed me to capture my own feelings about the participants' experiences, with the summaries providing a means to encapsulate their lived experiences, as outlined in section 3.4.4.5 below.

3.4.4.4 Thematic Analysis

With eight filled-in matrices, the next step was to analyze across my initial codes to find emergent patterns. The process began with an examination of themes within the columns, examining one category of socialization at a time to identify commonalities in where, when, and how students were exposed to socializing agents. This first step resulted in a collection of 14 groupings of socializing agents that were present for multiple of the participants. The same approach was then applied to the columns for perception of the discipline and both dimensions of belonging. The patterns that emerged from these columns revealed what kinds of experiences were most salient in developing a SoB to the discipline and university, as well as some of the more common responses with respect to what made students like or dislike their prospects in their chosen major.

The next phase of the thematic analysis looked across the columns to garner a broader picture of the student's socialization, as well as its influence on their SoB. Brief trajectory summaries were written, detailed further in the following section, as part of this step. This broad overview of socialization also provided the means for me to understand why the students chose to engage with certain socializing agents when they had the opportunity do so. Finally, the high-level overview of each participant's socialization trajectory and the subsequent development of their SoB emerged from looking across the full matrix. These overviews were then compared, producing a set of trajectories that will be further discussed in Chapter 4.

3.4.4.5 Additional Summary Documents

As part of the second-cycle coding, I produced summaries of each of the participants' matrices. These included key positive, negative, and neutral socializing agents and a brief description of their relation to the student. I also used these documents as an opportunity to

produce short summaries of the students' overarching trajectories of socialization from pre-college to fourth year. These summaries were invaluable in the secondary analysis of my data as they provided the basis for my categories of the trajectories. Additionally, the categories of drivers that led to the participants seeking out specific kinds of socializing agents were added on to the summaries for each participant along with details of where and why that particular student sought the support they did. By maintaining the detail of each participant's experience, I kept the individual at the forefront of my analysis, despite the trends that began to emerge. Though multiple participants may have shared some overarching patterns of socialization, I was careful to maintain enough detail in the summaries that I would not generalize their lived experience.

3.4.5 Research Quality

In order to ensure the quality of my dissertation study, I looked to the frameworks posited by Daniel (2019) and Tracy (2010) for guidance. The TACT framework put forth by Daniel (2019) presents four key measures of research quality: Trustworthiness, Auditability, Credibility, and Transferability. The eight criteria presented by Tracy (2010) largely fall under these four categories, but provided another perspective that helped me to understand quality in the context of my work. I will address each of the facets of the TACT framework and how they applied to my study in turn.

The trustworthiness of my research stems from the use of established methods and a strong theoretical foundation for my research questions and approach. I have grounded my study in two well-established theories in educational research and justified their use for this study in Chapter 2. My data collection methods have been clearly communicated earlier in this chapter and are rooted in established research practice. The requirement of triangulation for the case study approach (Yin, 2018) also adds to the trustworthiness of this data, as I was able to

contextualize and frame participants' accounts within the institutional and temporal context they were created in. I have also made clear my own positionality and worldview as a researcher, both of which affect how I approached this work and its findings. As a cisgender white male, I could not personally relate to many of the challenges and experiences the participants described. I was careful not to dismiss their accounts or provide alternative explanations for their perceptions of their experiences, instead focusing on keeping the sentiment of their accounts intact in my reporting of their journeys. With consideration for these measures, I made sure that the foundation of my dissertation work is trustworthy.

My method for ensuring the auditability in my dissertation was twofold: transparency and reflexivity through memos. The former applied to both my methods and my positionality as a researcher. I did everything I could in this chapter to clearly communicate my research methods and methodology, as well as my rationale for both the final approach and any changes I made to it along the way. In doing so, I have allowed the reader to understand the entire process behind this work. The memos I wrote ensured I was taking time to reflect on my own experience with the research process and my perceptions of the data that was emerging. In doing so, I was able to keep my own assumptions at the forefront of my mind and mitigate their influence on how I worked within the data (Walther et al., 2013).

Two of the measures that were taken for the trustworthiness of my data also protected its credibility (Daniel, 2019). The careful and rigorous description of the research process and the triangulation of data both ensure that my work has been carried out in a credible fashion. To further bolster this credibility, I included numerous direct quotes from participants to reduce the chance of misinterpretation that comes with qualitative analysis (Hatch, 2002). I was also able to

speak with other members of the UKSA project team about the data on numerous occasions to clarify my understanding or check my interpretation of certain experiences as well.

Finally, the transferability of my study is primarily ensured by the rich descriptions I provide for each participant's experience in the next chapter. In this chapter I provided demographic information and details about how the participants were recruited and subsequently selected for use in this dissertation. The next chapter outlines the specific facets of their experiences that are most salient to addressing the research questions proposed in this study, supported by rich detail and numerous direct quotations. Guided by the questions presented by Daniel (2019), I have ensured quality throughout my research process in both the actual conduct and the written product. The key addition from Tracy (2010) was the importance of ethical research, which is detailed in the next section.

3.4.6 Ethical Considerations

Ethics are an important part of any research study. Throughout the process of completing this dissertation and throughout the duration of the UKSA project, appropriate measures were taken to protect participants' privacy and confidentiality, ensure their autonomy and comfort in the research environment, and adhere to all Institutional Review Board requirements (Orb et al., 2001). Every participant was assigned a pseudonym from the start of data collection. Data gathered from the participants, whether in the form of interviews or sample assignments—not used in this particular study, but important to the UKSA project overall—were kept in password protected databases accessible only by members of the research team. Consent forms were required for each individual interview, with descriptions of the interview and broader project included to help participants understand what they were participating in. These were reviewed again prior to beginning the interview process. Questions were welcomed as part of the

negotiation of this process to ease any concerns participants may have had and clarify their role in the research project. For the video conferencing interviews, the researchers—myself included—made it explicitly clear to the participants that they were not required to use their cameras and that no video recording would be saved or used in the project. These measures ensured the procedural aspects of ethics for this study (Tracy, 2010).

In order to maintain ethical practice during the actual implementation of my data collection approach (Orb et al., 2001), I made sure to remain cognizant of the questions I was asking and gauge participant comfort throughout the interview. None of the interview protocol questions covered topics that were likely to cause negative responses from the participant, but I was nonetheless cautious with follow-up questions and additional probes. I remained vigilant for "ethically-important moments" (Guillemin & Gillam, 2004), but no such events occurred. When working with the participants, particularly during the COVID-19 global pandemic, I was understanding of the participants needs and rescheduled as needed to make sure that they were able and willing to complete the interview on a given day without burdening themselves.

3.4.7 Limitations of the Study

In the current study design, five limitations were identified:

1) The interview protocols were not specifically designed for this study
2) Interviews were conducted by different interviewers over the course of the study
3) The COVID-19 pandemic impacted student experiences and data collection
4) There were no students who left STEM or dropped out of university in the study
5) Participant demographic representation was limited by attrition

Each of these limitations will be discussed in more detail below.

3.4.7.1 Protocol Design

In an ideal scenario, the protocol used to perform an interview is directly crafted based on the research question or questions it is trying to address. The protocol's questions would be designed and chosen based on their ability to gather useful information from the participant in a fair and transparent way that does not influence the participant's response. As a result, a final protocol is often tightly focused on addressing the research questions with a limited number of extraneous or unrelated inquiries (Hatch, 2002). In studies such as this one, where the data—or at least some part of the data—existed prior to the formulation of the study's research questions, one cannot retroactively alter protocols or interview data to fit the new questions. As such, the existing data may be based upon protocols that do not directly address some facets of the research questions and contain a substantial amount of extraneous information. Using secondary data can place an additional burden on the researcher to interpret participant responses when they do not directly align with the research questions (Walther et al., 2016). Additionally, it adds the task of separating which parts of interview transcripts contain relevant information at all, as some interview questions may have no bearing on the topic of the study whatsoever.

This study made use of existing data from a broader overarching project, meaning that the interview protocols were not designed specifically for this dissertation. Instead, they were created to address a wide variety of topics in line with the objectives of the project. The protocols included questions addressing student assessment experiences, learning preferences, and their expectations of their institution and themselves. It also included several questions addressing students' social engagement, from professional associations to interactions with fellow students. The protocols for this project also evolved year to year, meaning that while the general content of the protocol remained consistent, the exact questions themselves sometimes varied. A

selection of the questions from these protocols that were most relevant to this dissertation study was provided above in section 3.4.3.1. The full protocols can be found in Appendix A. These selected questions were often the most informative or insightful, but as part of the analysis, all the participants' responses were parsed for mentions of or references to social engagements or their perceptions of the disciplinary community they were a part of. As noted previously in section 3.4.4.3, it was also sometimes necessary to code concepts that existed under the broader umbrella of socialization or belonging. The umbrella approach to coding was especially important for belonging, as the protocols never specifically asked students if they felt that they belonged, though they did address whether students would choose their major and university again, which can be an indicator of belonging. Instead, descriptions of feelings that contribute to belonging were noted, including feeling valued, mattering, and committed to the institution or discipline. The exact theoretical constructs that guided this study may not have been targeted, but the broad question base provided ample means to build complete stories for each participant. Despite the protocols not being specifically designed for this study, there was ample information present to complete the analysis.

3.4.7.2 Interviewer Consistency

Throughout the four years of data collection that resulted in the dataset used in this study, a total of four different individuals—me being one of them—conducted interviews using the overarching project's interview protocols. One individual conducted the first-year interviews, another conducted the second-year interviews, and another graduate student and I shared the responsibility of the third- and fourth-year interviews. While it is not inherently bad to have multiple interviewers, particularly considering the scope of a project like this one, it did introduce several challenges. The interview protocols each year were designed for semi-

structured interviews, allowing the interviewer to probe deeper into student responses and engage with the participant actively. As a result, each member of the interviewing team had the liberty to follow-up as they saw fit, resulting in variable amounts of depth for each question both between individual students and individual interviewers. Furthermore, there were inherently some differences in how the questions in the protocol are presented, which may have prompted different responses (Matteson & Lincoln, 2009).

Including interviews from other interviewers also presented a challenge in that I was being introduced to the content of the interviews secondhand. In qualitative research, it is critical for the researcher to establish a connection with their data, understanding not only the words that have been said, but the context in which they were spoken as well (Heaton, 2013; Walther et al., 2016). As such, it can be challenging to understand the context behind data that was not collected oneself. This limitation can be overcome by listening to the audio recording, reading the transcript thoroughly, and situating the interview with respect to others from the same participant. All of these steps were taken as a part of the analytical process. Additionally, two of the three other interviewers remain actively engaged members of the UKSA project team who were contacted if further clarification was necessary as the analysis took place.

3.4.7.3 Impacts of COVID-19

It is no question that the global COVID-19 pandemic had sweeping impact across all aspects of academia and university life. Nonetheless, it was worth exploring how the pandemic affected this study. The effects of the pandemic began to affect the project in full part of the way through the data collection during the third year and remained prevalent through the full fourth year. Due to the ability to conduct interviews via phone and teleconferencing software, it is difficult to say whether the pandemic had an impact on the number of participants in the study in

the third and fourth years. While the number of interviews declined between the second and third years—from 20 in Year 2 down to 8 by Year 4— some attrition is normal in longitudinal studies (Bauer, 2004; Caruana et al., 2015). The number of participants remained more stable between the third and fourth years, though there was a slight decrease. There are also some concerns about the quality of interviews conducted online instead of face-to-face, most notably around the establishment of rapport with participants (Weller, 2017) and the respecting of participants' privacy and confidentiality (Khalil et al., 2021). The longitudinal nature of the study and use of phone and video conferencing interviews beginning only in the third year allowed for the building of rapport over the first two years of data collection so that participants were already familiar with the research they were participating in, even if the interviewer and interview medium changed. The management of ethical concerns around informed consent, privacy, and confidentiality were addressed in-depth in section 3.4.6 above.

Perhaps the most significant limitation on this study posed by COVID-19 was not on the study itself, but on how it altered participants' lived experiences. Given the focus of this study on social interactions, engagement with disciplinary and university communities, and evolving experiences, the abnormal conditions imposed by the pandemic had significant consequences for what students described. Social distancing requirements, online classes, and the restriction of lab work severely impacted students' abilities to interact with their peers, professors, and their discipline (Aristovnik et al., 2020). As such, their experiences cannot be considered a "normal" evolution of socialization, but this did not diminish their importance. Instead, it provided a means to explore how students reacted to their new experiences and how different prior socialization contributed to their pandemic situations. While this study was not explicitly focused

on the impacts of COVID-19 on socialization, they were undeniably present, and must be considered.

3.4.7.4 Persistence vs. Attrition in the Study Population

Many previous studies on socialization examined how positive socialization experiences—or lack thereof—impacted student retention at various levels of education. This dissertation sought to further add to this body of literature. However, it is necessary to note that my study population did not contain any students who left STEM or the university altogether. The absence of these students does not diminish the significance of the findings with respect to why the eight participants ultimately chose to persist, but it does indicate a need for further research to understand the socialization and belonging development in students who do ultimately decide to leave, dropped out, or were removed from the institution for any number of reasons. To fully understand the phenomenon being studied in this work, such perspectives would be necessary in future studies. The value of the findings of this dissertation stand, however, as they depict distinct journeys of eight different individuals and what lessons their experiences hold for future educational research and practice.

3.4.7.5 Participant Demographics

There was an additional limitation stemming from the longitudinal nature of the study and attrition of the participants, in that it was impossible to control the demographic composition of the participant pool. As was explained more in the description of the participants in section 3.4.2 above, the recruitment strategy in the first year was to net as many participants as possible, which allowed for purposive selection in the second year with the intention of diverse representation. However, after this point, attrition became the only factor that influenced participation in the third and fourth year, and as a result, the original sample of twenty dwindled

to the eight students in this study. As such, the resulting sample could no longer be considered representative of the department's demographic makeup.

3.5 Summary

Throughout this chapter, I detailed the research methodology and methods employed in completing this dissertation work. The overarching UKSA study was outlined and the implications of using secondary data for my analysis were ultimately minimal as a result of the open-ended intention of the original data collection. A case study approach was employed to understand the phenomena of interest—the interplay of socialization and belonging—within a bounded institutional and temporal context. Multiple disciplinary contexts are embedded within a single institutional case, with a total of eight participants evenly divided between the contexts. Data was collected through a combination of semi-structured interviews, some of which I administered in the third- and fourth- years of collection, and the use of institutional documents and information compiled by the UKSA project team. The interviews were the primary focus of the analysis, with the documents providing important contextual information that aided my understanding of the participants' accounts. The analytical steps were outlined from the process of familiarizing myself with the data to two cycles of coding guided by a trajectory mapping approach to protect the longitudinal nature of my analysis and research questions. I then detailed the measures I took when ensuring the quality and ethicality of my research work. Finally, I considered the limitations of this study and the degree to which they influenced the process and the outcomes.

Chapter 4 – Results

4.1 Chapter Roadmap

My participants described eight journeys of socialization in this study. To better characterize these stories and the similarities that can be drawn between them, I will briefly summarize each participant's trajectory in terms of both their socialization and their belonging. These summaries will be followed by the outcomes that emerged in response to each sub-question, in turn. The patterns from the sub-questions will then be expanded upon to fully address the overarching research question. Findings that did not pertain to any specific research question but were still considered noteworthy will be addressed last.

4.2 Participant Trajectory Summaries

In order to properly introduce the participants in my dissertation, I will use this section to provide summaries of each individual's trajectory of socialization, disciplinary sense of belonging (SoB), and university SoB. Elements of these trajectories will be highlighted throughout the chapter, but this section provides a broad overview so that the stories do not have to be pieced together from quotes and anecdotes. Each participant's discipline and any university or disciplinary transfers are noted in the section headings for quick reference. Though the participants' trajectories were unique, common themes emerged across them. These themes will be explored throughout the later sections of this chapter. The narratives I created provided a brief overview of four years of data through my eyes as the researcher. The participants' stories will be developed throughout the rest of the chapter with quotes and rich descriptions relevant to the themes as they are addressed.

4.2.1 Annie – Chemical Engineering

Annie's socialization patterns remained consistent throughout her four years of study, largely grounded by enduring membership in the university swim team and her overwhelmingly positive interactions with professors in every year of study. Despite being involved with the swim team for four years, she described their impact very little beyond how much time she had to devote to the sport. The team's primary function seemed to be as a source of comparison when she highlighted why engineers think and behave differently from others. Outside of the swim team, she maintained a close group of friends which became increasingly dominated by her peers in Chemical Engineering (ChE) throughout the second half of her undergraduate career.

Within the discipline itself, Annie's experiences were largely positive. She looked up to her professors and spoke highly of her interactions with teaching assistants (TAs) in lab environments. Her department's academic advisors were also a source of encouragement and direction for her, particularly as she diverged from her initial path in the fourth year to pursue a budding interest in Nuclear Engineering that spawned from an internship the summer before. She was professionally involved in both the American Nuclear Society (ANS) and American Institute of Chemical Engineers (AIChE), the former by choice and the latter automatically through her membership in the ChE department.

Annie's primary negative socialization experiences at the university were twofold: the first-year engineering (FYE) course sequence and the limited diversity present in the ChE department and university. Her frustrations with the FYE sequence stemmed simply from the limited chemistry-related content in the courses and her feeling that the courses were preferential towards other engineering disciplines like Computer Science (CS). The diversity-related concerns can be broken into two groups as well, the first being a general unhappiness with the

racial and ethnic diversity of the overall university population. Annie came from a very diverse urban environment, so this sudden decline in diversity was a shock to her. The second, more intense frustration stemmed from the lack of women faculty in ChE. Annie expressed this displeasure consistently throughout all of her years in the ChE program, wishing that she had a woman role model in the discipline.

The evolution of Annie's disciplinary SoB through the years was upward but nuanced. What began as a general interest in chemistry wavered at various points, whether due to the aforementioned frustrations with FYE requirements or her desire that her minor, green engineering, could be her major instead if it was offered as such. Nonetheless, she was steadfast in stating that ChE would be her major if she was given the chance to choose again, despite wanting to pursue Nuclear Engineering in the fourth year. Even then, she wanted to pursue it with a focus on its interaction with ChE. She established a community within the discipline and found a support network through her professors and advisors. Ultimately, Annie cherished her time in the major with both its people and its content.

Conversely, the trend of Annie's SoB within the university more broadly was easier to track. She established herself well in the first year. The swim team was a consistent source of interaction, even if her teammates were not her closest friends. Annie struggled some in the second year, considering other universities with better engineering programs as a result of her frustrations with the discipline at that point. Despite early difficulties, the third and fourth years both brought significant boons to her SoB in the form of professional and personal support networks. Capping off this growth was Annie's decision to pursue her graduate studies at the same institution, demonstrating that she moved past her apprehensions about the quality of the

engineering program. She felt obligated to carry the university's name well even beyond her time studying.

4.2.2 Anthony – Chemical Engineering

Anthony came to the university with a plan and his socialization trajectory reflected his predetermined goals. Even before he arrived at the university, he was finding ways to pursue his interests in medicine through shadowing family friends. Once he arrived at the university, he only doubled down. This commitment led to a divergence in the trajectories of his socialization within the discipline and with the university more broadly. On the disciplinary front, ChE was never more than a steppingstone to medicine and a backup if his primary objective did not work out. Anthony worked with the ChE department extensively through being a TA and working in an immunology lab—a hybridization of his major and medical interests—but these engagements never meant that much to him. They were useful experience, but not his passion. By the fourth year, Anthony no longer considered ChE as a suitable backup. He had been sufficiently dissuaded from pursuing an engineering career at this point, though this was primarily due to his commitment to making medicine work. The only major negative disciplinary socializing agent was his ChE advisors. While going into medicine is not an exceedingly rare choice for ChE majors, Anthony's advisors were simply not prepared to help him with his aspirations. They often pushed him towards more traditional engineering opportunities like co-ops and internships, in which Anthony had no interest. Juxtaposed against a handful of professors who went out of their way to relate the course material to medicine at Anthony's request, the advisors made Anthony feel like he did not belong in the ChE department.

Whereas Anthony's socialization in his discipline slowly pushed him to the margins, his experiences in the university as a whole did the opposite. Anthony found two key communities

in his first year: a religious organization and a professional medical club. The religious organization gave him a strong personal community, contributing a support network and many of his closest friends. Religion was also a key part of Anthony's identity, and the club helped to develop this facet of his identity further, even spilling over to influence how he wanted to practice medicine down the road. The medical club was Anthony's primary source of experience with medical professionals, as well as giving him the opportunity to travel abroad and practice some basic medicine himself. He rose through the leadership of the club over time, eventually becoming its president. Coupled with contributions from the university's health professions advising, Anthony found the support he needed to feel confident in his career goals.

As a result of these divergent trajectories of socialization, his university and disciplinary SoB were in stark contrast. By the fourth year, Anthony wanted little to nothing to do with ChE. He no longer viewed the field as a suitable backup. While he had some alienating experiences, this lack of belonging seemed to stem more from his much stronger identification with medicine. For the majority of his undergraduate experience, the ChE department provided decent support and he was interested in the material, but he was consistent in saying that it was not what he wanted to do with his career. He valued what the major has given him in terms of work ethic, mental fortitude, and the general curriculum, holding almost a begrudging respect for the discipline despite distancing himself from it going forward. On the other side of the spectrum, Anthony could not have been more connected to the university. Apart from some minor frustrations with how the university responded to the COVID-19 pandemic, he adored his campus and community. He expressed an interest in giving back to the university once he is established and wanted to represent the university name well. His experiences with a variety of

personal and professional socializers left him wanting for nothing but slightly better weather and an in-person graduation ceremony.

4.2.3 Arun – Chemical Engineering

Arun had a singular focus throughout his years as an undergraduate student: prepare himself for a job once he graduated. His post-graduation objective was reflected in his reason for selecting ChE as a major in the first place, as he deemed it to fall perfectly at the intersection of employability and potential for his work to have a broader impact on the world. His employment-mindedness continued in the first year wherein he complained that the FYE course sequence should be geared more towards industry-style work. Curricular frustrations did not end in the first year either and by the fourth year he was no longer fond of ChE as a whole. He believed it to be too theoretical and expressed a preference for majors he perceived to be more practical like civil or industrial engineering and CS. Working around these frustrations, Arun found other ways to pursue career experience. Strangely, while he seemed fully aware of the career center on campus and what it had to offer, he found his job opportunities elsewhere. Access to a widely distributed email that contained internship and co-op opportunities and a university-wide job searching app seemed to satisfy his needs. Arun did secure a co-op prior to his third year and it carried over into his fourth year of study as well. He praised the experience highly, stating that it helped develop his outlook on ChE more than any class ever could.

Outside of his employment hunt, Arun was barely involved in the campus community. He never held membership in any kind of club on campus and only joined AIChE because he was automatically enrolled. He spoke briefly of his friends in ChE, but these interactions seemed largely to be predicated on academic help and advancing his studies. Arun also talked about developing a network of professionals and peers that would one day be colleagues, circling back

once more to his focus on employment. His interactions with professors were a mixed bag of distaste for their teaching approaches—echoing his curriculum frustrations—and praise for their accessibility in office hours and for clarification on assignments.

Arun's disciplinary SoB was never fully established. He was fond of the potential that ChE held for a meaningful job but was immediately put off by the lack of industry focus in the first year. While he liked the courses in his second year, he was already beginning to consider other engineering majors, as well as physics or chemistry. By the third year he no longer wished to pursue ChE if he had the chance to choose his major again, now favoring CS. By the fourth year he was completely disinterested in ChE, despite finishing his degree in it. The major was not as broadly applicable as he had hoped, and it was far too theoretical for him. The content and delivery of the major simply did not align with what he envisioned a college education should be: an intention and direct preparation for industry work.

While not the downward spiral that Arun's disciplinary SoB trajectory became, his SoB at the university did not fare that much better. His compliments to the university remained largely vague, with nondescript praise thrown to the various resources with which the university provided him. He seemed overall satisfied with the career center—despite not using it—and the other career-related resources he utilized. The almost complete lack of social engagements did not seem to bother Arun. In the second year he went so far as to say that there would be more for him at the university if he was a more social person, but he was not and he was not worried about it either. He did emerge with a group of friends in ChE by the time he graduated, a network which he valued highly and touted as one of the primary benefits of a university education. Overall, it seemed that Arun was happy enough with the university, surrounded by a sea of opportunities and contacts in which he had no interest.

4.2.4 Ayame – Chemical Engineering

As an international student from China, Ayame faced a number of challenges in socializing into both the university and her discipline. At first her limited proficiency with English led her to gravitate towards connecting with other Chinese international students. She found many of them in ChE over the four years, something that also comforted her in her major. The further she got in her undergraduate career, the more she branched out, at least until the COVID-19 pandemic limited her social interaction altogether. Nonetheless, the core of her friend group remained consistent. She was mostly uninvolved in any kind of social clubs and professional societies, joining AIChE automatically in the third year but never seeing much value in it. Ayame's interactions with others in the ChE department were generally mixed. Most of her professors were good to her, but she did not enjoy a few of their teaching styles. She admitted that the quality of a professor had a significant impact on how interested she was in their class and how well she felt she could perform in it.

The greatest challenge that Ayame faced in her socialization was on the professional front. Despite being interested in pursuing co-op or internship opportunities, Ayame ran into a wall almost immediately due to the limitations on these positions for international students. These roadblocks put her off industry-related professional pursuits almost immediately and she instead turned to pursue research in the third and fourth years. While she seemed aware of the resources related to career development that were on offer, she never made use of them because she knew that getting an internship was simply too unlikely. Her research labs became a source of pride and security for her, making her feel like she could still contribute to the discipline.

Arriving to the university, Ayame was about as close to a blank slate of belonging as a student can be. She decided on ChE as a result of a vague interest in chemistry and a

recommendation to pursue engineering at this institution from an advisor in China. She knew very little about the discipline or the university, only that someone she trusted felt them to be a good match for her. On the disciplinary front, Ayame slowly developed an affinity for ChE. At first, she was timid and hesitant to define her relationship with the major, explaining that she needed to learn more about what it had to offer. As she learned more and took more ChE-specific courses, she found more of a place for herself. Despite a brief consideration of computer science as an alternative in the third year due to her work with programming in one of her research labs, she reaffirmed ChE as her preference in the fourth year. By that time, she had decided to pursue further study in graduate school and felt that ChE would be able to support her interests in both an academic and professional career. While she was not as resolute as some other students in the dataset, she felt comfortable and supported in the discipline and saw a future for herself in it.

Moving from a major city in China to a college town in the United States provided a tenuous backdrop for Ayame's SoB at the university. It was a major change and much of it felt different and frustrating to her. Logistical issues and complaints about the small size of the town were consistent throughout her interviews, but at the same time she praised the support she received and felt generally content with what was offered to her. By the fourth year it was clear that her priority with the university was the quality of its ChE programs, and she was content in that regard. While it did not seem apparent that Ayame would gladly stay at the university forever, she was satisfied with her time and the support it provided her. She found a small personal community at the institution and grew more comfortable over time.

4.2.5 Caroline – Biochemistry

Caroline's socialization into biochemistry began prior to her arriving at university with International Baccalaureate (IB) chemistry, though she still did not yet know what exactly

biochemistry was. She decided against engineering due to a pre-college biomedical engineering summer program. Once she arrived to the university however, her passion for biochemistry only grew. This growth was helped along by professors she described as genuine, knowledgeable, and approachable. Though she had some complaints about various teaching styles and classroom practices, she thought highly of her instructors overall. By the second year she had found a home within biochemistry in a computational research lab. She remained in this lab for the remainder of her undergraduate career, often touting the support that she received from her research advisor, graduate students, and undergraduate researchers alike. This experience fed Caroline's interests in research, spurring her on to pursue graduate school and plan for a career in academic research.

Outside of her research group, Caroline's primary networks came in the form of a living-learning community on campus and a religious student organization. The former served as a bridge in her first year, giving her access to more experienced students who could give her advice and make her more comfortable with the transition to college. In the second year, Caroline became one of these mentors herself, imparting her knowledge to new first-years in turn. Though it was short term—she could only live in the community for two years—and came with the inconveniences of life in a residence hall, she valued it deeply. The religious organization, on the other hand, served as the core of Caroline's personal network for all four years. Despite not being religious prior to attending university, she found the organization to be welcoming and supportive. By the fourth year, she even described it as transformative, having redefined who she was. She credits the religious organization with greatly boosting her personal confidence, complemented by her research lab developing her professional identity and skills.

She briefly mentioned other involvements, like the American Society for Biochemistry and Molecular Biology (ASBMB), but these were largely tangential to her primary development.

As noted previously, Caroline did not know much about the specifics of biochemistry when she arrived to the university, but the more she learned, the more she loved it. By the second year, biochemistry became her sole focus and the only route she saw for herself going forward. While her personal network spanned beyond the boundaries of the major, she maintained a group of friends, further fortified by support from her lab group. She felt supported on all sides and recognized the availability of plentiful research opportunities. As her career aspirations developed, they formed more and more around working in biochemistry in an academic setting to continue not only her research but teaching as well. By the time of graduation, she reflected positively on the experiences that she had, feeling that the department had set her up for success and laid down a strong foundation. In summary, her disciplinary SoB started well and only got stronger over time.

Caroline was drawn to the university by a perceived abundance of research opportunities and a fondness for the principles that seemed to guide university life. Over time her SoB grew, but unlike in biochemistry, the university path had bumps along the way. As a student with attention deficit disorder (ADD), Caroline often clashed with the Services for Students with Disabilities (SSD) office. While there were accommodations in place to support her, she felt as if they “lowered the bar,” though she did not elaborate on exactly what this phrase meant. She continued to say that she would have preferred learning and studying strategies which would have helped her to be able to rise to the challenge presented to her, leading to frustrations about the treatment of students with disabilities. The support was present, but it was not what she wanted. Furthermore, Caroline described sometimes feeling isolated as a woman in a male-

dominated STEM field. Ultimately, this discomfort was alleviated by exposure to strong women role models in her research lab. Despite some of these challenges, Caroline came to love the university, calling it home in her third year. She was resolute about choosing the same university again given the choice. It was not perfect, but she did not expect it to be. The university was a safe and secure environment with the support and resources provided for her to thrive.

4.2.6 Catia – Biochemistry – University Transfer After Year 2

Catia's journey through her undergraduate studies was unlike any other student in this study. Between her second and third years, Catia transferred universities. Her motivations for doing so were primarily based in her tuition and university rankings. Her second university—the university that served as the focus of this study—was considered in-state for tuition purposes due to her family's legal residency, while also being the top-ranked biochemistry program in the state. During this transition, she remained devoted to biochemistry.

In her first year, Catia made efforts to become adjusted to her new surroundings, joining a religious fellowship while also maintaining some relationships with groups she had been a part of in her native Russia. She became involved with a biology-related student organization that aided her in navigating both her class schedule and research opportunities. By the second year, however, she had left the religious organization behind, preferring to operate on her own for the most part. Catia valued general interactions more than any individual experience as they provided her chances to practice her English. As an English not as first language student, the more opportunities she had to practice, the more comfortable she became, and in turn the more she was willing to interact with others.

Following her transition to the new university, she once again joined a religious organization. As she had done this at her prior institution as well, she explained this pattern of

behavior as providing her a familiar stepping off point for introducing herself into a new community. Her involvement was once again brief. Despite having no luck finding research opportunities for the prior summer, Catia was able to land a position in a microbiology lab in her third year that would go on to provide her primary community up until she graduated. She valued her research not only because it provided her the opportunity to further her career aspirations, but because it also surrounded her with like-minded students and supportive faculty. By the fourth year, Catia's involvement in campus life outside of the research lab was minimal. The COVID-19 pandemic limited what few social outlets she had previously engaged with even further. She occasionally interacted with her professors for feedback and her research work continued, but she mentioned little else. At that point, she had already been accepted into graduate school for biochemistry and felt like there was little more for the university to give her.

Catia's university SoB was difficult to map to a clear trajectory due to the change of universities in the middle of her career. At her first institution, she was fond of the resources provided to her by the university, apart from the health center due to how long it took to get an appointment. She was, however, hesitant about choosing the university again as early as the first year due to her limited knowledge of U.S. universities. By the second year, she doubled down, stating that she would have chosen a university with in-state tuition. Nonetheless, she still appreciated the resources and the people she had met. Her satisfaction with her overall experience at the first institution indicated that she did not choose to change universities due to a weak SoB or feelings of alienation. She was happy but saw benefits in tuition reduction and a stronger research program. Following the transition to the second university, Catia had to start over in a sense. She no longer had any personal community, but given her independent nature, it did not seem to bother her. She found better research opportunities, adequate support, and

reduced tuition to be more than enough to sate her needs. Never getting all that involved in the campus community, her research lab provided the support and advancement that she needed. By the time she was approaching graduation, Catia was very fond of the university. Despite her fondness for the institution, she still would have considered more highly ranked biochemistry programs if she were given the choice to start from the very beginning. As a transfer choice, however, her second university would have been her choice every time.

The consistency of biochemistry made Catia's disciplinary SoB much easier to track. Catia chose the major due to its location at the intersection of her interests in biology and chemistry. She did not immediately feel like a biochemist in the first year due to having to clear the first-year requirements. She looked forward to diving more into biochemistry-specific content. As she did in later years, her passion for biochemistry only grew. Her decision to pursue graduate school was made as early as the second year. She noted a lack of community in the biochemistry department at her first institution, but it did not bother her much, the content was enough to keep her happy. In the third year, following her transition, her research lab became the center of her progress. The experience of research deepened her interest in graduate school and further study in biochemistry, which led to her enrollment in an accelerated master's degree program. In the fourth year her classes started to relate to the research areas in which she was interested. As a whole, the department was supporting her in achieving her goals, which was far more important to her than a close personal community. Throughout her undergraduate career, Catia's feeling that biochemistry was right for her was reaffirmed again and again. She never found a close personal community, but she never sought one either. The pursuit of biochemistry knowledge itself was more than enough.

4.2.7 Chaaya – Discipline Transfer from Chemistry to Chemical Engineering by Year 3

Chaaya's journey was split by her transition from chemistry to ChE between her second and third year of study. It was not an instant break, but a slow transition involving a double major in the second year and the ultimate removal of the chemistry major entirely. Her socialization trajectories were further complicated by a co-op work experience that staggered her progress from other students who started the same year she did. The offset schedule made it difficult for her to maintain friends and connections at the university, while also delaying her graduation. She is the only student in this study who was not set to graduate at the conclusion of the fourth year of data collection.

Chaaya never really established a solid foundation with her peers when she arrived at the university. Her roommate was too messy for her and while she got involved in a variety of clubs, many of these came and went over the tenure of her undergraduate studies. Involvement in campus life was a consistent source of frustration. In early years, she wished she could have been more involved, but felt held back by the amount of time she had to commit to her schoolwork. In later years, her co-op split her from her friends and the COVID-19 pandemic dashed any hopes she had of getting involved while on campus. She maintained personal connections with friends from high school, but even by the third year they were the majority of her friend group. Nonetheless, those friends she did maintain throughout her time at the university were impactful enough that she attributed much of her personal growth to them in the fourth year.

The shining star of the socialization she experienced in her disciplines was her chemistry advisor. They were very helpful in directing Chaaya towards a path that worked for her and providing personal support as well. Their relationship was almost that of personal friends. Unfortunately, the quality of this relationship resulted in Chaaya reflecting negatively on her

ChE advisors, who were less personable and did not help her as much. Professors were a consistent positive for Chaaya across both disciplines, bringing a passion and energy to the classroom that she appreciated greatly. Her appreciation for the passion of her chemistry instructors was even further enhanced by less enthusiastic economics professors who paled in comparison. Chaaya persisted in her economics minor— added in the third year once she had left chemistry behind—nonetheless. In general, work experiences were positive and when they were not, they at least guided her away from domains of ChE she was not interested in. A summer internship in environmental research, for example, showed her that she no longer wanted to pursue environmental engineering. An internship with an aerospace company was even more formative, with one coworker helping her reframe how ChE fit into everyday life.

Industry experience was not only a key part of Chaaya's socialization, but it was also the cornerstone of her disciplinary SoB. As she met chemistry graduates in the first year, Chaaya quickly realized that none of them had jobs that she could see herself in. While chemistry content was still interesting to her, she felt that ChE was a more suitable way to bridge the content with employability. This was evidenced by her initial decision to double major. Her time in co-ops and internships was often when she felt most at home. She frequently expressed an interest in the business side of industry, eventually picking up a minor in economics. By the fourth year however, she casted doubt on her choice of major. To her, an industrial and systems engineering major with a chemistry minor would have been better suited to her direction. ChE would get her where she needed to go but was not the best option anymore. The transition into ChE may have made Chaaya feel more like she was where she was meant to be, but that feeling diminished over time. She never felt like ChE had failed to support her, as the assistance she received in pursuing industry experience was invaluable, but it never quite felt like home.

Chaaya's struggles with integrating into the university community left her somewhat adrift on campus. Her difficulty making and maintaining friends meant that she had a somewhat narrow support network, though it was bolstered by her chemistry advisor. Her early struggles with residence hall life meant that her day-to-day experience was poor. The university was not her first choice to begin with, but financial constraints meant that she had to go in-state. Over the years, her SoB did not improve by much. The campus environment, when considered broadly, was favorable to her and she liked the studiousness of the student body. Nonetheless, she never expressed any sort of connection or commitment to the university. Akin to her feelings about ChE, the university had done an adequate job of supporting her, but nothing provided her the necessary support to make her feel like she belonged fully.

4.2.8 Chloe – Chemistry

Chloe took her socialization into her own hands from the first year, starting a STEM sorority with a friend. They saw a need for more accessible support for women in STEM and decided to make it happen. Over the years, the organization continued to grow and attract new members. The sorority came to be not only the core of Chloe's friend group, but her proudest achievement as well. Accompanying her involvement in the sorority, Chloe participated in several clubs, generally for a year or two at a time. She started with a religious organization in her first year, gradually becoming less involved as they gave her a weird feeling. By the third year, she had transitioned to playing club sports. Many of her friends were also chemistry majors, but her extracurriculars ensured that she maintained a diverse friend group overall. Chloe's family played a role in her approach to her undergraduate studies as well. Her father was paying for her college, which was out of state, so she felt obligated to at least honor some of their requests with respect to her choice of major. This obligation also left her feeling pressured to

perform well academically. By the third year and with the help of her on-campus communities, she decided to prioritize her own happiness and health more. The stress of her father's and her own expectations had weighed heavily on her.

Uncertain at first about what exactly she wanted to do with her degree, Chloe started her undergraduate program with intentions of pursuing medicine following graduation. However, as she interacted more with professors and her advisor, she began to broaden her horizons. In the second year she connected with the health professions advising team, a choice she wished she had made earlier. Their support furthered her interest in the medical field. In the third year, however, her future intentions took a sharp turn thanks to her involvement with an on-campus research lab. Her experiences with other graduate students and her research advisor made her less certain about wanting to go to medical school, as she then began to consider a career in academic research. She committed to this path in the fourth year, aiming for a Ph.D. instead of her originally planned M.D.

This last-minute redirection did not come from a frustration with chemistry. Instead, it was quite the opposite. While Chloe did not thrive in chemistry in high school, she came to enjoy the material even if her instructor was not the greatest. Overcoming some struggles in the first year, she appreciated the material the more she understood it. Rather than simply memorizing concepts, Chloe felt like her professors were asking her to understand the material. Her enjoyment even surprised her. Through the second and third years her love for chemistry only deepened, as it allowed her to embrace the nerdy part of herself. She touted the chemistry community as uniquely strong and supportive and credited them with supporting her through the challenges of the major. The only minor dip in her experience was the forced variety in the fourth-year curriculum. Where she would have liked to be able to specialize in the portions of

chemistry that most appealed to her, she was required to branch out. It was a combination of the passion she had for the material and the network that she had established that led to her decision to stay fully in chemistry for graduate school, right where she believed she belonged.

Chloe chose her university from amongst several of her top prospects simply because it was where she felt she could be happiest. Ultimately, she was right. From the first year onwards, Chloe's university SoB was remarkably strong. Though she did not love life in the residence halls, she outright stated that she would not want to be anywhere else. She saw a plethora of opportunities and resources laid out before her and seized them. Despite going through some rough patches in both her academic and personal lives, Chloe found the support she needed to persist. Furthermore, she went so far as to separate many of these challenges from the university altogether, explaining that they were simply stressors and difficulties she would have found at any university because of the challenge of university life. The fourth year brought some challenges for Chloe, namely in a rejection of her appeal to pay in-state tuition—she had formally changed her address and taken other necessary steps—and the pandemic's shutdown of most on-campus activities. Even then, she once again separated the tuition decision from the university, blaming the institution as a "corporate machine" rather than any cruel individual or group. She also lamented that due to the pandemic she could not be as involved in university life as she would have liked. Nonetheless, she was firm in her position that she would never have chosen anywhere else to go, because nowhere else could have given her the same experience.

4.3 How do students' socialization experiences evolve from pre-college engineering or science to degree completion? (SQ1)

It seemed inevitable that across four years of undergraduate study, students would experience a wide range of socializing interactions. New opportunities would arise as they were

exposed to new professors, peers, and organizations. Old relationships would strengthen or fade away. How and why these changes occurred, however, was more difficult to predict. With this research question, I sought to understand the patterns of change students' socialization experiences went through, as well as delve into the reasons for these changes. Understanding this also contributed substantially to my ability to address the overarching research question of this dissertation.

Students' socialization into their chosen major and their university begin prior to their arrival to the institution. This pre-college period will be addressed first. Following that, the socialization trajectories that occurred during the participants' undergraduate careers will be addressed. During the four years of study at the university, three patterns of engagement emerged. Several students found communities early and their relationships with said groups deepened and strengthened over time. Others chose to engage in the bare minimum social interaction required to achieve their personal objectives. The final group found meaningful interactions with some but struggled to find a consistent community. These three groups will be labeled as the *Anchored*, the *Independents*, and the *Wanderers* respectively. Table 4.1 below identifies which of the participants belong to each group. The groupings are not mutually exclusive, with students occasionally displaying elements of other trajectories, but the participants have been sorted into the groups to which they belonged for the majority of their time at the university. Following the exploration of each of these patterns, a final note will be given to the role of the first-year curriculum and its role in students' socialization into their majors.

Table 4.1: Summary of Socialization Evolution Patterns

Trajectory Group	Description	Members
Anchored	Students established early connections that deepened over time, forming the foundation of their network(s).	Annie, Anthony, Caroline, Chloe
Independents	Students engaged only in the socialization that was necessary to achieve their desired outcomes.	Arun, Catia
Wanderers	Students found meaningful interactions here and there, but never found a consistent community. Sometimes wish they wished they could have been more involved.	Ayame, Chaaya

4.3.1 Pre-College Socialization

Pre-college socialization experiences were primarily discussed during first-year interviews, though several students would occasionally mention pre-college experiences in the later interviews as well. Due to sparse inclusions in the interview protocol, pre-college data was limited in both frequency and depth. Nonetheless, the little information that was provided insight into why the participants did not always start their socialization and belonging trajectories at the same point. I have chosen to break the patterns into two closely related themes: exposure to the university and exposure to the discipline.

4.3.1.1 Exposure to the University

The level of exposure the participants in this study had to their chosen university varied widely. Beginning with the participant who had the least amount of exposure to the university, Ayame knew almost nothing about where she was going to complete her studies. She had a teacher who supported his students in applying to colleges, often providing recommendations based on their interests and test scores. Ayame took his advice without much protest, resulting in a very indifferent approach to selecting her institution: “Well, I just basically applied for some schools and [saw] which schools accepted me and [chose] a school. After I got, I received

[admission], I just chose those schools and saw which one I'd like to go [to]." Her knowledge that the institution was "a good engineering school" also came directly from her teacher.

On the opposite side of the spectrum was Caroline, who embraced her time visiting campus—despite being out-of-state—and learning about it online. Caroline became excited about the various research opportunities the university offered online, and further bolstered her attachment by visiting the campus. She also highlighted the university's motto and principles of community as meaningful in her decision to attend. The memories of her early experiences persisted as well, as she reflected in the second year:

> I looked at a lot of universities, and something about [this university], when I left here I couldn't get it out of my head. I love how nice everyone is, we've got so many great opportunities. Yeah, I wouldn't change it, I love it here.

The rest of the participants' experiences existed between these extremes. Annie and Anthony had the chance to interact with other students on-campus; both found that they related well to the people they met. Coincidentally, both used the phrase *"*down-to-earth*"* to describe the overall impression they got of the student body. Chaaya and Chloe also spent time on the campus prior to enrolling, with the campus itself being a deciding factor in their decisions. Chloe explained:

> It was really, I just fell in love with the school the first time I came. The campus was so beautiful, and everyone was really happy. Well, there's a good science department which is important also but since [my other top choice] and [this university] both had really similar programs, it was really where I could picture myself best and where I saw myself happiest and that was here.

Chaaya was also swayed by the campus, but her concern was more about its size. She compared the campus to that of another institution she had considered, sharing that “I wanted something bigger, 'cause I guess I like meeting more people and I guess a small campus would, I would feel restricted.” Catia and Arun, by comparison, made their decisions without ever stepping foot at the institution. Catia had family in the region of her initial university and was therefore familiar with it, making it a more comfortable option than going to a part of the country she had never been in. Arun simply had limited criteria for his choice: in-state tuition and a strong engineering program, both of which the university offered.

4.3.1.2 Exposure to the Discipline

Whereas the participants’ levels exposure to the university’s values and campus were widely varied, the degree to which they were exposed to their chosen major was more consistent. All the students describe some degree of affinity for chemistry during their high school studies. Interestingly, Ayame was once again the least confident in her decision, attributing her choice of major to the recommendations of her teacher in China. As for the other students, their reasons for deciding to continue in chemistry were variable, depending on what they knew about the major and how it related to their goals. Chaaya’s motivation was simple: she knew she was good at chemistry, so she liked it. Anthony and Chloe were both aware of their respective majors’ feasibility as a route into medical school. Catia saw biochemistry as an intersection of her interests in chemistry and biology. Annie was the same with ChE, but as a combination of mathematics and chemistry. Arun viewed ChE as a synthesis of his desire for employment and his interest in chemistry. Whatever their individual motivations, none of the participants wandered blindly into their majors, having at least been introduced to the content.

Outside of the classroom however, there were a few key experiences for some students. The majority of the students did describe having much experience with their chosen disciplines outside of a classroom setting, though the lack of information may have been a product of how few questions addressed pre-college experiences in the interview protocol. Anthony, on the other hand, was shadowing doctors at a local hospital as early as his first year of high school thanks to his connections to family friends. He continued this experience throughout high school and once he had decided that engineering might be a suitable major for him, he focused his efforts to understand their role in the medical field:

> And then in an engineering setting, obviously there's engineers in a hospital, and I took the opportunity to kind of seek out engineers, talk to them about what they do every day, not a lot of chemical, mostly biomedical or mechanical, but kind of still the same sense, learning about what an engineer does in a hospital, so yeah.

On top of his hospital experiences, one of Anthony's cousins was already a ChE working in industry and could therefore provide another perspective on the major's applications. These experiences combined to provide Anthony a well-rounded view of the major, how it would apply to his medical aspirations, and how it might serve as a backup plan.

The other outlier to this set of experiences was Catia. As part of her time in high school, Catia was a part of a group of students whose curriculum was specifically focused on biochemistry. Additionally, she collaborated with students at a local Russian university to conduct two different biochemistry research projects. She worked with them on bacteria and genetics, getting hands-on experience in a university lab setting. Given her budding interest in research at the time, this experience was crucially formative. She described the experience as "really amazing, because we were literally doing all this, and with chemicals and different

technologies, and it was really interesting and just amazing." Without this experience Catia may well have still chosen biochemistry, but she would not have necessarily pursued research so aggressively—a key motivation for her later transition from her first university to the second. Both Catia and Anthony were exposed to valuable experience by virtue of their personal connections: Catia through her school programs and Anthony through his family.

4.3.2 The Anchored – Consistent Communities

While the individual socializing agents within an organization may come and go, the Anchored group of participants all shared a persistent connection to one or more on-campus organizations that defined their experiences. Their roles and responsibilities changed over the years, but their closest communities did not. Some communities like Chloe and Caroline's research labs provided professional development. Others like Annie's involvement with the swim team and her core friend group provided social support. The STEM sorority Chloe founded and Anthony's medical club did both.

In some cases, the decision to get involved was intentional. While explaining why he did not feel the need to join a ChE professional society in his first year, Anthony shared, "I think I've gotten involved with other things that I have found would be beneficial for both professional success and social success. I know I mentioned a few of those before, like [the medical club], [the religious organization]." He had identified the areas of development that were important to him and targeted organizations that could support those needs. Chloe took this one step further, identifying a need and deciding that she was the one to address it:

> But my friend and I, we are founding a chapter of a women in STEM sorority here …I am in [a religious organization] which takes up a lot of my time and I love it but I do want to get to know people who were also in my major. I have gotten to know people in

> my major but also got to know people in the sciences… We also wanted it to be able to be something that you could find people to have a community that uplifts academic achievement.

The decision to become involved was not always intentional, as participants occasionally ended up exactly where they needed to be. Caroline did not specifically choose to be a part of her residential learning community but valued it in both of the years she was involved. In the first year, she praised the availability of "second-year leaders who are willing to help you find a [work-life] balance." The role of these mentors was strong enough that she chose to remain a member of the learning community to become a mentor herself and help the next class of first-year students:

> I've changed a lot, especially through the [living learning community]. My freshman year I was a part of a group, and we had to do group projects and everything, so I was learning a lot about how to be in a group. And then this year I've been a leader and I've never been in a leadership role, so I've learned so much about how to be a leader.

Were it possible to continue in the residential community for more than two years, it is possible that Caroline would have. Nonetheless, her decision to remain involved and take on a leadership role for the first time in her life was a clear indication that she felt connected to the community. Caroline was not left wanting for support after her time with her residential community had come to an end, however. She had already become deeply entrenched in a religious organization on campus in the first year and stayed with them for all four years. By her final year, the impact her involvement had had on her was immense:

> That [religion] helped a lot of anxiety that I had towards school and then also being a part of [the campus ministry] gave me community which helped a lot of my social anxiety and gave me a lot more confidence in myself. My friends at high school were terrible.

This excerpt of her fourth-year interview was immediately followed by praise of her research lab, which she was part of for three years:

> Then with undergraduate research, with being in science, a lot of people experience imposter syndrome and I remember so clearly I was working in the lab, it was my first semester in the lab and I was like feeling I was still behind, I was working so slowly and the other grad student in the lab was like, 'Caroline, you're doing really good. You're working really quickly. You're ahead of other students, you're doing really good work. You're good.' That just built on my confidence so much and then just over this whole time I've gained a lot more confidence in myself and my abilities through not only getting much better grades than I did in high school and earning those grades and feeling like, 'Yes, I earned those,' but then also just a ton of experiences that I've had.

In concert, her communities were transformative, leaving her "a completely different person for the better than when I started at the beginning of [the university]." While no other participant's experiences were quite this impactful, Anthony and Chloe both highlighted their enduring relationships with various organizations as key parts of their time at university. Anthony described his medical club as "a really important part of my development," and highlighted one major contribution of his time with the religious organization:

> Where I'm kind of getting my diversity exposure is through the campus ministry, and I think that that is a crucial piece of what makes [the ministry] so great. And, I think it's a

> crucial piece of what makes a lot of medical schools so great, because we have to make culturally competent doctors and part of that is being exposed to all different classmates, all different types of professors. Not only so that we're graduating doctors from a bunch of different races and backgrounds, but so that we can learn from each other and how to deal with people from different backgrounds.

Chloe described her STEM sorority as “the best thing ever,” particularly for their support during some difficult times. The sorority was “vital in helping me heal and be happy,” providing support for Chloe both academically and personally. For these three students, enduring relationships were the cornerstone of development, sometimes even being transformative. Annie, by comparison, was not so strongly impacted. Despite being a part of the swim team for four years, often spending twenty or more hours per week training and competing, she rarely mentioned them in any detail. Most of their inclusion in her interviews was to provide a basis to compare engineers and non-engineers. She even lamented that she felt her two worlds were entirely separate, explaining in the second year that “I’m very isolated in my major from athletes and then when I go to practice, no one there is a chemical engineer.” It was through swimming, however, that she met a mentor who introduced her to nuclear engineering in her third year, completely changing the course of her studies in the fourth. Even though the swim team was not always the most impactful piece of her experience, it did facilitate a critical interaction. The separation of her swimming and disciplinary communities was not necessarily a bad thing for Annie, as she developed close friends in ChE despite her time investment in the sport. This network of peers was largely a product of shared classes and a communal study space which allowed her to meet and work with others in the major. The open setting allowed them to “all suffer together so we all bond together.” While individuals may have come and gone, Annie

persistently remained connected to her peers and classmates throughout her undergraduate studies, providing the core of her support network in the major and the university alike.

It is worth noting that while all four of these participants had one or more consistent communities providing the bulk of their support, they were all engaged in smaller, more temporary ways as well. Anthony and Chloe both played recreational sports. Annie was involved with a religious athlete fellowship and got involved with a student organization focused on supporting women in STEM post-graduation in her fourth year. Caroline made costumes for the theater department on campus. Each student had their own way of socializing with the campus community outside of their core networks, but those networks were the defining element of their undergraduate experiences.

4.3.3 The Independents – Goal Driven in Relative Isolation

Where the Anchored participants found solace in enduring relationships, the Independents instead turned towards their own individual goals and passions to drive them forward. This is not to say that Arun and Catia did not form meaningful relationships and have valuable interactions with socializing agents at the university. They were not in complete isolation. These interactions were simply not defining elements of their undergraduate careers. Instead, Catia followed her passion for research and Arun devoted himself towards getting a job. Their respective interests were sufficient motivation to persist to graduation, despite limited social networks and support.

One of the defining characteristics of the Independents is their self-identified lack of desire to engage socially with their peers or campus community. Catia was adamant in her second-year interview that she simply preferred to do things herself. After naming several on-

campus resources like the health centers and clubs, she explained, “I never used counseling center or any other organizations in here, I just never had any problems… There’s quite a bit but I can deal with my problems myself. If I would not, then I would go there.” She expressed a similar sentiment in handling her academic life in the same interview: “But, if I don’t get something in the class, I will study for it more later. It’s not that I will come to teacher and ask about it because usually I will just figure it out myself, it’s easier for me.” In other interviews, she also shared her distaste for leading and following in group assignments, as she often felt that she could do a better job if she did the entire project herself. Arun expressed a similar sentiment while giving his overall rating of his time at the university at the end of his second year:

> Like, depending on who you are, if you’re more of a social person you might feel like university is more for you. I’m not as much of like a social person so I guess that’s why I’d give it a nine. I mean, I guess I’d be just as comfortable giving it a ten honestly.

What this quote emphasizes, however, is that for the Independents a low level of social interaction did not necessarily detract from the overall university experience. Arun acknowledged that if he were more social there might have been more for him, but he was not and he was not worried about it.

For the Independents, interactions were often intentional and carried out with a specific outcome in mind. No example evidenced this better than Catia’s participation with religious societies at both of her institutions. Her tenure in each was short, usually only maintaining membership for one semester. She explained why in her third-year interview, “I’m just curious about studying different religions. And now thing is that in my previous university while I was involved there, the [religious] society there helped me to adjust to new environments. That’s the

same thing I did here." Catia knew that while the organizations did further a personal interest, they were also a great way to become acclimated to a new environment, hence the repeated short-term involvement. She used them to get more comfortable in her new surroundings and then moved on. Arun used somewhat similar logic in dismissing the prospect of membership in AIChE:

> I haven't necessarily been familiarized with how much it'll help me, outside of what I already have, because there's a lot of networking resources just through the department that I've been able to use. I'm sure that the professional organizations would help, but I'm not sure if it would help that much more than whatever other resources that I have already.

The final defining characteristic of the Independents is their singular focus on their respective goals: a job for Arun and research experience for Catia. Arun's interactions on campus fell into two primary categories: working with career service outlets—though not the career service office itself, interestingly—and his studies. The former was marked by consistent praise. Arun was highly satisfied with the numerous resources that are available in terms of professional development. He shared in the fourth year that the only support he was really looking for from the university was in terms of the job search, stating "the main one [source of support] I can think of is really just the job search. I mean, I think that's probably one that I value the most really." This support was effective for Arun, as he secured several internships and co-ops throughout his undergraduate career. While he did not go into substantial detail about these experiences, he did highlight the impact they had on him, sharing in the fourth year that his time in industry had been far more developmental than his studies: "I was there, the manufacturing

plants and stuff, and so it was really a lot about that, I'd say more changed my outlook rather than the curriculum itself. It was the work experience."

As noted above, the academic side of Arun's time on campus was not his favorite, being rife with criticism and unhappiness. From his dissatisfaction with the lack of specific applications of the skills he learned in the FYE sequence onwards, he maintained a view that the ChE curriculum was too theoretical. Complaints about the lack of project-based work and preparation for industry arose in the second and third years. He was unhappy with the curriculum by the fourth year and was steadfast in saying that he would have chosen a different major could he go back and do so. He shared, "But I still think in terms of satisfaction of my major, I'd say there's a lot of things that maybe I expected and didn't really end up being the way I thought it would be." When asked to elaborate, he continued, "Just really how oriented it [the curriculum] is, or theoretical stuff. Yeah. It seems like we have very specific knowledge in a lot of cases." Earlier in the same interview he had contextualized this point a bit by noting the emphasis the ChE curriculum placed on certain domains of ChE industry, like gas and oil: "The content isn't taught with the idea of 'you should be able to apply this just in many places.' It's pretty focused in… A lot of this stuff is geared towards oil and gas industry." At no point in his undergraduate studies was Arun all too pleased with how ChE was being presented, but he received enough career development support that he persisted, nonetheless.

Catia's research journey was a better hybridization of university opportunities and disciplinary connections than Arun's disconnected industry pursuits. The desire to pursue research began prior to her time at the university thanks to her work with local university students during high school. Her first year was largely uneventful research-wise but picked up in

the second year as she began to work with the career center to find research internships or opportunities for the coming summer—ultimately a fruitless search. Following the second year, however, she transitioned to her new university. This change was motivated by in-state tuition being available at the new institution, a higher-ranking biochemistry program, and greater availability of research opportunities. Thanks to the plethora of labs on campus, Catia was able to get involved almost immediately after transferring, starting her research career in her third year. Despite the challenge of the COVID pandemic and thanks to her research being largely remote, she continued her research work through the summer after the third year and all through the fourth year as well. The lab effectively became the center of her existence on campus. She described a sense of community within the lab, though they did not socialize together frequently. When asked about out-of-lab interactions, she responded, "not much, but we have lab meetings and we discuss things, not always related to our lab." The lab was her home on campus but remained almost entirely focused on work which suited Catia just fine.

Neither Catia nor Arun was particularly involved in campus life, but both praised the university for its resources and reflected positively on their experiences all the same. Arun had issues with his chosen major but enjoyed his time on campus. Catia was given the opportunity to thrive at her second university and did so in the manner that suited her. The availability of resources and support for advancement was more than enough for both to fulfill their goals for their undergraduate studies.

4.3.4 The Wanderers – Scattered Interaction and Limited Options

The Wanderers were defined by their unfulfilled desire to have been involved on campus or with their discipline. However, either as a consequence of their own actions or a result of

forces outside of their control, neither participant was able to fulfill their desire to participate, at least to the extent they wished. These limitations often resulted in redirections of the participants' initial plans for their time in undergraduate. The two members of this group, Ayame and Chaaya, faced very different challenges in establishing and maintaining the support structures they would like. For Ayame, the primary roadblock was the restrictions placed upon international students searching for internships and co-op opportunities. As a ChE student, Ayame wanted to get involved but quickly acknowledged the reality of what opportunities were simply not available to her: "I was not considering to co-op or internship because it's too hard to find it for international student and not many companies want you. I'm funding [sic] research for the next semester and still waiting for the professors to reply." At first, she was not sure what she wanted to get out of research, just that she needed to do something to further her work. Over time however, research became a central part of her time at the university. She worked in two labs simultaneously, choosing to remain with one from the third year into the fourth. Her desire to work in industry had not waned though, as revealed in her fourth-year interview:

> I know many ChE students go to internship or co-op, but I think none of the international students, especially I know that Chinese students, none of them have the chance. So, the company don't [sic] want us, so I go to the graduate school. I hope I can find some internship or co-op in the graduate school.

Ayame felt obligated to pursue graduate school as a result of the difficulties of finding a job as an international student. She acknowledged a lack of resources for international students searching for jobs but pinned the blame on the companies for not wanting to do "extra work to hire international students." Alongside this shift in post-graduation planning, the usefulness of several on-campus resources that are available to her were negated. She mentioned how career

fairs were not useful to her, how the career services office was helpful but that she chose not to go and minimized her time investment in AIChE.

Though her career aspirations were sidelined during undergraduate study, Ayame still found communities and connections. Most often these were found within groups of fellow Chinese international students. Even as she progressed deeper into ChE, the majority of her friends were still international students, though they became more concentrated within ChE over the years. She explained this as a result of it being "easier to communicate with other Chinese. You tend to communicate… you tend to make friends with Chinese." Apart from her friends and roommates, however, Ayame remained relatively uninvolved. Her research supervisors were a positive influence, but she never formed close connections with her lab mates.

Chaaya faced problems in maintaining relationships for reasons almost perfectly opposite those Ayame was dealing with: her co-op experience hindered her ability to keep friends. Chaaya began in chemistry due to an interest in the material, but quickly began to transition to ChE in the second year. Simply put, chemistry did not offer her any jobs in which she was interested. She learned of this unpleasant reality as part of her first-year seminar course, where her interactions with the guest speakers drove her decision to switch majors:

> There's a required one credit class that we took last semester, and a lot of the people who came in, if you wanted to get more money from your job, you would have to go to graduate school. The chemistry department itself, I feel like it burns out students. So, I figured if I'm gonna be burnt out, I might as well do chemical engineering.

Her interests shifted more towards starting her own business—evidenced by the addition of an economics minor in her fourth year—and she sought out work experiences to match. She

was able to secure a co-op that began in her second year and staggered her academic schedule. A pair of summer internships after the second and third years rounded out her work experience. By the third year, however, the damage was done to her social network. She lamented, “I wouldn’t say I have that many friends in chemical engineering to begin with… Since I came back it’s just kind of weird to get back into the relationships that I had before.” Most of her friends at the time were carryovers from high school, so she was not entirely without a support structure. In the fourth year she also added that she had been able to maintain some friends in ChE from before she left for her co-op but had not been able to make many new ones due to how little time she had after coming back and before the university was shut down by the COVID-19 pandemic.

Chaaya was involved in a number of clubs throughout her years, though she did not attend all of them frequently. She also tended to drift from club to club, rarely maintaining membership for more than a year. In the third year she even acknowledged that she would “show up to things randomly sometimes,” further emphasizing her lack of deep connections to any one organization. What was consistent, however, was her desire to have done more. She frequently expressed a desire to be more involved but felt limited by her academic schedule and work commitments. The campus shutdown in her fourth year as a result of the COVID-19 pandemic was the final nail in this coffin. She summarized this in a retrospective in her fourth year:

> When I came back I was like, okay. I’m going to reorganize and do more things. And then after COVID I just gave up, because I had two and a half months to do it… I wanted to join more activity clubs, like roller skating or something. I don’t know, more fun clubs. Because I felt my life is already a lot of academics.

The final theme in Chaaya’s trajectory was that of comparison: one great relationship negatively affected her perception of later interactions with similar socializing agents. Most

notably was her chemistry advisor. Chaaya spoke highly of her advisor in chemistry in the first year, saying that "she just listens. She's very good at that. She loves helping, I can tell. So, it's just that enthusiasm. As I said before, I love that." Chaaya almost viewed her personal advisor as a friend, maintaining some level of contact with her as late as the third year. By that time, she had already fully transferred to ChE, but kept in touch with her advisor because it was a meaningful connection. The downside of her close bond with her chemistry advisor, however, was that it set her expectations for her ChE advisors at a level that they simply could not reach. She explained in the fourth year, "Our advisor, he's super nice and everything, but I just feel like he's not as close to us as I want him to be, or any of our advisors." Chaaya also juxtaposed her economics professors against her ChE professors, a comparison that was not favorable to the former group:

> I know my economics department, I have a minor in economics, and I just don't feel the same support that I do from those teachers as I do from my chemical engineering classes… So, I feel like that department isn't as great or helpful.

By the time of graduation, both Ayame and Chaaya reflected positively at their time at the university, despite the challenges they had to overcome. Their paths may have diverged from their original intentions, but they found their way in the end. What the Wanderers lacked, most notably, was the personal development that was described by those in the Anchored group. Neither Chaaya nor Ayame described significant changes in themselves since arriving to the university. Ayame felt marginally more comfortable speaking to others but did not feel any different. Chaaya's response summarizes this trajectory well, reflecting that:

> I definitely have [changed]. I think a lot can be attributed to the friends I've made. And I guess the books I've read. But I think that's also maturing in general. So I don't know how much of it is actually because of school.

The influence of her friends was noted, but the overall experience was simply not the transformative four years that Caroline and her Anchored peers described.

4.3.5 The Role of the First-Year Curriculum

As hinted at in some of the above trajectories, the first-year curriculum was a roadblock for three participants' introductions into their majors. Each had their own issues with the first year. Arun believed that his FYE course was holding him back from really getting to explore his chosen major, directly in opposition to what he perceived the purpose of the course to be. He explained:

> I feel like it's just kind of holding students back from choosing their major, exploring a field, figuring out if that's what they really want to do. I mean general engineering was the whole idea was you're trying to explore a field beforehand but it hasn't, it doesn't really do much of that… It doesn't actually do anything specific to a major and doesn't help you decide what you want to do.

Annie expressed similar concerns, though her focus was specifically on the limited content in the FYE curriculum related to ChE. She felt that much of the content was geared towards other majors, like civil or aerospace engineering. When guest speakers came to her classes to present, only one was a ChE. Her semester long design project focused on the construction of a drone. She summarized her issues with the course in her first-year interview:

> I understand that it's an engineering class, and so it would be hard to necessarily incorporate chemistry, but if there was a way you could put a project that would be a little bit more relevant to chemical engineering would be great [sic].

Though she did not have to participate in the FYE courses, Catia expressed frustration with the first-year curriculum of her biochemistry program as well. Her complaints stemmed from a lack of Advanced Placement (AP), International Baccalaureate (IB) or comparable testing at her high school, which meant that she was placed into the general chemistry courses despite having already taken comparable classes in high school. She rationalized it as a "problem of globalization," but remained frustrated about having to retake the content regardless.

Across these three participants, one commonality about their frustrations with their first-year curricula emerged: they all wanted more exposure to their majors. Arun felt like he was not being given the chance to properly explore ChE—a fault that proved critical by the fourth year given his misjudgment of the potential of the major. Annie wanted more ChE content in the general engineering courses because the rest of her pre-requisites were not telling her anything about it. Catia wanted exposure to biochemistry material because she had already covered the basics. Regardless of major, these students felt like they would have been much more interested in their major's specific content than a general introduction. As a socializing influence, the first-year curriculum served to simultaneously frustrate these three students and further their desire to study their chosen major—a somewhat paradoxical outcome.

4.4 What types of socialization do students engage in at their university, and why do they choose the specific types of socialization they have control over? (SQ2)

Having established the overall socialization trends of the eight participants in the first research sub-question, the second was designed to delve more deeply into the specific socializing

agents at work. While certain elements of the students' socialization experience were involuntary or necessary—like seeing professors and peers in the classroom—others were intentionally sought out. The role of the unintentional socializing agents should not be dismissed, as the unavoidable interactions with professors, TAs, peers, and various administrative offices on campus make up a significant portion of the overall socialization experience. Through this research question I sought to understand the breadth of socializing agents the participants interacted with, as well as their impetuses for seeking out those in the "intentional" grouping. The results of this sub-question will be presented in two parts: a brief exploration of each category of socializing agent, followed by the themes that emerged from analyzing participants' drivers for choosing their avenues of interaction. Fourteen total categories emerged from the analysis, playing unique but often interconnected parts in the participants' support networks and personal and professional development. Across these fourteen groups, five general patterns emerged as the impetus for an individual's choice to connect on specific socializing agents, often guided by personal, professional, and academic needs.

4.4.1 Categories of Socializing Agents

To condense the broad range of socializing agents the participants interacted with over the tenure of this study, the agents have been categorized. Each category will be addressed, summarized, and specific interactions with each will be highlighted where appropriate to emphasize broader themes about each. There is some overlap of categories, particularly when considering socializing agents that hold multiple roles within the participants' social spheres. Professors who also serve as research lab supervisors, for example, will have their influence separated to the respective categories. Due to the relatively low level of granularity in the responses, however, these cases are rare.

4.4.1.1 Professors

Of the socializing agents students described, professors were the only ones whose impact was noted by all eight participants. Most of these interactions were only briefly touched upon as students described whether they liked or disliked certain classes. Several students described favoring certain professors' teaching styles over others or preferring one class's assignment types. Chaaya described her instructors as being passionate and enthusiastic about their material which she appreciated greatly. Ayame and Caroline shared that a poor-quality instructor could ruin a class they would have otherwise enjoyed. For the most part, however, students' comments about their professors in their teaching roles were vague and clumped all their professors together as a singular entity while pointing out when one or two did not fit the overall impression.

The primary interaction that students sought out with professors beyond normal class attendance was further academic support and advice via the professors' office hours. Many of the students visited their professors either after class or during office hours for assignment clarifications, grading questions, and occasionally just conversation about the discipline. Even Catia and Arun—the Independents—would engage in this manner from time to time. Annie was the most devoted to attending office hours, using them to supplement lectures even when they were being held online in her fourth year. In the third year she described the value of office hours being that they allowed the professor to give "more attention to each student" and the ability to go through lecture materials "more slowly and patiently" than he was able to in class. This more individualized support was a boon to Annie's academic performance and her overall perception of the ChE department. Other participants gave similar praise to the accessibility of their professors, but once again in mostly nondescript ways. The interview protocols were geared

towards general experiences in class, with only one inquiry into preferred teaching styles. As a result, specific interactions generally arose in the interviews as a product of their significance to the student.

The most impactful experiences participants had with professors were standouts among the general lack of detail. Anthony's experiences with his professors in the fourth year spanned lectures and office hours, but in both he found immense support for his medical aspirations:

> I would say the majority, especially when it comes to professors, when I made it known to them that I wanted to be a doctor, they would go out of their way to even to the whole class present, how their class could go into the medical field, even though it was just one person that was interested in that.

Anthony went on to explain that he would sometimes carry these conversations into office hours, with professors going on for as long as an hour about the various applications of their class's material to medicine. This support came at a time when he was feeling pushed out by ChE advisors who did not understand his career goals, making the professors' backing that much more important.

The other standout experiences with professors came from Chloe. Her most impactful experiences with professors were both entirely separate from the classroom. In the third year, Chloe mentioned a professor who would invite chemistry students who were on campus during the summer over for social gatherings like cookouts and game nights. The professor made sure the students were taken care of while they were on campus, which Chloe cited as a major contribution to the feeling of community within the department. Chloe also described another professor that noticed when she was facing overwhelming anxiety and offered support. Chloe

was one of the two participants that talked about the role of mental health resources on campus. In the fourth year, they were not sufficient for her needs. She described that "In my experience, there was one teacher. My senior year, she was the only person who has ever taken me aside and asked me if I was okay. I wasn't." Chloe's experiences with the counseling center and other mental health resources will be discussed in the appropriate category of socializing agents below more in depth. Nonetheless, the role of the individual professor cannot be downplayed for covering a gap in the support that Chloe needed. While it was not the professor's responsibility to provide this kind of counseling, she went out of her way to do so, leaving a lasting impression on Chloe.

4.4.1.2 Teaching Assistants

In many of the participants' interviews, TAs were lumped in with professors when they gave an overview of their classroom experiences. As a result, very few specific instances of connection between students and TAs were mentioned. Annie once again was a standout, reaching out to TAs for assistance when she could not reach her professors or had questions she felt like a TA could answer. Caroline expressed her frustration with professors and TAs in her first-year interview, blaming grading inconsistencies and significant grade disparities between sections on the individual graders:

> I think sometimes your grade is determined by your teacher, which really sucks, or the TA or whoever you get… I think that would really benefit biology and other classes as well, just to have more of a standard as to how the tests should be and how you should be teaching and what material you need to teach because it's pretty inconsistent right now between teachers and TAs.

The grading complaints were echoed by Ayame who found that her grades on lab reports could vary wildly depending on who graded the submission. She got different feedback from different graders, with one telling her to use past tense in the reports and another saying it did not matter. Ayame also reported secondhand that one of her friends was in a mathematics class being taught by a TA and found the quality of the teaching to be lower. It was not clear whether this was a recitation section, or a full-on lecture being run by the TA. Ayame also described the odd experience of doing the ChE department's senior lab course entirely online due to the pandemic. She described TAs doing the lab experiments themselves and then having to use their recorded results to perform analysis after the fact. All ChE majors were required to take the same course, but Ayame was the only one to specifically reference the role of the TAs.

Flipping the script somewhat, Anthony, Caroline, and Chaaya all served as TAs for introductory courses in their respective majors. Anthony found his position through one of his professors and ended up teaching through his second, third, and fourth years. Though his work was consistent across the years, he did not address it in depth, as inquiries about on-campus work were limited in the interview protocols. To him, teaching was just a side part of his life on campus. Caroline similarly got involved early, though she began as a tutor for student athletes before transitioning into a TA role in her third year. In the fourth year she was offered a position assisting with a biochemistry lab class, a role that had never previously been offered to undergraduate students. However, due to the pandemic, the department needed extra help. She valued the opportunity greatly, as by the fourth year she had already decided she was inclined to teach later in her career:

> My department head knows that I want to go more into teaching and do this graduate teaching scholars' program for Ph.D. students, here at [the university] and she's super

> supportive. My department is very supportive with helping me learn not just biochemistry, but learning how to teach and that's exciting.

Chaaya's TA experience was not discussed in depth and seemed to be the shortest lived. She only mentioned it in her third-year interview and said no more about it.

4.4.1.3 Advisors

Advisors were separated into two categories for the sake of analysis: discipline-focused and profession-focused. Both were professional staff at the university in designated roles. Discipline-focused advisors are those that specifically represent the majors being explored in this study, while the profession-focused category describes advisors specifically tailored to professional field like medicine. Discipline-focused advisors will be highlighted first. For those participants who did not arrive to the university knowing what they wanted to pursue a career in, discipline-focused advisors played a key role. Annie, for example, did not know what she wanted to do with ChE on arrival, but kept in touch with her advisor. He went out of his way to support her academic development, and she took notice:

> He's 100% always supported me in all of my dreams and he knows my interests. And when he sees an article that he thinks I would like, he sends it to me and he's like, 'Oh, this made me think of you.'

Chaaya similarly formed a close connection to her chemistry advisor, almost to the point of being personal friends. When she transitioned to ChE, she kept in touch with her previous advisor. While she still praised her ChE advisor for his efforts, she lamented that it could not compare to the unusually close connection she shared with her chemistry advisor. Anthony,

however, did not have such great relationships with his ChE advisors. Given his medical inclination, he found their recommendations to be off base for his chosen trajectory:

> One thing I'll say is a lot of them don't really know much about the medical field and that's understandable. They've never been premed or never been to med school. I think it's hard for them to give me practical advice. I will say that I have been somewhat pressured, I felt like, to get a co-op, which I think is an incredible thing to do if you're an engineer… I felt like they were reluctant to give me raw advice, because they just really wanted me to get a co-op.

Though he did not view their advice as malicious or disrespectful to his intent, it did make him feel like an outsider as a student on a premed track in ChE. To further his pursuits, however, he found comfort in the health professions advisors on campus. Specifically trained to support students pursuing medical school, the health professions advisors were a much more positive socializing agent for Anthony. He described the office as being "really good at setting me up and giving me all the information that they possibly can to get me into the schools that I would want to be at." Chloe expressed similar sentiments in her second year. At the time, she was interested in pursuing medicine via the military and described an exchange with a woman in the health professions advising office who could "talk to me about that a little bit when nobody else was really able to give me advice." The positive connection Chloe shared with the health professions advisors did not diminish her appreciation of her chemistry advisors, as she praised them for their assistance in finding resources and opportunities both on and off campus. Nonetheless, they were simply not equipped to answer all of her questions about medical school. Having a specific set of experienced advisors trained to cater to specific professional pursuits

proved to be beneficial to both Anthony and Chloe when their discipline-focused advisors were not able to help them.

4.4.1.4 Professional Organizations

Not a single one of the participants in this dissertation described meaningful interaction with their respective professional societies. This in and of itself is a notable outcome, given that almost all of the participants were members of the groups at one point or another. Most respondents admitted that they were members of their organizations but were not involved, “card-carrying members” as it was phrased in several interviews. ChE students were automatically members of AIChE by their senior year thanks to the department—though Anthony makes no mention of it whatsoever—and biochemistry students were made to take the admissions test for ASBMB in the fourth year. Chloe did not make any mention of the ACS and by the third year Chaaya had already transferred out of chemistry. Chaaya did mention a chemistry fraternity, but that too had gone the way of minimal time investment. Arun was the most upfront about his lack of participation, explaining:

> I haven't necessarily been familiarized with how much it'll help me, outside of what I already have, because there's a lot of networking resources just through the department that I've been able to use. I'm sure that the professional organizations would help, but I'm not sure if it would help that much more than whatever other resources that I have already.

Most of the other participants simply blamed a lack of time or other involvements. Anthony was not interested in a career in ChE, so his medical club sufficed. Annie became engaged with the ANS in her fourth year as her interests shifted but said little of her involvement either as a result of her recent membership or a lack of follow-up probes in the interview. She

was also the most involved in AIChE, having taken advantage of their tutoring resources and at least a few social gatherings, perhaps underplaying her level of involvement in her responses. Overall, professional societies simply did not provide sufficient benefit for most participants to find the time investment required worthwhile.

4.4.1.5 Research Labs, Groups, and Advisors

Seven of the eight participants were involved in research in some capacity during their undergraduate careers, with Chaaya being the only outlier. Arun only briefly mentioned his experience in his second year with no details, so the focus will be on the experiences of the remaining six students. Among those six, all of them reflected positively on their experiences with their research labs. Anthony was the most reserved in his praise, once again citing the separation between ChE and his "real passion," medicine. Nonetheless he did point to the professor running his lab as a great mentor in the third year.

Ayame's satisfaction with her research experiences stemmed largely from the fact that she could actually secure such a position as an international student. Her aspirations were originally geared towards industry—and remained that way despite her decision to pursue further study via a master's program—but she could not find an internship position due to the restrictions placed on her due to her international student status. When discussing how the university was helping her to find a job, she explained:

> I think if we want to work in lab, like looking for undergraduate research, is there money position for you to choose, you then ask the professor to get the position. And for the like corporate internship there are many chances, but not for us. I mean, for you as citizens almost.

Had she been able to secure work experience in industry, it is possible that she would never have become engaged in research. She found value in being able to apply her knowledge practically and learn new things but made little mention of the people around her in the lab.

Annie's engagement in research began only in the fourth year following a summer internship in nuclear engineering. She sought out an opportunity to further pursue and develop her newfound interest on campus, finding a research lab working with molten salts. From her experience she highlighted both her lab supervisor and her undergraduate research advisor as important resources as she suddenly shifted from her original intention of pursuing medical school to instead studying nuclear engineering at the graduate level. They supported not only her work in the lab but her preparation for graduate school as well:

> I also got some support from the person I was doing research for. I got support from him too. And he read over everything I wrote. And before I applied it, he was willing to help me through everything too. And then maybe my undergraduate advisor more helped me make the decision with what I want to do. Do I want to accept a job or do I want to do continue with grad school? And so, I felt like there was plenty of support to help me figure out exactly what I needed.

The remaining science students all shared much more involved relationships with their research labs. Caroline worked consistently in the same lab for three years, while both Catia and Chloe worked in their respective labs for two each. As noted in section 4.3.2 above, Caroline's lab was the core of her existence on campus. It was an invaluable source of personal support and professional development. Her advisor and the other students, both graduate and undergraduate, combined to provide a strong community for her localized entirely within the lab. She cited a specific experience where a graduate student in her lab was able to cheer her on and help her

move past her feelings of imposter syndrome. Catia's social connections with others in her lab were minimal, but the experience was nonetheless crucial to her development as a professional. She had been involved in research even prior to enrolling at the university which originally fostered her interest in research while her undergraduate experiences only deepened her passion for it. Chloe's experiences with her research lab were somewhat similar to Annie's, wherein her research mentor was a pivotal figure in developing Chloe's interests in graduate school and opening her eyes to the possibilities it held:

> And he just pours information to me, and then I'm able to go to group meetings and really talk to graduate students. Real PhD students that give me advice and that have done such a wonderful job of caring about me as an undergrad and just being like, "You can do it." So that's probably been one of the most important things for my learning this semester, just because it's taught me about... helped me see the options for my future and see what I want to do, and what it looks to be a PhD student.

For the students in chemistry and biochemistry, research labs were critical not only in developing their professional skills and preparing them for graduate school, but also in building their confidence and helping them find their passions. For the ChE students, research labs were less critical, often taking a backseat to higher priorities or serving as a backup when the priorities were unattainable. Regardless of the specific role they played for the individual, research labs and the people within them were positive socializing agents for all of the students who discussed them in-depth.

4.4.1.6 Co-ops and Internships

Where the science students found value in their research labs for professional development, the ChE students instead tended to turn to internships and co-ops where possible.

As noted previously, internships were a major source of frustration and negative socialization for Ayame whose international student status meant that she was not afforded the same opportunities. Anthony's feelings about industry experiences were also addressed previously when he criticized his ChE advisors for pushing him to pursue summer employment that was not suited to his goals. For the remaining three ChE students, here including Chaaya after her change of major, internships were an important source of information and training.

Arun's entire college experience revolved around trying to secure work experience and land a job after graduation, so he went into his job search early and aggressively. He found an internship after his first year and a co-op after his second that continued through the third. The experiences he had during his time in industry shaped his view of the ChE discipline and curriculum, as well as his future prospects. His future goals were shaped "more because of my work experience than the academic experience." He reiterated this sentiment in the fourth year following another summer internship, "I was there, the manufacturing plants and stuff, and so it was really a lot about that, I'd say more changed my outlook rather than the curriculum itself. It was the work experience." Though he was glad to have his time in industry, it ultimately made him more disappointed in his choice of ChE. The major was just not as broadly applicable as he once thought.

Annie and Chaaya had similar internship experiences, though their outcomes were directly in opposition to one another. Each went into an internship as a means to explore an area of interest. The difference was, Annie ended up redirecting her path towards to subject of her internship. Chaaya steered away from the focus of hers. Annie engaged with a nuclear research lab in the summer before her fourth year and was fascinated by the work she did. This led her to

begin reaching out for resources that would guide her to further study in the field, engaging in nuclear research in her final year and applying for graduate school thereafter.

Chaaya, on the other hand, went to work in an environmental engineering after her second year and hated her experience. Up to that point, environmental engineering had been her primary interest. Reflecting on the experience though, she said: “I found out I don’t really like it [environmental engineering] so I think next time I go into industry it’ll probably be research and development or process engineering or production.” This was an important redirection for her, as she had been struggling to find a path for her undergraduate career. A second internship after her third year went similarly, narrowing Chaaya’s future prospects by showing her more of the things she did not like. This time around she was shadowing a mentor at an aerospace company running tests on flights. When asked whether that was something she would want to do long term, she simply replied, “Not at all, really. I think I want to work closer to chemicals, and this is really far from it. Even oils and fuels, I don't really like.” While neither of these experiences seemed particularly enjoyable for her, they were nonetheless valuable in helping Chaaya figure out what she wanted to get out of her degree in the future.

4.4.1.7 Career Services and Support

Numerous resources were available to students to support their individual career goals, but for one reason or another only a few made use of them. As noted previously, Ayame felt that co-ops and internships were out of her reach and therefore did not make frequent use of the career center or attend any career fairs. Anthony found that his medical club was sufficient to provide him the networking and experience he was looking for, though he recognized the value career-related resources held for other ChE students around him. Caroline and Catia were a similar way, recognizing the resources as available, but not suited to their interests. It was

evident across participants that the availability of the career development resources was clearly communicated, it was simply a matter of whether they were perceived as useful or not.

For a student so committed to pursuing work experience, Arun made surprisingly little use of the dedicated career center on campus. Befitting of his Independent nature, he was more inclined to make use of job searching apps and emails that informed him of opportunities, things that he could use on his own. Nonetheless, in the fourth year he emphasized career search support as the primary resource the university provided him, saying that "The main [resource] I can think of is really just the job search. I mean, I think that's probably the one that I value the most, really." The extent of his interaction with the career center itself was limited to having a few interviews take place in it, but this did not diminish his praise for the resources overall.

Annie, while less career focused than Arun, made greater use of the career center throughout her four years of study. She was aware of the opportunities available to her as early as the first year, though she did not make much use of them at the time. A sophomore seminar course provided her exposure to various ChE professionals, granting her an opportunity to network and broaden her horizons. She also discussed more of what the career center had to offer, ranging from putting on job fairs to helping her with her resume and elevator pitch. In her third year she describes the opportunity for ChE students to go on sponsored plant tours to various industrial sites near the university and gain exposure to real-world applications of their course material. She described the opportunity as open to all ChE students, but none of the other participants made mention of it, indicating that it was either optional or simply less impactful on them. Her involvement with career resources waned in the fourth year due to her decision to pursue graduate study instead. She had a job offer in the fourth year but explained that it "wasn't

quite the route I wanted to go." The support she needed for that decision came primarily from her academic and research advisors.

The strongest praise for—and most consistent use of—the career center and its adjacent resources came from Chaaya. Seeing as her motivations for transferring to ChE were almost entirely based on her preference for industry work, this did not come as a major surprise. In the second year while still double majoring, Chaaya praised the professional development offerings ranging from the student success center to professional fraternities and sororities. Riding off the back of a successful co-op, she showered the career services with praise in the third year:

> Oh my god, the career employment services are amazing. I know engineers in general are just set up to get a job. We have all these workshops and all these classes and people are constantly looking at our resume. And then the career services in specific; they're so good at helping with the resume and interview skills. I've been to them once or twice and they've helped a lot.

In the fourth year, she also revealed that she found all of her work experiences through the various career fairs the university put on. She qualified her use of the employment resources—apart from career fairs, which she viewed as easy for everyone to access—as something she "looked for" and if others had not, they likely would not have found the same kind of support she did. This was reflected in the participants who did not use the career services who, while aware of the existence of some of the support being offered, were not able to articulate the specific assistance they could or did receive.

4.4.1.8 Clubs

With the sheer variety of clubs and on-campus organizations available to students, it was no surprise that many students dabbled in several throughout their four years of study. Chaaya bounced between several clubs ranging from creative writing to politics. Caroline made costumes for the university's theater department, time that she said provided a "nice change of pace, a nice break for my Friday afternoon," a sort of mental reset from thinking about her studies all the time. These were important social connections, no question. However, the two participants for whom clubs played a standout role were Anthony and Chloe. Both dabbled in several groups—Anthony played intramural sports and ran triathlons, Chloe played ultimate frisbee—but what sets them apart was the central role one organization played in each of their respective journeys.

Anthony was involved with two organizations that dominated his undergraduate experience, but one was a religious organization. Due to the frequency of mention and importance in several participants' trajectories, religious organizations will be addressed in their own section below. The primary organization Anthony was involved in was a medical club. Given his lack of participation in any form of ChE-specific organizations, the medical club served as his primary avenue for professional development. He became involved with the group in his first year, wherein he described their value both socially and professionally:

> It's a smaller club, so there's a good community, so I've gotten to meet a lot of people, so socially it's been really great. And then as far as the meetings go, they often times bring in a guest speaker who is always very engaging and teaches you really good skills for interviewing for putting together a good resume, for throwing together a good application or personal statement.

The club provided additional opportunities to him as well, including a trip abroad to provide basic medical care with professional supervision. Over the years, Anthony became more heavily involved with the club, attaining the vice president position in his third year and the president position the following year. He worked with the rest of the club's leadership to give presentations to younger students and led volunteering efforts at local clinics, animal shelters, and food banks. In the third and fourth years, the organization was not able to do as much as it usually was due to restrictions on travel and limitations imposed during the pandemic. Nonetheless, while reflecting in the fourth year, Anthony called the club "a really important part of my development." Both personally and professionally, the medical club had been at the center of Anthony's development.

Chloe's story was not all that different from Anthony's, though it was in a different field. In her first year, Chloe wanted to join an organization related to her major but did not want to join a generic engineering fraternity. She and a friend decided to start their own chapter of a STEM sorority on campus with a focus on uplifting academic achievement. They were successful by the second year, having had to jump through all of the required hoops to start an on-campus organization, and Chloe already pointed to the sorority as the source of most of her friends. The disciplinary nature of her sorority also bridged the gap between her academic and personal networks, as she explained in her third-year interview, saying "So even the study groups are my hangout groups too, we all just… I'm living with other people from my classes next year." By the third year, the sorority had taken over her life thanks to having to manage the administrative side of the organization in addition to her other commitments. She did not see her new role as a bad thing, though it did keep her from getting involved in other professional societies. By the fourth year, Chloe was beaming about how much the sorority had grown and

how much of an impact it had on her life. She had become connected to so many different groups of people through the sorority, including her closest friends, her faculty role model, and even the ultimate frisbee team, indirectly. She explained in her fourth year:

> My sorority, I talk about it probably too much, but those women are my inspiration. My favorite thing was we had so many people from backgrounds all over the place, different communities, different orientations, everything. We were all just equalized in this group.

Founding the sorority was the crowning achievement of her college career and one of her proudest accomplishments. At every turn the members were there to support her and lift her up, they were "vital in helping me heal and be happy." Her involvement was a key part of her experience, something that she did not believe she would have found at any other university.

4.4.1.9 Religious Organizations

Religious organizations made repeated and impactful appearances in the interviews of four participants. I chose to separate them from the overarching clubs' category due to their prevalence and importance throughout these four students' trajectories. Chloe's interaction with a religious organization began in her first year and ended by the third. She had gotten involved in search of a social community and found it, noting in the second year that most of her friends came from the group. However, by the third year, she had left due to her relationship with the group being "in a weird spot." Some elements of the organization made her uncomfortable, so she departed in pursuit of more positive interactions.

As previously noted, Catia's participation in religious organizations was short-lived, but followed a unique pattern. For her, religious organizations were a comfortable way to become acclimated to a new university environment. Summarizing her involvement across both

institutions in the third year, Catia explained, “In my previous university while I was involved there, [religious] society there helped me to adjust to new environments. That’s the same thing I did here.” She was involved for one to two semesters at the start of her time at each of her two institutions before leaving for no specific reason. She had gotten the value out of her involvement and was ready to move on.

Religious organizations played the largest role in the socialization of Anthony and Caroline. Their respective organizations were one of the two primary socializing communities for the two participants, complementing Anthony’s medial club and Caroline’s research lab. Both maintained consistent membership over four years, though Anthony took leadership roles in his community early on. Anthony’s friend group was more split than Caroline’s thanks to the social aspects of his medical club, but both cited large personal communities stemming from their involvement in their respective organizations. What really separates the two, however, was how they described the impact that their participation had on them.

Anthony was religious when he arrived to the institution, lending itself to his early assumption of leadership roles in worship. His membership in the group allowed him to honor that aspect of his identity and develop it further, while also connecting him to others like him in that regard. Looking back in his fourth-year interview, Anthony explained this well:

> I think I've stayed true to who I am. I've always been somebody with pretty firmly set values and boundaries for myself, and I wouldn't say any of my core values have changed at all. But, I've definitely grown, I've definitely developed, and can definitely look back and see just the way that this university has left an impression on me and the way that my friends have left their individual marks on me.

In contrast, Caroline was not religious at all when she came to the university. Her initial motivations for joining the group were not made clear in her interviews, but in the third year she explained her continued participation:

> Well one, I wasn't a Christian before coming into college, so then joining this just really supported me. Obviously, I love God, so then I really want to keep pursing that and it provides me an easy way to really be a part of a community of friends who also worship God, and are just as committed as I am… We've grown really close, and that, I think, is like the biggest part that keeps me going is my friends who are there with me.

Her dual devotion to her newfound faith and her friends provided a personal and spiritual support network that she relied upon. The organization was crucial in developing her self-confidence and helping her overcome her anxiety around school. Where Anthony was building upon an already established facet of himself, Caroline was discovering a new piece of her identity, one that she felt she had been missing before. For Anthony, involvement was developmental, for Caroline, transformative.

4.4.1.10 Sports Teams

Sports teams played supporting roles for several students, but only played a major role in one participant's undergraduate life. Anthony and Chloe both played intramural or club sports at one point or another, but rarely had lasting commitments or involvement; Chloe intended to continue if the pandemic had not shut down on-campus activities. Some others discussed the role of attending football and other sports teams' games as a fun part of campus life, but only tangentially. The only student for whom sports played a central role was Annie, a member of the varsity swimming team. Her involvement totaled 20-24 hours per week, a hefty time investment. Despite the amount of time she spent with her team, the impact they had on her was surprisingly

small. More often than not her references to the team were only in regard to her time investment and her isolation as a ChE on the team. She used her teammates as examples to juxtapose an engineering way of thinking against that of other majors in several interviews. Though she did refer to her teammates as her friends, she tended to find her closest friends among her classmates instead. Ultimately, the swim team proved to be a frustration to her in her later years, as the time commitment kept her from being involved in all of the ways she wanted to be. The most impactful interaction to come from her time on the swim team was a chance interaction with a nuclear engineer that led her down the path to change her future plans and pursue graduate school. It is worth noting, however, that her place on the team came with an athletic scholarship which alleviated the financial burden of coming to the university, for which she was very grateful.

4.4.1.11 Senior Design

Unique to the ChE participants in the study due to a lack of comparable capstone courses in biochemistry or chemistry, senior design provided an avenue for students to interact more closely with faculty, graduate students, and industry representatives in controlled environments. Despite the pandemic, Annie had her senior design class in person, albeit in smaller sections than normal. She got to deepen her connection with a few of her friends when they were assigned the same project. Her experiences with her team's industry sponsor were not always positive, however, as they often gave feedback that conflicted with their professor's advice. Ayame made note of the presence of industry sponsors but did not go into detail about her experiences.

Arun reflected positively on the interactions he had with his team's assigned graduate assistant who guided them through the senior design process and helped them when they got stuck in their work. Despite some complaints about a lack of autonomy, Arun was pleased by the

senior design course being more similar to industry work than the rest of the curriculum. Anthony spoke with similar admiration of his senior design advisor, in his case a professor, sharing, “Like I said, [project advisor], who's our teacher for senior design really, I mean, is pretty incredible, he's supporting all these different projects, and is always available quick to respond.” Senior design also gave Anthony a chance to reflect more on the contributions of the rest of the department in preparing him for the project he was confronted with. Apart from Anthony, who was at the time firmly rooted in his medical pursuits, the remaining ChE students all pointed to their senior design course as an important contribution to their preparation for getting a job.

4.4.1.12 Family

The majority of interactions students described with regards to their families were related to financing college and the expectations that this placed on the students themselves. I believe this shared emphasis was likely due to the structure of the protocol, which was largely focused on experiences at the university, but did ask about how students were financing their education and if that affected their experience. There were occasional mentions of going home for holidays or breaks but they rarely contained any detail. Most of the students who discussed the financial side of their education felt obligated to make the investment worthwhile, though this looked different for different students. Arun felt that it was his “responsibility to not do things that are expensive, and that won’t be of use to [him].” He described his choices as trying to ease the financial burden on his parents by making it no worse than it had to be, a preventative outlook. Ayame was focused on post-graduation outcomes, admitting in the second year that she felt that she had to get a good job with a high salary to make her parents’ investment worth it. Anthony

and Chaaya both recognized the privilege of having their parents paying for school and the opportunities it opened for them. Anthony explained in his fourth-year interview that:

> I would say that that definitely affects the way I view school, I think I'm so fortunate and so thankful that my parents paid for college, because I have friends that pay for everything, college card expenses, all this stuff. And, I think it definitely adds an element of stress as they give away money in the form of tuition. I think, that that kind of puts a sour taste in their mouth about the school, and it just feels like they can't really focus on the positive, because they're giving away a lot of money to attend school.

The most nuanced interactions with family came from Chloe, however, as she explained the relationship she navigated with her parents. After a difficult first semester in chemistry, Chloe considered a change of major. However, because her parents were paying for her education, when her father said she could not change, she listened. They were still supportive when she was struggling but felt that she had to stick with her major. In the second year, she reflected that she felt obligated to perform well and get a good job so that she could repay her parents for their investment, much akin to what Ayame said. By the third year, however, Chloe had a change of opinion. Her parents continued to be supportive, but she felt that they were putting a lot of pressure on her. She explained:

> Even second semester with being at home and having a lot more time to think and contemplate, I've decided that, yes, I owe college to my dad, but I also owe it to myself to be happy… in the past I've been like, 'I have to get good grades because I owe this to my dad.' But now… I push myself and I want to do well, because I want to do well.

This shift in her locus of control was a turning point in her college career. More of her decisions were made with her own outcomes in mind and she began to try to take more of the financial responsibility on herself. She even completed the necessary steps to apply for in-state tuition, though this effort was snubbed by the university. Money from a grandmother's will allowed her even more financial independence from her parents, though they remained supportive of her efforts all the same.

4.4.1.13 Friends

Isolating the influence that participants' friends had on them was difficult at times due to having to disentangle their interactions from the context in which they occurred. For example, Anthony or Caroline's friends from their respective religious organizations were included in that section. As such, the friends being discussed in this section are separate from other impactful organizations or groups. Two distinct categories emerged when examining students' experiences with their friends: disciplinary friends and non-disciplinary friends. The former are friends who were majoring in the same field, the latter could be in any other major. This separation was pertinent for analysis due to their differing roles in developing participants' university and disciplinary SoBs. Disciplinary friends tended to be a source of academic support as well as social interaction, whereas non-disciplinary friends were only the latter. Disciplinary friends could contribute to a student's views on their discipline's community, non-disciplinary friends affected how students perceived their broader university experience.

More often than not, students with strong connections to particular on-campus organizations had less need to maintain disciplinary friendships outside of those contexts. Anthony, for example, mentioned having a handful of friends in ChE, but by the second half of his undergraduate career, rarely interacted with them beyond studying and doing homework with

them. On the other side of the spectrum, Chaaya was heavily reliant on her ChE friend group for social support. Due to the scheduling of her co-op and the timing of campus shutting down due to the pandemic, she had a hard time maintaining many of the friends she made early on. Many of her ChE friends had graduated, but some had gone on co-op rotations the same time she had, aligning their schedules. Annie's closest friends all came from ChE, though it did not start that way. In the first year most of her friends were from mechanical engineering, which she attributed to mechanical being the largest major in the college of engineering. By the second year, however, the majority of her friends were also ChE students, which she attributed to sharing classes with them all the time. Her ties to the ChE community only grew stronger as time went on, though in the fourth year she admitted she was friends with a lot of mechanical engineers once again, which may be linked to her significant other being a mechanical engineering student. Arun, business minded as usual, viewed making connections as one of the most valuable parts of having studied ChE. He framed it as establishing a network of "peers who will be professionals in the future".

Non-disciplinary friends were less commonly highlighted by the participants, but they still came up in several students' trajectories. Most notably was Ayame, who found solace in the community of Chinese international students on campus. Though in later years the new friends she made were generally in ChE, she maintained a diverse friend group from her first year as well. Catia followed a similar path, making friends from a diverse range of majors at first, but ultimately settling into a majority biochemistry social circle—as small as it might have been for Catia in particular—in later years, particularly after her transfer to her second university. For both of these participants, the role their friends played was that of social anchoring in an unfamiliar space. For both, having come from other countries—though Catia was not technically

an international student—meant that they had to adjust to a very different environment. Having students that were familiar with her language and culture aided Ayame in adapting. Catia needed to get her feet set before she was off to the races, leaving many of her initial friends behind once she got involved with her lab.

4.4.1.14 Mental Health Resources and Accommodations

Only two students talked about counseling and mental health services on campus and neither provided much in the way of praise. Caroline discussed in several interviews the role that the Services for Students with Disabilities (SSD) office played in her life. In working with her attention deficit disorder (ADD), the university's offerings were not satisfactory to her. She made her feelings clear on the matter as early as her second-year interview:

> I don't really like the department for that, it's very hard to get help from them. If they do, it's generally not the best for ADD. Basically, you go in and you want help with, how do I study? And then you walk out with a test accommodation and a prescription. It's like, well this is not what I wanted. I didn't want the bar lowered, I want to reach the bar that the university sets for me and what my classes set for me.

In this instance, her frustrations stemmed not from a lack of available resources, but from how help was being provided for her specific needs. The process of getting accommodations was not accessible either; she described it as a "production" and a "laundry list of things [she] would need to provide." She continued in the second year to also express disappointment in the wait associated with getting a counseling appointment to help her with the stress of university life. Her frustration was reiterated in the third year, and again in the fourth. In a sea of praise for the university, the mental health resources were the single island of criticism.

The other student that discussed the availability of mental health support was Chloe, with an emphasis on the fourth year. When she needed help in the fourth year due to the stress of the pandemic and pressures of senior year, she found the counselling center to be unavailable:

> I've been to the counseling and had the [name of university counseling center]. I've struggled with a lot of anxiety and depression and that resource was lacking. It felt like a band aid that the university just wanted to put on students that were struggling. It didn't fix anything. Not saying that I was just looking for a cure, but it wasn't. That's a general kind of consensus. It's not enough. It's definitely not sufficient. I think that mental help wise, I had to find that kind of stuff.

As noted in section 4.4.1.1 above, a professor came to her aid in the fourth year, providing support when the university could not. Chloe was sympathetic to the counselling center, however, positing that they were doing the best with the resources they had. She argued that the counselling center simply did not have enough resources to begin with. Like Caroline, Chloe loved the university, but the lack of mental health resources was a significant detriment to her experience.

4.4.1.15 Summary of Connections

The participants' engagement with the fourteen identified socializing agents has been summarized in Table 4.2 below. I have also flagged any socializing agents that alienated students or detracted from their belonging.

Table 4.2: Summary of Socializing Agent Interactions

	Prof	TA	DA	PA	PO	RL	CI	CSS	Club	RO	ST	SD	Fam	DF	NDF	MH
Annie	✓	✓	✓		✓	✓	✓	✓			✓	✓		✓		
Anthony	✓	✓	X	✓		✓			✓	✓	✓	✓	✓	✓		
Arun	✓				✓		✓	✓				✓	✓	✓		
Ayame	✓	✓			✓	✓	X					✓	✓		✓	
Caroline	✓	✓			✓	✓			✓	✓						X
Catia	✓				✓	✓				✓					✓	
Chaaya	✓	✓	✓				✓	✓	✓				✓	✓		
Chloe	✓			✓		✓			✓	✓	✓		✓			X

Key:
Prof – Professors | **TA** – Teaching Assistant | **DA** – Discipline-focused Advisor | **PA** – Profession-focused Advisor | **PO** – Professional Organization | **RL** – Research Lab | **CI** – Co-op/Internship | **CSS** – Career Services/Support | **Club** – Clubs | **RO** – Religious Organization | **ST** – Sports Teams | **SD** – Senior Design | **DF** – Disciplinary Friends | **NDF** – Non-disciplinary Friends | **MH** – Mental Health Resources
✓ - Neutral or Positive interaction
X – Notably negative influence on belonging

4.4.2 Drivers for Engaging with Socializing Agents

As laid out above, students engaged with a wide variety socializing agents throughout their academic careers. The question that followed was why students chose said agents and what they hoped to gain from the interactions and relationships. Across the eight participants of the study, five general drivers emerged, as detailed in Table 4.3 below. The Professional Aspirations category broke down into two sub-groups, industry and research, depending on which route the student intended to pursue. Students often displayed multiple drivers, unsurprising given the variety of agents most students interacted with. Different needs were met by different groups. A summary of each participant's drivers can be found in Table 4.4 at the end of this section.

Table 4.3: Drivers for Socialization

Driver Category	**Description**	**Students in Category**
Personal Support	Seeking a social group or emotional support, acclimation to an unfamiliar environment, or personal development	Annie, Anthony, Ayame, Caroline, Catia, Chloe
Academic Support	Seeking connections that will benefit academic performance	Annie, Arun, Chloe
Professional Aspirations - Research	Seeking connections that will benefit research experience or future research opportunities	Caroline, Catia
Professional Aspirations - Industry	Seeking connections that grant industry experience or future work opportunities	Anthony, Arun, Ayame, Chaaya
Finding a Path	Seeking connections that will give the student a sense of direction with their overall collegiate trajectory	Annie, Chaaya, Chloe

4.4.2.1 Personal Support

Most of the students in the study were motivated by the desire to have a personal network to some degree. Even Catia, an Independent, sought connections at each of her universities that helped her become more comfortable in the new environments. The most common socializing agents students sought out in this category were their friends, religious organizations, and clubs.

Students went to these groups as a means of coping with and overcoming the challenges of university life. Some found solace in old friend groups with whom they kept in touch, others made entirely new networks. For Chloe, college was a fresh start, a way to break away from negative relationships she had in high school. Had family members been more commonly mentioned, they would logically fit into this category in most cases as well.

Specific impetuses within this category varied slightly between participants. As noted, once Catia had gotten acclimated at her universities, she left her personal networks behind in favor of professional ones. Others, like Anthony and Caroline, maintained these social networks because they were developing a part of their identities. Some were looking for social activities to fill their time and happened to make friends along the way. Whatever the specific driver, personal communities were by far the most sought after in this study.

4.4.2.2 Academic Support

This category was defined by those students who actively sought out disciplinary peers, TAs, and professors in pursuit of help with their academic progress. Annie was the perfect example of this impetus at work, consistently going to professors after class and in office hours when she had questions. She also worked with her peers in study groups and capitalized on her access to tutoring through her status as a student athlete. Though Arun was not actively involved in some parts of campus life, he too went to his professors for help because he viewed strong academic performance as a step on the path to a good job. Chloe's academics did not go well in her first few semesters, leading her to reach out for assistance to get back on track. She found sufficient help from her professors, calling office hours the "the quickest and easiest way for me to figure something out." This became somewhat problematic in the fourth year when the COVID-19 pandemic forced professors to hold their office hours online, which simply was not

the same for Chloe. Rarely transformative but almost uniformly helpful, academic relationships typically reduced students' stress levels and set them up on a path to success in their studies.

4.4.2.3 Professional Aspirations – Industry and Research

In general, this category of driver was rooted in students making connections that would further their professional goals, whether in research or in industry. Depending on which route students were targeting, the socializing agents that mattered most changed. Those pursuing industrial aspirations like Arun and Chaaya made the most use of the career office, recruitment email lists, and job-searching apps. These agents gave them connections to resources and opportunities within the university and external to it. The initial connections could then become internships and co-ops, which in turn helped to shape, develop, and redirect the students' interests. Ayame is included in the professional aspirations category despite her lack of industry work due to her persistence in searching for an internship during and a good job after graduate school. Though her work on campus was focused on research, she was making use of that experience as a boost for later work opportunities. She found a way to develop her professional skills despite the roadblocks she found when considering internships.

Those students who were seeking professional development on the research side tended to favor relationships with professors, lab groups, and graduate students in their pursuit of experience in their major. Caroline, Catia, and Chloe all were looking for more information about how research was conducted, but also what graduate school would be like and what careers would be available to them following graduation. Research labs exposed students to a lot of different types of socializing agents, but what the individual was looking for determined which ones with whom they were most likely to seek connections.

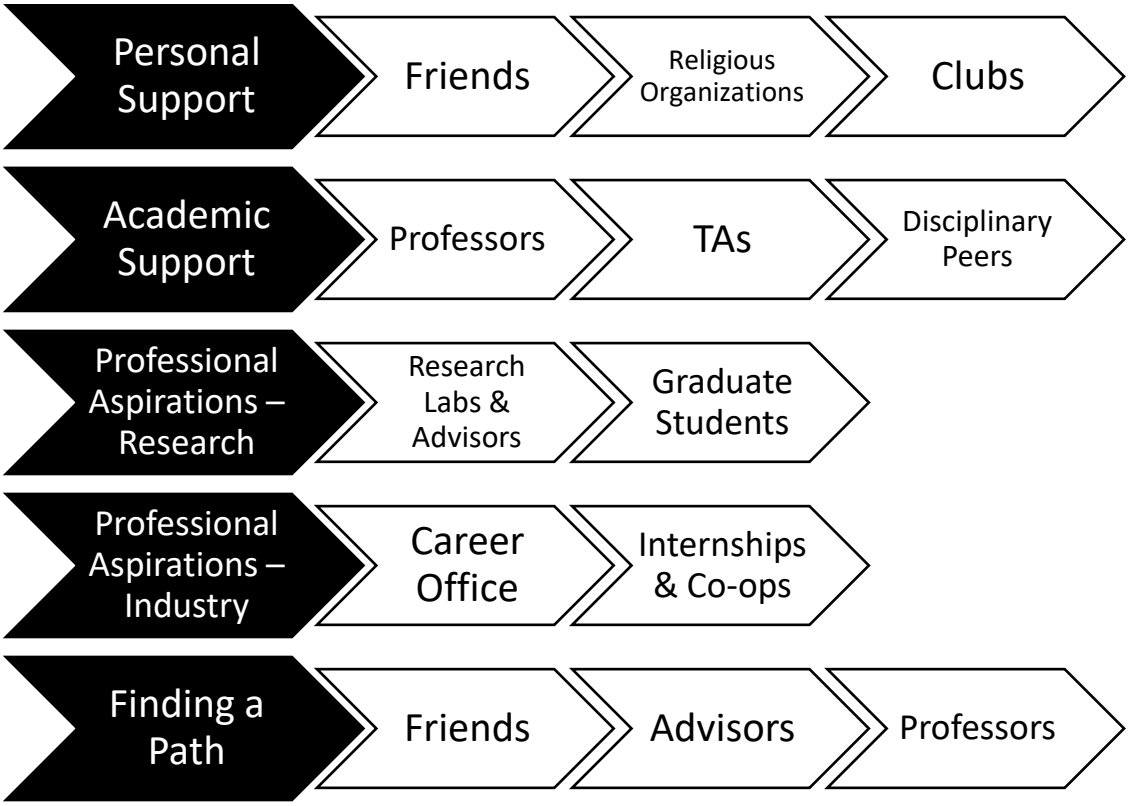
4.4.2.4 Finding A Path

This driver is the least clear cut of those that appeared in the study, primarily because it was so variable between participants. In general, students with this impetus for engagement were uncertain about their post-graduate plans and were looking for help determining what they wanted to do. Some even looked for ideas about what to do during their undergraduate careers. Due to this uncertainty, participants in this group interacted with the broadest range of socializing agents. Annie's redirection came from a chance connection through the swim team. Chaaya's exposure to professionals in chemistry showed her that she did not like her job prospects, while her later internships in ChE further narrowed her selection criteria for post-graduate work. Chloe was convinced that she was going to pursue a medical degree until her senior year when her research lab group convinced her that a PhD might be a better route for her goals. Her trajectory was also affected by her father's insistence that she remain in chemistry, which ultimately led to her lab involvement and her discovering her love of research. Academic advisors were pivotal in guiding all three of these students to explore their options. All the students in this group were looking for direction, reaching out to just about anyone who could help them, and all found their way eventually with the help of a collection of socializing agents.

4.4.2.5 Summary

Five distinct drivers for socialization emerged from my participants' accounts of their undergraduate careers. Each driver led students to seek out and interact with specific socializing agents to fulfill their needs, further their goals, or help them find direction. The five drivers and the most important categories of socializing agent for each driver are summarized below in Figure 4.1.

Figure 4.1: Summary of Drivers and Associated Socializing Agents



4.5 In what ways does a student's socialization experience influence, if at all, their sense of belonging to both their chosen discipline and their university?

Having explored the mechanisms of socialization in the previous sections of the chapter, this section—guided by the overarching research question—sought to investigate the interplay of socialization and belonging. By the end of the analysis process, it became clear that socialization was a crucial part of developing students' SoBs, though it was not the only influence observed. Several environmental, political, and cultural aspects of the university also played parts, but these will be addressed later. For now, the focus will remain on the socializing agents and their impact.

Fundamentally, developing an SoB is about social support, connectedness to one's community, and feeling recognized and valued by others. All of these were dimensions described

by Strayhorn (2018e) and make up the foundational components of belonging. As noted earlier in the dissertation, the interview protocol did not directly target belonging, though students' comments about choosing the same major or university again provide indicators, and subsequently the analysis process relied upon these feelings being present instead, as defined in the codebook. Furthermore, students' descriptions of attachment or commitment to the institution were included in the deduction of their SoB. The socializing interactions the students went through were the foundation of the relationships that provided these feelings and attachments. Whether it was Caroline feeling validated in her research lab by graduate student reassurance or Arun finding the help he needed in his job search, the value of these interactions was clear in every year of data. Even pre-college experiences were noteworthy here, as students who were able to experience the campus were able to gain some semblance of anticipatory belonging despite not being a part of the community themselves just yet. Chloe, who got to visit campus prior to enrolling, felt that the university was where she could see herself being the happiest. Anthony and Annie both visited and got to meet current students, which left a positive impression on both of them. These experiences allowed them to understand whether their personalities and emotional needs aligned with the campus community, as well as whether their academic and professional aspirations would be supported.

The rest of this section will explore various facets of socialization's effects on SoB. First, the influences that emerged from the data that could not be labeled socialization as defined in this study will be identified, separating the influences on disciplinary SoB and university SoB. The development of each type of SoB will be explored and the influence of various socializing agents will be identified. Finally, several common areas of complaint amongst the participants

will be highlighted, noting some of the most frequent negative socializing agents and influences in the study population.

4.5.1 Non-socialization Influences

Though the primary focus of this research question and this dissertation is socialization, I would be remiss to not briefly address some of the other factors that affected the development of students SoB. Different cultural, academic, and environmental factors played into the development of both types of SoB, often in unique ways. As will be addressed later, these factors had a much greater impact on the development of disciplinary SoB than university SoB.

4.5.1.1 University SoB

Separate from students actually engaging with on-campus resources, the mere availability and accessibility of said resources affected participants' perceptions of the campus environment. Many of the participants noted that they were aware of certain support structures like the health center or career counseling, but simply did not make use of them. The context of many of these comments indicated that the students were happy about the availability, however, as it made them feel more like the university cared for needs that they simply did not have at a given moment but could in the future. Anthony noted in the third year that the sheer volume of opportunities provided was one of the greatest benefits of the institution, explaining:

> I think just the services they offer are support enough. I think we have awesome facilities to be able to delve into whatever interests you have. I think that's the best support you can offer, is to open up the door for you to enjoy what a college campus is.

Others like Annie and Chloe alluded vaguely to a plethora of support structures without directly indicating whether they were involved or not. Arun, whose main focus was

employability, made similarly styled comments about the career center, which he seldom used. Its presence was enough for him to feel like the university was looking out for his goals. The participants seemed to feel supported knowing that if they ever needed help, it would be there.

The overall feel of the university population and the university's values were also brought up in several interviews. The former was addressed by several students, particularly when they discussed why they chose to attend the university. The phrase "down-to-earth" was used by two students, while others described the student body as welcoming and kind. Caroline placed value in how safe she felt on campus, and Anthony appreciated how clean the campus was kept. The subjective "feel" of campus had a notable effect on how proud different students were to call the university home. With respect to university policies, Caroline was the most outspoken, highlighting the university motto and its focus on community. In the first year, she explained that these were a big part of why she chose to attend the university, sharing that she "really liked the principles here… Like the pillars, you know, [university motto] and I can't remember them all. I just like that community aspect." A few others made brief mentions of these policies as well.

The final influence of note was the diversity of the university population. This will be addressed again specifically within the disciplinary context as well. Diversity played positive and negative roles for different students, often depending on their background. Annie hailed from a racially diverse region of the US, so the comparative lack on campus was a shock to her. She explained that while there was "not a whole lot of diversity" on campus, it got even worse if you left campus, where there was "no diversity at all." Caroline was satisfied with the gender makeup of campus but noted a distinct lack of diversity with respect to race and sexual orientation in both her classes and the university as a whole. For Anthony, however, coming to campus was a

chance for him to meet people from a wide variety of backgrounds and nationalities, which he valued highly. A similar sentiment was expressed by Arun. Ayame had the unique perspective of valuing the diversity on campus because it meant that there were other students like her with whom she could interact. The presence of other Chinese international students helped her to feel less isolated from the very beginning of her time on campus.

4.5.1.2 Disciplinary SoB

Frequently juxtaposed against the composition of the overall university population, diversity within the major was addressed by half of the participants. Once again, diversity was a positive or negative influence depending on the participant in question, even being both in Annie's case. Annie was not pleased with the lack of women among her professors in ChE but was glad that the gender diversity among students was better in ChE than some of her other engineering courses. Chloe had similar sentiments to Annie, though her frustration with the lack of women faculty was less intense. Annie viewed it as a major letdown, as she wanted a woman role model to look up to in ChE. Chloe felt like it was a minor disappointment. Caroline felt that while the gender diversity in biochemistry was fine, the lack of diversity in race and sexual orientation was reflective of a university that was not particularly diverse as a whole. She lamented that she sometimes felt odd as a woman in a male-dominated STEM field, particularly in the first year, but this improved as she got into biochemistry fully. In the fourth year she expressed a desire to have more open conversations with others about her religion and sexual orientation, which she viewed as important parts of herself that she could not discuss freely. She shared:

> It's average for [this university] that there's not a lot of variety of races of students in our school. Then in terms of gender or LGBTQ+ community, that isn't really present in the

> biochemistry department, people just don't talk about it and don't bring it up. I don't think anybody would be against talking about it or bringing it up, but as someone who has been heavily involved in the theater department where people talk about it all the time…that's just not present in the biochemistry or chemistry department… it doesn't feel like there's any community. In that specific regard, I wish it was better.

Catia had a very different take on diversity than her peers, stemming from her time living in Russia. In the first year, she thought that her first institution was "a really diverse university, like, for me, it really is, because in Russia, we don't have a lot of diversity, like in sense of, I think, nation, or race, or ethnicity." Moving forward from that interview, however, she became less concerned with the topic. She considered the diversity to be "good enough for [her]," but when asked to describe it further in the second-year interview, she dismissed the question, simply stating that as long as everyone had equal opportunities to apply, it did not matter who got into the biochemistry department. In later interviews she similarly dismissed the topic, saying that it did not really matter to her and that she did not pay much attention to it.

The other non-socialization factor that contributed to the evolution of participants' disciplinary SoB was a sense of how well the curriculum suited their goals. The alignment of curriculum and goals had two primary facets: the individual student's enjoyment of the material and the degree to which students were in control of their own specialization. Arun had the worst experience with both of these dimensions, beginning with the FYE curriculum. He hated that he had to do general engineering work before getting into ChE, wishing he could do so directly. At the end of his first year, he went so far as to say:

> If there was a university at [this state] that I felt was like, what provided, had the same like, find the like, as the tuition being similar and like provide the same opportunities in

> terms of whatever major I wanted to at like [this university], but it didn't have the general engineering, I'd definitely like pick that university.

As he continued in the major, he found that at all levels the material was too theoretical, and the work too far separated from its industry equivalent. On the complete opposite end of the spectrum, Caroline became more connected to biochemistry the more she learned about it, a pattern that could be seen in several participants. Her research lab provided her the opportunity to specialize as well, delving into her research aspirations early. Chloe split the middle, enjoying the content more as she learned about it, but finding trouble in her senior year with the curricular requirements:

> There’s definitely things that I wish that your senior year could be a little bit more specialized, especially second semester senior year. I feel like by the time that you get there, you have an idea of what you want to do. I wish that I could’ve taken more organic chemistry classes. I wish that it was more in my schedule to be able to start focusing and getting deeper into what I’m interested in.

Specialization frustrations tended to be fairly minor in comparison to the positive impact that connection to the material had. Despite wishing she could have taken more organic chemistry, Chloe was still appreciative of the chance to learn about other domains of chemistry even if they were less interesting and less useful for her future career. Anthony had similar feelings, appreciating the grounding that ChE had given him but recognizing that much of it would not be useful in medical school. Altogether, the more a student enjoyed the curriculum they were studying, the more likely they were to speak fondly of their overall experience, even if there were patches of difficulty or other detractors along the way. It was crucial to the

participants SoB within their discipline that they felt a connection to the material that they were learning.

4.5.2 Developing University SoB vs. Disciplinary SoB via Socialization

Distinct but interwoven, participants' development of belonging at their university and in their discipline could often be tied back to separate groups of socializing agents. University SoB was more commonly developed through interactions with extracurricular interactions, friend groups, and the resources the university provided. Disciplinary SoB by comparison was affected by professors, disciplinary peers, research labs, and work experiences. There was overlap, most commonly in the influence of disciplinary friend groups who often played dual roles as academic and social support. Chloe's sorority, for example, was a STEM sorority that provided the core of her personal development while also contributing to her sense of place within biochemistry.

4.5.2.1 University SoB

Belonging at the university level began for most students with their knowledge of the environment in which they were about to immerse themselves. As noted previously, not all participants were able to visit the campus, instead relying on online resources or the advice of others to build their image of their chosen institution. From there, students branched out in finding their communities and their place at the university. By the end of the first year, every student had found some kind of community, but this did not mean that all participants' SoB were equivalent. Catia expressed hesitation, admitting that while the resources she was being provided with were fine, had she known more about the offerings in the US, she may not have chosen the same institution. This further developed in the second year when she admitted that she probably would have chosen a different institution to get in-state tuition. Anthony, by contrast, had no hesitation at the end of his first-year interview, outright stating that "I definitely feel like I made

the right choice" when it came to his university. Catia's involvement on campus had gotten her acclimated, but Anthony's made him feel at home.

Over the remaining years of the study, the three trends of socialization resulted in very different trajectories of belonging. The Anchored participants saw steady growth in their belonging as a result of their prolonged engagement with consistent communities. Despite the growth, their opinions of the university were not unblemished; all of the Anchored students had one or more issues with their time at the university that diminished their experience. The value of their anchoring communities, however, was not to make their time on campus flawless, but to provide them the means to overcome the things they did not like. None explained this better than Chloe in the fourth year:

> I definitely, like in some of the tougher moments, especially when I was getting denied from in state [tuition], I was having moments where I was like, did I choose right? Am I just wasting my money being here? It's really hard and I can get just the same education somewhere else. It's always been fleeting thoughts, especially because of the people… My sorority, I talk about it probably too much, but those women are my inspiration…We were all just equalized in this group. Yeah, we're stressed; let's hang out. Yeah. I wouldn't have found that at another school. I know that for a fact.

Catia and Arun, the Independents, did not find such strong bonds to their chosen university. As late as the third year, Arun admitted that he "might've done the option where it's like you take your first two years in community college, and then transferring my credits." He followed up saying that he likely would end up at the same institution regardless, but this admission seemed to indicate that the primary value he saw in his university education was the academic preparation, which he could have gotten elsewhere. He liked his chosen institution well

enough, but there was no distinct connection like the one that Chloe described. Catia's endpoint was different, though she was also not strongly connected to her university. Catia found a home in her major—this will be discussed later—and the university's resources were simply enough to support that passion. Seemingly less of an affinity, and more of a lack of alienation. Reflecting on her initial university choice, she explained that, "for transfer, yeah. I would still choose [the same university]. If I was applying from the beginning, I would probably try to apply to [another public research university in the same state] first. Even though I love [this university]." The next question confirmed that this choice would have been motivated by the other institutions stronger ranking in biochemistry, underlining her stronger allegiance to her discipline. Both were more concerned with whether the university provided the necessary resources to achieve their desired professional outcomes than finding close personal networks.

Finally, the Wanderers—Ayame and Chaaya—found a middle ground: enough support to enjoy their time at university, but not enough to be transformative. Ayame was happy enough with her time surrounded by other Chinese international students. The resources were good, though she never did like the food. She felt the university was a "good fit." Chaaya found that some aspects of university life suited her, but she always wondered whether she could have aimed higher:

> But see, I really, really like the people. But I just know having someone else pay for it, I feel like I could've got into a better school or something, something with more prestige. But I really did like meeting all the people and they're really nice in my major. All the professors were nice and stuff. So it's like a 50/50.

In earlier interviews, Chaaya similarly mused whether she could have applied to a more highly ranked university and whether that would have suited her. The Anchored found deepening

connections to their on-campus communities and subsequently the university as a whole. The Independents instead found tunnels towards their objectives, making use of whatever resources would benefit them along the way and judging their institution by its ability to get them to their goal. The Wanderers found what support they needed most, but never connected as deeply to the university as they may have wished.

4.5.2.2 Disciplinary SoB

Disciplinary belonging did not align so neatly with the trajectories of socialization noted previously. To some degree, every student found social connections within their major, even the Independents. Arun and Catia both talked about friends in the major, Catia in her lab and Arun more generally. Views of professors varied slightly but were overall positive. Some students found valuable connections with their advisors, others did not, but none spoke negatively—apart from Anthony due to their lack of understanding of his aspirations. Across what appeared to be universally positive socialization journeys within the discipline for all eight participants, a wildly disparate set of trajectories for belonging emerged. The separation between the uniformity of socialization and the variety of SoB stemmed from the increased role of the curriculum, content, and personal objectives students discussed. Anthony was a prime example. While he had no struggles finding connections with his professors and peers in ChE, he never felt like he belonged. The closer he got to medical school, the further he intentionally distanced himself from the major. In the third year, he addressed the issue of community in his major, stating that "I think there is a lot of community, it's not so much a community that I want to be involved with. I have my group of three or four chemical engineers that talk with in class and hang out with a little bit out of class." By the fourth year he no longer so much as viewed ChE as a suitable backup plan if medicine did not work out, saying it would make him "miserable."

Despite having all of the resources to establish a strong SoB in his major, Anthony chose not to due to its misalignment with his goals. This frustration was not enough to entirely alienate him from the major, as he still would have chosen it again as a possible route into medical school. He enjoyed the material and despite some hiccups along the way, maintained a grudging respect for the discipline even as he left it behind.

Several students found that they had qualms about choosing their major by the time they were preparing to graduate. Arun felt that the curriculum in ChE was too theoretical for his taste, without the broad industry applications for which he had hoped. He wished that he could have taken CS in the third year, adding considerations for civil and industrial engineering in the fourth. Though he had friends in the major, it simply could not support his goals and he felt let down by it. Chaaya's SoB in chemistry went a similar way, though much more quickly. As soon as she had established that the jobs she could get with a bachelor's degree in chemistry were not suited for her, she left. Even once transferred to ChE, she had some regrets, saying in the fourth year that industrial engineering would have suited her business interests better. She was fond enough of the content to want to maintain a minor in chemistry even if she had gone an alternative route. Annie did not feel regret about her choice of major, though she was among the group of participants who ended up favoring a different discipline in the end. Turning towards nuclear engineering following her fourth year, Annie wanted to maintain a ChE focus as she went due to a love of the material. Had nuclear engineering been an option for undergraduate study—which it was not at the time of her enrollment—she was uncertain whether she would have pursued it, as she would have "missed chemistry if I were just doing nuclear." As can be seen even in this sample of participants, passion for the content of the major was an important determining factor in their disciplinary SoB.

The remaining participants all ended up with upwards trajectories of belonging, though not all were equal. Ayame's was the weakest of the remaining group, finding that ChE was interesting to her and that she wanted to pursue it further. As she learned more about the major, she liked it more, a consistent theme across Ayame, Caroline, Catia, and Chloe. As they delved further into their respective majors, they fell deeper in love with the content. Through research, Caroline and Catia found their passions and were given the opportunity to pursue them. For Catia, later years brought classes that were more applicable to her research interests, which she loved. Caroline's lab group showed her again and again that she was among the people that she aspired to be. She "couldn't imagine doing anything else." Chloe similarly found a deep appreciation for her discipline, though the final year was frustrating to her due to the lack of flexibility in the classes she could take. Despite already knowing the areas of chemistry she was most interested in she was forced to take classes focusing on other specializations. Her love of chemistry remained, nonetheless. In the fourth year, she described the transformative influence the major had on her:

> I really feel like chemistry, and this has probably one of the nerdiest sentences I might speak, but it's really shaped who I am. I think that my freshman year, I didn't think I could do it. I almost failed out of my chemistry class. It was so challenging. Every single year I've come in contact with a new chemistry that has challenged me and has been hard, and then every year I get though it, and every year I can do it. I think that something it's taught me is resilience. Things are hard, but you just have to work. It's not going to just show up at your door one day and be like, oh, you did it. Chemistry.

Similar sentiments were shared by Caroline and Catia, albeit less passionately phrased. The intersection of social support, enjoyment of content and curriculum, and alignment of the

major with professional and personal goals seemed to be the sweet spot for these three to develop a strong disciplinary SoB.

4.5.3 Common Areas of Complaint

Occasionally during analysis, a socializing agent or environmental factor would emerge as a consistent negative influence, damaging students' experiences and hurting their opinion of their major or institution. The focus for this section will be those agents that were uniformly or near-uniformly negatively viewed, as opposed to others with whom one or two participants had a bad experience. While several of these topics have been covered earlier in this chapter, I felt it necessary to reexamine them with a particular focus on how they affected participants' SoB.

As noted in section 4.3.5, the first-year curriculum was problematic for a number of participants. Arun found that it held him back from exploring his major, though he did not mind the work itself all that much. He expressed a strong preference for engineering programs that did not have a general first-year course sequence. Annie felt that the amount of ChE content was lacking in her FYE courses, which instead favored other engineering topics like programming and construction. Catia was bored in her first-year classes, feeling as if she was retaking courses for which she should have already received credit. Between these three, a somewhat paradoxical outcome emerged: their distaste for the first-year curriculum indicated a stronger sense of belonging to their eventual major than other participants. They displayed a desire to pursue their major-specific content early. For Arun, this desire negatively affected his university SoB, pushing him to prefer a comparable university without a general engineering program. The other two were not so affected, though Annie argued for improvement to the FYE curriculum and Catia expressed a desire for more transferrable testing standards globally. Among the other five

participants, the first-year courses were only mentioned in passing, leaving it as a neutral part of their studies, something they had to get done.

Only noted by two students but an important negative all the same, campus mental health resources were problematic for those who needed them. Whether they were inaccessible, as in Caroline's case, or insufficient, as they were for Chloe, the challenges in obtaining help when it was required put a damper on the overall university experience. Particularly set against the backdrop of strong support and abundant resources for other needs, this was a particularly disappointing discovery for both participants. For both Caroline and Chloe, this was the biggest blemish on an otherwise excellent view of their university, ensuring that their strong university SoB came with a caveat.

Finally, more neutral than negative, professional societies held almost no bearing on any participant's disciplinary SoB. Most students did not even join them by choice, apart from Annie joining the ANS in her fourth year. ChE students and biochemistry students alike were automatically enrolled, but none—save for Annie—made any particular use of the groups. With the resources the departments must have invested to ensure that their students could obtain membership, it seemed like a waste. The question that remained on this front was whether it was an issue with the societies themselves, or a sign of strong support from other sources. Arun explained his lack of participation for this very reason, questioning what AIChE could give him that the university was not already. Students seemed to value the organizations more highly in an anticipatory fashion, with most expressing a desire to join once they had the time or opportunity to do so. Despite the initially perceived value of professional membership, those very same students often had minimal participation in the organizations once they had become members.

4.6 Additional Findings

The final notes that I wanted to include here are findings that did not fit well under any of the research questions or sub-questions. The primary focus of this dissertation was on the mechanism of socialization and its effect on the development of SoB. However, during analysis, a pattern emerged when looking exclusively at the interaction of disciplinary and university SoBs. With particularly strong feelings of belonging to one domain of the university, students could often succeed in other areas despite weaker or even nonexistent belonging to them. Additionally, while the primary focus of the work was not a comparative look at differences in socialization and SoB development between science and engineering, I believe it still warrants brief discussion all the same. My findings did not reveal any significant differences, but a clear trend emerged around how students' professional aspirations and the future they associated with their chosen major influenced their choice of socializing interactions.

4.6.1 One SoB Without the Other

Examining the university and disciplinary dimensions of SoB separately was an intentional decision that stemmed from a discovery made during the initial pilot analysis process. Anthony, the first participant examined, did not have a strong SoB to his discipline due to his eventual goal of practicing medicine, but he did feel connected to the university. This variance did not diminish his overall university experience, as his personal communities on campus were more than enough to sustain some frustration with his major. As analysis continued, a few other participants displayed similar patterns, having a stronger SoB to either their discipline or their university. Arun displayed a moderate level of belonging to his university due to the resources it provided him in terms of employment. He also had all but turned away from ChE by the time he was finished due to curricular complaints and disappointing job prospects. Nonetheless he valued

his time at the university because it had set him up to pursue his professional career all the same. Catia was the opposite, feeling strongly connected to biochemistry—though not its community per se—due to her love of research. Her SoB at the university was never particularly strong due to her Independent nature, but she was never upset about it.

The pattern that emerged from these participants was an indication that as long as a student found the communities and opportunities they were looking for, they did not have to belong to all domains of the university they engaged in. It was clear that the participants could have a meaningful and impactful college experience without belonging in every space they entered. As long as they came to belong in the spaces that mattered most to them, it was enough to support lacking SoB elsewhere.

4.6.2 Disciplinary Differences

The prevailing difference between the ChE students and those in chemistry and biochemistry came from their post-graduation aspirations more than their actual on-campus and curricular variations. Overall, ChE students viewed their major as preparing them more for industry than research, though Annie, Anthony, and Ayame all participated in research at various points of their undergraduate careers. Only Annie showed any interest in pursuing research as a career following her graduate school studies. The science students, by comparison, viewed their trajectories as naturally leading more towards research; Chaaya made her disciplinary transition explicitly because she could not see herself working in a lab, the future she saw in chemistry. As a result, each group sought out the socializing agents that were best suited to furthering their own professional interests. ChE students tended to make use of career services and job listings more often, where the chemistry and biochemistry students found more value in their research labs. Despite three of the ChE students being involved in research, their connection to the lab

environments were comparatively weak. Given that research was not their end goal, they did not see as much value in the work they did. Conversely, many of the science students were aware of career-related offerings, but none made any significant use of them. Advisors typically provided all of the advice they needed with respect to graduate school and future research work.

Beyond the separation of professional motivations, experiences between the two groups were surprisingly similar. The majors share many of the same foundational classes, contact time in lab-based classes was comparable between all three disciplines, and there was some room for individual specialization in the curricula. Detail about the impacts of specific classes was also somewhat limited due to the structure of the interview protocol, so this finding may simply be inconclusive. There were multiple pairings within the dataset where a science student and an engineering student shared remarkably similar paths, even with such a small sample to begin with. Anthony and Caroline found personal support in religious organizations and friend groups while pursuing professional aspirations through their respective persistent engagements. Arun and Catia, though geared for entirely different end goals, found the specific resources they needed and pushed through otherwise disconnected time on campus. There were slight differences in how each group approached their college experience, but this study has not discovered any glaring separations.

4.7 Summary

This chapter presented the findings of my analysis of eight distinct students' accounts of their undergraduate socialization and belonging. Each trajectory was briefly outlined, highlighting key socialization experiences and the development of disciplinary and university SoB for each participant in the study. Across these accounts, three general trajectories emerged. The Anchored—accounting for four of the eight students—found early connections to one or

more communities that grew over time, bolstering them against negative socialization in later years and providing them a solid sense of place on campus or in their discipline. The Independents and Wanderers, each containing two students, were not so well connected to their institution or discipline but for divergent reasons. The Independents simply did not want to be overly connected, finding purpose in their post-graduation goals and establishing the links they needed to pursue them. The Wanderers, on the other hand, wanted more than they found, being limited in their potential for a variety of reasons. Across all three trajectories however, it was abundantly clear that the experiences a student had prior to arriving to their institution laid the foundation for where their feelings of belonging started, whether in the discipline or the university. Visits to campus allowed students to more quickly adapt to their new environment, and experiences in their respective disciplines often set those students ahead in terms of knowing what exactly they wanted to get out of their major. The first-year curriculum also appeared periodically in responses as a stumbling block for disciplinary belonging.

Filling out the ranks of the socializing agents the participants interacted with were fourteen distinct groups ranging from advisors to family members. Professors were the only agent cited by all eight students, though most were not overly impactful. On-campus organizations frequently had major influence on students' belonging, particularly among the Anchored. No one group stood out as being overly impactful across the board; rather, the combination of agents an individual student connected was unique and produced wildly varying disciplinary and university SoBs. While some socializers were just a part of academic life, like professors and teaching assistants, other were specifically sought out by the participants. Their reasons for doing so were also captured in the analysis, including personal and academic support, advancing professional goals, and finding a path forward through the plethora of options laid out

before them. Socialization experiences shaped university and disciplinary belonging in distinct ways, as they drew upon separate but sometimes overlapping groups of socializing agents.

Building upon the individual interactions and networks the participants formed, it became clear that while socialization was a key part of developing a SoB, it was not the only influence. University policies, physical environments, and diversity within and external to the major all played a role in making students feel like they had a place in the community. Gender diversity among faculty was particularly salient for several of the women in my study as the lack of women professors left the students without the role models they were hoping for. Pre-college experiences once again influenced how the diversity—or lack thereof—of the broader university population's diversity was received. Those from more diverse regions received the predominantly White campus negatively, where those without much exposure to diversity cherished the opportunity to meet people from different backgrounds. Additional areas of complaint amongst the population included the first-year curriculum as previously noted, and the lack of readily available mental health support.

Finally, there were a few findings outside of the bounds of the research questions used in this study. First, for several students it became apparent that a strong disciplinary SoB could compensate for a weaker university SoB and vice versa. This compensatory effect has significant ramifications for student support practice, which will be discussed more in the next chapter. Additionally, there were not significant differences between the experiences of ChE, chemistry, and biochemistry students. Most differences that were present stemmed from where the students believed the major would take them following graduation. The ChE students tended to favor industry work and as a result spent more time with career development resources, whereas the chemistry and biochemistry students focused their attention on research experience wherever

they could. With all of these findings in mind, I will be discussing the significance of them and the implications they hold for the broader engineering education community in the next chapter.

Chapter 5 - Discussions, Implications, and Concluding Remarks

5.1 Introduction

The work I did for this dissertation produced four key findings around the mechanisms of socialization and socialization's impact on the development of students' SoB. The predominant outcome of this study was the development of three distinct longitudinal trajectories that categorized students' socialization experiences through their undergraduate careers. Through the process of developing these trajectories, it became clear that early career socialization was the most important for setting students up for later success. I found that disparate pre-college exposure to the discipline and university left students on uneven starting ground when it came to the development of feelings of belonging. The final finding identified that students could use one particularly strong SoB to compensate for and even mitigate the consequences of weaker belonging in other domains of their lives. Following an exploration of these four findings, I will cover how this work addressed some of the existing gaps in educational literature. I will also address the implications of this work for the Engineering Education community and for future research. Finally, there will be a summary of this chapter and my concluding remarks on the process of completing the dissertation and its contributions.

5.2 The Beginnings of a Collection of Socialization Trajectories

Each socialization trajectory captures and describes the evolution of socialization experiences from arrival on campus to graduation and how said experiences contribute to students' SoB on campus. This kind of model suits the original framework of socialization well,

as Weidman (1989) originally described life at a university as a time of change and maturation that could influence students' receptivity to socializing influences. Despite the small amount of longitudinal research that exists on socialization, trajectories have been previously been used as way to understand the evolution of participants' interactions in business school graduates (Ashforth & Saks, 1996) and K-12 classroom behavioral management (Hughes, 2022; Wortham, 2005). These trajectories were shorter in scope, spanning anywhere from a single day to one academic year, and were generally focused on a single narrower contained context like a classroom. Nonetheless, these studies supported the longitudinal nature of socialization and the importance of drawing connections across a full set of experiences.

The trajectories identified in this work began to reveal how the individuals, groups, and organizations that students chose to engage with informed their place on the university campus. The Anchored found one or more groups that provided them a feeling of personal, professional, or spiritual safety. Their anchoring communities allowed them to branch out and weather negative experiences more comfortably as they always had a home community to return to. Their early and persistent involvement gave them a strong foundation from which their feelings of belonging could further develop. The Independents felt no such need for putting down roots with people or organizations, instead choosing to entrench themselves in their work and their personal and professional goals. The primary impetus for their involvement was moving towards an objective which generally remained consistent across their careers. While the specific goals were not consistent, socialization patterns were: Independents sought out only the interactions that would provide them some value in acclimating to their environment and achieving their objectives. As such, their SoB derived primarily from whether their discipline and university environments were beneficial to their progress. Finally, the Wanderers found temporary

connections with others, only to have them end for one reason or another before moving on to another individual or group. Their SoB tended to be a product of their combined experiences as they tried building a broad but shallow base of connections that met their needs. As a result of the nature of their networks, their feelings of belonging were often less developed and more fragile but present all the same.

Despite the differing patterns of socialization across the trajectories, it is worth observing that seven of the eight participants persisted to the completion of their degree. Chaaya did not graduate in the time span covered by the data due to her co-op work rotations but expressed a strong desire of wanting to finish what she had started. The record of degree completion—or intended completion—indicates that all three identified trajectories have the potential to sufficiently support students' SoB, which in turn is a key factor in their persistence (Maestas et al., 2007; Strayhorn, 2018e). Though the three trajectories observed in this dissertation are far from a comprehensive list—future possibilities for development are discussed later on in the chapter—they are the beginnings of a tool that could help advisors and faculty identify what an individual student needs to succeed and connect them with the socializing agents most pertinent to them (Strayhorn, 2018c).

5.3 The Importance of Early Career Socialization

My dissertation work has reinforced existing literature on the value of early engagement once a student arrived on campus. Regardless of which trajectory students followed, the first two to three semesters of their undergraduate careers were often the most impactful. The first strong connections students made shaped the way a participant engaged for the rest of their undergraduate studies, even among the Independents and Wanderers. This aligns with one of the core tenets of Strayhorn's (2018e) framing of SoB: context and timing can give heightened

importance to the development of belonging. The finding also supports the research focus that has been placed on the socialization of newcomers to an organization, both academic (Chen & Yao, 2015; Iverson et al., 1984) and professional (Ashforth & Saks, 1996; Korte, 2009; Kowtha, 2008). As students arrive to an unfamiliar context wherein others have already established themselves, they are forced to renegotiate their identities and roles in the new environment (Freeman et al., 2007). This renegotiation can be difficult for some students and comfortable for others, often bringing about changes in the beliefs and values students arrived at college with. Such change was demonstrated most clearly by Caroline who had not been religious prior to starting her first year but found support from a religious group on campus and identified her faith as one of the primary facets of herself by the fourth year.

Alongside the evolution of personal values and beliefs, my work has also reflected the importance of early socialization for its role in students' defining of their life goals. Poor quality or conflicting direction provided by instructors and advisors have been linked to higher risks of attrition, particularly when students were in the early stages of their careers trying to make a decision about their major (Meyer & Marx, 2014). Timelines for major selection require students to narrow their focus and make choices at the end of the first year that can shape their careers well past graduation (Hill et al., 2016). As such, it is crucial to provide adequate socialization into the discipline(s) of interest to facilitate the decision-making process. The value of such introductions can be seen in Chaaya's trajectory, as her exposure to professional chemists in a first-year seminar course convinced her that her goals did not align with what a chemistry degree alone could provide. This reconciliation of one's objectives with the potential of a given discipline has been documented previously in the work of Vulperhorst et al. (2020) as an important factor in students' choice of major.

My findings, in tandem with existing research about early career socialization, place particular concern on the common thread of frustration with first-year curricula across ChE and chemistry alike. If there was misalignment between what students had hoped to be doing in their first year of university and what they were actually doing, they tended to voice their frustrations clearly. Interestingly, however, these frustrations did not seem to negatively affect the participants' belonging in their discipline; rather, dissatisfaction with the first-year curriculum seemed to make students more excited about getting fully into the discipline in following years. The three participants that expressed their issues with the first year seemed to separate the first year from the rest of the major's content. Arun's distaste for the lack of industry focus and the abstractness of the curriculum align with previous research that identified a lack of "engineering-related experiences" in FYE courses as a cause for attrition (Bucks et al., 2015). More generally, the first-year curriculum and experience have been identified as an important factor in students' persistence in previous research (Yorke & Thomas, 2003), a finding reinforced by my work. Given the importance of first-year socialization in helping incoming students find a place in their new university setting, first-year curricula must be a focus of additional inquiry in the future to better understand how the varied needs of new students can be addressed.

5.4 Pre-College Socialization Inequality and the Beginnings of Belonging

There is a substantial body of existing literature that addresses students' pre-college experiences with STEM ranging from their introduction to STEM concepts in their K-12 education (e.g., Hammack et al., 2015; Phelps et al., 2018; Wang et al., 2018) to family influence on major decision (e.g., Schreuders & Mannon, 2007; Shaaban, 2016) and academic preparedness (e.g., Cançado et al., 2018; Gleason et al., 2010; Tomasko et al., 2016). My work contributes to this literature but more closely aligns with the work of Strayhorn (2018a) and

Barth et al. (2021) in examining the role of these pre-college socializing events in developing a student's baseline belonging on campus. Just as I chose to separate university and disciplinary belonging, so too will the pre-college experiences be addressed in turn.

5.4.1 Developing University Belonging

The more information a student has about a university, the more accurately they are generally able to predict how they will experience it when they arrive. Subsequently, their improved understanding means that their anticipatory socialization is less likely to misguide them and provide expectations that are ultimately not met. This concept of normative congruence—the notion that students will seek out environments that align with their own expectations, beliefs, and values—is a key factor in the decision making process for prospective students (Strayhorn, 2018e). The necessary knowledge to begin the anticipatory stages of socialization process can be gleaned in numerous ways ranging from online resources to on-campus visits; however, these methods of introduction to the campus environment are not equivalent to one another. On-campus experiences immerse the student directly into the campus environment allowing them to feel out how they relate to their surroundings (Swanson et al., 2021).

The significance of being on campus is illustrated in the enrollment rationale provided by several students in my dissertation, as outlined in Chapter 4. Those who had been on campus prior to enrolling—Annie, Anthony, Caroline, Chaaya, and Chloe—made their decision based on the subjective "feel" of the campus and community in addition to the statistics and information provided online and through written materials. The participants who had not visited campus—Arun, Ayame, and Catia—relied solely on the written and digital materials. As a result, the five who had set foot on campus as prospective students were more confident that they would have a

place in the campus community when they arrived for their first years. Their university belonging was higher in the first year at least partially as a result of this exposure. The prior introduction to the environment and community they chose to situate themselves in allowed them to find their own niche and establish connections more quickly. Though not a strict prerequisite for any of the trajectories, it is worth noting that four of the five students who visited campus were able to establish communities early and fit into the Anchored group, with Chaaya being the outlier as a Wanderer. The others either did not have the means to visit—as in the case of Ayame and Catia who would have had to travel internationally to do so—or did not view it as necessary. Arun had two criteria that were both met by what he could read online: in-state tuition and a well-ranked engineering program. Despite what would have been a short trip compared to most of the others in the study, he simply did not see the value in visiting.

My findings contribute to existing models of socialization by underlining the importance of perceived fit not only to an institutions' policies and values, but to its community and culture as well (Conrad et al., 2006; Weidman et al., 2014). College visits have been the subject of studies analyzing their impact on postsecondary enrollment rates (M. C. Smith et al., 2022) and collegiate aspirations, knowledge, and participation in college-level courses in secondary schooling (Swanson et al., 2021). This dissertation builds upon these findings by examining the value of the visit in establishing normative congruence in prospective students and identifies a link between visiting and the speed with which students are able to integrate into their new communities.

5.4.2 Developing Disciplinary Belonging

My dissertation aligns with much of the existing work on why and how students choose to pursue science and engineering. All eight participants identified an interest or strength in

science and mathematics as a key factor in their choice of major, a common theme in existing literature (e.g., Madara & Namango, 2016; Matusovich et al., 2009; Passow, 2008). Arun viewed ChE to be a safe choice for employability (Shaaban, 2016), while Anthony and Chloe saw their majors as suitable routes into medical school. The engineering-to-medicine pipeline has occasionally emerged in previous work on students' future aspirations (Kirn & Benson, 2018) and has become a more recent topic of interest in the medical field as well (Rambukwella et al., 2021). For all of these participants, their introduction to mathematics and science had come in their schooling, but several found other ways of experiencing STEM as well.

Beyond the standard exposure in high school classroom environments, those with additional experiences still aligned with existing research on persistence in a chosen major. Those who were most exposed to professionals and work experiences in their chosen discipline—Anthony and Catia—were among the most resolute in their commitment to their respective majors. The work of Pierrakos et al. (2009) underlined the importance of knowing engineers and meaningful experiences with engineering work. Extrapolated to STEM in general, Anthony had both and Catia had significant experiences in research prior to enrollment in a university. This knowledge of or exposure to professionals in the discipline may have been the missing piece in Chaaya's pre-college socialization that led her to changing majors once she eventually learned where a bachelor's degree in chemistry would place her following graduation. As part of recruitment efforts, there have been numerous attempts at introducing and integrating engineering into high school curricula (e.g., Goonatilake & Bachnak, 2012; Kittur et al., 2017; Phelps et al., 2018; Ryder et al., 2012). My study extends the value of these programs to include the development of students' ability to align the content and prospects of a given discipline to their own personal objectives and interests. Establishing or identifying gaps in this alignment

could be powerful tools in supporting students' SoB in their chosen major, which in turn improves their performance and likelihood of persisting (Strayhorn, 2018c, 2018e).

5.5 One SoB Without the Other

Previous research on belonging has shown that it is a multi-dimensional phenomenon where an individual's multiple identities can come into conflict with one another to produce complex feelings of simultaneous belonging and ostracization in the same university context. (Strayhorn, 2018e). Somewhat similarly to my dissertation work's separation into university and disciplinary belonging, Smith et al. (2012) divided belonging in higher education into four distinct categories: belonging to class, belonging to major, belonging to the university as an institution, and belonging to the university as a community. These four were then quantitatively assessed at the end of each of four years of study at a variety of types of universities and changes were analyzed. What my dissertation contributes to this development is an understanding of how different facets of belonging interact with one another.

Strayhorn's (2018e) model stresses that belonging is a fundamental need of all students. What became evident during the analysis of my data was that students did not need to belong strongly in every context they inhabited in order to feel satisfied with their overall undergraduate experience. Anthony, for example, felt that he belonged strongly to the university but purposely distanced himself from ChE. Despite this intentional separation, he persisted through his degree path and maintained that ChE was a suitable path towards his career goals that he would have chosen again. For most students, having a strong SoB to either the university or their chosen discipline compensated for a weaker SoB to the other. The caveat of this outcome in this dissertation is that for the most part the participants had positive associations to both their university and discipline, meaning that additional research will be necessary to determine just

how much one SoB can compensate for. The exception in my study population was Arun. By the end of his fourth year, he was entirely dissatisfied with ChE and what it had given him, apart from the potential to pursue a job. However, due to his primary goal for his university experience being postgraduate employment, even the professional development was enough—coupled with the on-campus career resources—to sustain him to graduation.

I posit that at this stage, my understanding of how one strong SoB can compensate for others is incomplete. Due to the nature of the interview protocols, there was little information provided about other facets of the participants' identities and how they were reflected in feelings of belonging. Caroline briefly bemoaned the lack of openness about religion and sexual orientation among those in her major, but it did not seem to significantly detract from her love for biochemistry. Ayame's status as an international student surfaced as a roadblock for her aspirations in industry via internships but was not explored much beyond that. In short, additional depth and targeted probing via intentional protocol design would be required to unearth the intricacies of the participants' intersecting identities and how they factored into their overall SoB. Nonetheless, as an actionable finding, I believe the supportive role of strong belonging in a singular domain is significant. For educators and administrators alike, it simplifies the initial stages of supporting students by dividing the task into smaller sections. If students can be made to feel that they belong in a single context on campus, whether to their major, to the university community, or even a narrower setting like a club or class, it may be enough to sustain their engagement for longer term changes and interventions to take effect. Ultimately, the objective remains for students to feel like they belong in every domain of their university life, and it remains the responsibility of faculty and administrators in all domains of university life to work towards this objective in ways appropriate to their role on campus. However, on the way to

that goal, building belonging in one space at a time could be a helpful approach. It is not a silver-bullet solution by any means, but it does make the challenge of supporting students' SoB more approachable.

5.6 Contributions to Identified Research Gaps

My dissertation was designed to address four gaps that exist in current research on socialization and SoB. Research Gap 1 is the lack of longitudinal studies that make use of either theoretical framework detailed in this study. Research Gap 2 addresses the limited use of a holistic view of socialization to understand the interactions of various reference groups. Research Gap 3 addresses the lack of understanding on how specific attributes and experiences that produce desirable outcomes in terms of belonging for students, and Gap 4 is the lack of understanding of how institutional attributes contribute to student belonging.

This work contributes to Research Gap 1 by providing a longitudinal examination of socialization's evolution and its effect on belonging over the course of four years of undergraduate study. The trajectories resulting from the analysis provide a first step in mapping how students interact with various reference groups throughout their college careers which can aid both the students and those supporting them in identifying key relationships that might be missing. The existence of the Anchored, Independents, and Wanderers depicts a diverse set of paths that students can follow and still succeed in their completion of a degree program. Building upon this, the journeys of belonging unearthed in this study are robust and detailed—though solely focused on the university and disciplinary aspects of belonging—and trace the specific memberships and relationships that are most pivotal in supporting or decreasing students' belonging.

For Research Gap 2, I have identified fourteen unique socializing agent groups with whom the participants in my study engaged, as well as how they interacted with one another. The categories and the subsequent examination of their interaction provide a broader view of the socialization process, rather than focusing on the specific influence of one reference group. I determined that the interplay of socializing agents is crucial in defining the outcome of a given interaction or relationship, allowing individuals with similar socialization experiences to react differently. Furthermore, the effect of non-socialization influences on students' choices and drivers for socialization emerged during the analysis process. Policy, campus climate, personal goals, and more all provided different students the impetus to reach out to specific groups on and off campus to make a meaningful experience out of their undergraduate careers. Finally, this dissertation has further developed the mechanisms of socialization by uncovering how and why students engage with various socializing agents at different times throughout their pursuit of a degree. The five drivers for engagement with these agents identified—personal support, academic support, professional aspirations in both research and industry, and finding a path—are a widely applicable way to understand students' needs and what kinds of support might most closely align with their needs.

The trajectories of socialization that emerged from my work, in combination with the exploration of the ingrained socializing experiences in said trajectories, provide my contribution to Research Gap 3. Understanding the trajectories that students' socialization took over four years and subsequently how their university and disciplinary SoB developed is a key step in building a better picture of the role that different socializing agents play. Across all three trajectories students engaged with a wide range of agents, each in turn providing their own influence in the context of the broader undergraduate career. Membership in any one of these

trajectories did not preclude an individual from engaging with any of the identified categories of socializing agents. It did, however, give some indication of what kinds of agents would be most impactful in shaping the student's SoB. Early connections that could develop and grow alongside the students quickly emerged as the most influential factor among the Anchored, whereas personal goals drove the Independents more than any relationship could have. Finally, the Wanderers held onto whatever positive connections they could establish to carry them through an otherwise shallow connection to their university and discipline. From these trajectories, it becomes clear that the context of the student's individual needs and desires characterizes the factors that will most directly support their SoB.

Finally, for Research Gap 4, my dissertation contributes an understanding of some institutional attributes that contribute to the development of belonging. University policies, subjective campus "feel," curriculum design and presentation, and the availability of resources—even if not used—all contributed to students' SoB. Though this was not the primary focus of the dissertation, all of these factors were clearly present in the trajectories of the eight participants, providing some baseline for further investigation of the kinds of institutional policies and practices that are impactful. My dissertation has begun to address four gaps in existing research on socialization and SoB and has laid the foundation for several directions of further investigation to continue addressing these gaps. These future implications will be expanded in the following sections.

5.7 Implications for the Engineering Education Community

My dissertation has four major implications for research and practice in the Engineering Education community. These implications center around my findings with respect to the

trajectories of longitudinal socialization, pre-college socialization and belonging, the role of the first year, and expanding the work done here along several dimensions.

5.7.1 Applying the Trajectories of Longitudinal Socialization

The primary product of my dissertation work was the three trajectories of socialization that emerged from my participants' undergraduate careers: the Anchored, Independents, and Wanderers. While these three covered a broad range of socialization experiences and the divergent development of SoB within and across trajectories, I do not view them as a complete model or full set of the potential routes students could take. They are simply the categories that were present in this data set. There are numerous other trajectories students could take with different experiences that could be uncovered with additional research. Most notably absent from my dataset were students who left STEM or the university altogether. These stories of attrition are a crucial piece of the retention puzzle, as evidenced by previous studies (Geisinger & Raman, 2013; Meyer & Marx, 2014).

Future research on socialization and belonging could round out my findings by identifying additional trajectories and the socializing agents and impetuses that drive them. These trajectories might include students who dropped out of STEM majors or the university, as previously noted. A deeper dive into the stories of students like Chaaya could also illuminate the reasons why students choose to change majors while remaining within STEM. Godwin and Potvin (2017) identified one such trajectory in their case study of Sara, whose experiences in engineering did not match the expectations she had from prior to college, leading her to transition to a science major that better suited her. Transfer students are also a population of note for future work, as they face their own gauntlet of challenges in the transfer process relating to information access (Reeping & Knight, 2021), credit transfer (Cheung et al., 2021), and course

difficulty (N. L. Smith et al., 2022). Catia's trajectory highlighted some of the challenges of changing institutions midway through undergraduate study, but more study is needed. The final trajectory I would like to theorize—though there are certainly others I have not yet considered or described here—is that of students who struggle academically and are not admitted to their chosen STEM major. Academic difficulties on their own have been identified as a cause for attrition (Tinto, 1987; Wallwey et al., 2022), which are then compounded by the student not being able to pursue their desired degree path. Future work would be needed to explore and expand the set of socialization trajectories for which my dissertation has laid the foundation.

From a practice standpoint, the trajectories established here are likely most useful to advisors and administrators. As Strayhorn highlights, advances in the use of data and technical systems in advising have allowed advisors to do their work "intrusively," predicting the needs of students before it is too late to help them (Strayhorn, 2018c, p. 24). While these systems allow advising personnel to identify students in need, they do not always provide the insight necessary to prescribe a specific intervention. By developing an understanding of what kind of support different students need—and how it evolves over the course of their undergraduate career—the trajectories developed in my work provide a tool to begin addressing this problem. My work also provides qualitative support for current research on student support, building upon the current body of literature by taking a closer look at some of the interactions and structures that have already been identified (Lee et al., 2022). If a student's socialization needs can reasonably be matched with any of the trajectories, the most impactful socializing agents can be identified and either recommended or provided. The value of these trajectories also spills over to instructors, teaching assistants, administrators, student affairs practitioners, and others who have influence on the students' SoB in various ways (Freeman et al., 2007; Strayhorn, 2018b; Wylie, 2019).

5.7.2 Supporting Pre-College Socialization and Anticipatory Belonging

My findings also underline the importance and inequality of pre-college socialization experiences for prospective STEM students. A clear separation emerged in the degree to which students felt they belonged to their campus community. This divide was largely a product of whether they were able to set foot on campus prior to enrolling or not. Whether students were geographically too distant to visit—as in the case of Catia and Ayame—or not convinced of a visit's value—as was the case for Arun—their enrollment decisions were not made on equal footing with their peers who had seen the campus for themselves. For recruitment professionals, this finding poses a difficult question: how can we lessen the gap in anticipatory belonging between those who visit and those who cannot or do not?

The answer to this question is not to force every student to visit campus. This option neglects the socioeconomic, scheduling, and geographical barriers that prevent students from making the trip and simultaneously ignores the reasons why students might choose not to visit. Certainly, students can be encouraged to make the trip where possible, but alternatives need to be considered. One option for introducing students to the campus environment is summer bridge programs, which have previously been studied and implemented as a means to shore up incoming students' academic proficiencies (Gleason et al., 2010; Grimm, 2005; Tomasko et al., 2016). More recently, however, they have also begun to be the subject of research focused on their impact on students' belonging, particularly among underrepresented populations (Barth et al., 2021; Strayhorn, 2018a). Often positioned directly before the start of an academic year and supported by scholarships, these kinds of programs provide the opportunity for students to arrive earlier than their peers and get exposure to faculty and academic content, providing socialization into the discipline they may not have had access to any other way. Further study is needed to

better understand how the programs can be intentionally designed to support students feelings of belonging, but they show promise (Strayhorn, 2018a). Moreover, bridge programs have limited space for students and, like many campus programs, could not be run during the COVID-19 pandemic. To further explore the issue of introducing the broadest possible population of potential students to the university campus, I turn my attention now to digital alternatives for traditional recruitment approaches.

During the academic years most strongly affected by the COVID-19 pandemic, online information sessions and virtual campus tours became the norm for college recruitment. Zoom presentations and 360-degree campus and residence hall tours became students' only means of direct exposure to the campus environment. The value of these virtual tours in comparison to an in-person visit has not yet been studied in-depth. There is an existing body of work investigating and recommending best practices for in-person visits (Okerson, 2016; Secore, 2018), but the two have not been compared. Pavlik (2020) presented an argument in favor of using virtual tours for students who could not make it to campus, though their efforts were—ironically—curtailed by the COVID-19 pandemic. As a means of getting a visual look at campus, virtual tours are an important tool. The challenge remains, however, of replicating the subjective "feel" of campus and the interactions that students get to have with faculty, students, and recruitment staff in a virtual environment. These were among the most important factors that were identified in my work that set apart why students chose to attend the university, and is reflected in the existing literature as well (Secore, 2018). Though none of the participants in my study attended bridge programs and the impacts of the pandemic were not felt until they were well-established, my findings provide sufficient impetus for additional research, nonetheless.

The other dimension of pre-college socialization that my findings highlighted was the value of early interaction with professionals in a student's chosen major. The question that my work produces is not a new one, but it is an important one. Given how important interactions with current practitioners are for the development of STEM identity (Weidman et al., 2014), accurate conceptions STEM fields (Cruz & Kellam, 2018), and belonging to the discipline (Ayala et al., 2021), it is crucial that we further the understanding of how these interactions can be made accessible to all prospective students. Only two of the participants in my study had substantial exposure to their preferred discipline outside of the classroom: Anthony with engineers at a local hospital, and Catia with research labs at a local university. There is a steadily growing body of literature on K-12 STEM exposure (e.g., Cui et al., 2011; Ramey & Uttal, 2017; Yilmaz et al., 2010). This fact is promising for the development and accessibility of exposure to the discipline, but the missing piece of how students can be introduced to professionals from their desired major remains. Chaaya's revelation upon meeting employed chemists in her first year underlines the need for students to understand the professional prospects of their degree program to better inform their decisions.

5.7.3 The Role of the First Year: Curricula, Networks, and Major Selection

My findings with respect to the role the first year of undergraduate study plays in socializing students into STEM and developing their SoB provide a jumping off point for additional research in two key domains: first-year curricula design and the importance of early intervention. The former point was one of the common areas of complaint amongst my participants and a key stumbling block in the formation of feelings of belonging to the respective disciplines. FYE courses have already been established as a key factor in student retention (Bucks et al., 2015). There is established knowledge that a large portion of engineering students

leave the major after the first year (Yoder, 2016). My findings contribute to this concern by exploring exactly what it is about the first-year curriculum that students do not like.

Though far from comprehensive, the complaints shared by my participants are revealing. Catia's frustrations with topics she had previously learned points to an insufficient credit equivalency system, particularly for international students (Souto-Otero et al., 2013). Arun's issues with general engineering classes indicate insufficient communication of the role of such courses and their place in the curriculum. With more transparency about their role, he may have been able to make an informed decision to attend a university that directly admitted him to his major, something he expressed a desire for in later years. Finally, and most critical of the curriculum itself, was Annie's frustration that the FYE course catered to some engineering majors more than others. Introducing every engineering major—a dozen or more at many institutions—is a nigh impossible task in addition to standard curriculum elements like design, ethics, and teamwork (Goldschneider & Chambers, 2022). One route towards improving first-year curricula is increased involvement of students and student feedback in the curriculum design process. Bovill et al.'s (2011) review of literature around first-year curriculum design found that there had been very few attempts to actively incorporate students in course design. Those that had, however, found the process was beneficial to the students and faculty alike. The shared rapport and understanding between the two parties resulted in courses that suited the interests of both. Perhaps the improvement process begins with an examination and revision of how feedback is collected, condensed, and involved in curriculum reform. I will provide my personal thoughts on this matter in the Concluding Remarks section below.

The importance of early socialization was not so directly addressed by my participants as the first-year curricula, but it emerged in the analysis process, nonetheless. Those students who

were able to establish their connections early—regardless of trajectory—were often most successful in finding their place and establishing their SoB. This was unsurprising, given the emphasis on belonging in unfamiliar spaces posited by Strayhorn (2018e). Anthony and Caroline found organizations where they could put down roots and grow over time. Catia used her temporary involvement at each institution to acclimate herself before going off on her own. Chaaya found a meaningful connection that she unfortunately had to leave behind after changing majors. Socialization in the first year did not predetermine students' belonging, per se, but it did often set the tone for future developments. If we are to identify students who are most likely to leave and support them effectively, it must be done quickly and intentionally. Belonging is an important contributor to retention (Ayala et al., 2021; Hausmann et al., 2009; Strayhorn, 2018c; Tinto, 1987) and there is a small but growing body of research on the effectiveness of interventions to support students who are struggling in that regard (Patrick & Borrego, 2016). Addressing the presence of stereotypes openly in class and normalizing that many undergraduate students experience and ultimately overcome academic or social difficulties raised retention rates and academic performance for students, particularly those from historically minoritized or underperforming populations (Binning et al., 2020). Similar messaging helped English as a Second Language (ESL) students develop anticipatory belonging, indicating one possible route towards helping students find their place on campus (LaCosse et al., 2020). Particularly for faculty and advisors, there is work to be done to design methods to first understand what students need and subsequently find ways to connect them with the resources needed to give them a place to belong.

5.7.4 Building on This Dissertation: Expansions Towards Primary Data, Inclusion, and More

I would like to conclude the discussion of the implications of my dissertation work with a look at some of the ways that I think this research could be built upon by future work by myself or other researchers. There are several dimensions that should be covered: future collection and use of primary data, belonging development across diverse student populations, and the impact of institutional and national contexts. Each will be addressed briefly in turn.

As covered in Chapter 3, this dissertation made use of data that was not explicitly collected with this dissertation's topic in mind. As such, certain aspects of socialization and belonging were simply not present in students' responses to the interview protocols. Given the individual and multifaceted nature of these two phenomena, this additional depth could provide greater insight into the participants' journeys throughout their undergraduate careers. The challenge remains in collecting comparable data, as longitudinal studies are notoriously difficult to fund and complete (Bauer, 2004; Caruana et al., 2015). Acknowledging the existing gaps in literature around socialization and belonging, however, I believe it would be worth it to pursue such focused studies in an effort to deepen our understanding of the mechanisms most useful in promoting belonging among our students.

One of the limitations of the interview protocols was that they did not include questions about students' personal identities; they had to volunteer that information on their own. While not overly detrimental to this dissertation's findings, things like an individual's gender, sexual orientation, race, and ethnic background can have significant effects on what belonging means and how it develops (Strayhorn, 2018c). There is a substantial existing body of literature on a range of topics, including how belonging develops for Black students (Hausmann et al., 2009; Strayhorn, 2018d), Latino students (Maestas et al., 2007; Strayhorn, 2018h), LGBTQ+

identifying students (Aerts et al., 2012; Strayhorn, 2018f), women in STEM (Deiglmayr et al., 2019; Seyranian et al., 2018), neurodiverse students (McLeod et al., 2019), international students (Glass et al., 2015; Yao, 2015), and historically minoritized students defined more broadly (Strayhorn, 2018g; Vaccaro & Newman, 2016). My dissertation does not contribute to this body of literature directly, but it does provide evidence of the value of longitudinal investigation, something that is rarely present in existing research.

The final future direction for my work is an application of this analytical method to more of the data from the overarching project from which my population was drawn. There are an additional five institutions and two other national contexts that could be examined, each with their own unique structures, policies, and curricula. The upside of such an expansion is that the data is already readily available, and I have established that the described analytical methods are effective. The downside is that the results would lack the aforementioned depth of understanding. Nonetheless, building upon these findings with equivalent data from other contexts could open the way for direct comparison between them and perhaps even allow for some level of understanding of disciplinary differences on a global scale—something the eight-student population of this study was not sufficient for even scoped down to a single institution.

Across all of the potential directions I have described, I hope that my dissertation inspires the broader engineering education research community to pursue additional work on socialization and belonging. If we are to tackle the long-standing issues of recruitment and retention, these two theories have a lot left to give. I believe that my findings pave the way for future development of research models and institutional practices alike.

5.8 Summary

My dissertation work has contributed to existing bodies of literature in several ways, while providing a number of implications for future engineering education research and practice. The findings in this work begin to address a number of gaps in current literature, most notably providing a longitudinal investigation of the interplay of socialization and belonging and the beginnings of a set of trajectories describing the phenomena. A holistic view of socialization with numerous reference groups is also presented in this work, expanding beyond current literature's focus on singular reference groups in isolation. Moreover, the findings underline the importance of pre-college and early career socialization in the formation of belonging. These concepts are explored and some of the mechanisms that are most influential in said formation are noted for both university and disciplinary belonging. I have identified that strong belonging in one aspect of undergraduate life can compensate for weaker belonging elsewhere, though this prompts further investigation with students with more negative socialization experiences and weaker belonging than was present in my dissertation's population.

I believe my work has significant potential in spurring future research and action by engineering education educators and administrators. The trajectories identified in this work—the Anchored, Independents, and Wanderers—are a promising but incomplete set that bears further investigation with a broader dataset. I have laid out a few ways to support pre-college socialization given the effects it has been demonstrated to have on students' SoB upon arrival to their institution, as well as what more needs to be studied to make the transition as comfortable as possible for as many students as possible. The importance of first-year socialization is underlined and laid out with consideration for current roadblocks and how they could be addressed. Finally, several directions of future research have been laid out from using more of

the overarching study data to examining the interaction of various individual identities in socialization and belonging. There is ample opportunity to build upon the findings in this dissertation, but they also stand on their own as a contribution to current engineering education literature.

5.9 Concluding Remarks

I have had many conversations on the path to completing this dissertation. With my advisor and committee, of course, but also with family and friends. I see the work that I have done in my day-to-day existence as an instructor and a student alike. The process of developing the idea behind this dissertation was rooted in my own undergraduate experience and my friends have told me that it is reflective of theirs. I would like to take this section as an opportunity to share some of my thoughts on where this study came from, the conversations I have had, and some of my personal thoughts on the results that are perhaps less concrete or actionable.

When I was an undergraduate student, I was a Wanderer. I tried to join a sports team but did not fit in with the culture despite my passion for the sport itself. I had friends in the first year, but not close ones. After my first year, I chose my engineering major because it sounded like it fit me best, despite me not knowing much about it in hindsight. I struggled to make connections in my major, getting snubbed by professors for research, finding myself isolated in many of my major-specific classes, and overall getting by on an interest in the content. My friends were my solace then, as I had been adopted into an existing friend group by a coworker from the previous summer. It was not until my third year that I found an organization that I fit in with and even then, it was soured by poor experiences as the president in my fourth year. In Industrial Engineering I finally found friends in the fourth year but by then I was looking for any way out. A futile and meaningless senior design project cemented my departure for greener pastures. I

never belonged in my major, nor did I belong strongly to my university. I belonged in my friend group and for me, that was enough. My interest in identity formation, belonging, and socialization stem from some of my own "failures" as an undergraduate student. My feelings that I could have done more and been more. I recognize that the tag "Wanderer" carries potentially negative implications for those who belong to the trajectory, but I do not believe it should. Not all those who wander are lost, after all.

In general, I try to avoid bringing up my dissertation unless someone asks about it. No need to impose that on anyone. With that in mind, I have been surprised by the number of people in my life who have wanted to know what I have been working on and what I have found. Perhaps it is because no one in my closest circles have pursued Ph.D.s of their own. Some of my friends from as early as middle school have shared their experiences with me in the context of my frameworks, giving me a sort of side-pool of data that informs my thinking but does not touch my results. It is enlightening, strangely enough, to apply your academic work to your personal life. I cannot recommend it in all circumstances, mind you. Being that my dissertation concept emerged from my life, however, it was meaningful to hear the experiences of those who had completed college right alongside me.

Perhaps the most impactful conversation I had was with an uncle who had only recently been helping my two cousins choose their universities. I was explaining my findings about pre-college socialization and the difference between the students who had set foot on campus and those who had not when his face lit up. He described how concerned he had been when my younger cousin chose their university because that campus visit had been so disappointing where others had been lively. He used the phrase "feeling the heartbeat of campus" to describe the value of being physically present, a phrase that I have desperately tried—to no avail—to find a

place for earlier in the chapter. In those few words, he had summarized everything I had been thinking about. I still had to tie it back into the literature, of course, but he did not need to know about that process.

Now to the hard part: the findings that I could not conceptualize or justify as broadly impactful, but wanted to address, nonetheless. Having been involved in the first-year curricula at two different institutions now, I was particularly struck by the frustrations expressed about that very topic. As a teaching assistant and instructor, I have heard from students time and again that there is not enough introduction to their majors in the class. It is one of the most common pieces of feedback we get. Nonetheless, it feels like little has changed. I wrestled with how to incorporate it more in my class and tried to do so, but I suspect I will get the very same feedback. That piece of my findings and the implications it leads to are particularly salient to me, and it is particularly painful that they are so stubbornly present. Balancing introductions to the majors and general engineering content is difficult given the sheer volume of material for each. A full class could be devoted to covering all of the majors—and perhaps should be, if it can be fit into the demanding STEM schedule. If it were required, however, we would get complaints from students who already knew what they wanted to pursue. If it were an elective, many students who would benefit from it would not take it. We return to square one, with much work left to do.

If there is one takeaway from this dissertation that I simply could not fit anywhere due to how abstract and lofty it is, it is the reminder that we are all socializing agents for our students. When we teach, when we meet with them, when we respond to emails—or do not—we are shaping their perception of the university, of the discipline, and sometimes of themselves. This is not a cautionary tale to be hyper-vigilant of everything we do on a day-to-day basis, that would be unhealthy. It is more of a reminder to be conscious of the impact that we can have and to be

present in our responsibilities. Particularly after doing the same kind of work for a long period of time—it only took me one semester to realize that my lectures were beginning to become a bit stagnant towards the end—it becomes easy to phone it in, do just what we have to, and move on. One thing that stood out from my participants' descriptions of the socializing agents that influenced them the most was that professors were entirely absent barring one sub-group: the ones that went above and beyond. Whether hosting social events for students in the summer, talking about a student's specific interests during office hours, or supporting research aspirations, the professors that stood out the most were the ones that, coincidentally enough, did the most. If I have one regret in my dissertation work, it is that I did not find a way to articulate this in the actual findings. Grounding the idea of being conscious of our impacts on our students and on each other simply lost the spirit of the sentiment for me—or sounded like an entirely separate dissertation. That is one undertaking that will just have to wait.

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Appendix A: Full Interview Protocols

Year 1

1. **Introduction / warming up**

- Thank you for agreeing to do this interview. We really appreciate it.
- Our project is about looking at how the university and what people study changes them; and also how students feel about their studies. Therefore, in this interview we are going to explore what is pre-occupying you in terms of your degree; what you are doing; where do you fit in relation to university education; what are you getting out of it; and how that affects you and your plans for life. I am interested in your views and opinions and what you think. There are no right or wrong answers, only your opinion. As it was mentioned this stays only between us – you and me and the research team. Nobody else will know what you said here.
  - *[Make sure they understand the anonymity – try to establish trust and rapport]*
- The interview will take about one hour.
- Do you have any questions regarding the project or the interview?
- [*Note to interviewer: We want to avoid constructing students as 'fragile' in our questions; they should have an opportunity to say it's all great and ask about the academic work to keep our focus on that*.]

2. **Formalities**

- I would fist like to go through the interview consent form with you.
  - *[Notes to interviewer: Show the interview consent form and go through it. Have them sign the form]*
- I will now switch on the recorder.

<u>[REMEMBER TO SWITCH THE DIGITAL RECORDER ON NOW!]</u>

- [*Say: This is [your name and last name] / xx interviewing xx on x.x.2017*.]

3. **Warming up and personal story 1:**

[*Note to interviewer: This group of questions should take about **3-5 min**. We will return to the personal context later, this is to warm up the interview and start talking, while still collecting their history and present.*]

Opening question:

- Which programme are you enrolled in? Is it Bachelor's or Master's?

- How did you get here to study chemistry / chemical engineering at this university? What would you say is your story?

Probes:

- How important were league tables and rankings in your decision making for the university?

- How important were career prospects and employability for your decision making about the discipline of study (and the university)?

- Was studying chemistry / chemical engineering your first choice?

- Was studying at this university your first choice?

Learning the content - knowledge

[*Note to interviewer: This group of questions should take about **10 min**. Start with key questions and if there is time move to sub-questions (indented questions). Try to get covered all the topics one way or the other.*]

Opening questions:

- Could you please talk me through a recent week of studying ? What does your timetable of taught sessions and studying look like during a week?

- What is the relation between structured work and your individual work? There is more of which?

- I am interested to learn about if you have any freedom or choice in what and how you study? In other words, do you have any freedom in deciding about the content of teaching – WHAT you learn? And do you have any freedom in deciding how you study – HOW you learn?

Probes:

- What forms of teaching do you have: lectures, seminars, individual, and group work?

- Which types or kinds of teaching and learning do you like? Which ones you don't?

- In the ideal world, how would the teaching and learning process look like? / If you were a teacher here, how would you structure the teaching and learning process? How is that different to what is there now?

- You probably had certain expectations before coming to the university about how your course will look like. How were those expectations met or not met? Did anything surprise you?

- What do you think of quality of the study here?

- What do you think of the quality of teachers here? And the infrastructure?

Assessment

[*Note to interviewer: This group of questions should take about **10 min**. Start with key questions and if there is time move to sub-questions (indented questions). Try to get covered all the topics one way or the other.*]

Opening questions:

- Can you talk me through an assignment you did recently?

- What do you do when you get your assignment back? [follow the whole of assignment process including feedback]

- What other kinds of assessments did you have so far (tests, seminars, oral, written assignments)? And what did you think of them?

- Can you chose / influence how you are assessed?

- How are you doing academically? What marks did you have so far?

Probes:

- Would you change ways in which you are assessed?

- What do you think is the purpose of assessment? [Jan]

- Do you think the way of assessing and grading is fair? [Jan}

- To what extent are you clear about what is expected of you in your course assessment?

- To what extent are you clear about how your tutors allocate marks?

Learning about the discipline – social relations

[*Note to interviewer: This group of questions should take about **5 min**. Start with key questions and if there is time move to sub-questions (indented questions). Try to get covered all the topics one way or the other.*]

Opening questions:

- If you imagine someone who is a chemist / chemical engineer, that is older, graduated, professional. What is this person like? Or in other words, how would you describe a chemist / a chemical engineer? / What is specific to a chemist / chemical engineer? *[take a note about the difference in personality traits or claims about knowledge – ask sub-questions?*

- How do you see yourself as a chemist / chemical engineer in say 10 years?

- Is it important for you to become like this? Does it matter to you?

- Do this university and the department give you opportunities to become like this? How, why?

- Are there any societies or students associations specific to your study (e.g. association of chemistry students)? (If yes, are you active in it? Why / why not?)

- Do you know if there are professional associations of chemistry/chemical engineering? Would you like to become part of it?

Probes:

- How are students of chemistry / chemical engineering here connected?

    o Do you know most or all of other students of chemistry / chemical engineering?

    o Does it have a community feel?

- Do you mostly have friends from this department or students from other departments at this uni / somewhere else?

7. **Knowledge – content**

[*Note to interviewer: This group of questions should take about **10 min**. Start with key questions and if there is time move to sub-questions (indented questions). Try to get covered all the topics one way or the other.*]

Opening questions:

- I do not know much about chemistry / chemical engineering. So as to someone who is not at home in this field, could you tell me what is chemistry / chemical engineering about.

- Did this knowledge change since you started studying here or did you know all that before?

- Is chemistry / chemical engineering hard or easy in general in terms of the content and knowledge you learn?

Probes:

- OPTION 1: If you would be the department head, or programme director, would you change what you study / the content? How? Which subjects?

- OPTION 2: What content did you expect to learn? And what happened here?

- Which concepts / definitions / theories are hard to understand in your opinion? How do you understand them / What are they / How would you describe them to me?

- Which concepts / definitions / theories are easily understandable in your opinion? How do you understand them / What are they / How would you describe them to me?

- What are the basic concepts in chemistry/chemical engineering and how would you explain them to me? Or in other words: If I were to find myself in a group of chemists / chemical engineers and they would talk about their work, what basic concepts would I need to know so that I understand at least a bit of what they are saying?

8. **Student experience**

[*Note to interviewer: This group of questions should take about **5 min**. Start with key questions and if there is time move to sub-questions (indented questions). Try to get covered all the topics one way or the other.*]

Opening questions:

- What is this university offering you in general? / What kind of services do you get from the university? And are you happy with them?

- What do you think is the university responsibility towards you?

- What do you think is your responsibility in relation to your study and in relation to the whole of student experience?

- Are there mainly men or women in your study programme? Does it matter? How do you feel? What about other minorities or foreign students?

- If there would be any problem with discrimination, would you know who to contact?

Probes:

- What do you think how is this university doing? Would you like to change anything?

- Are you part of any other university societies or associations?

    o Why / why not?

- Are you aware of Your university Student Union/ NUS?

    o Would you like to get involved with Your university Student Union / NUS?

    o Or any other similar organisation?

Attitude towards HE and the university

[*Note to interviewer: This group of questions should take about **5 min**. Start with key questions and if there is time move to sub-questions (indented questions). Try to get covered all the topics one way or the other.*]

Opening questions:

- Why did you decide at all to study / go to the university (…and not go to work or do something else)? Why do you want a university degree? *[take special care about employability]*

Probes:

- *[If not already answered]* What do you hope to gain from being here and studying chemistry/chemical engineering?

- Are you thinking about your future job? Are you already doing anything about it?

- Do you have a LinkedIn account? (Did anybody here at the university suggest that you create one?)

- Would you study online? With private providers? Does it matter?

10. **Context and personal story**

[*Note to interviewer: This group of questions should take about **5 min**. Start with key questions and if there is time move to sub-questions (indented questions). Try to get covered all the topics one way or the other.*]

Opening questions:

- How are things going for you in general?

    o Social/paid work/other living circumstances

- Is this your first time living away from parents? How is it like?

- Where do you live? [particularly note if living at home]

- Are you worried about the student loans?

    o Have financial considerations influenced your decision making for studying?

- Do you think your expectations towards the university and lecturers are different/higher because you are paying (high) tuition fees?

- How would you describe yourself?

- Do you feel like you've changed since you came to the university?

11. **End questions**

[*Note to interviewer: This group of questions should take about **3 min**. Start with key questions and if there is time move to sub-questions (indented questions). Try to get covered all the topics one way or the other.*]

Questions:

- On a scale of 1-10 to what extent are you satisfied with the study course in general?

- On a scale of 1-10 to what extent are you satisfied with the university life in general?

- *[if time and not answered before] If you would now have to choose again your study discipline, would you choose the same?*

- *[if time and not answered before] If you would now have to choose again your university, would you choose the same?*

- Is there anything that you think is important about your education and we haven't discussed?

Probes:

- *[If not already answered] Was this university your first choice? / In the ideal world where would you like to study?*

- *[If not already answered] Would you study anything else?*

- *[If not already answered] If yes, what?*

12. **Formalities**

- Thank you very much for cooperating.
- Feel free to get in touch if you have any questions.
- We would also like to give you this voucher – as a sign of appreciation for your time.
- *[Note to the interviewer: Give them the voucher.]*

Year 2

1. **Introduction / warming up**

    - Thank you for agreeing to take part in this interview. We really appreciate it.

- As you may remember, our project is about how the university and what people study changes them; and how students feel about their studies. In this interview we are going to explore what is pre-occupying you in terms of your degree; what you are doing; where you fit in relation to university education; what are you getting out of it; and how that affects you and your plans for life. Because we are interested in your experience throughout your degree and how this changes, the interview will seem very similar to the first interview with many of the same questions, but we are interested in your experience now.
- I am interested in your views and opinions, and what you think. There are no right or wrong answers, only your opinion.
- As it was mentioned this stays only between us- you, me and the research team. Nobody else will know what you said here
    - *[Make sure they understand the anonymity – try to establish trust and rapport]*
- The interview will take about one hour.
- Do you have any questions regarding the project or the interview?

2. **Formalities**

- I would first like to go through the interview consent form with you.
    - *Show the interview consent form and go through it*
    - *Have them sign the form*
- I will now switch on the recorder

[REMEMBER TO SWITCH THE DIGITAL RECORDER ON NOW!]

- [*Say: This is [your full name] interviewing xx on x.x.2018*]

3. **Warming up and personal story [use questions that are relevant for your own context]**

1. Are you still enrolled into Chemistry / Chemical Engineering & BA / MA **[ask appropriately for each specific student] [use context appropriate phrasing]**

2. Are you considering doing a year abroad or in industry next year? When do you need to make a decision about this? How does it work / what are you hoping to get out of it? **[delete if not relevant]**

3. How are things going for you in general?

4. Where are you living this year? How is it? **- [refer to last year's specific situation of each student]**

5. Part time paid employment / summer placement **[refer to last year's specific situation of each student] [delete if not relevant]**

4. **Learning the content - knowledge**

1. Could you please talk me through a recent week of studying? What does your timetable of taught sessions and studying look like during a week?

   - **Probe:** Is there anything else? **[if little detail is provided]**

2. Thinking about all of the things you have just talked about **[repeat the description / words used by each student e.g. "lectures", "labs", "workshops", "tutorials"]** what parts do you find are really essential for building your learning? Why?

   - **Probe:** Would you change anything in terms of the way the course is taught?

3. Tell me a little about the practical work / labs that you do in Chemistry / the Chemical Engineering courses. What do you think is the role of practical work in your course / degree?

   - **Probe:** Would you change anything about this practical work?

4. What is the balance between your structured work / contact time (lectures, labs, tutorials) and your individual work / non-contact time (study time, assignments, preparation)? How much time is roughly given to each? **[note any particular changes for each specific student]**

5. Did you have certain expectations about the second year of your studies and what were these? Has anything surprised you?

6. What do you think of the quality of the study and lecturers this year? How does this compare to last year?

7. What do you think of the quality of the infrastructure (lab facilities, lecturer/seminar/workshop rooms, building) this year? How does this compare to last year?

8. What do you think is the main difference in terms of the curriculum and the teaching and learning process compared to last year?

5. **Assessment**

1. Can you talk me through **this** assignment? **[NB: 'This' refers to the particular assignment that we will ask them to bring]**

2. What other kinds of assessments have you had so far?

3. What do you think of them? Are they different to last year? What do you think about this?

4. When you got this and your other assignment back, do you check the feedback immediately or leave it for later?

5. Do you find feedback clear and useful? How does the feedback you've had so far this year compare to last year?

- **Probe:** How do you use feedback? **[if not covered in question 4 and/or 5]**

6. Are you clear about what is expected of you and what you need to do in your assessments?

7. Are you clear about how your lecturers allocate marks?

8. Do you think the way of assessing and grading is fair?

9. What do you think is the purpose of assessment? Why does it even exist?

10. How are you doing academically? How does this compare to last year?

6. **Knowledge - content**

1. **CHEMISTRY:** As you know, I'm not a Chemist, but I do understand that in Organic Chemistry that reaction mechanisms are considered very important. Could you tell me a bit about why you think this is, why are you spending time in your course learning to understand how a particular organic reaction occurs?

- **Probe:** Could you tell me a bit about why understanding reactions is important in learning Chemistry?

- **Probe:** Why is it important to understand the reagents, conditions and mechanisms?

- **Probe:** Why would you need to know about the aldol reaction for example?

2. **Chemical Engineering:** As you know, I'm not a Chemical Engineer, but I do understand that the mathematical modelling of flow processes, including fluid flow and heat and mass transfer, is considered very important. Could you tell me a bit about why you think this is, and why you are spending time in your course learning to derive and use mathematical

- **Probe:** Can you tell me a bit about why understanding flow processes is important in learning Chemical Engineering?

- **Probe:** Why is it important to understand reactors, separators, heat exchanges and energy efficiency?

- **Probe:** Think about chemical Engineers working in particular industries such as oil, gas and food, when, how and why would they use modelling for flow processes/fluid flow/heat/mass transfer in different types of design?

3. Think back to a recent time in your chemistry course /one of your chemical engineering courses when something really 'clicked' for you / 'crystallised in your head' / an 'ah-ha' moment. Describe that, remember I don't know much about the course you are doing, so explain to me a bit why this was challenging, and then what specific insights helped you grasp it?

4. In your everyday life, do you think you see things in a different way because you are studying Chemistry/ Chemical Engineering? Can you give me some specific examples? How do you think this differs from your friends in other programmes for example?

5. What do you think is distinctive about engineering / science knowledge? How would you describe an engineering / scientific 'way of thinking'? If possible give a real example that can help me understand what you are thinking.

6. Now that you're in your second year, how would you explain Chemistry / Chemical Engineering to me as someone who isn't familiar at all with Chemistry / Chemical Engineering?

7. Has this knowledge changed compared to last year? Is harder or easier this year?

7. **Learning about the discipline – social relations**

1. Now that you're in your second year, how would you describe a Chemist / Chemical Engineer? Is there anything specific to being a Chemist / Chemical Engineer? How has this view changed from last year?

2. Do you see yourself becoming like this say in 10 years? **[NB: 'this' refers to the description they have given to question 1]** Is it important for you to become like this? Why does it matter / not matter? **If students are unable to describe/say it's not important to become like their description then ask where they see themselves in 10 years [Note any changes]**

3. Do you think this university and the department are supporting you to become like this / equipping you with these skills? How?

4. How are students studying chemistry / Chemical Engineering here connected? Do you know most or all of the other students studying Chemistry / Chemical Engineering? Is there a sense of community? How does this compare to last year?

5. Are most of your friends from this department / other departments at this university / somewhere else? How does this compare to last year?

6. Are you a member of any disciplinary societies? Any professional Associations? [Chemistry / Chemical Engineering Society / Royal Society for Chemistry / Institute

for Chemical Engineering? Why / Why not? **[refer to last year's specific situation of the person]**

8. **Wider Student experience**

1. What other services, outside of those that are academic **[use context appropriate phrasing]** does this university offer to you as a student? Which ones have you used?

2. Are you aware of any services this year that you weren't aware of last year?

3. Are you happy with the services that you get from the university? Is there anything missing?

4. Do you have any particular needs or expectations this year that differ from last year?

5. What do you think is the university's responsibility towards you? **[note any particular changes for each student]**

- **Probe:** Do you think the university is doing this successfully?
- **Probe:** Would you change anything about this university?

6. What do you think is your responsibility as a student? **[note any particular changes for each student]**

7. Are you aware of this university's standing in rankings and league tables? Does this university offer this information to you as a student here / where do you learn about it? Do you think it is important?

8. Last year you talked about the diversity of the student body in your class. How is it this year? How do you feel about it? Does it matter?

- **Probe-** Are there mainly men or women on your course? What about ethnicity?
- **Probe-** If students talk about a particular issue in relation to diversity, e.g. few women- ask how they feel about this, have they personally experienced an issue in relation to this, would they know who to talk to if they experienced discrimination

9. Are you part of any other university societies or associations [these are general societies – like swimming]? Why / why not? **[refer to last year's specific situation of the person and note any changes if relevant]**

9. **Attitude towards HE and the university**

1. What do you think about the value of university education? Why do you want a university degree?

2. What do you hope to gain from being here and studying Chemistry / Chemical Engineering? **[take special care about employability]**

3. Has the university offered anything to you in terms of employability? Such as any specific modules? A careers service? Have you visited the careers office yet?

   - **Probe:** Are you thinking about your future job? Are you already doing anything about it?

4. Have you thought much about your student loan this year? Is it something that worries you? Why? **[delete if not appropriate]**

5. Does paying / not paying tuition fees influence your expectations towards the university and lectures? How / why?

6. Last year you mentioned [no awareness/awareness of LinkedIn / account/no account] **[refer to last year's specific situation of the person]** is this still the same / has this changed?

   - **Probe:** Has the university suggested creating a LinkedIn account?
   - **Probe:** What do you think is the benefit / use of LinkedIn?

10. **Personal story**

1. How would you describe yourself?

2. Do you feel like you've changed compared to last year / since coming to university

11. **End questions**

1. On a scale of 1-10 to what extent are you satisfied with the study course / programme study course in general?

2. On a scale of 1-10 to what extent are you satisfied with the university life in general?

3. If you were to choose your course / programme again, would you choose the same?

4. If you were to choose your university again, would you choose the same?

5. Is there anything else you want to discuss that we haven't already?

12. **Formalities**

- Thank you very much for cooperating.
- Feel free to get in touch if you have any questions.

- We would also like to give you this voucher – as a sign of appreciation for your time.

Year 3

1. **Introduction/warming up**

- Thank you for agreeing to take part in this interview. We really appreciate it.
- As you may remember, our project is about how the university and what people study changes them; and how students feel about their studies. In this interview we are going to explore what is pre-occupying you in terms of your degree; what you are doing; where you fit in relation to university education; what are you getting out of it; and how that affects you and your plans for life. Because we are interested in your experience throughout your degree and how this changes, the interview will seem very similar to previous interviews with many of the same questions, but we are interested in your experience now.
- We are interested in your views and opinions, and what you think. There are no right or wrong answers, only your opinion.
- What you talk about today stays between us- you, me and the research team.
    - *[Make sure they understand the anonymity – try to establish trust and rapport]*
- The interview will take about one hour.
- Do you have any questions regarding the project or the interview?

2. **Formalities**

- I would first like to go through the research brief and consent form with you.
    - *Show the research brief and consent form and go through it*
    - *Have them sign the form*
- I will now switch on the recorder

[REMEMBER TO SWITCH THE DIGITAL RECORDER ON NOW!]

- [*Say: This is [your full name] interviewing xx on DATE*]

3. **Warming up and personal story [use questions that are relevant for your own context]**

1. Are you still enrolled into Chemistry/Chemical Engineering & BA/MA **[ask appropriately for each specific student] [use context appropriate phrasing]**
2. Will this be your final year? **[ask appropriately for each specific student]**
3. How are things going for you in general?

4. Where are you living this year? How is it? - **[refer to last year's specific situation of each student if important] [adapt wording based on year abroad/industry/placement]**

5. Ask about summer placements/projects that students may have done **[delete if not relevant]**

6. Do you have any part time paid employment? **[refer to last year's specific situation of each student] [delete if not relevant]**

4. **Learning the content - knowledge**

1. How are you finding your third year of your studies? Has anything surprised you?

2. Could you please talk me through a recent week of studying? What does your timetable of taught sessions and studying look like during a week?

   - **Probe:** Is there anything else? **[if little detail is provided]**

3. Thinking about all of the things you have just talked about **[repeat the words used by each student e.g. "lectures", "labs", "workshops", "tutorials"]** what parts do you find are really essential for building your learning? Why?

   - **Probe:** Would you change anything in terms of the way the course is taught?

4. Tell me a little about the practical work/labs that you do in Chemistry/the Chemical Engineering courses. What do you think is the role of practical work in your course/degree?

   - **Probe:** Would you change anything about this practical work?

5. What is the balance between your structured work/contact time (lectures, labs, tutorials) and your individual work/non-contact time (study time, assignments, preparation)? How much time is roughly given to each? **[note any particular changes for each specific student]**

5. **Assessment [adjust questions 1-3 if students are not in their final year]**

1. How are you getting on with your final chemistry report/dissertation/final chemical engineering design project? What do you have to do?

2. Do you have a supervisor? How does that work? How does your supervisor support you?

3. Has the course supported you in any other way with your final chemistry report/dissertation/final chemical engineering design project?

4. What other kinds of assessments have you had so far? What do you find most useful for building your learning? Why?

5. When you get your assignments back, do you check the feedback immediately or leave it for later?

6. Do you find feedback clear and useful?

   - **Probe:** How do you use feedback? **[if not already covered]**

7. Are you clear about what is expected of you and what you need to do in your assessments?

8. Do you think the way you are being assessed is fair?

9. Do you think the grading is fair?

10. What do you think the purpose of assessment is? Why does it even exist?

11. How are you doing academically?

6. **Knowledge - content**

1. **CHEMISTRY:** As you know, I'm not a Chemist, but I do understand that in Organic Chemistry that reaction mechanisms are considered very important. Could you tell me a bit about why you think this is, why are you spending time in your course learning to understand how a particular organic reaction occurs?

   - **Probe:** Could you tell me a bit about why understanding reactions is important in learning Chemistry?

   - **Probe:** Why is it important to understand the reagents, conditions and mechanisms?

   - **Probe:** Why would you need to know about the aldol reaction for example?

2. **Chemical Engineering:** As you know, I'm not a Chemical Engineer, but I do understand that the mathematical modelling of flow processes, including fluid flow and heat and mass transfer, is considered very important. Could you tell me a bit about why you think this is, and why you are spending time in your course learning to derive and use mathematical modelling?

   - **Probe:** Can you tell me a bit about why understanding flow processes is important in learning Chemical Engineering?

   - **Probe:** Why is it important to understand reactors, separators, heat exchanges and energy efficiency?

- **Probe:** Think about chemical Engineers working in particular industries such as oil, gas and food, when, how and why would they use modelling for flow processes/fluid flow/heat/mass transfer in different types of design?

3. In your everyday life, do you think you see things in a different way because you are studying Chemistry/Chemical Engineering? Can you give me some specific examples?

4. What do you think is distinctive about engineering/science knowledge? How would you describe an engineering/scientific 'way of thinking'? If possible, give a real example that can help me understand what you are thinking.

5. How would you explain Chemistry/Chemical Engineering to me as someone who isn't familiar at all with Chemistry/Chemical Engineering?

6. What are the most important things you gained from studying Chemistry/Chemical Engineering?

7. **Learning about the discipline – social relations**

1. Who do you see yourself becoming in 10 years? How is this informed by what you are studying? Is it important for you to become like this? Why does it matter/not matter?

2. Do you think this university and the department are supporting you to become like this and equipping you with these skills? How?

3. Is there a sense of community on your course or in your Department? Do you socialise with other students in your department?

4. How diverse are the students on your course? How do you feel about it? Does it matter? Is it important? Why/why not?

- Probe- If students ask what this means- are there mainly men or women on your course? What about ethnicity?

- Probe- If students talk about a particular issue in relation to diversity, e.g. few women- ask how they feel about this, have they personally experienced an issue in relation to this, would they know who to talk to if they experienced discrimination

5. Are you a member of any disciplinary societies and/or professional associations [Chemistry/Chemical Engineering society/Royal Society for Chemistry/Institute for Chemical Engineering]?

8. **Wider Student experience**

1. What other support do you get from the University? Are you happy with it? Is there any support you need that you are not getting?

- **Important note/probe:** If students focus on academic support, ask students to think about other university services outside of those that are academic **[this question is about wider university services that support student experience]**

2. What do you think your responsibility as a student is? **[note any particular changes for each student]**

3. What do you think the university's responsibility towards you is? **[note any particular changes for each student]**

   - **Probe:** Do you think the university is doing this successfully?
   - **Probe:** Would you change anything about this university?

4. Are you aware of this university's standing in rankings and league tables? Where do you get this information? Is it important to you? Why?

5. Are you part of any other university societies or associations [these are general societies – like swimming]? Why/why not? **[refer to last year's specific situation of the person and note any changes if relevant]**

9. **Attitude towards HE and the university**

1. What do you hope to gain from being here at this university?

2. Are you thinking about your future career? Are you doing anything about it?

3. Has the university offered anything to you in terms of employability? Such as any specific modules? A careers service? Have you visited the careers office yet?

4. Have you thought much about your student loan this year? Is it something that worries you? Why? **[delete if not appropriate]**

5. Does paying/not paying tuition fees influence your expectations towards the university and lecturers? How and why?

6. Last year you mentioned [no awareness/awareness of LinkedIn/having/not having an account] **[refer to last year's specific situation of the person]** is this still the same/has this changed?

   - **Probe:** Has the university suggested creating a LinkedIn account?
   - **Probe:** What do you think is the benefit/use of LinkedIn?

10. **Personal story**

1. Do you think you have changed as a person since coming to university? How?

11. **End questions**

1. On a scale from 1-10 to what extent are you satisfied with the study course/programme study course in general? Why?

2. On a scale from 1-10 to what extent are you satisfied with the university life in general? Why?

3. If you were to choose your course/programme again, would you choose the same?

4. If you were to choose your university again, would you choose the same?

5. Is there anything else you want to discuss that we haven't already?

12. **Formalities**

- Thank you for your continued support (check that students are happy to be contacted again next year)
- We would also like to give you this voucher – as a sign of appreciation for your time
- Feel free to get in touch if you have any questions

Year 4

1. **Introduction/warming up**

- Thank you for agreeing to take part in this interview. We really appreciate it.
- As you may remember, our project is about how the university and what people study changes them; and how students feel about their studies. In this interview we are going to explore what is pre-occupying you in terms of your degree; what you are doing; where you fit in relation to university education; what are you getting out of it; and how that affects you and your plans for life. Because we are interested in your experience throughout your degree and how this changes, the interview will seem very similar to previous interviews with many of the same questions, but we are interested in your experience now.
- We are interested in your views and opinions, and what you think. There are no right or wrong answers, only your opinion.
- What you talk about today stays between us- you, me and the research team.
    - *[Make sure they understand the anonymity – try to establish trust and rapport]*
- The interview will take about one hour.
- Do you have any questions regarding the project or the interview?

2. **Formalities**

- I would first like to go through the research brief and consent form with you.
    - *Show the research brief and consent form and go through it*
    - *Have them sign the form*
- I will now switch on the recorder

[REMEMBER TO SWITCH THE DIGITAL RECORDER ON NOW!]

- [*Say: This is [your full name] interviewing xx on DATE*]

3. **Warming up and personal story [use questions that are relevant for your own context]**

1. Are you still enrolled into Chemistry/Chemical Engineering & BA/MA **[ask appropriately for each specific student] [use context appropriate phrasing]**

2. Will this be your final year? **[ask appropriately for each specific student]**

3. How are things going for you in general?

4. Where are you living this year? How is it? **- [refer to last year's specific situation of each student if important] [adapt wording based on year abroad/industry/placement]**

5. Ask about summer placements/projects that students may have done **[delete if not relevant]**

6. Do you have any part time paid employment? **[refer to last year's specific situation of each student] [delete if not relevant]**

7. **If and where relevant, and not already discussed, ask about the impact of the Pandemic**

4. **Learning the content - knowledge**

1. How are you finding your fourth year of your studies? Has anything surprised you?

2. Could you please talk me through a recent week of studying? What does your timetable of taught sessions and studying look like during a week?

    - **Probe:** Is there anything else? **[if little detail is provided]**

3. Thinking about all of the things you have just talked about **[repeat the words used by each student e.g. "lectures", "labs", "workshops", "tutorials"]** what parts do you find are really essential for building your learning? Why?

    - **Probe:** Would you change anything in terms of the way the course is taught?

4. Tell me a little about the practical work/labs that you do in Chemistry/the Chemical Engineering courses. What do you think is the role of practical work in your course/degree?

- **Probe:** Would you change anything about this practical work?

5. What is the balance between your structured work/contact time (lectures, labs, tutorials) and your individual work/non-contact time (study time, assignments, preparation)? How much time is roughly given to each? **[note any particular changes for each specific student]**

6. **If and where relevant, and not already discussed, ask about the impact of the Pandemic**

5. **Assessment**

1. How are you getting on with your final chemistry research project/final chemical engineering dissertation/research project? What do you have to do? **[use context appropriate phrasing]**

2. Do you have a supervisor? How does that work? How does your supervisor support you?

3. Has the course supported you in any other way with your final chemistry research project/final chemical engineering dissertation/research project?

4. What other kinds of assessments have you had so far? What do you find most useful for building your learning? Why?

5. When you get your assignments back, do you check the feedback immediately or leave it for later?

6. Do you find feedback clear and useful?

- **Probe:** How do you use feedback? **[if not already covered]**

7. Are you clear about what is expected of you and what you need to do in your assessments?

8. Do you think the way you are being assessed is fair?

9. Do you think the grading is fair?

10. What do you think the purpose of assessment is? Why does it even exist?

11. How are you doing academically?

12. **If and where relevant, and not already discussed, ask about the impact of the Pandemic**

6. **Knowledge - content**

1. **CHEMISTRY:** As you know, I'm not a Chemist, but I do understand that in Organic Chemistry that reaction mechanisms are considered very important. Could you tell me a bit about why you think this is, why are you spending time in your course learning to understand how a particular organic reaction occurs?

- **Probe:** Could you tell me a bit about why understanding reactions is important in learning Chemistry?
- **Probe:** Why is it important to understand the reagents, conditions and mechanisms?
- **Probe:** Why would you need to know about the aldol reaction for example?

2. **Chemical Engineering:** As you know, I'm not a Chemical Engineer, but I do understand that the mathematical modelling of flow processes, including fluid flow and heat and mass transfer, is considered very important. Could you tell me a bit about why you think this is, and why you are spending time in your course learning to derive and use mathematical modelling?

- **Probe:** Can you tell me a bit about why understanding flow processes is important in learning Chemical Engineering?
- **Probe:** Why is it important to understand reactors, separators, heat exchanges and energy efficiency?
- **Probe:** Think about chemical Engineers working in particular industries such as oil, gas and food, when, how and why would they use modelling for flow processes/fluid flow/heat/mass transfer in different types of design?

3. In your everyday life, do you think you see things in a different way because you are studying Chemistry/Chemical Engineering? Can you give me some specific examples?

4. What do you think is distinctive about engineering/science knowledge? How would you describe an engineering/scientific 'way of thinking'? If possible, give a real example that can help me understand what you are thinking.

5. How would you explain Chemistry/Chemical Engineering to me as someone who isn't familiar at all with Chemistry/Chemical Engineering?

6. What are the most important things you gained from studying Chemistry/Chemical Engineering?

7. **Learning about the discipline – social relations**

1. Who do you see yourself becoming in 10 years? How is this informed by what you are studying? Is it important for you to become like this? Why does it matter/not matter?

2. Do you think this university and the department are supporting you to become like this and equipping you with these skills? How?

3. Is there a sense of community on your course or in your Department? Do you socialise with other students in your department?

4. How diverse are the students on your course? How do you feel about it? Does it matter? Is it important? Why/why not?

- Probe- If students ask what this means- are there mainly men or women on your course? What about ethnicity?
- Probe- If students talk about a particular issue in relation to diversity, e.g. few women- ask how they feel about this, have they personally experienced an issue in relation to this, would they know who to talk to if they experienced discrimination

5. Are you a member of any disciplinary societies and/or professional associations [Chemistry/Chemical Engineering society/Royal Society for Chemistry/Institute for Chemical Engineering]?

6. **If and where relevant, and not already discussed, ask about the impact of the Pandemic**

8. **Wider Student experience**

1. What other support do you get from the University? Are you happy with it? Is there any support you need that you are not getting?

- **Important note/probe:** If students focus on academic support, ask students to think about other university services outside of those that are academic **[this question is about wider university services that support student experience]**

2. What do you think your responsibility as a student is? **[note any particular changes for each student]**

3. What do you think the university's responsibility towards you is? **[note any particular changes for each student]**

- **Probe:** Do you think the university is doing this successfully?
- **Probe:** Would you change anything about this university?

4. Are you aware of this university's standing in rankings and league tables? Where do you get this information? Is it important to you? Why?

5. Are you part of any other university societies or associations [these are general societies – like swimming]? Why/why not? **[refer to last year's specific situation of the person and note any changes if relevant]**

6. **If and where relevant, and not already discussed, ask about the impact of the Pandemic**

9. **Attitude towards HE and the university**

1. What do you hope to gain from being here at this university?

2. Are you thinking about your future career? Are you doing anything about it?

3. Has the university offered anything to you in terms of employability? Such as any specific modules? A careers service? Have you visited the careers office yet?

4. Have you thought much about your student loan this year? Is it something that worries you? Why? **[delete if not appropriate]**

5. Does paying/not paying tuition fees influence your expectations towards the university and lecturers? How and why?

6. Last year you mentioned [no awareness/awareness of LinkedIn/having/not having an account] **[refer to last year's specific situation of the person]** is this still the same/has this changed?

   - **Probe:** Has the university suggested creating a LinkedIn account?
   - **Probe:** What do you think is the benefit/use of LinkedIn?

7. **If and where relevant, and not already discussed, ask about the impact of the Pandemic**

10. **Personal story**

1. Do you think you have changed as a person since coming to university? How?

11. **End questions**

1. On a scale from 1-10 to what extent are you satisfied with the study course/programme study course in general? Why?

2. On a scale from 1-10 to what extent are you satisfied with the university life in general? Why?

3. If you were to choose your course/programme again, would you choose the same?

4. If you were to choose your university again, would you choose the same?

5. Is there anything else you want to discuss that we haven't already?

12. **Formalities**

- Thank you for your continued support (check that students are happy to be contacted again next year)
- We would also like to give you this voucher – as a sign of appreciation for your time
- Feel free to get in touch if you have any questions

Appendix B: Codebook

The codes in this codebook exist under the umbrella of an individual student's four years on campus. I did not specifically code with respect to each individual student (e.g., "Anthony University Socialization") due to my approach to the data analysis as detailed in Chapter 3. I recognized the implicit assumption that the codes existed within a broader ecosystem of the students' experiences to begin with, but going through each individual's interviews from all four years before moving to the next participant allowed me to focus on the codes presented below.

Code	Definition	Subcode	Definition	Example
University Socialization	Any socializing interaction taking place on the university campus, generally with relation to university-sponsored or education-related activities	Formal University Socialization	Any socializing interaction taking place within a university-controlled space with oversight from university faculty or staff (e.g., a classroom or lab)	I would say it depends on the course. I absolutely love my chemistry professor and he provided a lot of different ways to learn, and I think that was what was helpful to me. So he provided both notes online and in the classroom, and there were just a lot of different ways that you could evaluate learning. And he gave us references to the textbook in case we wanted to use the textbook, which is why I did, and that happened to help, whereas my math class last semester was multivariable and we didn't use the textbook at all. And so that was a very different kind of learning style. And then there, I would say, it was a little bit more limited. He gave us notes in class and packets to fill out in class. And that's how we learned. And I would say that's kind of how my math classes have been. They've been the

				more limited classes for learning styles. -Annie, Year 1
		Informal University Socialization	Any socializing interaction taking place on the university campus, but not strictly controlled or overseen (e.g., a dining hall or residence hall)	So coming in to college I was like Oh my God everyone is going to be such nerds, I'm in chemistry, I'm a nerd. I'm going to be so weird but there is ton... completely normal people there are people who are in sports, there are people who are in arts, there are people who do all kinds of different things that I just would never have expected. That are interested in science and stuff. There's a lot of dudes. There's a ton of White people. I don't know, just in general I've met a lot of different types of people. I think I have met... I think I have encountered more diversity in my personal life from meeting people outside of my classes and I think could be because I have all of my classes with the same people. -Chloe, Year 2
Personal Socialization	Socializing interactions that occur with personal networks including friends (both on- and off-campus), family, and			A lot of my friends are there. Well one, I wasn't a Christian before coming into college, so then joining this just really supported me. Obviously, I love God, so then I really want to keep pursing that and it provides me an easy

	purely social organizations on campus (e.g., clubs, religious organizations)			way to really be a part of a community of friends who also worship God, and are just as committed as I am. Like I said, a lot of my friends are a part of there. My two roommates are a part of [a religious organization]. I've had a weekly Bible study with some of those girls since freshmen year, and we've met up every week for the entire, like all the semester so far. We've grown really close, and that, I think, is like the biggest part that keeps me going is my friends who are there with me. -Caroline, Year 3
Professional Socialization	Socializing interactions that were directly related to professional work (e.g., internships or co-ops) or professional organizations (e.g., American Chemistry Society)			Even that, I would say it's less about, the curriculum, and more about... I was working as a co-op in the [Chocolate and cocoa products company]. The [Chocolate and cocoa products company] chocolates. I was there, the manufacturing plants and stuff, and so it was really a lot about that, I'd say more changed my outlook rather than the curriculum itself. It was the work experience. -Arun, Year 4
Negative Socialization	Socializing experiences belonging to			One thing I'll say is a lot of them don't really know much about the

	any of the above codes that clearly hinder a student's connection to or perception of a community, group, or institution			medical field and that's understandable. They've never been premed or never been to med school. I think it's hard for them to give me practical advice. I will say that I have been somewhat pressured, I felt like, to get a co-op, which I think is an incredible thing to do if you're an engineer. But one thing that I had to discern for myself was, is that the right thing for me, not wanting to be a chemical engineer and knowing that. And I felt like they were reluctant to give me raw advice, because they just really wanted me to get a co-op. I felt like that advice wasn't really tailored for me. -Anthony, Year 3
Perception of Discipline	Statements that indicate some aspect of a student's feelings about their major, its future potential, curriculum, content, or interaction with other disciplines			At first it's really different from chemistry. It's not a chemistry, more like physics. It's a really different subject that before I never know about it. But... I don't know, anything else? I just chose all those engineering courses [inaudible 00:01:18], because I don't need engineering. I don't want to do physics, I don't want to do other engineering. Like, sales or anything so just... I found I'm good at chemistry, so I chose

				chemical engineering. But before, I don't know it, it was a different really different. -Ayame, Year 2
Disciplinary Sense of Belonging	Any student statements that indicate feelings of—or the absence thereof—comfort, mattering, safety, appreciation, or belongingness to the student's chosen major	Presence of Disciplinary Belonging	Any student statements that indicate feelings of comfort, mattering, safety, appreciation, or belongingness to the student's chosen major/discipline	Probably maybe eight or nine, they gave me a really strong foundation and understanding of the material, but beyond just the material of biochemistry of what you learned in textbook, it also taught me a lot about problem-solving and how to look at new research because by the time something gets written in a textbook it's already outdated. A lot of like when you actually take a course from a biochemistry professor, they do so much to impart the idea that it's always continual learning, always learning new things, there's always new techniques, things are changing and you're going to fail sometimes in research, but you're going to just keep looking through it and it's a process. The department did a really good job of imparting that idea, but just sucks that it took until my junior year to get my first biochemistry course in my biochemistry degree. The first two years are all chemistry and biology.

				Interviewer: If you were to choose your course or program again, let's go again with biochemistry, still would you choose the same? Caroline: Yeah, definitely. I couldn't imagine doing anything else. -Caroline, Year 4
		Absence of Disciplinary Belonging	Any student statements that indicate the absence of feelings of comfort, mattering, safety, or belongingness to the student's chosen discipline/major. Also includes experiences that distinctly alienate them/make them feel unwelcome in the discipline.	I wouldn't say there is really a sense of a really deeply connected community, but to some degree, yeah. Also, I'm personally not really taking part in most of the events and things like that, just because I'm not really interested. So I'm probably the wrong person to ask. -Catia, Year 4
University Sense of Belonging	Any statements that indicate feelings of—or the absence thereof—comfort, mattering, safety, appreciation, or belongingness to the institution	Presence of University Belonging	Any student statements that indicate feelings of comfort, mattering, safety, appreciation, or belongingness to the student's	I really like it. I really like the opportunity we're given. I feel like it's a great place to always meet people when you want to. -Chaaya, Year 2

			university/institution	
		Absence of University Belonging	Any student statements that indicate the absence of feelings of comfort, mattering, safety, or belongingness to the student's university/institution. Also includes experiences that distinctly alienate them/make them feel unwelcome in the university/institution.	Like, same things I talked about: career center- okay, why not 10, because university health center, I would say. Because I'm not really healthy person, so I thought I would have to use it a lot, but I'm not because I don't like it. Because I don't like this whole system with the insurance in the United States, because in Russia, everything is free. So... yeah. And you just have to write a lot of things, sign a lot of things... just takes a lot of time to deal with insurance stuff. It would be nice if the university health center would have extended working hours, because it closes at like 5:30 PM, and not all people can reach it. And it's not working on weekends at all, so I might have some issues on weekend also. -Catia, Year 1

Notable Overlaps/Gray Areas:

1) Personal socialization occurring on campus, as with student interactions with on-campus clubs or interactions with friends at the institution, could also potentially fit the description for informal university socialization. I chose to code them as personal socialization due to their purely social nature, though there were some I considered coding in both.
2) "Employers" are listed under personal socialization in Conrad et al.'s (2006) original framework. I chose to code them as personal socialization in the case of part-time jobs (e.g., working at a coffee shop) and professional socialization in the case that it was directly related to their chosen major/industry (e.g., internships). In some cases, an

employer could also have been counted as Formal University Socialization (e.g., students working as teaching assistants).

Appendix C: Sample Analytical Matrix - Chloe

In this appendix, I have included the full Analytical Matrix for Chloe as a sample. Each sheet will be labeled. Specific experiences per the Codebook in Appendix B are documented in the correspondingly labeled sheets. The Summary Sheet served as my personal synthesis of the notes for each year and code category.

Summary Sheet

	University Socialization	Personal Socialization	Professional Socialization	Perception of Discipline	Disciplinary Sense of Belonging	University Sense of Belonging	Changes in Belonging
Pre-College	Got to visit campus to see her brother, a senior in engineering, really thought it was pretty and liked the people she met	Bad experiences with peers in high school made her want to go out-of-state. Finances were tricky but her father said that if she wanted to go, they would make it work. Had some good professors in high school, interestingly not her chemistry professor.	Went on a mission trip to Africa and met a woman doing medical care and travelling the world. Teachers in HS had made her consider teaching, but this showed her other ways to help kids, she liked the pediatric care route better.	Felt like she didn't really understand chemistry in high school, just memorized what she needed. Instructor wasn't great but she liked the material itself.	Liked chemistry despite having a mediocre instructor in high school, wasn't sure if it was right for her but it would get her into med school	Decided on VT between her top choices because it's where she could see herself being the happiest.	N/A
Year 1	Overall happy with her professors, having consistent ones from first to second semester helps her	Has made friends in the major, at this point most are from a religious organization she's a part of, but most are in STEM still.	Has been introduced to a variety of researchers and STEM professionals through a first-year experience class.	Despite some struggles in the major, she's enjoying what she's learning, she feels like she's actually	Very strong. Despite some difficulties and not doing as well as she would have liked, she's been well supported and she loves the material.	Very strong as well. Really loves campus, doesn't want to go home. Lots of resources	Disciplinary: Big upswing, especially from the first semester even. Feels like she's learning

	adjust to their styles. Adviser has been very helpful in guiding her towards resources and opportunities. Has found a lot of encouragement from professors and peers in her difficult times. Doesn't like sociology.	Working to start a STEM sorority with a friend of hers. Parents have some say in what she studies, told her to stay in chemistry, but also provided encouragement when she was down.	Broadened her horizons on what she could do. Planning to go pre-med, hasn't yet contacted the medical advising folks.	coming to understand the material rather than just memorizing like in high school. Enjoying chemistry more than she thought she would, considering adding biochemistry double major as it's not that much more work	She has friends in the major and wants to start a group to support other women in STEM. Sees chemistry as something she will continue studying and something that will get her to med school.	and opportunities both to thrive academically and socially. Doesn't love dorm life but even in her tough times says she wouldn't want to be anywhere else.	the actual content, feels well supported. Needed some pushing to stay in after first struggles, but she's here now. University: Started high but it's higher now. She said she could see herself being happiest here and I think she was right.
Year 2	Frustrated with a few of her classes, and their professors. Overall happy with the rest of the professors though. Looks up to them as role	The STEM sorority she helped start is doing well and helping her make more friends. She has a close group of friends from her classes in chemistry,	Wishes she had worked with the health professional advisors earlier, they've been really great to her. Gets a lot of emails and communicati	Loves chemistry content to pieces, has come to embrace her nerdiness because of it. Considers herself a chemist and would even once she's	Very very strong. Loves chemistry to the point o being a bit self-conscious about it. Looks up to her professors and the senior	Don't know how it gets much higher than "I love it here and I wouldn't want to be	Disciplinary: Growing still. She's embraced chemistry as part of who she is moreso than

	models and goes to them for help when she doesn't understand a concept. Health and general guidance advisors have been very helpful for her. Met a more diverse group of people in terms of interests than she had expected.	most of her non-chemistry friends come from the religious group, though she's less involved now. Feels obligated to do well because her parents are paying, though she would try hard regardless.	on about various opportunities, trying to find research on campus for the coming summer. If that doesn't work out, she's looking at local hospitals and doctor's offices for potential work experience. Trying to get a part time job as well.	become a doctor down the line. Views chemistry as the first step in a long education required for such a profession. Better more concrete understanding of what chemistry is all about this year than last, specialized classes have helped.	students as people she wants to be more like. Chemistry is her passion and she would absolutely choose it again. Some classes haven't been great, but she views them as minor downsides.	anywhere else." Has had some rough patches but felt supported through them. VT was her first choice and she would absolutely come back again.	previous years, it's a core part of her identity. University: Peaked, top the charts, how do you get higher from here. She loves it despite its downfalls and wouldn't want to be anywhere else even with the rough patches that it's come with.
Year 3	Research lab has taken a forefront in her life, feels very supported by the other students, the faculty involved, and one specific mentor.	Left the religious organization mostly behind in favor of her sorority and ultimate frisbee. Has re-evaluated her expectations of herself	Has a part-time job on campus now. Hasn't nailed down exactly what she wants to do, but her advisors have been helpful in showing her opportunitie	Really enjoys her classes still, a bit apprehensive about one dreaded biochem class but she's past it now. Sees chemistry in the world	Topped out. She couldn't imagine not being a chemistry major. She loves her friends, the professors, her sorority, her lab, everything. Has a few	Staying peaked. Loves everything about her school except the health center. Very supportiv	Disciplinary: Up to the top. Couldn't love chemistry any more if she tried, wants to share that love

	Finding more and more friends in her classes and now they're also forming study groups. Professors are still approachable and supportive. Some professors and her research group also do social events together as a community.	based on her dad paying for school to prioritize her own health and happiness more. Says that she has friends in all of her classes, making more of them through the sorority as well.	s. Her research labmates have also shown her a lot about what it means to be a graduate student and do further study. Sorority is the only professional org she's in, but she wants to join the chemistry club if she has time.	around her a little bit and thinks that a scientific way of thinking is practical, analytical, and focused on getting information before solving a problem. Research lab work has helped inform her on the importance of understanding before trying.	minor changes for some of the teaching methods and emphases, but overall very high. Feels like chemistry at this university has a uniquely strong supportive community. Hasn't made up her mind yet, but wants to continue in chemistry for sure.	e community, lots of good resources. Through all of her low patches she never felt like it was the university's fault, just something she would go through at any university due to the challenge.	with her eventual children even. University: Staying peaked. She doesn't want to be anywhere else and that hasn't changed since last year. Even points out that the rough patches aren't the fault of the university to begin with.
Year 4	COVID threw a wrench in her plans, she really struggled with not being able to always access her professors. Still felt supported by her professors,	Limited in her engagement due to COVID, but the sorority is still a core part of her life. She's got very close, lifelong friends from her major. Wishes she	Still involved with her research lab as much as she can be, was supposed to work there over the summer but COVID prevented that. Has maintained	Frustrated a bit with the senior year curriculum as the classes are specific and not related to what she wants to do. She likes organic chemistry the best and is pursuing	Just slightly below the top. The frustration about the curriculum in the fourth year is really the only detractor here. She's pursuing further study and loves chemistry	Staying peaked despite the challenges in the 4th year. COVID deflated some of her 4th year plans and definitely threw a	Disciplinary: Very slight dip, very very slight. Mostly just due to her wish that the curriculum could better suit her

	most did their best and recorded lectures were good for her. A few classes did not adapt to online as well. One professor was the best mental health support she got at the university, actually checking in on her when no one else did.	could have spent senior year doing more to develop her relationships but COVID said no. She had spent so much time working she wishes she could have done more. Family was instrumental in helping her afford college, this time in money from her grandmother's will.	her part-time job since she got it, a big part of helping finance her education. Lab group has helped her determine where she wants to go, no long aspires to be an MD, but now going for a PhD instead, so no health advising this year. Sorority is her professional group, one of her proudest accomplishments.	further study in it with a PhD at another university after graduation. Believes that the more she's learned the harder it gets to define chemistry because it's just so broad. Nonetheless sees the content more and more in her everyday life, views people as chemistry at their core.	still, she wouldn't want to do anything else as her major. The support from the chemistry department has been good and she has a core friend group in the major. Chemistry has helped shape her, taught her persistence and resilience through all of its challenges.	wrench in her engagement. There was a significant issue with out-of-state tuition where the university as a corporate machine snubbed her and hurt her experience. Even through that she wouldn't want to go anywhere else, nowhere else could have given her the same experience.	interests and not force a bunch of other branches of chemistry on her. University: No change, interestingly. Despite the massive stressor of the university snubbing her desire to pay in-state tuition instead (rudely, at that), she loved her time and what it taught her and the community it gave her. Wouldn't do anything else.

University Socialization

Pre-College	Year 1	Year 2	Year 3	Year 4
Visited campus with her brother and really liked the campus. It was pretty and all the people seemed really happy	Feels like she doesn't have very much control over how professors teach, she's only one voice and different professors might teach differently (F)	Does not like the one biochemistry professor she's worked with so far, he doesn't explain things very well (F)	Doing work in an organic chemistry lab for credit, has been for the past year (F)	Struggled with online learning, always someone who wanted to be in the professor's office hours, tried online but it wasn't the same (F)
	Will ask the professor about missed points if she doesn't understand why she lost them (F)	Likes to go to office hours, incentivized by getting feedback questions answered (F)	Talking with some of her friends and classmates who had taken classes before her gave her a better sense of preparation going into some of her classes (I)	Did enjoy the lectures being recorded though, she used to record lectures on her own so that she could review them even before online learning (F)
	Sometimes compares grades and talks to peers about feedback and grades (F & I)	Feels like professors make all of the necessary resources for academic success available (F)	When she didn't have class in the mornings, she would go to the library to study with friends (I)	Had an issue with one professor gearing the class more towards ChE students than the chemistry students (F)
	Chemistry lab professor is in her first semester teaching the class, so there's some inconsistency and struggles in terms of procedures and guidelines for assignments (F)	Sees her professors and those who have taught her as her role models, people she wants to be like in the future (F)	Has a research mentor in a post-doc in the lab who has been pivotal, supporting her, giving her advice, helping her learn. Has given her an idea	One class did not adapt well to COVID. Still required group work, but she didn't know anyone in the class and isn't comfortable reaching out or

			of what it looks like to be a PhD and opened some options for her future (F)	meeting up with them (F)
	Having similar teachers from first semester to second has made it easier because they're consistent in how they teach and what they focus on in tests (F)	Some of the classes foster connections between classmates. OChem for example only has biochemistry, ChE, and chem students, so that's a community in itself (F)	One of the new things this year is that she's made more friends in her major with whom she's formed study groups (I)	Had one professor take her aside and as if she was doing okay when she wasn't, really meant a lot when the rest of the university wasn't supporting her as well (I)
	Advisor has done a really great job of helping her find opportunities that will help her in the future (F)	Health professionals advisor has been really great, provided some advice when nobody else could on a niche topic (F)	Professors are open and willing to help students when they need it (F)	Has a separation in her mind between the professors and the university. The university to her is a corporate machine (Not socialization, just interesting)
	Department in general is helpful in providing opportunities for research and work experiences (F)	The types of people she's met have been more varied than she expected. Thought everyone would be nerds, but there are people in sports, the arts, etc. She welcomes it (I)	Gotten lots of support from her professors and the head of her lab especially (and even some grad students) in exploring options and learning about graduate school (F)	Professors have been very helpful in shaping what she wants to do, so were the grad students in her research lab (F & I)
	Has found that the quickest and easiest way for her to figure out difficult material is to go to her professors for	Guidance counselor was great, helped her feel comfortable with adding biochemistry because she was	Professor invited the chemistry students who were around over the summer to social gatherings to make sure they	

	office hours and ask questions (F)	nervous about it (F)	weren't alone, had a community (I)	
	Wishes that her peers would help her out a little bit when she's struggling, but she doesn't think they're expected to (F & I)		Her lab also serves as a social group, doing cookouts, lunches, etc. (I)	
	Only class/professor that she really doesn't like is sociology, professor assigns very long readings and purposefully makes discussions confusing		Her being in the minority (female) in chemistry has inspired her to work hard and go to grad school and encourage other women in STEM (F & I)	
	Consistently encouraged by the people around her to continue to work and that she can push through the tough times (F & I)		Advisor has done a great job emailing her with lots of opportunities on and off campus (F, professional as well)	

Personal Socialization

Pre-College	Year 1	Year 2	Year 3	Year 4
Didn't have good experiences with peers in high school, so she didn't want to go in-state where many of them would be going	Involved with a religious organization on campus that takes up a lot of her time on weekends for leadership training	Sorority is going well, making lots of new friends through it	Some of her best friends have been biochemistry majors, in addition to her chemistry friends, she has friends in all of her classes	Really enjoyed her living situation this year because it was some of her very closest friends
Finances for out-of-state were a bit tricky but her	Founding a chapter of a Women in STEM sorority on	Feels like most of her non-chemistry friends just kind	Founded the STEM sorority chapter which has given her	Not a lot of her friends, even in her majors, opted to do a

parents (names father) supported her to go if she wanted to go, which she did	campus with one of her friends	of zone out when she talks about chemistry, it's not their place to care about it, not relevant to them	another community on campus	poster presntation for their final project, it wasn't required or anything
Didn't like her chemistry teacher in high school but enjoyed learning the chemistry itself	Wants to get to know more people in her major, most of her network now comes from the religious organization	Has a close friend group in chemistry, they have a group chat and a bunch of classes together, they suffer through physics together	Got involved with the ultimate frisbee team as another social outlet	Has some persistent friend in chemistry, celebrated approaching graduation with them. Lifelong friends among them, really made classes feel doable, bonding though struggle
Had some really good teachers in high school, some very positive experiences that pushed her in the direction of wanting to teach, but the trip to Africa tipped her to wanting to help kids in a different way	Has some frineds in chemistry, mostly from her gen chem for majors class. They all do homework together	Forming the sorority has given her the chance to make a bunch of new friends	Involvement with the religious organization has petered out, she said they felt weird to be around after a while, not a cult, but something was off (Younglife do be that way, I know)	Growing up with brothers helped her feel like she didn't have to take any crap from guys around her
	Some friends from varied majors come from her residence hall	Less involved with the religious organization, but still carries over some friends from that	Feels like in the past, dad paying for her college meant that he had a say in what she would do. Has thought on it and realized that while, yes, that's	Reflects on some of her social engagements through the years: running club 1st year, but she doesn't like being told to run; religious

			still true, she also owes it to herself to be happy and succeed for herself	organization, but they weren't very nice to her; ultimate frisbee, great but stopped by COVID; sorority, the best thing for her
	Says that overall most of her friends are in STEM because they're all struggling through the first-year courses together	Feels obligated to do well and perform because her parents are paying for her education, wants to give them the money back once she has a job		Really wishes she could have spent more of her senior year developing her relationships more, but COVID stopped that
	Without her dad's help, she wouldn't be at VT to begin with	Meeting more people since she came to college has helped her figure out more about who she likes to associated with, which has helped her grow more confident		Funding school was really made possible this year by money left in the will of her grandmother
	Because they're financing her education, parents have a say in what she's studying and so she considered a switch to HNFE in the first semester but dad said no			Parents have been open and supportive to her, but she wanted to be independent this year
	Parents provided encouragement when she was struggling			

Professional Socialization

Pre-College	Year 1	Year 2	Year 3	Year 4
Went on a mission trip to Africa and met a woman who was a doctor that travelled the world interacting with and helping kids in needy areas. That inspired Chloe to want to become a doctor and help kids.	First-year experience class has exposed her to a lot of researchers and a few people in the medical field and pharmaceuticals. Helped broaden her perspective on what one could do with a chemistry or ChE degree	Talking to some local hospitals and doctors offices for potential work if her on-campus research search doesn't go well	Has gotten a part time job at a coffee shop, as she had been trying to do the previous year	Has worked her part-time job since she got it to make sure she could keep making money
	Plans to work with the health professionals advising, but has not yet had the time to go	Trying to get a part time job on campus at a coffee shop so she can make some money	Only professional organization she's in is the sorority she founded, ended up being a lot of work	Was supposed to work in her research lab over the summer but COVID prevented that
		On an email list for a professional health group, wants to get more involved but hasn't been able to yet	Considering joining the chemistry club and helping with their outreach programs	STEM sorority is one of her proudest achievements, one of her favorite things, and remains the only professional society she's a part of
		Gets a lot of emails aobut job opportunities and internships, research opportunities, etc.	Health professions advising has been helpful for developoing her resume and supporting her	

		Health professionals advising has been very helpful to her, wished she had started going earlier. The woman she met was very encouraging.		

Perception of Discipline

Pre-College	Year 1	Year 2	Year 3	Year 4
Took IB chemistry in high school and enjoyed the content, even if the professor wasn't great	Really enjoying what she's learning so far, despite tough experiences with the professor in high school	Fully tacking on the biochemistry double major this year, as well as a Spanish minor	Not sure if she wanted to do biochemistry because of one dreaded class, but thinks it's a lot of good information relative to what she might be interested in	Frustrated with the content of her classes this year because to finish the degree she had to take a bunch of classes that had nothing to do with what she wants to do in the future
Felt like chemistry was a good route to go pre-med, which is what she wanted to do	Considering a double major in biochemistry because one of her professors talks about how chemical processes affect the body	Enjoying the more specialized classes, they're turning out to be very different from what she learned in her general chemistry first year	Research in the lab has helped make the importance of understanding reactions more clear: you have to be able to predict the outcome, you can't just randomly try things	Gunning for a PhD in organic chemistry, says she's starting it right after 4th year at a different university
Says she probably didn't actually understand chemistry in high school, just pretended to	Biochem double major wouldn't be substantial extra work	Experience in biochemistry classes so far has been pretty frustrating, feels pointless	Sometimes will think about day-to-day processes in terms of the chemical reactions taking place	Focus is once again on prediction, if you understand a reaction you can predict how it's going to function in application. Lab work helped show her that.

Chemistry in high school was more about memorizing what her teacher said and regurgitating it, never fully understood what was going on	Enjoying chemistry much more than she thought she would, even if it's hard and she doesn't always get the grades she wants	Chemistry revolves around understanding reactions so that said reactions can be applied in appropriate ways, and manipulated as needed	Feels like the major has trained her to approach the world in a very analytical/factual way, trying to bring in as much information as possible before solving a problem	Has started to see chemistry more and more. Thinks people are fundamentally chemistry from illness to reactions in the brain to hormones and basic body functions
		Sees some chemistry in her day-to-day life, understanding how things are structured and some material properties		Feels like science gives you a jump start in thinking analytically in problem solving
		Would consider herself a chemist still even if she became a doctor because it's a way of looking at things, trying to find answers		The more she's studied, the harder it is for her to define "chemistry" as a field because there's so much more to it
		Views her objective of being a doctor as something that requires a lot of time in school, chemistry being the first step		Feels like it's hard to go anywhere in chemistry without a graduate degree

Disciplinary Sense of Belonging

Pre-College	Year 1	Year 2	Year 3	Year 4
	Somewhat surprised that she likes chemistry as much as she does and that she wants to add biochemistry and everything	Feels like a chemist now, one day hopes to be someone who has graduated and knows lots of the cool things she sees senior students talking about	Chemistry feels very close-knit, the professors are open and willing to help, she has her chemistry friends, feels like the community is potentially unique to this university's chemistry department	Chemistry has really shaped who she is, it has challenged her at every turn but has taught her resilience and perseverence, and the more difficult it has gotten, the more doors it has opened she feels
	Feels like the diversity isn't great, but that the atmosphere is open and welcoming enough	Really passionate about chemistry, feels a little bit self-conscious about it	Aspires to be a doctor eventually, but is considering a master's a PhD in chemistry along the way. Still hasn't made up her mind about exactly what she wants to do	Retrospective is that she thinks she would have said that it sucked each previous year (especially first year), though she hasn't
	Chemistry is something that she enjoys and something she can see herself doing to get a degree and get into med school	Finds role models in the professors and those who taught her	Wants to have met someone and started a family, wants to raise the kids to love chemistry	Chemistry definitely plays a role in who she sees herself becoming in the future, chemistry gives her an affirmation that she is strong and smart and can do whatever she puts her mind to
	Despite rough performances and having some self-doubt about why she was studying	Chemistry has helped her embrace her nerdiness and how much she	A little bummed by the lack of female faculty in the chemistry department, only	Overall, chemistry department itself has been good, staff support the students, professors

	chemistry, she was enjoying what she was learning	likes the content, used to think it was weird	had one in the first year and she wasn't a core professor. Doesn't bother her per se, just something she noticed	help create community, etc. Occasional condescension, but it comes with the job, she says
	Would choose to study chemistry again	Overall happy with her classes, a few frustrating ones, namely physics, biochemical calculations, and biostatistics, but to her they're "little specifics"	Overall very satisfied with the chemistry department, thinks there could be a few minor changes to a few classes, maybe more clearly highlighting the key takeaways from the classes, but it's good	Overall diversity is pretty good for her, women and PoC are definitely minorities but thinks the sciences are generally more diverse, especially with international students
		Absolutely sold on doing chemistry again given the opportunity	"I couldn't imagine not being a chemistry major", would choose again 100%	Frustration in senior year definitely brought down her love of the chemistry program, but she appreciated getting exposed to the various domains of chemistry

University Sense of Belonging

Pre-College	Year 1	Year 2	Year 3	Year 4
Decided on VT because between her two top choices it was really the one where she could picture herself best and saw herself being the happiest	Really enjoying her time on campus. Likes to come back, having a lot of fun, lots of friends and a beautiaful campus	Likes her housemates, likes living off campus much better than being on campus	Loves the school, feels like it has created a very supportive community.	COVID really ruined things for her. She had focused so much on school, saying "I'll do fun things senior year", now she's stuck in her house senior year
Ranking was a part of her decision between the two universities, but was less important than reputation as a good school (4th year interview)	Feels like the university has both given her the opportunity to learn and grow, but also make friends and do fun things that she wouldn't have been able to do if she hadn't come here	Very fond of the resources from the university in terms of health and counseling, but also for all of the social activities like intramural sports	Resources are great, apart from the health center, she's had poor experiences there	Very frustrating experience with VT this year. She's an independent this year, pays VA taxes, has an address, works, etc. Wanted to get in-state tuition, but they wouldn't give it to her. Handled it very poorly on their end, were somewhat disrespectful. Mader her feel like the institution didn't care about her.
	Really likes the surrounding nature and the opportunity for outdoor activities	Feels like it is her responsibility to make use of the resources the university provides and be a positively impactful member of the community	Loves the university, loves her friends, the school, the opportunities it has provided, and football	People at the university still cared for her, even if the institution itself felt like it didn't

	Overally very happy with her life on campus, only complaint is that she doesn't like dorm life much	Has had rough patches in university life, but overall "absolutely love"s it.	In all of her rough patches, never felt like it was the fault of the university specifically. Just that they were struggles that would occur in college anywhere	University is lacking in mental health support, went through some struggles and didn't find the help she needed through the resources available, says they're doing fine job but the counselling center needs more resources to begin with
	Even in the down times during her year here she says "she wouldn't want to be anywhere else"	VT was her top pick and she would absolutely choose it again. Going to be the person with all of the university merchandise, proud to be part of it and will display it proudly.		Tech did a good job of providing niches for her to find herself and not feel pressured to conform or join the organizations that everybody joins
	Would choose to go to VT again	"I absolutely love being here and I wouldn't change it, even with the lows of whatever has happened in the past three semesters."		Overall very satisfied with her university life over the last four years, feels like she fits into her own community that she had the chance to build
				Despite the tough moments (especially the tuition issue) she never felt like anywhere else would have been better. She would have been pulled

				in different directions, done different things, met different people. Couldn't have had the experience she had anywhere else.