Disciplinary Socialization in First Year STEM Students

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Abstract

Whether knowingly or not, students choose to become part of a disciplinary community when they choose their major. This membership comes alongside a set of written and unwritten rules, expectations, and responsibilities. The process by which students learn these membership requirements, referred to as socialization, is a socially driven affair. Students may gain this knowledge from peers, senior students, mentors, or faculty, all of whom constitute socializing agents. For many students, this process can begin before they even arrive at school through interactions with their parents, teachers, or college faculty. The purpose of this qualitative study is to investigate the role of interaction with socializing agents for first-year STEM students at a large research-intensive institution in the Southeast United States. Fifteen interviews from first-year undergraduate students from three STEM disciplines were analyzed to explore and compare experiences with disciplinary socializers. We found that there was a pattern of low engagement within the discipline across all three of the majors involved in the study, particularly with respect to professional organizations. The primary socialization that had impacted student decisions occurred prior to their enrollment in their major of choice. Having identified these patterns, further work must be conducted to understand the way forwards to foster effective socialization in the first year across all of the identified STEM majors.

Background and Objectives

Retaining students in STEM majors has remained a stubbornly difficulty issue for the collective STEM education community to address. Studies vary, but typically report that only roughly half of all students who enroll in science and engineering persist to the completion of their degree [1]. For underrepresented minority students, the estimates are even lower, ranging from eighteen to twenty-two percent [2]. Addressing this issue begins with the moment that students arrive on campus, as their first year can lay the foundation for their experiences as they proceed through their undergraduate careers. However, understanding the reasons that students might choose to leave their initial discipline requires an examination of why they chose that discipline in the first place. For many students, this begins well before they even apply to a university. Students might choose STEM due to alluring job prospects, pressure or encouragement from family members, or the recommendations of an instructor or counselor. Others might be following a passion for science or math, or using their undergraduate program as an intermediate step in their journey towards an advanced degree [3], [4]. Of primary interest for this analysis is the influence of person-to-person interactions that fostered students' interests in STEM. These interactions can be paramount in initiating and developing students' feelings of belonging within their eventual disciplinary community.

One approach to improving the retention of students across a wide variety of disciplines is to foster their sense of belonging within the disciplinary community. This phenomenon is reasonably well researched and a beneficial link has been established between stronger feelings of belonging and retention and other positive aspects of the students' academic experiences [5]. There have also been studies identifying a sense of disciplinary belonging as an important

component of students' academic identity [6]. What remains comparatively unclear to the impact of this sense of belonging is the process by which it is developed. Some work has been done to explore this space, identifying that instructional environments focused on the student and their understanding of content provide the best backdrop for the fostering of this sense of belonging [5], [7]. Outside of academic environments, however, there is little research that explores how a sense of belonging can be developed.

In order to consider students to be well and truly ingrained within their disciplinary communities, there is more to consider than whether they feel as if they belong. There are rules, expectations, and beliefs typically associated with these communities that must be gained in order for students to fully be welcomed into their discipline. The process by which an individual gains these requirements is known as socialization [8]. The socialization process is complex and highly individualized, varying for every student that goes through it. Despite this, there are some common themes that can be explored. Guiding this exploration is Weidman's [9] conceptual framework for understanding the socialization of undergraduate students, displayed below in Figure 1.
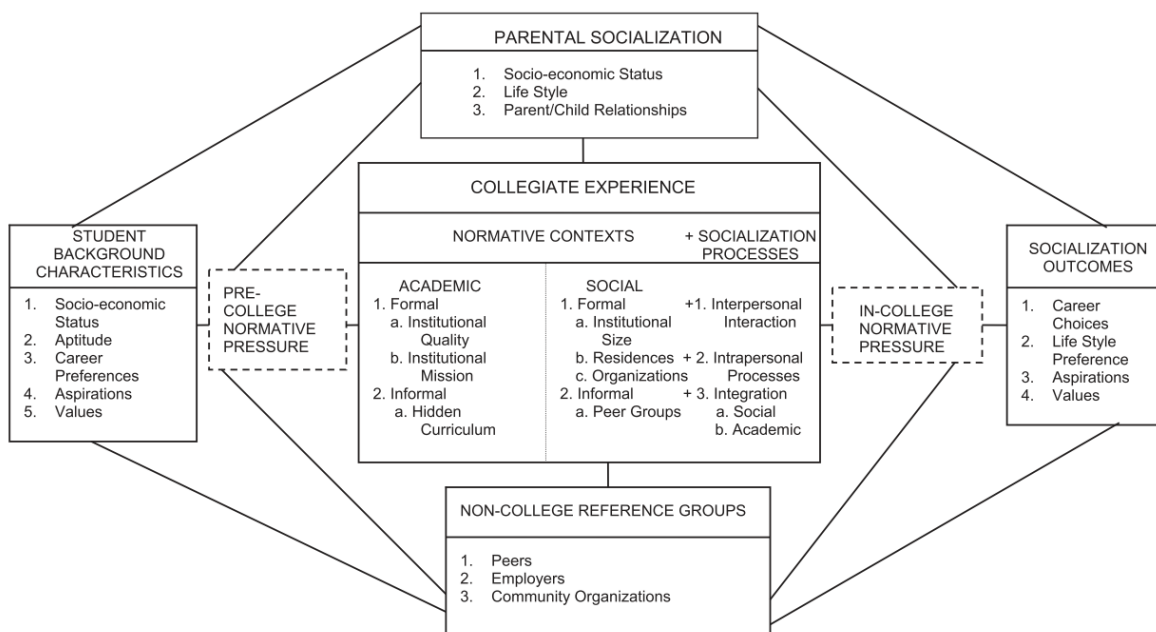
Figure 1: Weidman's [9] Model of Undergraduate Socialization

Socialization, as suggested by its root word, is a process that involves other people. These socializing agents can take many forms including mentors, family members, and peers, and all provide a necessary source of information regarding the nuances of their newly acquired role in their disciplinary community. When the opportunities to engage with these socializing agents are lacking in quality or frequency, student retention suffers [10]–[12]. These patterns have been established at both the graduate and undergraduate level, and the impact that socialization can have varies widely by institution and discipline [13]–[15]. This interpersonal interaction is one of Weidman's [9] three types of socialization processes crucial for undergraduate students. This

model also reinforces the individual nature of socialization, highlighting the influence that a wide variety of characteristics like socioeconomic status and personal values can have on the process. Using this conceptual framework as a guide, this study examines the interpersonal interactions within both the academic and social normative contexts for a variety of students in three distinct but closely related disciplines at a single institution. Interview transcripts from Biochemistry, Chemical Engineering, and Chemistry students will be analyzed in order to answer the following research questions:

1. What types of socializing agents do students engage with prior to arriving at their university and what impact, if one at all, do these agents have on students' choice of discipline?
2. What types of disciplinary socialization do first-year students engage in at their university and why choose these specific types?
3. What differences, if any, exist in the engagement with disciplinary socialization between first-year biochemistry, chemical engineering, and chemistry students?

Broader Project Background

This qualitative analysis makes use of an existing dataset that is part of a larger project involving six different universities equally distributed between the United States, United Kingdom, and South Africa. The research team for this project consists of faculty and graduate students from each of the three countries, with five of the six institutions having direct representation on the research team. This project is longitudinal, following mostly undergraduate and a handful of graduate students for four years, with interviews in the middle of the second semester of each year. The United Kingdom and South African data collection are one year ahead of the United States, in their fourth and third years respectively. The primary author became involved with the project in the second year of US data collection, the co-authors have been involved since the beginning of the US involvement.

Methods

Participants

The students that participated in this study were all interviewed in the second semester of their first year at the aforementioned Mid-Atlantic university. The study institution is a primarily STEM focused university. The participants were from three disciplines: three from Biochemistry and six each from Chemistry and Chemical Engineering for a total of fifteen students. All self-reported demographic information can be found in Table 1 below, along with the pseudonyms assigned to each participant.

Pseudonym	Discipline	Race	Sex
Seojun	Biochemistry	Asian	Male
Catalina	Biochemistry	Hispanic	Female
Robin	Biochemistry	Caucasian	Female

Kai	Chemical Engineering	Caucasian	Male
Drew	Chemical Engineering	Caucasian	Male
Hoa	Chemical Engineering	Asian	Female
Bret	Chemical Engineering	Caucasian	Male
Denny	Chemical Engineering	Caucasian	Male
Gabe	Chemical Engineering	African American	Male
Gail	Chemistry	Caucasian	Female
Isabella	Chemistry	Caucasian	Female
Finn	Chemistry	African American	Male
Harley	Chemistry	Caucasian	Female
Jian	Chemistry	Asian	Male
Elora	Chemistry	Indian	Female

Table 1: Self-Reported Demographic Information

Data Collection

The population for this study is a sample drawn from an existing dataset tied to a larger study encompassing six universities across three countries. In order to mitigate the potential variation caused by differences in university culture or curriculum, data from a single school was used for this analysis. Thirty-six first-year students from this particular institution were interviewed. These interviews were recorded and subsequently transcribed. Fifteen of these transcripts were selected via stratified random sampling to provide a sample representative of the self-reported demographic breakdown present in the larger overall dataset [16].

To generate the dataset from which this sample was taken, semi-structured interviews were conducted during the second semester of the participants' first year of study. The protocol for data collection was designed to gather broad perspectives on the students' experience in their degree up to the point of data collection. Students were asked to reflect on their choice of university and major, as well as their experiences with courses and assessment. Furthermore, participants were asked to speak about various aspects of their social experience thus far in their university career, including the disciplinary makeup of their friend group and their participation in disciplinary professional societies and other extracurricular activities. Interviews lasted approximately one hour each. The recordings were sent to a professional transcription service and were checked once more by the research team to ensure the accuracy of the transcript.

Analysis

The process for this analysis began with familiarization with each of the individual participant's interview transcript. Each was read first for accuracy of transcription and re-read for understanding. Once familiarity was established with each individual's case, the coding process

began. Descriptive coding was employed in order to capture the most notable overarching ideas in the data and organize them for later comparison. Particularly notable phrasings or quotations were coded In-Vivo in order to capture the inherently personal and unique phenomena that socialization and social interaction can be [17]. The codes established from the first few interviews analyzed were then applied to the rest of the dataset, with new or outlying codes being added to the codebook when necessary and appropriate.

Following the completion of the analysis of individual interviews, the codes that emerged were compared both within and across the disciplines. Comparisons between students within each of the three disciplines allowed for the formation of a more general image of what the socialization experience of a student in each looked like. Using these, analysis the comparison between each of the three disciplines could be carried out. Disciplines could be compared across each of the codes, allowing for the emergence of similarities and differences between each. These could then be interpreted further in an attempt to uncover why these might exist within the sample set.

Positionality

The primary author acknowledges a history of both positive and negative socialization experiences that had distinct influence on his own academic journey. He was trained as an Industrial Engineer and does not have any formal experience with any of the disciplines being examined in this study. Additionally, he has previously worked with both the first and second years of data collected from the overarching project as part of his graduate assistantship and coursework as a graduate student. His previous experiences with this data have partially guided his research questions and interests, but this work stands separate from his past efforts.

Results

The analysis of this set of interviews revealed several notable themes. These themes will be presented in the same order as the research questions that they most closely address. Examining the students' responses revealed a near unanimous emphasis on the *importance of pre-college socialization* in the decision process for both discipline and university. Moving forward to the start of the students' undergraduate studies, the most notable themes were the prevalence of *peers as socializers* and the unexpected *lack of participation in professional organizations*. Finally, to address the third research question, there was *no discernable difference* between any of the three disciplines involved in this study. Potential causes for this will be explored later on in the discussion section of this paper. For the sake of clarity in what students belong to which discipline, each major will be abbreviated as shown in Table 2.

Discipline	Abbreviation
Biochemistry	BCh
Chemical Engineering	ChEng
Chemistry	Chem

Table 2: Abbreviations for Each Discipline in Quotations

Importance of Pre-College Socialization

In tracing their path into both their institution and their discipline, students cited a wide variety of sources of pre-college socialization. Frequently their interest in STEM could at least be partially attributed to having an inspiring instructor during their studies in high school. Kai (ChEng) explains:

> I think most of my passion for chemistry comes from my high school teacher because he was so meticulous about it, he was so fair about it but, he had a process to it that I really admired and that really drove me to learn more about it.

Denny (ChEng) echoes this sentiment, citing "mainly AP chemistry. I had a good teacher" as the reason he "fell in love with it [chemistry]." Isabella (Chem) similarly cites AP chemistry as the source of her passion for her major. These instructors served to provide the students not just with the content knowledge they would need to continue with their studies in the field, but an interest and passion for it as well. Though not a chemistry professor, Seojun (BCh) cites his high school biology instructor for introducing him to CRISPR technology which catalyzed his interest in genetics and biochemistry in general. This exposure to positive disciplinary role models served to be crucial in each student's decision-making process, though these experiences did not exist in isolation.

Outside of the formal academic environment, many students still found sources of inspiration to pursue STEM. Several students attributed their disciplinary interests to familial influence in one way or another. Robin (BCh) explained that she had an uncle who studied Biochemistry and while she could not say exactly what he did in his job, she found his example comforting as it showed her that "there's lots of places to move up with a degree in biochemistry." The familial influence came from a variety of sources, as Bret (ChEng) highlighted the influence of a cousin on his decision making:

> My cousin's a chemical engineer, so I talked to her a little bit about what a day in the life of a chemical engineer looks like and I thought it was really cool. So if I didn't want to go to med school at the end of all this, chemical engineering sounds like a really cool opportunity.

Following a similar path as Bret, Finn's (Chem) interest was piqued by the usefulness of chemistry in pursuing a medical education. He shared that "Science as a whole has always been something I'd liked from elementary school just because my dad was a dentist. I always found that if I wanted to be a dentist I have to be good at science." While his interest in dentistry faded over time, the established passion for chemistry remained. Similarly to the influential instructors, family members generally served as positive role models in the discipline. One notable outlier to this pattern was Drew (ChEng). Drew's interest in the field of chemical engineering was spawned from a particularly memorable instance of perceived incompetence:

> My dad, he had stage-4 kidney cancer. He wasn't supposed to live past two years, and six years later, he's cancer-free, and they've used the term miracle in the office, but I mean I'm sitting there at some of the doctor's appointments and

my dad would ask some questions about some of the medicines that he's on, and I mean this is a world renowned cancer doctor, and he's sitting there and he says, he shrugs his shoulders like, "I don't know.", and we're sitting there and like really? Here it is, he's professional and he's sitting there shrugging his shoulders like, "I don't know what this is supposed to do to you. This is just a trial. We're going to see where it goes.", and to me that's frightening.

Peers as Socializers

In some capacity this theme overlaps with the previous one, though in the precollege context the majority of the demonstrated influence that friends or peers had was on choice of school, rather than discipline. Both Kai (ChEng) and Catalina (BCh) cited friends attending the institution as a major contribution to why they chose to attend as well. However, once the participants began their undergraduate studies, their peers became similarly developing members of their disciplinary community, subsequently becoming socializing agents themselves. Catalina (BCh) valued her ability to participate in the research project for this reason, stating that "I like contributing to research experiences like this so that people can help the curriculum get better, maybe engaging in more opportunities and events." This was the only outright mention of a student acknowledging their role as a socializing agent, though there were many examples of students finding inspiration from others like them.

Many of the participants were more than happy to talk about the composition of their friend group, and the overwhelming majority shared that most of their friends were also from STEM majors. However, being the first year of their studies, many attributed this to their living situation over them directly seeking out other STEM majors. Drew (ChEng), Robin (BCh), Harley (Chem), and more pointed to their residence hall as the source of their friends. A unique challenge for Biochemistry majors was highlighted by Seojun (BCh) in this regard, however. He shares that he does not have many friends from his major, explaining "I guess that's just chance 'cause I know biochemistry isn't that overwhelmingly popular, 'cause it's a bit of a more specific or niche major." He laments that Biochemistry is not as sizable as engineering, hoping that "eventually biochemistry will become just as big as engineering someday." Despite this, he is like many others in being part of a STEM-dominant friend group.

Finn's experience highlights the primary role of peer socializing agents at this stage of study from his perspective: homework help. He explains, "Obviously the chem major friends are from class, and whenever I need help they're there. I've grown closer with them." Class is the second most commonly cited source of friends, as Kai (ChEng) corroborates. Other than the residence hall and class, friends came from a variety of sources. This included the marching band for Gabe (ChEng) and fraternity life for Denny (ChEng). One experience of note, however, was Bret's (ChEng), where in he shares that "I haven't met many of my friends through engineering functions, it's been through other functions." This emphasizes a lack of opportunity for socialization through events either promoted by or surrounding engineering topics, which may explain the prevalence of the other sources for disciplinary friends.

Lack of Participation in Professional Organizations

One of the ways for undergraduate students to establish connections to their broader disciplinary community is through participation in a professional organization. These exist for a wide variety of disciplines and serve to provide connections between industry professionals, researchers, students, and faculty alike. Student chapters exist for many of these organizations and at the study institution, there are student chapters of the American Institute of Chemical Engineers (AIChE) and the American Chemical Society (ACS). Though there is no student chapter for a Biochemistry organization, though there is an established club for Biochemistry students. In addition to these formal organizations, there are also professional fraternities for both Chemistry and Chemical Engineering. Several students also mentioned labs that were dedicated to work in the various disciplines. Despite the plethora of available options, the striking trend in the data was a near-unanimous lack of involvement in any of them.

Students were asked about their choice and provided a variety of reasons for not joining professional societies. Finn (Chem) was blunt, explaining that he hadn't joined any professional groups because of his own laziness. "That's about it," he shared, "I just tell myself I don't have time for it." Though not as direct, Kai (ChEng), Drew (ChEng), and Gabe (ChEng) similarly cited a lack of time or energy as their primary reason for staying away from their respective organizations. Gail (Chem) and Isabella (Chem) both pointed to a lack of information about ways to become involved, with Isabella explaining:

> I just haven't really heard that much about it. I don't really know what the professional groups are at all and I don't know how to go about looking for it. I could probably look online and stuff like that, but again, I just came into this major so it's a little bit new for me. I knew what some of the professional groups were in the College of Agriculture Science; I know what the professional sorority was in that one. I just don't know if there's a chemical fraternity or specialty group like that.

This perspective highlights an important point regarding professional organizations. They are far from the end-all be-all of engagement with one's disciplinary community and are certainly not the silver bullet to the issue of attrition. Isabella is not involved in a professional society with respect to her major, but she does participate in a Pre-Veterinary club. In a similar vein, Bret (ChEng) is engaged with a medicine-oriented organization. These indicate early interaction with a disciplinary community that each student aspires to become more involved with once they have completed their undergraduate studies. Bret goes on to elaborate that his participation in the medical club and his other extracurriculars are satisfactorily beneficial for his growth as a student. With respect to a Chemical Engineering organization, he explains "I just haven't really felt the need yet. I think maybe when I get into the meat of chemical engineering it would be a little more relevant because you'd be around the people that you're struggling with to pass."

In the sample used in this study, only one student mentioned engagement with a disciplinary professional organization. Harley (Chem) created a STEM sorority with several friends to help other girls in STEM find a community of individuals like them. She explains her motivations:

I just thought it'd be a good way to help girls in STEM that aren't in a sorority or anything to improve their knowledge of chemistry and the STEM majors. I thought that was really, really good and it's a good resume builder, but I don't just want to say that. But it will… it feels like it empowers women in the STEM major to continue to do what they want to do.

Discussion

The analysis of this data has led to the unearthing of several patterns with respect to first-year undergraduate STEM students' experiences with disciplinary socialization. The first is the sheer variety present in the types of socializing agents. While the focus in this paper was on peers, family, and pre-college instructors, this was only a glimpse at the breadth that students spoke to in their accounts. Individual students mentioned tutors and mentors as sources for inspiration in their academic pursuits. The latter came in several forms, whether individual or group, and often overlapped with other classifications of socializing agent like professors or senior students. Some students spoke about interactions they had with a professional chemist or engineer and the impact that this had on their journey. Drew (ChEng) shared that his love for Chemical Engineering bloomed from speaking to a factory manager, having been initially sparked by his unhappiness with his father's medical care. Regardless of the type, every student was able to name numerous agents that were crucial in shaping their academic development. Beyond the scope of the choice of major, socialization also had a notable influence on students' choice of institution. While this was not the emphasis of the analysis, it became clear nonetheless.

There are two primary takeaways from these findings. First, the socialization process is incredibly diverse and does not function the same for any two students. As Weidman [9] highlights, there are a plethora of factors that affect a student's interests, opinions, and attitudes well before they arrive at college. Subsequently, there is no universal solution for students who find themselves feeling isolated or left out of their disciplinary community. Some, like Robin (Chem) and Kai (ChEng), simply feel like they do things better on their own. Others might feel overwhelmed by the curriculum and not have the time or energy to devote to becoming actively engaged. This finding is not new in socialization literature, but instead reinforces a well-documented idea e.g. [9], [18], [19].

The second takeaway addresses the corresponding research question. Students take advantage of the types of socialization that are most readily available and convenient to them more frequently than those that require the expenditure of a greater amount of effort. As could be seen in numerous students' accounts, friends came from classes and residence halls, rather than efforts to establish connections with fellow members of the discipline. Few students spoke about making use of tutoring or office hours for classes and only one was actively engaged with a professional organization for their discipline. This indicates that while opportunities for socialization are readily available, they are not necessarily accessible. Arriving at a university is an incredibly stressful experience for many students, wherein they are expected to rapidly adjust to a new lifestyle and environment. At the same time, they are subjected to a deluge of information regarding academics, expectations, and social and professional opportunities. By examining the experiences of first-year students specifically, the effects of this chaotic transition can be directly

studied. Based on what can be seen, the issue limiting socialization is not the number of opportunities, but instead the difficulty in fitting them into undergraduate life. Further work is needed to understand how this can be best addressed.

The final research question is the most difficult to address, as it is also the most complex of the three that this study sought to address. As mentioned in the results, the analysis of this sample revealed no discernable difference in the socialization experiences for Chemistry, Biochemistry, and Chemical Engineering undergraduates. Friend groups were established in similar, highly individual ways. The pre-college experience of the students often pointed to chemistry teachers, regardless of discipline. Seojun (BCh) was alone in indicating the influence of an instructor from another discipline, and this hardly constitutes a disciplinary trend. The almost universal lack of participation in professional organizations also spanned all three disciplines, though Biochemistry students are at an inherent disadvantage in this regard given the lack of a student chapter for any national organizations. Across all of the primary vectors of analysis employed in this study, the labels could have been removed from each of the students and the results would have remained largely the same.

A finding like this must be considered with respect to the context in which it is found. Many of the students admitted that even in the midst of their second semester they were still working to adjust to their newfound university environment. Several expressed interest in engaging further with their disciplinary community more in later years once they felt more established or had more time. Simply put, the students have only been members of their disciplinary community for a very short time. Had these interviews been collected even at the end of their first year, the responses may have been different. This does not diminish the importance of the lack of difference, however, as it indicates a struggle for disciplinary communities to welcome new members quickly and efficiently. Returning to a previous issue, accessibility is limited early on, which must be remedied in order to improve the early-career socialization experiences. On the same note, the indiscernibility of accounts from different disciplines indicates that the various majors do not establish a strong unique identity in the first year of study. Academically this could be attributed to the curriculum including general requirement courses like calculus and physics in the first year, but further analysis would need to be done to explain this satisfactorily. In the social sphere, it is evident that student experiences are not definitively shaped by the disciplinary community they have chosen to join, instead favoring residence halls and extracurricular activities this early in the undergraduate career.

Future Work

As previously mentioned, the overarching study from which this dataset was taken examines the experiences of undergraduate students longitudinally across their entire time at each of six institutions. Data is already available for the second year of study for the students analyzed in this study and the third-year data collection is recently concluded. Performing an analysis on the second, third, and ultimately fourth year data addressing the second and third research questions from this study could provide valuable insight into the socialization process as it progresses. This is of note particularly in identifying whether there is a difference in socialization experiences

across disciplines as students begin to specialize and take more classes within their specific major.

In the grand scale of this project, there is room for a great deal more analysis. Where this analysis focused on differences across disciplines, the focus instead could shift to examine differences between the socialization experiences of students of different sexes or racial identities. The data for this project also involves three different countries, allowing for a cross-national analysis of disciplinary socialization and identity. Continued engagement with the student interviews from this project will provide the basis for the eventual development of a longitudinal model of socialization for undergraduate STEM students, drawing upon the varied contexts available in the scope of the study.

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