Unraveling the Complexities of Science Identity Development among First-generation College Students in Learning Assistant-Supported Introductory Science Classes

By

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DEDICATION

To my late father, Sylvester Ayangbola,

Your unwavering support and belief in my potential have always been my guiding light. You laid the foundation for my academic journey, and this work is a testament to your enduring influence and the values you instilled in me. Your memory continues to inspire me to strive for excellence and to persevere in the face of challenges. I dedicate this dissertation to you with love and gratitude.

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Finally, to God, my Abba, for His unconditional love, unending grace, and unchanging fellowship.

ABSTRACT

This dissertation investigated the science identity development of first-generation college students (FGCS) within learning assistant (LA) -supported science classes. The research aimed to uncover the complex and multifaceted processes through which FGCS come to see themselves as "science people" and how various elements of the educational environment influence this identity development. Conducted through three interrelated studies, this dissertation integrates identity theory with a science identity framework within an interpretivist paradigm to provide a comprehensive understanding of the personal and contextual factors at play.

Manuscript 1 explored the initial perceptions and descriptions of a particular group of FGCS. Findings revealed that these FGCS described a "science person" through the lens of nature-identity, viewing scientific capability as an inherent trait. Participants often believed that being good at science was something innate rather than a skill that could be developed. This mindset posed a significant barrier to their self-identification as science people.

Manuscript 2 examined the impact of LA-supported learning environments on FGCS science identity development and what factors within the learning environment impacted their science identity. The study revealed that vicarious experiences, verbal recognition, and mastery experiences provided by LAs significantly enhance FGCS science identity. Key factors within the learning environment, such as collaborative group work, peer teaching, engaging course material, and a supportive classroom atmosphere, are crucial for positive science identity development.

Manuscript 3 provided a detailed narrative of Tea, a nontraditional FGCS, highlighting her science identity trajectory over a semester. Tea's journey highlights initial challenges, such as self-doubt and feelings of isolation, which were mitigated through consistent support and encouragement from her LA. Tea initially described a science person using nature identity, attributing scientific ability to innate traits. However, through her interactions with LAs, Tea's perception evolved. The manuscript highlighted Tea’s science identity trajectory and the factors supporting her development. Findings highlight the importance of mastery experiences, verbal persuasion, and a growth mindset in fostering science identity.

The findings from these studies collectively emphasize the significant role of supportive educational environments in the science identity development of FGCS. The dissertation contributes to the field by highlighting the critical role of LAs in creating inclusive and flexible learning environments that foster a sense of belonging and engagement among some FGCS. Practical implications for practice include adopting and enhancing LA programs and adopting inclusive learning environments, which is in line with the most recent recommendations for evidence-based teaching broadly. Future research directions are suggested to explore supportive learning environments further as a construct that impacts science identity.

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Introduction

The pursuit of STEM (Science, Technology, Engineering, and Mathematics) education has been identified as critical for fostering innovation and addressing global challenges (Fayer et al., 2017; Xie & Killewald, 2012). STEM education is crucial for developing the skills and knowledge necessary to tackle some of the world's most pressing problems, from climate change to public health crises (Bybee, 2013). As technological advancements continue to reshape our world, there is an increasing demand for a workforce that is proficient in STEM fields (Goldin & Katz, 2008; Riegle-Crumb et al., 2010). However, to fully harness the potential of STEM, it is essential to ensure that this workforce is diverse and inclusive. The journey through STEM fields is often riddled with obstacles, particularly for first-generation college students (FGCS) leading to higher attrition rates (Chen, 2009; Engle & Tinto, 2008; Ives & Castillo-Montoya, 2020). FGCS are a growing demographic in higher education. These students, who are the first in their families to attend college, can bring unique perspectives and strengths to their academic pursuits. Some of these students exhibit levels of resilience, determination, and resourcefulness, having navigated complex educational landscapes with limited familial guidance (Garrison & Gardner, 2012; Havlik et al., 2020). Despite these strengths, FGCS face unique challenges in developing a science identity, and this can hinder their academic success and persistence in STEM fields.

Science identity, defined as the recognition of oneself as a "science person" and being recognized as such by others, is a pivotal factor influencing persistence and success in STEM disciplines (Carlone & Johnson, 2007). Educational interventions, such as the Learning Assistant (LA) program (Otero et al., 2010), play a crucial role in supporting FGCS in STEM. The LA model involves experienced students who assist their peers in learning and understanding complex scientific concepts. This peer-led support enhances academic performance and also fosters a sense of belonging and community (Barrasso and Spilios, 2021; Van Dusen, 2017) which may potentially be beneficial for FGCS. By providing relatable role models and creating collaborative learning environments, the LA program can help FGCS develop a strong and positive science identity. This dissertation aims to understand the science identity development of FGCS in Learning Assistant (LA)-supported science courses, focusing on their experiences, perceptions, and the impact of supportive learning environments.

Statement of the Problem

FGCS encounter barriers that hinder their integration into the scientific community. These difficulties include a lack of familial guidance in navigating higher education, financial pressures, and feelings of isolation and self-doubt (Carrigan et al., 2019; Chang et al., 2020; Jehangir, 2010; McCallen & Johnson, 2020). Despite their potential, FGCS struggle with the perception that they do not belong in science, which can adversely affect their academic performance and career aspirations in STEM fields (Garriott et al., 2017; McCallen & Johnson, 2020; Stephens et al., 2012). Existing literature highlights the importance of science identity in educational outcomes, such as students' achievement in STEM fields, yet there remains a gap in understanding how FGCS develop a science identity, particularly in environments designed to support their learning, such as LA-supported courses. This gap necessitates an in-depth exploration of FGCS experiences to understand factors that can enhance their science identity and promote their persistence in STEM.

Purpose of the Study

The overarching goal of this dissertation is to understand how first-generation college students in LA-supported science classes experience science identity development. By conducting three distinct but interrelated studies, this dissertation seeks to:

1. **Explore Perceptions and Descriptions of Being a Science Person:** The first study (Manuscript 1) delves into how FGCS perceive and describe what it means to be a "science person," uncovering underlying barriers and contributing a nuanced understanding of their initial science identity perceptions.
2. **Examine the Impact of LA-Supported Learning Environments:** The second study (Manuscript 2) investigates the role of LA-supported science courses in enhancing FGCS's science identity, focusing on the interactions and factors within the learning environment that contribute to positive identity development.
3. **Trace the Trajectory of Science Identity Development:** The third study (Manuscript 3) follows the science identity development of a first-generation student over a semester in an LA-supported introductory biology course, providing a narrative of personal growth and the transformative impact of consistent support and encouragement.

Through these studies, this dissertation aims to provide insights into FGCS's science identity development, highlighting the importance of supportive learning environments. The findings are expected to inform educational practices and policies that foster inclusive and empowering environments for FGCS, ultimately contributing to their success and persistence in STEM fields.

Theoretical Framing

This dissertation is grounded in interpretivism, which posits that reality is socially constructed and understood through subjective experiences and interactions (Schwandt, 1994). Interpretivism emphasizes the importance of understanding the meanings and interpretations individuals ascribe to their experiences. In the context of this research, interpretivism provides a lens through which to explore the science identity development of first-generation college students (FGCS) by focusing on their personal narratives, interactions, and the socio-cultural contexts in which they learn. Also, throughout this work the following assumptions are made as described by Kim & Sinatra (2018): (1) that all individuals have the potential to develop a science identity; (2) that science identity is a process that develops over time; and (3) that the interactions between an individual and their surroundings influence their science identity development (Kim & Sinatra, 2018).

Identity Theory

Identity is generated at the boundary between society and the individual (Archer, 1994). To understand identity, one must keep both the dynamics of the individual and that of social organization in consideration. An individual’s identity is formed and shaped by interactions with others in society, and those interactions influence the character of society. In identity theory, identities are constantly evolving and continuously changing. Identities are the outcome of continuous reproduction (Elmesky & Seiler, 2007). They are perpetually being formed and reformed. Identity theory, as proposed by Gee (2000), is a framework that explores how individuals construct their identities through participation in various social practices. Gee (2000) describes identity as what it means to be a certain kind of person. That certain kind of person possesses one or more identities that dictate how they respond to situations in which they find themselves. For this study, it provides a useful lens through which to explore how FGCS perceive and describe what it means to be a "science person." Gee's model categorizes identity into four types: Nature-identity (N-identity), Institution-identity (I-identity), Discourse-identity (D-identity), and Affinity-identity (A-identity). These categories help to explore the various dimensions of science identity. For study 1, I used Gee’s identities adapted to the science identity perspective to provide a framework for the thematic analysis of the data, which resulted in themes that align with Gee’s N-, A-, and D-identities with a science identity perspective.

Operationalized Science Identity (OSI) Framework

While Identity theory provides a broad view of describing science identity, the OSI framework provides a more detailed approach to understanding it. The Operationalized Science Identity (OSI) Framework, introduced by Hosbein and Barbera in 2020, offers a comprehensive approach to understanding what shapes an individual's science identity. According to this framework, five crucial constructs contribute to developing science identity: mindset, situational interest, verbal persuasion, vicarious experiences, and mastery experiences. Studies 2 and 3 employ these five constructs of the OSI Framework to provide a detailed understanding of how various factors contribute to developing a strong science identity among FGCS.

Research Questions

The overarching research aim for my dissertation is to investigate the question: How do first-generation college students in LA-supported science classes experience science identity development? To answer this, we attend to the following research questions:

1. How do first-generation college students perceive and describe what it means to be a "science person"?
2. What is the perceived impact of LA-supported science courses on the science identity development of first-generation college students?
3. How does the science identity of a first-generation college student evolve over a semester in an LA-supported introductory biology course?

Structure of the Dissertation

The dissertation is structured as follows:

- **Chapter 1: Introduction**: This chapter provides the context, statement of the problem, the purpose of the study, research questions, and theoretical framework.

- **Chapter 2: Manuscript 1**: Presents the first manuscript, exploring perceptions and descriptions of being a science person among FGCS.
- **Chapter 3: Manuscript 2**: Presents the second manuscript, examining the impact of LA-supported learning environments on FGCS's science identity.
- **Chapter 4: Manuscript 3**: Presents the third manuscript, tracing the trajectory of science identity development of a first-generation student in an LA-supported course.
- **Chapter 5: Conclusion**: Synthesizes the findings from the three studies, discusses implications for practice and policy, and suggests directions for future research.

Positionality

As a female international doctoral candidate specializing in Chemistry Education, my research endeavors revolve around the experiences of first-generation college students in introductory science classrooms. While I am not a first-generation college student myself, my role as an observer and investigator in this context is deeply informed by my background and experiences. I recognize that my position as an international student who has navigated the intricacies of higher education affords me a unique perspective on the challenges and opportunities that come with pursuing academic goals in a foreign context. My own journey through higher education has sensitized me to the complexities of adapting to unfamiliar academic environments, which can be similarly experienced by first-generation college students. It is essential to acknowledge that my personal background may influence the framing of research questions, the interpretation of findings, and the development of insights throughout this study. While I approach this research with a commitment to objectivity and impartiality, I am aware of the potential biases that may arise from my own experiences. To mitigate the influence of my positionality on this research, I actively engaged in reflexivity throughout the research process. This means I continuously reflect on how my identity, experiences, and assumptions may shape the research. Additionally, I sought out diverse perspectives, particularly those of my advisors, to provide feedback on my work. This helped ensure that my interpretations and conclusions were grounded in the experiences and viewpoints of the students themselves.

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Manuscript 1: Exploring Science Identity Among First-Generation College Students: Perceptions and Descriptions of Being a Science Person

ABSTRACT: This study explored how first-generation college students (FGCS) perceive and describe what it means to be a "science person," aiming to uncover underlying barriers to their science identity development. Data were collected through semi-structured interviews with eleven FGCS enrolled in General Chemistry I and General Biology I. Thematic analysis identified three major themes: Personal Science Identity Traits, Positional Science Identity, and Participatory Science Identity. The findings reveal that these FGCS perceive a "science person" as someone with a natural curiosity and passion for science, recognized by formal roles within the scientific community, and actively engaged in scientific practices. This research contributes to the literature by providing a nuanced understanding of the initial perceptions of a science person for FGCS, filling gaps in existing studies on science identity. The implications for practice emphasize the need for educational institutions to enhance targeted support and create inclusive environments that value diverse definitions of a "science person." Future research should explore the evolution of these perceptions over time and the impact of various interventions on the science identity development of FGCS.

1. Introduction

Students often have stereotypical perceptions of scientists (Archer et al., 2010; Aygun & Celik, 2022; Finson, 2002; Ivgin et al., 2021). Understanding the perceptions of first-generation college students (FGCS) on what it means to be a "science person" is crucial in understanding their science identity development. Science identity, or how individuals perceive themselves in relation to science and identification with the scientific community (Carlone & Johnson, 2007), significantly influences students' engagement, persistence, and success in science disciplines. Understanding the formation of science identity among FGCS is important for addressing the unique challenges and barriers they face in STEM fields. FGCS often confront distinct obstacles in higher education, including limited access to resources (Pascarella et al., 2004; Pratt et al., 2019), lack of familial support (Canning et al., 2020; Mendez et al., 2022), and cultural dissonance within academic environments (Atherton, 2014; Reid & Moore, 2008). These challenges can be particularly pronounced in STEM fields, where developing a strong science identity is essential for success.

Previous research has highlighted that students' perceptions of scientists are often shaped by stereotypical images, which can impede their ability to see themselves as potential scientists (Krause, 1977; Chambers, 1983; Schibeci & Sorenson, 1983). The portrayal of scientists in educational materials also plays a significant role in shaping these perceptions. Studies have shown that textbooks and other curricular resources frequently reinforce stereotypes by depicting scientists as predominantly white, male, and isolated individuals (Barman et al., 1995; Chi et al., 2023; Kaur, 2015). These representations can deter students who do not identify with these images from pursuing science careers, thereby perpetuating a lack of diversity in STEM fields. Research on the Draw-A-Scientist Test (DAST) has consistently revealed that students, including first-generation college students, hold stereotypical views of scientists that solidify by the fifth grade and persist into higher education (Finson, Beaver & Cramond, 1995; Medina-Jerez et al., 2011). These stereotypes can negatively impact students' engagement and interest in science and their ability to envision themselves as scientists. Kaur (2015) synthesized research on students' perceptions of scientists, concluding that students consistently visualize scientists as individuals who "look a certain way (e.g., white males), may have idiosyncrasies (e.g., absent-minded), demonstrate certain habits of thought (e.g., objectivity), work in a certain manner (e.g., using special apparatus), and in certain surroundings (laboratories)" (p. 71).

Studies also show that the greater the perceived distance between students and stereotypical science role models, the less likely they are to engage with science or pursue science-related careers (Cakmakci et al., 2011; Dewitt et al., 2013). Additionally, these stereotypes can hinder the development of positive attitudes towards science (Meyer et al., 2019), reduce motivation to learn science (Finson, 2003), limit participation in science-related activities (Toğrol, 2013), and negatively affect science performance (Bang & Baker, 2013; Good et al., 2010) and future academic and professional choices in science fields (Cleaves, 2005). This study builds on existing research by examining how FGCS perceive and describe what it means to be a "science person," using Gee's identity theory as the theoretical framework. By exploring their narratives, we aim to uncover the factors that influence their perception and identification with science.

1.1 Focusing in on First-Generation College Students

FGCS are individuals whose parents did not complete a four-year degree and often face unique challenges, including academic preparedness and financial constraints (Chen, 2009; Engle & Tinto, 2008; Martinez, 2020; Pascarella et al., 2003). Research indicates that these students often experience a lower sense of belonging (Stebleton et al., 2014; Jantzer et al., 2021), influenced by factors such as perceived mismatches with the identity of a science person and cultural differences within academic departments (Metzger et al., 2023). Developing a science identity is crucial for the academic success and retention of first-generation students, emphasizing the need for targeted support programs and resources in higher education.

Despite the increasing enrollment of FGCS in higher education, more comprehensive research is needed to explore how these students perceive and construct their science identities. Most studies have concentrated on general barriers to success in STEM, such as academic preparation and financial constraints, without delving deeply into the identity formation processes specific to FGCS (Garrison & Gardner, 2012; Rick & Warren, 2021; Stephens et al., 2012). Conclusions from these studies often center around addressing the 'deficiencies' of FGCSs; however, this study explores how students describe this identity, which can be important to understand to foster positive perceptions they describe.

When first-generation students identify as "science people," they are more likely to feel a sense of belonging within the scientific community. This belonging can reduce feelings of isolation and imposter syndrome, which are significant barriers to persistence (Carlone & Johnson, 2007). A strong science identity can boost students' confidence in their abilities to succeed in science courses. This self-efficacy can encourage first-generation students to persist through difficult coursework and seek help when needed (Hazari et al., 2010). Understanding how these students perceive and describe their science identities is crucial for promoting inclusivity and diversity within STEM fields. By examining how FGCS conceptualize a science person, insights from this study can inform educators about the specific mechanisms needed to foster a strong science identity among FGCS. In addition, understanding the science identity perception of FGCS can help address the unique barriers they face, thereby enhancing their academic and career trajectories in STEM.

To bridge the gap in the current literature, this study explores how FGCS perceive and describe what it means to be a "science person." By applying Gee's (2000) identity perspectives, this research seeks to provide an understanding of the science identity perceptions among first-generation students.

2. Theoretical Framework

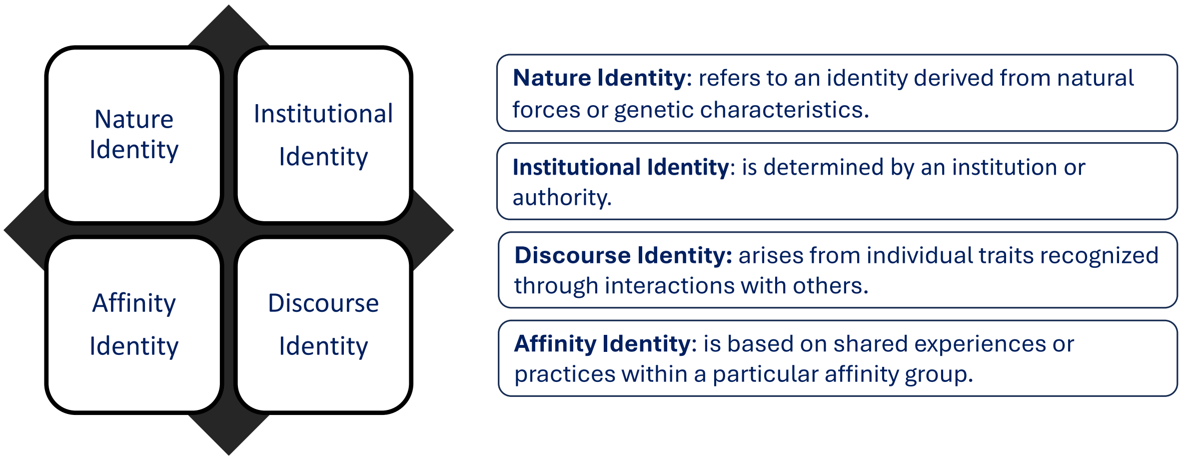
2.2 Identity Theory

Identity theory provides a basis for understanding the relationship between the individual and the social structure and how each influences the other. The "kind of person" one is recognized as "being" at a given time and place, which can change from moment to moment in the interaction, from context to context, and can be ambiguous or unstable. Being recognized as a certain "kind of person" in a given context is what I mean here by identity.

Gee's (2000) identity theory, proposed by educational linguist James Paul Gee, is a framework that explores how individuals construct their identities through participation in various social practices, particularly literacy and language. Gee (2000) describes identity as what it means to be a certain kind of person. That certain kind of person possesses one or more identities that dictate how they respond to situations in which they find themselves. Gee's identity theory posits that individuals have multiple identities shaped by social interactions and cultural contexts.

Figure 1-1

Gee's Identity Framework



Gee identifies four perspectives on identity: Nature-identity (N-identity), Institution-identity (I-identity), Discourse-identity (D-identity), and Affinity-identity (A-identity).

1. Nature-identity (N-identity): N-identity refers to a "state developed from forces in nature"(Gee, 2000, p.100). For example, a student with a natural curiosity about the natural world might be seen as having an inherent interest in science. This identity is recognized by both the individual and others as a natural part of who they are, not necessarily cultivated through social interactions.
2. Institution-identity (I-identity): I-identity is determined by an institution or authority, such as roles and titles conferred by organizations. Example: A student who is designated as an "honors student" by their school. This identity is conferred through the institution's recognition of the student's academic performance.
3. Discourse-identity (D-identity): D-identity arises from individual traits recognized through interactions with others. Example: A student known for their enthusiasm and

passion for science might be called a “science enthusiast” by peers and teachers. This identity is constructed and reinforced through social interactions and conversations.

4. Affinity-identity (A-identity): A-identity is based on shared experiences or practices within a particular affinity group. For example, a school’s robotics club member may identify as a “robotics enthusiast.” This identity is shaped by participating in club activities and sharing common interests with other members.

Overlapping Perspectives: While these four perspectives are distinct, they often overlap and interact in complex ways. For example, a student’s natural aptitude (N-identity) might be recognized and nurtured through institutional support (I-identity), which is further reinforced through positive social interactions (D-identity) and active participation in science communities (A-identity). These overlapping identities can collectively strengthen one’s identity.

In this study, Gee’s identity theory provides a comprehensive lens through which to explore how FGCS perceive and describe what it means to be a "science person." By applying this theoretical framework, we aim to uncover the types of identities these students reference to formulate their definitions.

Research Question

In this exploratory case study, we aim to gain insight into the following research question:

- How do first-generation college students perceive and describe what it means to be a science person?

3. Methods

In this section, I describe the context, student participants, selection criteria, data collection, and data analysis. This research was approved by the local institutional review board (IRB-FY2023-18).

3.1 Study Context and Participants

The study was conducted at a large southeastern public institution with a diverse student body. At this university. 33% of undergraduates identify as first-generation students. The research focused on two foundational science courses, General Chemistry I and General Biology I, which are designed for science majors. These courses were chosen because they serve as gateway courses where students often decide whether to pursue a science degree (Robinson et al., 2019). These courses utilized active-learning strategies such as clickers, think–pair–shares, and worksheets, supported by the presence of learning assistants (LAs) (Otero et al., 2010), undergraduate students tasked with facilitating discussions and interactions during class activities.

At the beginning of the semester, the instructors administered a "Getting to Know You" survey to all students in these courses. This survey included a section where students could indicate their interest in participating in the study. Students who expressed interest were then contacted for further participation. From the initial pool of interested students, those who identified as FGCS were selected. This demographic was identified through a demographic survey conducted via Qualtrics. Out of the 80 students who completed this survey, 30 were FGCS. An invitation was extended to all first-generation students for semi-structured interviews, resulting in eleven students participating. Table 1-1 describes the distribution of the study participants across both courses. All eleven participants were included in the study's analysis. As an incentive to encourage students to participate, participants were compensated $25 for their time.

Table 1-1

Study Participants

Participants (Pseudonyms)	Major	Year
Steve	Allied Health Sci.	Sophomore
Chris	Forensic Sci.	Freshman
Alice	Forensic Sci.	Freshman
Emma	Biochemistry	Freshman
Becca	Forensic Sci.	Freshman
Kris	Biology	Sophomore
Daniel	Computer Sci.	Junior
Tea	Psychology	Senior
Sara	Information Systems	Sophomore
Artemis	Biology	Freshman
Mary	Computer Sci.	Freshman

Note: A blue-shaded cell means the participant was in Chemistry class, and a green-shaded cell means the participant was in Biology class.

3.2 Data Collection

Data were collected through semi-structured interviews with FGCS enrolled in General Chemistry I and General Biology I courses. We opted for individual interviews, considering them the most effective means to capture students' nuanced experiences and reflections. The interview protocol, detailed in Appendix 1-A, was designed to explore students' perceptions of a "science person". The protocol included questions about their educational background, first-generation status, and science identity. The interview provided a baseline understanding of how students define science identity and their incoming science identity status. It included questions such as “How would you describe a typical science person?” and “What inspired you to choose your major?” Each interview lasted approximately 20-40 minutes and was conducted in person. The interviews were audio-recorded and transcribed. By employing this methodology, we aimed to establish a comprehensive understanding of how students define science identity and their initial perceptions thereof.

3.3 Data Analysis

Thematic analysis was used to analyze the qualitative data following the guidelines provided by Braun and Clarke (2021). This method involves a rigorous process of coding and theme development, ensuring that the analysis remains grounded in the data while capturing the participants' perspectives.

This process involved generating initial codes from the interview transcripts, refining these codes into broader categories, and synthesizing overarching themes. The first stage of analysis involved generating initial codes from the data. For instance, one participant described a science person as: "I suppose that means someone who enjoys science and wants to follow that for a career. Very observational and a person who questions a lot of things about the world." From this excerpt, the initial codes identified included: Enjoys science, Career in science, Observational, Questions the world. After the initial coding, secondary coding was conducted to refine and organize the initial codes into broader categories, revealing deeper patterns and relationships. The following secondary codes emerged: Interest in Science, Commitment to learning. Next, secondary codes across the data were then synthesized into overarching themes, e.g., FGCS perceives a science person as someone who possesses a natural interest in science and a commitment to continuous learning. These themes were aligned with Gee’s identity perspectives, and definitions were modified to reflect science identity. For this example, the theme was summarized as Personal Science Identity traits, which is Nature-identity adapted. Table 1-2 provides an excerpt of the codebook, which outlines codes, and examples from the data. The codes in this excerpt are a subset of the comprehensive codebook developed during the data analysis process. For the complete codebook, please refer to Appendix 1-B. These codes were refined through a peer-debriefing process, ensuring that they accurately captured the essence of the participants' responses and aligned with the study's theoretical framework.

Table 1-2

Manuscript 1 Codebook Excerpt

In-vivo Codes	**Secondary Codes**	**Definition**	**Example Data**	**Related Invivo Codes**
Enjoys science	Interest in science	Enthusiasm, curiosity, and passion that students express toward science.	"I think a person who obviously enjoys science.	Enjoys science, enthusiasm for scientific subjects, curious about scientific phenomena, passion for learning science
Working in a lab	Professional roles	Formal positions and recognized titles within the scientific community, such as scientists, researchers, professors, and doctors, signifying institutional recognition.	"I honestly only ever think of a scientist as someone who's working in a lab, who's working on their PhD…	Working in a lab, researcher, PhD student, scientist, doctor

In-vivo Codes	Secondary Codes	Definition	Example Data	Related Invivo Codes
Doing experiments	Engagement in science	Active participation in scientific activities, such as conducting experiments, participating in research projects, and engaging in scientific discussions.	"Someone who is at least currently or constantly in a broad sense trying and actively doing stuff to experiment to find out other things."	Doing experiments, participating in research, engaging in scientific practices, involvement in academic circles

Trustworthiness

To ensure the credibility and trustworthiness of our data analysis, a peer-debriefing process was integrated into the study. This process helped to ensure that the analysis and the interpretations are well-founded and credible. This process involved collaboration with a faculty researcher who has expertise in science identity, as well as presenting our codes and themes to a research group. The peer debriefers reviewed the codes, code definitions, and validated the emerging themes, ensuring they accurately represented the data and aligned with the theoretical framework of Gee's identity perspectives.

The presentation to the research group provided an additional layer of scrutiny, where the codes and themes were critically evaluated. Feedback from this group helped refine the codes and interpretations, ensuring they were robust and reflective of the participants' experiences. The critical evaluation by both the faculty researcher and the research group confirmed that the findings were logically derived from the data and well-supported by the evidence. This collaborative review process helped to confirm the credibility of the findings and justify the conclusions drawn. Incorporating the critical feedback and suggestions from both the peer debriefers and the research group during the analysis enhanced the rigor and credibility of the study.

3.4 Limitations

While this study provides valuable insights into the science identity perceptions of FGCS, several limitations should be acknowledged. The study was conducted within a particular context of General Chemistry I and General Biology I courses at a single institution. This limits the transferability of the findings to other institutions that have a different context. The findings of this study may not be transferable to the experiences of all FGCS across all university settings. The data collected through semi-structured interviews are based on self-reported experiences and perceptions, which may be subject to recall bias or social desirability bias. Participants might have provided responses they believed were expected or favorable rather than their true experiences and feelings. However, this was mitigated by starting each interview session, building rapport, and making them comfortable. Finally, it is important to note that the data for this study captured participants' perceptions at a single point in time, at the beginning of the semester. This study does not account for changes or how experiences and perceptions might evolve throughout the semester. Despite these limitations, these firsthand accounts provide important insight into the perceptions of being a science person by FGCS.

4. Findings

This section presents how this group of FGCS described what it means to be a science person. Three major themes emerged from the data, and these themes aligned with Gee’s framework. The themes are: FGCS perceives a science person 1) as someone who possesses a natural interest in science and a commitment to continuous learning (Personal science identity traits), 2) by their formal roles and recognition in the scientific community (Professional Science

Identity), and 3) as actively engaged in and affiliated with the scientific community (Participatory Science Identity). These three themes align with Gee's Nature-identity (N-identity), Institution-identity (I-identity), and Affinity-identity (A-identity), respectively. Table 1-3 summarizes the themes and their definition and provides an example quote for each theme and how it aligns with Gee's identity.

Table 1-3

Themes and Theme Definitions

Summary Theme	Definition	Example Quote	Aligns with Gee's
Personal Science Identity Traits	Traits and characteristics related to science that students perceive as inherent.	"I think a person who obviously enjoys science."	Nature-identity (N-identity)
Positional Science Identity	Science identity defined based on roles or institutional recognition.	"I honestly only ever think of a scientist as someone who's working in a lab."	Institution-identity (I-identity)
Participatory Science Identity	Identity shaped through interactions and engagement with the scientific community.	" [one who] embraces the central philosophies and sort of associates with academic circles."	Affinity-identity (A-identity)

4.1 FGCS perceived a science person as someone with a natural interest in science and a commitment to continuous learning. (Personal Science Identity Traits)

Personal science identity traits are personality traits and preferences associated with identifying as a science person. These traits can be intrinsic, naturally part of the individual, or extrinsic, learned and adopted over time. Participants described some of these traits as a natural inclination and preference for science subjects. The most common personal science identity traits participants described are an interest in science and a commitment to continuous learning within science.

Interest in Science: Participants highlighted being interested in science as a defining trait of a science person. Interest in science encompasses enthusiasm and enjoyment for the subject. One of the participants articulated this well, stating:

> "I think a person who obviously enjoys science. I don't think you necessarily have to excel to consider yourself a science person. You don't have to get it the first time. If you're really dedicated to enjoying science, it's just like, do you enjoy it? So, I would consider somebody who is a science person, somebody who would rather do science and enjoys learning it and wants to better themself in the field as well. That's my opinion."

He suggested that being a science person does not hinge on immediate success or exceptional talent. Instead, dedication and persistence in learning and improving within the field are key indicators. This perspective highlights that enjoyment and dedication are more important than immediate proficiency. He emphasized the willingness to invest time and effort in self-improvement within the field of science, suggesting that continuous learning and growth are essential attributes of a science person. This suggests that intrinsic interest is important for motivation and in defining one's identity as a science person. Similarly, another student noted that a science person is someone who enjoys science and sees it as a potential career path, saying:

> "I suppose that means someone who enjoys science and wants to follow that for a career."

This student's perception highlights the idea that a profound interest in science often leads individuals to consider it as a professional pursuit. It reflects the notion that personal interest can drive career choices and long-term dedication to the field. The description of enthusiasm and enjoyment of science is complemented by the notion that a science person has a profound interest in scientific subjects. As another participant added:

> "How would I define a science person? I mean, someone who's interested in some type of science..."

This comment highlights the perception that an interest in scientific subjects is a fundamental characteristic of a science person. The use of "some type of science" indicates the diversity within the scientific community, where different individuals may gravitate towards various branches of science based on their personal preferences. These shared traits emphasize the intrinsic interest first-generation students believe drives individuals in the scientific community. A genuine passion for science and a preference for scientific subjects were considered defining traits of a science person.

Continuous Learning Within Science*:* The theme of continuous learning within science reflects a foundational aspect of curiosity and a desire for knowledge an individual would possess. Participants described a science person as being curious and inquisitive about the natural world. For instance, one participant characterized this trait succinctly:

> "I would describe a science person as just anyone with an interest in learning about the world around them."

Her perspective highlights the intrinsic interest and intellectual curiosity central to scientific inquiry. This quote suggests that science people are fundamentally driven by a desire to understand their environment and the processes that govern it. This viewpoint emphasizes the importance of curiosity and an ongoing quest for knowledge in defining a science person. Even further, another participant elaborated:

> "A science person, I think, is someone who is interested in learning, experimenting, doing science in general, just someone who is interested and really wants to know about it. I think science people, I think that's a really broad term… someone who just wants, who craves it, and who will go out of their way to learn more of it."

This elaboration indicates that a science person is characterized by a deep, intrinsic desire to acquire knowledge. The use of the word "crave" conveys a powerful, almost insatiable curiosity that drives individuals to continuously seek out new information and understanding. This participant's description suggests that being a science person involves a proactive and enthusiastic approach to learning, experimenting, and engaging with science. Participants also noted that science people tend to question the world around them and seek answers through empirical investigation, driven by a natural curiosity to explore scientific concepts. This curiosity drives them to ask questions, seek explanations, and explore scientific concepts, which they perceive as fundamental traits of individuals who identify with science.

In summary, the theme of "interest in science and learning" underscores the fundamental curiosity, passion, and intellectual engagement that this group of FGCS believes defines a science person. It reflects a genuine enthusiasm for exploring the wonders of the natural world and a commitment to lifelong learning and discovery. Success in the scientific field involves a genuine interest and desire to keep learning, which is associated with an innate curiosity and passion for knowledge.

4.2 FGCS identified a science person by their formal roles and recognition in the scientific community. (Professional Science Identity)

The theme, professional science identity, refers to how individuals perceive identity within the scientific community based on position or role within it. During the discussion on defining a "science person," participants offered varied perspectives, with some framing their descriptions around specific roles within the scientific community. These perceptions reflected how certain participants characterized individuals based on their professional functions. It became evident that the participants viewed a "science person" through the lens of their professional science identity, i.e., to be a science person, someone needs to practice within the profession.

For instance, when asked to describe a "science person," one of the participants associated "science person" with traditional roles. She stated,

> “I honestly only ever think of a scientist, a researcher, someone who is working in a lab, who is working on their PhD, or who is working on some form of a big research program or project or whatever to help whatever. That is the only thing I think of”.

Her perspective clearly defines a "science person," mainly focusing on those engaged in formal research or academic pursuits. Her definition revolves around roles typically associated with advanced academic or professional settings, such as scientists, researchers, or individuals pursuing higher degrees like PhDs. According to this participant, science persons are primarily involved in laboratory work, research projects, or academic endeavors, emphasizing their roles and positions within the scientific community. Her insights highlighted the prevalence of traditional role-based perceptions in defining scientific identity.

Similarly, another participant describes a science person as extremely smart, mainly associating them with the medical profession. She responded to the question by saying,

"*A science person? Extremely smart. When I think of a science person, I think of doctors ...*"

Her response displayed an overlap between the personal science identity traits (extremely smart) and the professional science identity (doctors). Her perspective offers a different lens through which to view professional science identity. Her narrative expands the scope of professional science identity beyond traditional research roles by associating science persons primarily with the medical profession and emphasizing qualities like intelligence and communication skills. Also, her view highlights the diversity of roles and perceptions within the scientific community, suggesting that professional identity in science encompasses a broad range of professions and attributes beyond the confines of academia.

Together, the participants' narratives contribute to a richer understanding of professional science identity, demonstrating the various roles and perceptions that shape their perspective on what it means to be a science person. Their perspectives highlight the diversity of professional identities in science, contributing to a shared perception of diverse roles within the scientific community.

4.3 FGCS perceived a science person as actively engaged in and affiliated with the scientific community. (Participatory Science Identity)

Similar to Gee's (2000) affinity identity, participatory science identity is an identity that an individual possesses because of their affiliation with an affinity group, in this case, the scientific community. Members of the affinity group participate in distinct practices that uniquely define the affinity group. For example, a science affinity group would be distinguished as practices that students perceive scientists would engage in which scientists tend to engage, such as experimentation in a laboratory, attending science classes, or participating in scientific research. The term participatory science identity suggests that individuals actively participate in scientific affinity groups and develop a sense of identity and connection with the scientific community through involvement.

For instance, one participant described a science person as "*someone who sort of embraces the central philosophies that are centered behind science."* The participant's description of a science person as someone who embraces scientific subjects and their underlying philosophies underscores the significance of aligning with the norms and beliefs of the scientific community. This alignment with the central philosophies of science is crucial for individuals to be recognized as part of the science community or to identify themselves as science persons. It highlights the importance of accepting the principles and philosophy of science as an affinity group, as this acceptance is fundamental to one's inclusion within the community. By attributing an understanding and acceptance of these foundational principles to a typical science person, the participant emphasizes the role of shared beliefs and values in shaping science identity.

Similarly, other participants' responses included the science affinity practice of experimentation and association with academic circles as characteristics that define a science person. One student described a science person as

> "someone who sort of associates with academic circles and things like that", while another stated, "A science person, I think, is someone who is interested in experimenting

> and doing science in general….someone who is at least currently or constantly in a broad sense, trying and actively doing stuff to experiment to find out other things."

The remark about being "associated with academic circles and things like that" suggests a recognition of the inherent involvement and participation in science that characterizes individuals within this domain. The other participant's description further reinforces this perspective, identifying a science person as someone with an interest in experimentation and scientific inquiry. She portrays a scientist as someone who actively engages in experimentation to uncover new knowledge, emphasizing the pursuit of scientific endeavors. Such engagement in scientific activities, synonymous with normative scientific practices, emerges as a fundamental aspect of a scientist's identity, reflecting a commitment to the principles and methodologies inherent to the scientific community. The association with academic circles suggests an understanding of the communal aspect of science and the importance of being actively involved in scientific discourse and collaboration. This involvement reflects a strong affinity for the scientific community and its perceived practices. Also, the portrayal of a scientist as someone deeply engaged in experimentation and driven by the pursuit of knowledge highlights the affinity for scientific activities and practices.

In summary, Participatory Science Identity is an identity that an individual possesses because of their affiliation with the scientific community. Participants' responses included characteristics of a science person who participates in science, such as embracing central philosophies of science, experimentation, and association with academic circles. Their descriptions highlight the shared commitment to the principles and practices of science, indicating a strong sense of affinity for science. This alignment with the values and practices of the scientific community contributes to the development of participatory science identity.

5. Discussion and Implications

The purpose of this study was to explore how a group of FGCS perceive and describe what it means to be a "science person". Understanding these perceptions can provide insights into potential barriers these students face in seeing themselves as part of the scientific community. This discussion integrates the findings within the context of existing literature, highlighting novel contributions and their implications for supporting first-generation students in STEM fields.

5.1 Summary of Findings

The analysis revealed three major themes: Personal Science Identity Traits, Positional Science Identity, and Participatory Science Identity. These themes align with Gee's (2000) identity theory, encompassing Nature-identity (N-identity), Institution-identity (I-identity), and Affinity-identity (A-identity) respectively. The overlap among these identities suggests that the perceptions of these FGCS of a "science person" are multifaceted and influenced by interest, institutional recognition, and social participation.

Most of the participants described a "science person" as someone with a natural curiosity and passion for science, indicating an intrinsic interest in scientific subjects and a commitment to continuous learning. This aligns with the Nature-identity (N-identity). Next, participants also often equated a "science person" with formal roles such as scientists, researchers, or doctors, highlighting the importance of institutional recognition and academic achievements in shaping science identity. This aligns with the Institution-identity (I-identity). Lastly, engagement in scientific activities and affiliation with the scientific community was seen as being a "science person" active participation in research groups and academic circles, fitting the Affinity-identity (A-identity).

5.2 Discussion

This exploratory case study examined how a group of FGCS describe and perceive a 'science person'. To understand the factors influencing the science identity of FGCS, we must first know how they characterize a science person. These perceptions could create alignment or discrepancies in how they characterize or perceive themselves as science people (Brown et al., 2015; Carlone et al., 2014). The findings revealed that the definitions of these FGCS of a "science person" or "scientist" encompass a broad spectrum of attributes

Gee's identity framework posits that individuals construct their identities through four perspectives: Nature-identity (N-identity), Institution-identity (I-identity), Discourse-identity (D-identity), and Affinity-identity (A-identity). In this study, the analysis of FGCS perceptions of being a "science person" revealed the presence of N-identity, I-identity, and A-identity, but notably, D-identity did not emerge from the data. D-identity refers to traits and attributes that are recognized through interactions with others and involve being seen as a certain kind of person through discourse and social interactions, often shaped by language and dialogue within specific communities. Several factors may explain why D-identity did not emerge in the data. The participants might not have had sufficient opportunities or experiences to engage in discourses that significantly shape their science identity. Additionally, the strong focus on intrinsic interests (N-identity) and institutional recognition (I-identity) seems to overshadow the role of D-identity. This suggests that FGCS may prioritize personal passion and formal achievements in science over the social interactions and discourse-based recognition that also contribute to a holistic science identity.

The focus on N-identity implies that being a "science person" is an inherent trait, which can be problematic for several reasons. Science identity is not an inherent quality; rather, it is constructed through experiences, learning, and social interactions (Carlone & Johnson, 2007). When science identity is perceived as something innate, FGCS who do not see themselves fitting this mold might feel alienated or discouraged, leading to self-doubt and reduced engagement. These students might believe they lack the natural curiosity, passion, or intellectual capabilities necessary to succeed in science, which can deter them from seeking help, participating in science-related activities, or persevering through challenges (Carlone & Johnson, 2007; Hazari et al., 2010). Additionally, FGCS may experience imposter syndrome more acutely, feeling inadequate compared to peers who seem to effortlessly embody these intrinsic qualities, thus exacerbating stress and reluctance to fully participate in the scientific community (Clance & Imes, 1978). To counter these barriers, it is essential to promote a growth mindset among FGCS, emphasizing that science identity can be developed through effort, persistence, and support (Dweck, 2006). Educators should focus on creating inclusive environments that recognize and nurture students' potential, regardless of their initial level of interest or capability. Highlighting stories of scientists who overcame challenges and developed their science identity through hard work and perseverance can help FGCS see themselves in these roles. By fostering a sense of belonging and validation through social interactions and institutional recognition, FGCS can build a robust science identity that transcends the notion of inherent traits (Hazari et al., 2010).

The perceptions of these FGCS about Positional Science Identity offer both strengths and barriers. Identifying with formal roles such as scientists or researchers provides students with clear goals and benchmarks for success, motivating them to achieve academic and professional milestones (Starr et al., 2020). However, the perception that being a "science person" requires achieving prestigious roles can create high expectations that may be intimidating or discouraging for some students (Hyater-Adams et al., 2018). Equating a "science person" with specific formal roles might exclude those who contribute to science in less conventional or recognized ways, limiting the diversity of the scientific community. Moreover, when students describe a "science person" based on formal roles, they may find it hard to see themselves fitting into those roles. This leads to self-exclusion from identifying as a science person unless validated by an institutional title.

Participatory Science Identity on the other hand, provides strengths through active engagement and community support. Participation in scientific activities and communities fosters a sense of belonging and practical experience, enhancing students' skills and confidence (Mendez et al., 2022). Being part of a scientific community provides students with a network of peers and mentors who can offer guidance, support, and collaborative opportunities (Greenall et al., 2022). However, not all students have equal access to participatory opportunities, such as research groups and science clubs, which can create disparities in developing science identity (Avraamidou, 2020). Additionally, engaging in scientific communities where peers may seem more knowledgeable or experienced can lead to feelings of inadequacy and impostor syndrome, particularly among first-generation students (Gonsalves, 2018). Furthermore, when students believe that being a science person requires conducting great experiments or achieving significant scientific accomplishments, they might exclude themselves from identifying as a science person if they do not meet these high standards.

Interestingly, the traits and characteristics described by first-generation students are not unique to this group. Previous studies have shown that many undergraduates, regardless of their background, share similar views on what it means to be a "science person" (Hazari et al., 2010; Carlone & Johnson, 2007). This commonality suggests that the initial definition of a "science person" might be universally broad, which might change as students progress through their academic careers and gain more specific experiences and recognition. Despite these commonalities, the unique contribution of this study lies in its focus on the initial perceptions of FGCS. By capturing their views at the beginning of their academic journey, we gain insights into the foundational barriers they might face.

5.3 Implications for Practice

Understanding the broad and inclusive nature of first-generation students' science identity can inform targeted interventions to support these students. Educational institutions should focus on early engagement by introducing first-generation students to various scientific roles and career paths early in their academic journey. Providing opportunities for hands-on experiences in research and participation in science clubs can help solidify their science identity, which has been supported in several studies (Huffmyer et al., 2022; Hurtado et al., 2009; VanMeter-Adams et al., 2014). Recognizing and celebrating the achievements of first-generation students in STEM through awards, research opportunities, and mentorship programs that highlight their contributions is also crucial to providing institutional validation. Additionally, fostering an inclusive environment that values diverse definitions of what it means to be a "science person" is essential. Encouraging faculty and staff to support students' intrinsic interests and provide continuous learning opportunities can further support these students. Providing continuous positive reinforcement and feedback to help students see themselves as part of the scientific community is also important. Offering tailored academic support to help first-generation students overcome specific challenges they might face in their STEM courses can further support their journey.

5.4 Future Research Directions

Future research should explore how these initial perceptions evolve and how different interventions impact the development of science identity among first-generation students. Longitudinal studies could provide deeper insights into the factors that most effectively support these students' persistence and success in STEM fields. Additionally, comparative studies across different institutions and demographic groups and FGCS could further elucidate the unique challenges and strengths of FGCS in STEM.

5.5 Conclusion

This study explored how a group of first-generation college students (FGCS) perceive and describe what it means to be a "science person," employing thematic analysis aligned with Gee's identity perspectives. Three major themes emerged: Personal Science Identity Traits, Positional Science Identity, and Participatory Science Identity, aligning with Nature-identity (N-identity), Institution-identity (I-identity), Discourse-identity (D-identity), and Affinity-identity (A-identity) respectively. These FGCS view a science person as someone with a natural curiosity and interest in science, identified by their formal roles within the scientific community, and actively engaged in scientific practices. These findings underscore the multifaceted nature of science identity and highlight the interplay between intrinsic interests, institutional recognition, and social participation. The emphasis on intrinsic interests and institutional recognition found in this study indicates that these students might prioritize natural curiosity and interest in science aligning with Nature-identity (N-identity). This suggests a need for educational interventions in promoting a growth mindset among FGCS. Future research should focus on longitudinal studies to understand how these initial perceptions evolve over time and how different interventions impact the development of science identity among FGCS. Comparative studies across different institutions and demographic groups would further elucidate the unique challenges and strengths of FGCS in STEM.

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Appendix 1-A

First Interview Protocol

This first set of questions addresses first-generation college student identity and will help us to understand the unique experiences first-generation college students have.

1. What does it mean to you to be a first-generation college student?
2. Has being a first-generation college student impacted your college experience so far?
    1. If yes, how?
3. What motivated you to pursue a college degree?
4. How did your family support or hinder you when you were applying and accepted to colleges?
    1. Did you rely on others to support you during this time?
        1. If yes, who and how did they support you?
5. What challenges have you faced in college so far?
6. What resources have been the most helpful to you in navigating college so far?
7. How have you managed to balance your academic and social responsibilities?
8. Has your college experience been different from what you had expected?
    1. If yes, how?
9. What has been your proudest moment as a college student?
10. What has been the most valuable lesson you have learned in college so far?
11. What advice would you give to other college students?
12. What would you like to see in your classroom to better support you as a college student?
13. What would you like to see universities do to better support college students?

This next set of questions addresses science identity and belonging.

14. How would you describe a typical science person?
15. Do you consider yourself a science person?
    1. Why or why not?
16. What inspired you to choose [their major] [science, technology, engineering, or math]?
17. What do you think it takes to be successful in STEM fields?
18. What do you think will be the most important skills you need to develop in order to pursue a career in STEM?
19. Do you feel like you belong in your [CHEM 1110/BIOL 1110] class?
    1. Why or Why not?
20. Is there anything about the course that has made you feel like more or less of a science person?

This question will help us to understand the impact of the LAs on identity

21. Describe your experience with your LA so far.
22. How have the learning assistants helped you feel like more or less of a science person?

Appendix 1-B

Manuscript 1 Codebook

Invivo Codes	**Secondary Codes**	**Definition**	**Example Data**	**Related Initial Codes**	**Theme**
Enjoys science	Interest in science	Enthusiasm, curiosity, and passion that students express toward science.	"I think a person who obviously enjoys science.	Enjoys science, enthusiasm for scientific subjects, curious about scientific phenomena, passion for learning science	Personal Science Identity Traits
Working in a lab	Professional roles	Formal positions and recognized titles within the scientific community, such as scientists, researchers, professors, and doctors, signifying institutional recognition.	"I honestly only ever think of a scientist as someone who's working in a lab, who's working on their PhD…	Working in a lab, researcher, PhD student, scientist, doctor	Positional Science Identity
Doing experiments	Engagement in science	Active participation in scientific activities, such as conducting experiments, participating in research projects, and engaging in scientific discussions.	"Someone who is at least currently or constantly in a broad sense trying and actively doing stuff to experiment to find out other things."	Doing experiments, participating in research, engaging in scientific practices, involvement in academic circles	Participatory Science Identity

Raw Data	Initial Codes	Secondary Codes	Themes
"I think a person who obviously enjoys science. I don't think you necessarily have to excel to consider yourself a science person., it's just like, do you enjoy it? Do you want to learn it? And are you willing to put in the time and do you want to put in the time to do it? So I would consider somebody who is a science person, somebody who would rather do science and enjoys learning it and wants to better themselves in the field as well. That's my opinion."	Enjoys science, dedication, interest in microbiology/biology, willingness to learn, better oneself in science	Interest in science, commitment to learning	
"I suppose that means someone who enjoys science and wants to follow that for a career. Very observational and a person who questions a lot of things about the world."	Enjoys science, career in science, observational, questions the world	Interest in science, commitment to learning, observational,	Personal Science Identity Traits
"I would describe a science person as just anyone with an interest in learning about the world around them."	Interest in learning about the world	Commitment to learning	

"I mean someone who's interested in some type of science, physical science, physics, biology, someone who's just interested in learning science."	Interest in physical science/physics/biology, learning science	Interest in science	
"I honestly only ever think of a scientist, a researcher, someone who's working in a lab, who's working on their PhD, or who's working on some form of a big research program or project	Scientist, researcher, working in lab, PhD, research program	Professional roles, scientific practices	
" I couldn't tell the difference between a science person and a scientist. Just somebody who studies science and wants to push the boundaries of knowledge, I guess."	scientist, studies science, push boundaries of knowledge	Professional roles, studies science	Positional Science Identity
"Just anyone who's working in the advancement of the natural and social world."	Advancement of natural/social world	Professional role	
Extremely smart. Someone that understands like... I don't know. When I think of a science person, I think of doctors, because they can articulate.	Extremely smart, articulate, doctors	Intellectual traits, Professional role	Personal Science Identity Traits, Positional Science Identity

"I would describe them as someone who likes scientific subjects and sort of embraces the central philosophies that are centered behind science and sort of associates with academic circles and things like that probably."	Likes scientific subjects, embraces central philosophies, associates with academic circles	Interest in science, affiliations	
"A science person, I would say they like learning about science, but it would be different from being a scientist. A scientist, I feel like they make theories and just make experiments based on it. And a science person, we do a lot of research."	Likes learning science, makes theories, experiments, research	Commitment to learning, scientific practices	Personal Science Identity Traits, Participatory Science Identity
"A science person, I think, is someone who is interested in learning, experimenting, doing science in general…but someone who just wants, who craves it and who will go out of their way to learn more of it…someone who is interested in experimenting and doing science in general….someone who is at least currently or constantly in a broad sense, trying and actively doing stuff	Interested in learning, craves knowledge, goes out of the way to learn, experimenting, doing science	Interest, Commitment to learning, scientific practices	

to experiment to find out other things.”

Manuscript 2: The Impact of LA-Supported Science Learning Environment on First-Generation College Students' Science Identity

ABSTRACT: This study explores the impact of Learning Assistant (LA)-supported introductory science courses on the development of science identity among First-Generation College Students (FGCS). Utilizing a qualitative case study design, the research was conducted at a large southeastern public institution with a diverse student population. Semi-structured interviews were conducted with FGCS enrolled in General Chemistry and General Biology courses. The findings reveal that interactions with LAs meaningfully enhance FGCS's science identity through vicarious experiences, verbal recognition, and mastery experiences. Additionally, factors within the learning environment, such as collaborative group work, peer teaching, engaging course material, and supportive classroom atmospheres, contribute to the development of a positive science identity. LAs not only provided academic support but also fostered a sense of belonging and challenged traditional stereotypes in science. The study highlights the importance of a supportive classroom atmosphere in fostering the development of science identity among FGCS students.

1. Introduction

Creating an inclusive learning environment that uses active learning approaches is a key mechanism in STEM disciplines to increase learning gains, persistence, and retention (Freeman et al., 2014; Lombardi et al., 2021; Sithole et al., 2017). Research shows that when students feel a sense of belonging, it positively impacts their science identity, making them more likely to continue their engagement in science (Master et al., 2016; Wilson et al., 2015). Over the past decade, a growing focus has been on shifting undergraduate STEM education from traditional lectures to more active and participatory classroom environments (Allen & Tanner, 2005; Park & Choi, 2014). A substantial body of evidence supports the efficacy of active learning over passive, traditional modes of teaching (Freeman et al., 2014; National Research Council, 2012).

One transformative program that has emerged to drive classroom change is the learning assistant (LA) program (Otero et al.,2010). The LA program takes a unique approach by harnessing undergraduates' expertise and agency to instigate change from within the classroom (Gray et al., 2016; Otero et al., 2010; Otero, 2015). LAs are undergraduates prepared to engage students and facilitate learning during class. Several recent studies have delved into the use of LAs to foster more active and inclusive learning environments (Alzen et al., 2017; Clements et al., 2022, Hernandez et al., 2021; Otero et al., 2010). These studies reveal that LAs not only facilitate learning and engagement but also enhance students' sense of belonging and foster interest, particularly among historically underrepresented groups, such as racially minoritized and first-generation students (Clements et al., 2022; Cole & Beck, 2022; Huvard et al., 2020). The potential of the LA program to empower students and enhance their science identity is a promising avenue for further exploration.

Science identity has emerged as a significant construct in understanding the engagement and persistence of undergraduate college students in science-related disciplines. Science identity refers to an individual's perception of themselves as a science learner and identification with the scientific community (Carlone & Johnson, 2007). Identity is a multidimensional construct continuously developing or changing as individuals experience their contextual social environments over time (Carlone, 2012; Gee, 2000). Studies have shown that to retain historically marginalized populations in STEM fields, it is imperative to create an environment that allows them to feel they belong to scienceor can become science people, fostering their science identity (Galano et al., 2023; Gonsalves, 2018; Kalender et al., 2019; Mendez et al., 2022). While the LA program has shown promise in enhancing learning, engagement, and a sense of belonging in STEM disciplines, its impact on science identity development in students has not been as widely explored. Understanding how the active and inclusive learning environment facilitated by LAs influences science identity formation is crucial, particularly for first-generation college students (FGCS) who may face unique challenges navigating STEM education.

This study aims to investigate the impact of LA-supported introductory science courses on the development of first-generation college students' science identities. We have chosen to focus on FGCS, as they are more likely to hold marginalized identities and less likely to graduate with their four-year degree than their peers (Cataldi et al., 2018). Although there are varied definitions of FGCS, this study defines FGCS as individuals whose parents or guardians did not complete a four-year degree (U.S. Department of Education, 2011). FGCS represent a significant proportion of the college student population in the United States, currently comprising one-third and projected to increase (Cataldi et al., 2018). FGCS face educational and career disparities, particularly in STEM fields, where they are less likely to major and more likely to drop out of STEM compared to their continuing generation peers (Riegle-Crumb et al., 2019). As a result, FGCS often feel pressure to conform to traditional STEM norms and sacrifice aspects of their identity to fit in (Johnson et al., 2011; Rosa & Mensah, 2021; Watkins & Mensah, 2022), making the STEM pathway less accessible to them. Structural barriers within higher education, including pedagogical norms and social contexts such as rigid curriculum structures, limited access to mentoring, and insufficient support networks, further exacerbate these challenges, contributing to feelings of alienation and discouragement among FGCS in STEM programs. Hence, understanding how the learning environment facilitated by LAs influences science identity formation is crucial, particularly for FGCS, who may face unique challenges in navigating STEM education. We seek to answer the following research questions: 1) How do FGCS perceive the development of their science identity in LA-supported science classes? 2) What factors within the LA-supported learning environment contribute to the perceptions of FGCS science identity development?

2. Background

2.1 The Learning Assistant Model

Learning Assistants (LAs) are undergraduates trained to support teaching and learning in various educational settings, particularly in STEM disciplines with high DFW rates (Alzen et al., 2018; Otero *et al.*, 2010; Van Dusen & Nissen, 2020). The LA program model includes three key components: 1) LAs engaging with students during class to enhance their learning; 2) weekly preparation meetings between LAs and course instructors to discuss course content and share feedback; and 3) a pedagogy seminar where LAs learn about equitable and inclusive teaching practices, reflect on their own teaching, and develop a support system to address challenges (Barrasso & Spilios, 2021; Otero et al., 2010). They help bridge the gap between instructors and students, fostering a collaborative learning environment. Implementing the LA model has shown significant potential in improving educational outcomes, promoting student engagement, and enhancing teaching practices (Otero et al., 2010; Talbot et al., 2015).

Impact on Student Learning and Engagement

The presence of LAs in the classroom has been positively associated with improved student attitudes toward science, increased engagement, and higher satisfaction with courses (Miller et al., 2013; Price & Finkelstein, 2008; Van Dusen & Nissen, 2017). Studies have shown that LAs can make classes more interactive and personal, helping students better understand concepts (Herrera et al., 2015; Knight et al., 2015; Sellami et al., 2017). For instance, students in LA-supported courses reported higher levels of motivation and enjoyment compared to those in traditional settings. This interactive environment helps students appreciate the course material more, leading to better retention rates in STEM majors and improved learning outcomes (Talbot et al., 2015; Cajkler et al., 2007).

Influence on Course and Curriculum Transformation

The LA model encourages the transformation of undergraduate courses and curricula. One of the main goals of the LA model is to promote the adoption of active learning strategies by integrating evidence-based teaching practices into the classroom (Otero et al., 2006; Otero, 2015). Courses that utilize LAs often see a shift from traditional lecture-based formats to more student-centered approaches, which can lead to better educational outcomes (McHenry et al., 2009; Sabella et al., 2016). Faculty involved in these programs are more likely to engage in discipline-based education research, further promoting innovative teaching methods (Otero et al., 2010; Sabella et al., 2016; Thompson & Garik, 2015).

Another major goal of the LA model is its important role in teacher recruitment and preparation (Otero et al., 2006; Otero et al., 2010; Otero, 2015). The experience gained by LAs often inspires them to pursue careers in education (Gray et al., 2016). This near-peer teaching model provides LAs with practical teaching experience, which is invaluable for their professional development. Programs involving LAs have been linked to increased interest in teaching careers among participants as they gain confidence and develop a deeper understanding of pedagogical techniques (Barr et al., 2012; Gray et al., 2010; Gray et al., 2012).

Institutional and Departmental Changes

Implementing the LA model can drive institutional and departmental changes. By demonstrating the effectiveness of LAs in enhancing student learning and engagement, departments may adopt more supportive policies and allocate resources to sustain and expand these programs. Institutions that embrace the LA model often see a cultural shift towards valuing and supporting undergraduate teaching assistants, which can lead to broader educational reforms (Otero et al., 2010).

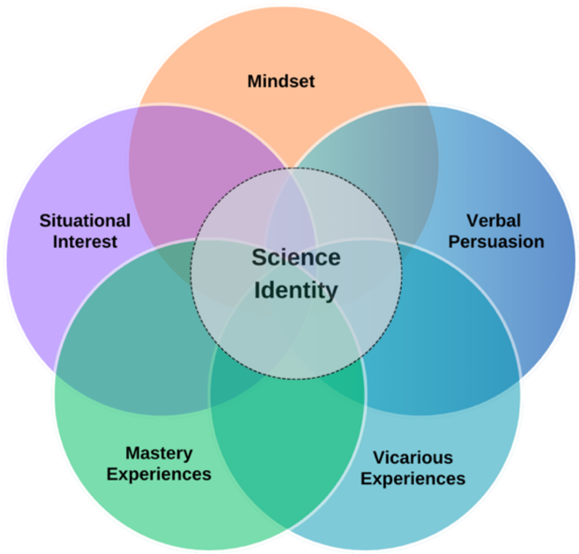
3. Theoretical Framing

3.1 Operationalized Science Identity (OSI) Framework

The Operationalized Science Identity (OSI) Framework, as introduced by Hosbein & Barbera in 2020, offers an operationalized approach to understanding what shapes an individual's science identity. According to this framework, five crucial constructs contribute to developing a strong science identity: mindset, situational interest, verbal persuasion, vicarious experiences, and mastery experiences.

Figure 2-1

Operationalized Science Identity (OSI) Framework



Mindset (Dweck, 2006) plays a pivotal role in this framework. It's all about how students perceive their journey to becoming a science person. Some believe that being good at science is an inherent trait, while others think it can be achieved through hard work and determination. The latter group, those with a growth mindset, tend to develop a more robust science identity because they see their abilities as improvable and not fixed.

Situational interest is defined in stages and revolves around a student's attraction to science in a specific context. This interest can be broken down into two parts: value-related and feeling-related. Value-related interest concerns how personally significant science is to the student, while feeling-related interest deals with the emotions they experience when engaging in scientific activities (Hidi & Renniger, 2006; Schiefele, 1991). Together, these interests shape how students view and relate to science.

Other important constructs are *verbal persuasion* and *vicarious experiences* (Bandura, 1997), which are forms of recognition (Carlone & Johnson, 2007). Verbal persuasion, for example, occurs when someone tells a student they are good at science, which can boost their self-efficacy and reinforce their science identity. On the other hand, vicarious experiences involve students observing and relating to others' successes or failures in science. Seeing someone else excel can inspire them and strengthen their belief in their own potential.

Finally, mastery experiences (Bandura, 1997) are critical to developing a science identity. These are the moments when students measure their abilities through their successes and failures in specific tasks. For instance, solving a challenging science problem in class can greatly enhance a student's feelings of competence. These positive experiences help build a robust science identity by making students feel capable and accomplished in their scientific endeavors. Together, these five constructs of the OSI Framework provide a detailed understanding of how various factors contribute to developing a solid science identity.

4. Methods

This study will use a case study design (Merriam & Tisdell, 2016). A case study is a qualitative research model in which “the researcher develops an in-depth analysis of a case, often a program, event, activity, or process” (Creswell & Creswell, 2018, p. 14). An instrumental case study approach allows a researcher to gain a better understanding of a particular issue that is directly related to the primary overarching issue (Creswell & Creswell, 2018). In this study, an instrumental approach will allow the researcher to better understand how FGCS experiences in an LA-supported science class impact their science identity development. Below, I describe the study context, student participants, selection criteria, data collection, and data analysis. This research was approved by the local institutional review board (IRB-FY2023-18).

4.1 Research context and participants

Data were collected from two introductory science classes, General Chemistry and General Biology, during the Fall 2023 semester. These courses employed active learning strategies and included Learning Assistants (LAs) to support student engagement. A total of 139 students were enrolled across both courses, with nine LAs assisting (three in Chemistry and six in Biology). Classes met twice a week for 85 minutes. Participants were recruited at the start of the semester, and interested students were identified through an electronic demographic survey. Purposeful sampling (Patton, 2002) was used to select participants who identified as FGCS. Of the 80 students who completed the survey, 30 met the criteria.

4.2 Data Collection

Three semi-structured interviews were conducted with each student at the beginning, middle, and end of the semester to capture the evolution of their science identity. The first interview occurred at the beginning of the semester, the second and third week of a 16-week semester. The second interview happened during the seventh and eighth week of the semester, and the third interview happened during the fourteenth and fifteenth weeks of the semester. As an incentive to encourage students to participate consistently in all three interviews, participants were offered $25 for each interview, with a bonus of $25 if all three interviews were completed. Table 2-1 describes the study participants and interview attendance.

Table 2-1

Study Participants

Participants (Pseudonyms)	Major	Interview 1 (Week 2-3)	Interview 2 (Week 7-8)	Interview 3 (Week 14-15)
Steve	Allied Health Sci.	**X**		
Chris	Forensic Sci.	**X**	**X**	
Alice	Forensic Sci.	**X**	**X**	
Emma	Biochemistry	**X**	**X**	**X**
Becca	Forensic Sci.	**X**	**X**	**X**
Kris	Biology	**X**	**X**	**X**
Daniel	Computer Sci.	**X**		
Tea	Psychology	**X**	**X**	**X**
Sara	Information Systems	**X**		
Artemis	Biology	**X**		
Mary	Computer Sci.	**X**	**X**	**X**
Total		11	7	5

Note: An "X" denotes the participant was present at the corresponding interview. A blue-shaded cell means the participant was in Chemistry class, and a green-shaded cell means the participant was in Biology class.

Data used for this study were from the first and second semi-structured interviews conducted with the students at the beginning and middle of the semester. Individual interview transcripts were used as the primary data source for this study because they provide the most prevalent instances of students' lived experiences as they actively reflect on their experiences. The interview protocol, detailed in Appendix 2-A, was designed to elicit students' experiences and interactions with LAs in their classrooms. Each interview lasted approximately 15-35 minutes and was audio-recorded with a digital voice recorder and later transcribed for analysis.

4.3 Data Analysis

Interview transcripts were evaluated using a thematic approach, as described by Braun and Clarke (2021). A thematic analysis is a process of evaluating qualitative data, such as transcripts, by identifying patterns or themes (Braun & Clarke, 2021). In this thematic approach, the data was evaluated using a six-step process. The first step was to get familiarized with the data. Becoming familiar with the date was done by reading the transcripts multiple times and writing notes and impressions of the transcripts. The second step was to generate initial codes; Table 2-2 provides an excerpt of the codebook with descriptions of codes. In step three, the codes were aligned with the constructs provided by the OSI framework. In the fourth step, the codes were aggregated into larger themes. Step five was the review of themes. The sixth and final step in the process was to define the themes. In this step, each theme was defined to explicitly describe what the theme represents.

Table 2-2

Manuscript 2 Codebook Excerpt

Code	Description	Related Codes	Example Quotes
Perception of Self as a Science Person	How students see themselves as science learners and their confidence in science.	Self-Reflection, Peer Recognition, Influence of LAs	"I think of myself as science person. So, I think I'm perceived as a science person."
Interaction with Learning Assistant	The types and quality of interactions between students and LAs and their impact on learning.	Supportive Relationship, Frequency of Interaction, Initiation of Interaction, Impact on Confidence.	"Whenever we have a question, we can immediately get an answer, so we don't forget our question, and then it's answered immediately."

Code	Description	Related Codes	Example Quotes
Impact of LAs on Self-Perception as a Science Learner	How interactions with LAs affect students' confidence and identity as science learners.	Confidence Building, Role Modeling, Positive Reinforcement, Competence and Mastery, Inclusivity and Belonging	"Just those little words just made me feel like 'Ooh, I got this, I got this, and I can move forward."
Support Provided by LAs	The different kinds of help that LAs give to students.	Academic Guidance, Emotional Support, Clarification of Concepts, Creating a Welcoming Environment, Personalized Assistance,	"Every time I have a question, it's welcomed, and that's just number one."
Impact of Course on Science Identity	How the course influences students' confidence and identity as science learners.	Engagement with Course Material, Classroom Activities, Peer Interaction, Personal Achievement	"So usually when we're in groups and stuff with our LAs and stuff I feel like a science person when I get to explain it to someone."

4.4 Trustworthiness

A peer debriefing process enhanced the trustworthiness of the research process and findings. This process helped to ensure that the analysis and the interpretations are well-founded and credible. This involved discussing and revising emerging themes and interpretations with peer reviewers. The peer reviewers examined the data interpretations, ensuring they were well-supported by the data. Their evaluation provided valuable insights, helping to validate the findings and offering an additional layer of scrutiny. This peer-debriefing process was crucial in reducing the risk of researcher bias, ensuring the study's findings were robust and credible.

5. Findings and Discussion

The findings of this paper illuminate the significant impact of interaction with learning assistants (LAs) on aspects of FGCS's science identity. Through in-depth interviews with participants, several key themes emerged, shedding light on how LAs contribute to the development of students' science identity. In this section, we present the findings of Research Question 1 first, followed by the findings of Research Question 2.

5.1 Role of Learning Assistants in Fostering Science Identity Development

The first research question this study addresses is: *How do first-generation college students perceive the development of their science identity in LA-supported science classes?* FGCS described positive experiences with the LAs and the diverse ways in which they inspire and guide them toward developing a science identity. Three major themes emerged as participants shared insights and highlighted the LAs' significant influence. 1) Vicarious experiences with LAs fostered science-related aspirations and challenged stereotypes in science; 2) Verbal recognition provided supportive guidance to overcome academic obstacles and instilled a higher self-efficacy; 3) LAs facilitated mastery and enhanced conceptual understanding. Table 2-3 provides a summary of the findings.

Table 2-3

Summary findings of research question 1

Research Question 1: How do first-generation college students perceive the development of their science identity in LA-supported science classes?	
Theme 1	Vicarious Experiences with LAs Fostered Science-related Aspirations and Challenged Stereotypes in Science
Theme 2	Verbal Recognition Provided Supportive Guidance to Overcome Academic Obstacles and Instilled a Higher Self-Efficacy.
Theme 3	LAs Facilitated Mastery and Enhanced Conceptual Understanding

5.1.1 Vicarious Experiences with LAs Fostered Science-related Aspirations and Challenged Stereotypes in Science

Vicarious experiences, as conceptualized by the OSI framework (Hosbein & Babera, 2020), involve students observing and relating to others' successes or failures in science. Participants shared memorable experiences with LAs, involving discussions about career paths and offers of assistance in networking opportunities related to participants' career interests. For example, Kris recounted one such experience where her LA provided career guidance and networking opportunities, stating,

> "When she was telling me about her career, I mean, I really did like that conversation and then saying that she could connect me with certain people... That was probably the most memorable."

These interactions with LAs not only fostered a sense of connection with science-related career goals but also inspired participants to envision themselves pursuing careers in science. This type of vicarious experience (Hosbein & Barbera, 2020) helps students see the possibilities within the scientific field, reinforcing their aspirations and commitment to pursuing science careers. Kris reflected on the impact of these interactions, stating,

> "I feel like when she was talking about her career, we were talking about what we want to do after we graduate. I feel like that was pretty nice because, again, it just seemed like I was talking to a real person."

Furthermore, Kris expressed how positive experiences with LAs influenced her science-related aspirations and decisions. She expressed her desire to become an LA herself, driven by the relationship and insights gained from LAs, stating, "Yeah, I mean, seeing them made me want to be an LA." These findings emphasize the role of LAs in inspiring and supporting them in their current pursuit of science-related careers.

Also, participants expressed how the presence of LAs challenges traditional perceptions of what a science person looks like, thereby influencing their own science identity and their perception of themselves as science learners. Mary, for example, noted, "They're not what you would generally think of whenever you think of a science person. So, you see them and think that you can be one too." Mary's quote highlights how the presence of LAs challenges stereotypical notions of what a science person looks like. By seeing individuals in the role of learning assistants who may not fit the traditional image of a scientist, participants like Mary begin to perceive themselves as a science person and capable of succeeding in science as well. Similarly, other participants recognized LAs, especially those who share their demographic characteristics, as sources of inspiration and models for success in science. Becca articulated this, stating,

> "So, if someone that is a person of color or even a woman is doing it [being an LA] and succeeding and being able to help other people, then you could also be succeeding and helping other people."

Becca's quote emphasizes the importance of representation and relatability in role models. She recognized that seeing LAs who share her demographic characteristics succeed in science serves as a powerful source of inspiration. Becca’s sentiment suggests that seeing individuals like herself (a woman of color) achieving success in science makes her believe that she, too, can succeed and make a meaningful impact in the field.

Similarly, another participant reported feeling more like science people due to the representation of diversity by LAs. Mary articulated the importance of the representation of diversity, stating,

> "They've helped me feel like more of a science person just by reinforcing my knowledge and just being the image of diversity among science people."

These quotes suggest that representation matters and that seeing diverse role models in science can positively influence students' self-perception and efficacy (Carlone & Johnson, 2007). By representing diversity, LAs shape students' perceptions of themselves as part of a diverse scientific community.

Participants also described LAs as motivational figures whose presence in the same learning environment inspires their academic journey. Interactions with LAs bolstered participants' self-efficacy and sense of belonging as science learners. Becca emphasized how seeing LAs pursue similar paths reinforced her belief in the achievability of her own goals, stating, "…you're seeing someone doing what you want to do, and you're like, that's achievable." Becca's quote elaborates on the role of LAs as role models and sources of recognition through these vicarious experiences. By witnessing LAs pursuing similar paths and achieving success, Becca feels reassured in her abilities and aspirations. Similarly, Kris, for instance, expressed how seeing LAs still in school motivates her, stating, "Well, you see them, the learning assistants. They're still in school, and you're like, oh, that could be me. It's like motivation." These quotes suggest that interactions with LAs not only provide inspiration but also instill a sense of self-efficacy in students, reinforcing their belief in the attainability of their goals.

Overall, these vicarious experiences with LAs helped these group of FGCS develop a stronger science identity by providing relatable role models (Master et al., 2016; Wilson et al., 2015), fostering career aspirations (Fouad & Santana, 2017; Marco-Bujosa et al., 2022), and challenging traditional stereotypes in science (Master et al., 2016). FGCS oftentimes have other marginalized identities; therefore, it is important that they comment on diversity and "see people like them," this suggests that they rarely relate to people within science. This emphasizes the importance of integrating diverse LAs into STEM education to support the development of science identity among FGCS (Gray et al., 2016; Otero, 2015).

5.1.2 Verbal Recognition Provided Supportive Guidance to Overcome Academic Obstacles and Instilled a Higher Self-Efficacy.

This theme encapsulates the multifaceted ways in which LAs contribute to the formation and strengthening of FGCS science identity. It encompasses their roles in providing recognition through encouragement, affirmation, motivation, and supportive guidance, ultimately shaping students' perceptions of themselves as science learners.

The interactions with LAs were highlighted as profoundly influential in shaping participants' self-perception as science learners. Participants described how the encouragement and affirmation received from LAs motivated them to persist in their studies and pursue further academic goals. Tea emphasized the impact of such interactions, stating, "When you have an extra person that is there motivating you and pushing you and telling you that, 'Yeah, you're on the right track'... It's so impactful." By acknowledging her progress and efforts, LAs served as catalysts for Tea's continued growth. Their affirmations not only validated Tea's abilities but also fueled her determination to excel, reinforcing her belief in her ability to succeed in challenging academic pursuits. Further, Tea recounted an instance where she felt recognized as a science person, mainly through affirmations and words of encouragement from LAs. Tea reflected, “Just those little words just made me feel like, 'Ooh, I got this, I got this, and I can move forward.” These small yet meaningful gestures served to validate Tea's identity as a science learner, instilling in her a sense of competence and belonging in the academic environment. As Tea reflected on these experiences, she expressed how such affirmations propelled her forward, emboldening her to actively participate and engage in class discussions. This highlights the importance of receiving positive feedback and encouragement from LAs to boost their self-efficacy in science. Even further, she shared specific memorable experiences where LAs provided invaluable support and guidance during challenging situations. She recounted a particular experience during an exam where the LA's encouragement was pivotal in bolstering her confidence, stating, "He [LA] literally... told me, 'You got this. Just take your time with it. You're fine. You're going to be fine with it.'" Through their words of reassurance and encouragement, LAs played a pivotal role in alleviating Tea's apprehensions and empowering her to overcome academic obstacles. These instances of supportive guidance not only helped participants overcome obstacles but also instilled a higher self-efficacy in their abilities.

5.1.3 LAs Facilitated Mastery and Enhanced Conceptual Understanding

This theme encapsulates the ways in which LAs contribute to the academic success and science identity development of FGCS in science classes. LAs provided essential guidance and conceptual understanding, fostering collaborative learning environments where students engage deeply with course material. Their support contributed to students' self-efficacy and competence, ultimately shaping their identities as capable and competent science learners.

Participants described the support provided by LAs as essential for academic success, emphasizing their role in aiding conceptual understanding and facilitating learning rather than simply providing answers. For instance, Kris, describing the kind of support the LAs provided, stated, "Academic help, of course. That's the main one" and "They ain't going to give you the answers, but they're going to try to make sure that you understand the material, they just help you learn" highlight the collaborative and instructional nature of the relationship between LAs and students. This theme highlights the importance of LAs in guiding students through challenging concepts and promoting a deeper understanding of course material. Similarly, Alice explained how the LAs made her feel more of a science person, she said: "I'd say more because they do help me understand the concepts." This reflects how interactions with LAs contributed to students' self-efficacy and identity in science. By assisting students in grasping complex scientific concepts and reinforcing their understanding, LAs play an essential role in bolstering students' self-efficacy and competence through master experience.

Further, success in their course impacted students' perceptions of themselves as science learners. Chris expressed how success in the course has made him feel more like a science person and increased his mastery experience, stating, "Just being able to do good in the class makes me feel like more of a science person, I guess." As Chris experienced success in the course, his mastery grew, leading to a greater sense of identity. This shows the transformative impact of academic achievement on students' perceptions of themselves as science learners, as success in the course fosters mastery and a greater sense of identity.

LAs were instrumental in fostering academic success by prioritizing conceptual understanding over providing direct answers. Participants highlighted their role in guiding students through challenging concepts and promoting deeper comprehension of course material. This approach not only aids in grasping complex scientific concepts but also enhances students' self-efficacy and identity in the subject matter. Through their assistance, LAs facilitate mastery experiences, wherein students successfully engage with complex academic content, leading to increased self-efficacy and perceived competence.

Limited Impact of Learning Assistants

While most participants described a positive impact of the LAs on their science identity development, only Chris provided a contrasting perspective that highlighted the limited influence

LAs had on his perception of himself as a science person. When asked if his interaction with LAs impacted how he saw himself as a science person, Chris responded, "Not too much, no." This initial response set the tone for further exploration into why LAs did not influence his science identity. Chris elaborated, "Well, I mean, they help in the class and all that. They don't really make me think any different about myself though, I suppose." This statement indicates that while Chris acknowledged the functional support LAs provided in understanding course material, this support did not translate into a change in how he viewed himself as a science person.

Despite the limited impact of LAs, Chris recognized other factors that contributed to his evolving science identity. When asked if anything had contributed to his feeling more like a science person, he reflected, "I suppose the course so far probably has changed me a bit without me noticing, made me a bit more confident in myself, just getting the good grades that I have so far." This acknowledgment highlights a significant point: Chris's increased confidence and sense of identity in science were more closely tied to his academic performance and the structure of the course rather than interpersonal support from LAs. Chris’s experience suggests that the tangible achievements within the course, such as earning good grades, played a more substantial role in fostering his science identity than his interaction with LAs. This insight points to the importance of course structure and personal academic success in shaping students' science identities. While LAs are effective in providing academic support, their role in influencing science identity may require further enhancement. Training LAs to engage more deeply with students on a personal level could help bridge this gap.

5.2 Factors within the Learning Environment Fostering Science Identity Development

The second research question, *“What factors within the learning environment contribute to the perceptions of FGCS science identity development?”* unveils the role of the course and learning environment in fostering science identity. Through participant interviews, additional themes emerged, shedding light on the diverse ways in which course experiences, such as classroom activities, out-of-class activities, and classroom atmosphere, shape students' identities as science people. Table 2-4 provides a summary of the findings.

Table 2-4

Summary findings of research question 2

Research Question 2: What factors within the learning environment contribute to the perceptions of FGCS science identity development?	
Theme 1	Classroom activities such as peer teaching, collaborative group work, and engaging course material fostered a positive science identity.
Theme 2	Out-of-class activities such as independent research and extracurricular engagements fostered a positive science identity.
Theme 3	LAs played a critical role in fostering a welcoming and positive classroom environment

5.2.1 Classroom activities such as collaborative group work, peer teaching, and engaging course material fostered a positive science identity.

This overarching theme encompasses various instances where students felt validated and recognized in their identities as science learners. Participants consistently mentioned group activities, group collaboration, and engaging material as course components that impacted their sense of science identity. From participating in engaging course material to explaining concepts to peers, these experiences reinforce students' sense of efficacy and mastery experience in the field of science. These activities helped students feel more connected to the subject matter and more confident in their abilities as science learners. This section focuses on three key aspects of classroom activities: Peer Teaching, Collaborative Group Work, and Engaging Course Material.

Peer Teaching: Peer teaching emerged as a significant factor in shaping students' identities as science learners. Becca highlighted the impact of explaining concepts to peers, stating, "I feel like a science person when I get to explain it to someone, and they're like, 'Oh, but how does that happen? Or how does that work?'" This demonstrates how teaching others not only reinforces the students' own understanding but also boosts their mastery experience and self-efficacy. Engaging in peer teaching activities allowed students to solidify their knowledge, develop communication skills, and gain recognition from their peers, all of which contributed to a stronger science identity.

Collaborative Group Work: Collaborative group work provided opportunities for students to engage with peers, share knowledge, and collectively solve problems. Alice recalled a positive experience during group work in class where she felt comfortable and engaged with her group members, contributing to the successful completion of tasks. When describing an experience where she felt like a science person; she said, "I guess one time when we were working in a group on a worksheet." This highlights the importance of peer relationships and teamwork in reinforcing students' science identity. Collaborative activities enabled students to learn from one another, enhancing their understanding and fostering a supportive learning community. Furthermore, instances where students like Kris felt recognized as science people, particularly during group activities or tasks where they demonstrate proficiency in answering questions and actively engaging with the material, are pivotal in reinforcing their sense of belonging and competence in the field of science. Kris elaborated on this experience, stating, "Oh yeah. Well, she [instructor] will make us do these little breakout groups, and then you have this little, you got to fill out this piece of paper with all these questions on there. I'll be feeling good when I actually know the questions and stuff..." This highlights the role of classroom activities in validating students' identities as science learners and fostering a supportive learning environment where students feel recognized and affirmed in their scientific abilities. By actively participating and demonstrating proficiency in class activities, Kris received validation and recognition from both peers and instructors, reinforcing her sense of identity and competence in the field of science.

Engaging Course Material: Engaging course material was critical in sparking students' interest and curiosity in science. Alice expressed how the interesting content of her course made her feel more like a science person: "I'd say I feel more of a science person because of how interesting the material is to me." This underscores the importance of designing a curriculum that captivates students' interests. When students find the material engaging and relevant, they are more likely to invest effort in learning and develop a deeper connection with the subject, thereby enhancing their science identity. Active participation in classroom activities reinforced students' self-perception as capable science learners.

In summary, students cited classroom activities such as peer teaching, collaborative group work, and engaging course material when discussing their science identity development. These activities provided students with the opportunity to interact, share knowledge, and engage deeply with scientific concepts, which enhanced their mastery experience, self-efficacy, and sense of belonging.

5.2.2 Out-of-class activities such as independent research and extracurricular engagements fostered a positive science identity.

Participants also described some out-of-class activities that impacted their perception of themselves as science people. From conducting additional research for assignments to attending extracurricular activities, these experiences reinforced students' sense of belonging and expertise in the field of science.

Participants like Chris felt recognized as science people when he was able to conduct additional research beyond the textbook for assignments and receive positive feedback from instructors. Chris articulated this, stating,

> "I mean, on some of the assignments like summaries and whatnot we have to do a bit more research on the subjects, and I feel a bit confident when I'm able to find details from other places than just the textbook and whatnot and to get feedback saying that's what they were looking for."

This highlights the importance of autonomy and initiative in demonstrating scientific competence. Students gained self-efficacy and recognition through independent research efforts, reinforcing their identities as capable science learners. The ability to go beyond the textbook demonstrates a deeper engagement with the subject matter and reinforced Chris's identity as a science person.

Extracurricular activities, such as attending science seminar events, can also influence students' perceptions of themselves as science people. Mary felt like a science person when given the opportunity to attend a seminar event. She reflected, “Well, our teacher gave us an opportunity to come and listen to a speaker. Probably I felt the most, I guess, science person then, being surrounded by other scientists.” Mary's sense of belonging and identity surged when she attended a science seminar event surrounded by fellow scientists. Although this experience was not an aspect of the LA learning environment, it was highlighted by students as an impactful opportunity availed to her by her instructor. This immersive experience outside the classroom emphasizes the profound impact of real-world engagement on fostering science identities. Her experience of being surrounded by other scientists reflects the profound sense of belonging and validation that such experiences can evoke. This demonstrates the importance of providing opportunities for students to engage with the broader scientific community, network with peers and professionals, and gain real-world insights into scientific practice, ultimately fostering their identity development as science learners.

5.2.3 LAs played a critical role in fostering a welcoming and supportive classroom environment.

The classroom atmosphere plays a pivotal role in shaping students' science identities for these FGCS. LAs were instrumental in creating a welcoming and supportive classroom environment, which was crucial for fostering a positive science identity. This section will focus on two key aspects: Personalized and Supportive Interactions and a Supportive and Inclusive Environment.

***Personalized and Supportive Interactions*:** LAs brought a personal touch to the classroom, which contrasts with traditional lecture-style classes. Chris appreciated this aspect, stating, "Most classrooms don't have that personal touch; it's usually just one person teaching the course, and they don't have time to interact with every student." This recognition of the personalized interactions facilitated by LAs highlights their ability to foster meaningful connections with students. Such interactions are essential for creating a sense of belonging and community, which are critical components of a positive science identity (Le et al., 2019). Becca also emphasized the clarity and supportive nature of LA explanations, stating, "He does a really good job of responding to questions, of just explaining it in a very straightforward way." Tea expressed satisfaction with the relationship and interaction with LAs, emphasizing their role in clarifying doubts and providing immediate assistance. She said, "Whenever we have a question, we can immediately get an answer, so we don't forget our question, and then it's answered immediately." This immediate feedback is important for fostering a supportive learning environment and enhancing students' self-efficacy (Lorsbach & Jinks, 1999; Monteiro et al., 2021). These personalized interactions foster meaningful connections, creating a sense of belonging and community essential for a positive science identity.

***Supportive and Inclusive Environment*:** The presence of LAs helped create a supportive and inclusive classroom environment. Becca noted, "Makes you feel like you belong a little more," emphasizing how LAs contributed to a sense of belonging and representation in the classroom. By fostering inclusivity and acceptance, LAs helped students feel valued and recognized, strengthening their identification with the scientific community. Similarly, the welcoming and non-judgmental attitude of LAs impacted students' comfort levels in seeking help and asking questions. Tea emphasized how every interaction with LAs made her feel more confident: "Every time I have a question, it's welcomed, and that's just number one." She appreciated that LAs never made her feel inadequate, stating, "Him not shunning me or making me feel like I'm an idiot and welcoming whatever question or answer that I have, even if it's wrong." This supportive approach fostered a positive classroom atmosphere where students felt safe to express their uncertainties and engage fully in the learning process.

6. Conclusion and Implications

The aim of this paper was to understand how FGCS perceive the development of their science identity in LA-supported science classes and what factors within the learning environment contribute to the perceptions of these FGCS science identity development. This manuscript provided valuable insights into the role of LAs in fostering the development of science identity among FGCS. The findings highlighted that interactions with LAs significantly enhance FGCS's science identity through vicarious experiences, verbal recognition, and mastery experiences. Additionally, the study revealed that collaborative group work, peer teaching, engaging course material, and a supportive classroom atmosphere within the learning environment contribute to a positive science identity.

The results of this study have important implications for educators and LA programs. Integrating LAs into science education can enhance FGCS's sense of belonging and identity as science learners, which is essential for their persistence and success in STEM fields. Educators should leverage the presence of LAs to create more interactive and inclusive learning environments, as evidenced by the positive impacts on engagement and self-efficacy reported by students. The findings also highlight the importance of collaborative group work, peer teaching, engaging course material, and a supportive classroom atmosphere in fostering a positive science identity. Educators should focus on creating collaborative group work opportunities, peer teaching activities, engaging course material, and a supportive classroom atmosphere to further enhance science identity among FGCS. LA programs should emphasize training LAs on the importance of providing verbal recognition, fostering mastery experiences, and serving as relatable role models, as these elements were vital in shaping FGCS science identity. Also, policymakers should allocate resources to support the expansion of LA programs in STEM education, particularly in institutions serving a high proportion of FGCS.

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Appendix 2-A

First Interview Protocol

This first set of questions addresses first-generation college student identity and will help us to understand the unique experiences first-generation college students have.

2. What does it mean to you to be a first-generation college student?
3. Has being a first-generation college student impacted your college experience so far?
    2. If yes, how?
4. What motivated you to pursue a college degree?
5. How did your family support or hinder you when you were applying and accepted to colleges?
    2. Did you rely on others to support you during this time?
        2. If yes, who and how did they support you?
6. What challenges have you faced in college so far?
7. What resources have been the most helpful to you in navigating college so far?
8. How have you managed to balance your academic and social responsibilities?
9. Has your college experience been different from what you had expected?
    2. If yes, how?
10. What has been your proudest moment as a college student?
11. What has been the most valuable lesson you have learned in college so far?
12. What advice would you give to other college students?
13. What would you like to see in your classroom to better support you as a college student?
14. What would you like to see universities do to better support college students?

This next set of questions addresses science identity and belonging.

15. How would you describe a typical science person?
16. Do you consider yourself a science person?
    2. Why or why not?
17. What inspired you to choose [their major] [science, technology, engineering, or math]?
18. What do you think it takes to be successful in STEM fields?
19. What do you think will be the most important skills you need to develop in order to pursue a career in STEM?
20. Do you feel like you belong in your [CHEM 1110/BIOL 1110] class?
    2. Why or Why not?
21. Is there anything about the course that has made you feel like more or less of a science person?

This question will help us to understand the impact of the LAs on identity

22. Describe your experience with your LA so far.
23. How have the learning assistants helped you feel like more or less of a science person?

Appendix 2-B

Second Interview Protocol

Let's talk a bit about your class context (General Chemistry/Biology)

1. What was your motivation for taking this course?
   i. What are your goals for this class?
2. How confident are you that you can understand science in class?
   i. How confident are you that you can understand science outside of class?
3. Do you value the content you're learning in this class? *How so?*
4. Tell me about a time when you felt confident with the material.
5. Do you enjoy learning *about science (*Chemistry/Biology) in this class?
   i. Do you enjoy learning science outside of this class?
6. Has this course made you interested in learning more about science?
   Probe: *In what ways?*
7. Have you had specific experiences that you can recall where you feel like you've been recognized as a science person?
   i. Tell me about a time (in this course) you've felt like a science person.

The next set of questions will focus on your relationship with the learning assistants.

8. Tell me about your *relationship and* interaction with the Learning Assistants in this class.
   i. How often do you interact with your LA?
   ii. What does the conversation initiation with your LA look like?
9. Can you share your experiences in LA-supported science classes? What stands out to you about these classes?
10. Does your interaction with your LAs impact how you see yourself as a science person?
    i.(If No) Does it impact your confidence in seeing yourself as a science person if you wanted to?
11. In your opinion, do LAs (learning assistants) have an impact on how students perceive themselves as science learners? If so, how?
12. Can you recall any specific interactions or experiences with LAs that made you feel more connected to or confident in science?
13. What made you feel a sense of belonging when interacting with the LA
14. What helped you feel like a science person (sense of belonging) in this course
15. Tell me about a memorable experience you've had with your LA.
16. How would you describe what kind of support your LA provides?
17. When do you find the support of your LA most beneficial, during regular class time or "study hours"? Why?

Science person

18. In our last interview, you defined a science person as _______. How do you define a science person now?
    i. How has this changed?
19. Do you think your LA sees you as a science person?

i. Do you think your instructor sees you as a science person?
ii. Do your friends or peers see you as a science person?
iii. Do you see yourself as a science-person?

20. What is it about science that interests you?
21. Why is science worth pursuing as a major/career?
22. Did you have role models or supporters who helped shape your interest in science?
23. Do you feel that you are part of a science community? How?
24. What has helped you persist in science?

First Generation Status Follow up

25. How would you describe stereotypical first-generation students.
26. Besides your first-generation status, are there other social identities that impact your experiences in your classroom, or in science in general? (such as race, gender, sexual identity, disability status, etc.")

Appendix 2-C
Manuscript 2 Codebook

Code	Description	Related Codes	Example Quotes
Perception of Self as a Science Person	How students see themselves as science learners and their confidence in science.	Self-Reflection, Peer Recognition, Influence of LAs	"I think of myself as science person. So, I think I'm perceived as a science person."
Interaction with Learning Assistant	The types and quality of interactions between students and LAs and their impact on learning.	Supportive Relationship, Frequency of Interaction, Initiation of Interaction, Impact on Confidence.	"Whenever we have a question, we can immediately get an answer, so we don't forget our question, and then it's answered immediately."
Impact of LAs on Self-Perception as a Science Learner	How interactions with LAs affect students' confidence and identity as science learners.	Confidence Building, Role Modeling, Positive Reinforcement, Competence and Mastery, Inclusivity and Belonging	"Just those little words just made me feel like 'Ooh, I got this, I got this, and I can move forward."
Support Provided by LAs	The different kinds of help that LAs give to students.	Academic Guidance, Emotional Support, Clarification of Concepts, Creating a Welcoming Environment, Personalized Assistance,	"Every time I have a question, it's welcomed, and that's just number one."
Impact of Course on Science Identity	How the course influences students' confidence and identity as science learners.	Engagement with Course Material, Classroom Activities, Peer Interaction, Personal Achievement	"So usually when we're in groups and stuff with our LAs and stuff I feel like a science person when I get to explain it to someone."

Note: Colors represent different participants

Initial Codes

1. Recognition of Feeling Like a Science Person: Peer Teaching and Validation - Sense of Expertise
2. Positive Interaction with Learning Assistant (LA)- Supportive Relationship and Clear Communication
3. Initiation of Interaction - Role of Learning Assistant in Prompting Discussions

4. Comfort with Peers and Learning Assistants - Influence of Age Proximity and Shared Experiences
5. Impact of Learning Assistants on Sense of Belonging - Representation and Inclusivity
6. Inspiration and Role Modeling - Influence of Learning Assistants as Role Models
7. Interaction with LAs Boosting Confidence in Science: Clear and Non-Condescending Explanation - Supportive Learning Assistant
8. Beneficial Support Outside of Class - Clarification and Deepening Understanding
9. Perception of Self as a Science Person- Self-Reflection and Peer Recognition
10. Belonging in Science Community - Sense of Inclusion and Future Engagement
11. Impact of LA on Feeling Like a Science Person: Inspiration from Learning Assistants - Role Modeling and Confidence Building
12. Recognition of Feeling like a Science Person through Classroom Activities: Recognition as a Science Person - Validation through Classroom Activities
13. Engagement with Learning Assistants - Supportive Interactions and Resources
14. Frequency of Interaction with LAs - Consistent Engagement
15. Perceived Impact of LA Support - Recognizing the Supportive Role of LAs
16. Impact of LAs on Self-Perception as a Science Learner: – Positive Influence on Identity as a Science Learner
17. Personal Aspiration Inspired by LA: Effect of LA Interaction on Career Aspirations – a desire to become an LA.
18. Connection to Science Career Goals through Interaction with LA: Connection with Learning Assistant - Personalized Conversations about Career Goals
19. Sense of Belonging Fostered by Learning Assistant's Supportive Attitude: Supportive and Approachable Interaction with LA
20. Experience with LA - Career Guidance and Networking
21. Type of Support Provided by LA - Academic Guidance and Conceptual Understanding
22. Beneficial Timing of LA Support - Effectiveness During Regular Class Time
23. Perception of Self as a Science Person by Learning Assistant: Influence of LA Interaction
24. Perception by Instructor and Peers - Influence of Interactions
25. Sense of Belonging in the Science Community - Facilitated by Science Classes and Associations
26. Positive Course Impact on Science Identity - Preference for Biology
27. Impact of Learning Assistants on Perception of Self as a Science Person - Motivational Influence
28. Recognition of Feeling like a Science Person: Recognition and Encouragement- Positive Feedback Boosting Confidence
29. Supportive Relationship with Learning Assistants: Effective Interaction Enhancing Learning Experience- Overcoming Self-Doubt
30. Positive Impact of Learning Assistants on Self-Perception as a Science Learner: Influence on Confidence
31. Impact of Interaction with Learning Assistants on Self-Perception as a Science Person: Affirmation and Motivation
32. Enhanced Connection and Confidence through Interactions with Learning Assistants: Continuous Support, Welcoming and Non-judgmental Attitude
33. Memorable Experiences with Learning Assistants: Supportive Guidance and Encouragement

34. Support Provided by Learning Assistants: Welcoming Environment and Comprehensive Assistance
35. Beneficial Support from Learning Assistants: Real-Time Assistance Enhancing Learning, Accessibility and Responsiveness of Learning Assistants:
36. Impact on Feeling Like a Science Person: Perception of Self as a Science Person: Evolving Confidence
37. Perception of Instructor: Universal Belief in Students' Potential
38. Perception of Peers: Recognized as a Science Person
39. Recognition of Feeling Like a Science Person: Group Collaboration
40. Interaction with Learning Assistants: Limited Engagement
41. Conversation Initiation with Learning Assistants: LA's Proactive Approach
42. Frequency of Interaction with Learning Assistants: Regular Engagement
43. Impact of Learning Assistants on Self-Perception as a Science Person: Uncertain
44. Impactful Interactions with Learning Assistants: Limited Recall
45. Description of Learning Assistant Support: Active Assistance
46. Beneficial Timing of Learning Assistant Support: In-Class Group Work
47. Perception of Being Seen as a Science Person by Learning Assistants: Equality in Communication
48. Perception of Being Seen as a Science Person by Instructor: Equality in Communication
49. Perception of Being Seen as a Science Person by Peers: Inclusion in Social Circles
50. Course Impact on Feeling Like a Science Person: Positive Influence
51. Learning Assistant's Influence on Feeling Like a Science Person: Positive Reinforcement
52. Recognition as a Science Person: Achievement in Assignments
53. Frequency of Interaction with Learning Assistants: Regular
54. Initiation of Conversation with Learning Assistants: LA Initiated
55. Impact of Learning Assistants on Classroom Environment: More welcoming
56. Impact of Learning Assistants on Perception as a Science Learner: Minimal Impact
57. Sense of Belonging with Learning Assistants: Personal and Supportive
58. Course Impact on Feeling like a Science Person: Increased Confidence
59. Memorable Experience with Learning Assistant: Individualized Attention
60. Description of Learning Assistant Support: Balanced Assistance
61. Beneficial Timing of Learning Assistant Support: During Activities
62. Impact of Learning Assistants on Self-Perception as a Science Person: Minimal
63. Perception of Being Seen as a Science Person by Learning Assistant: Uncertain
64. Perception of Being Seen as a Science Person by Instructor: Unsure
65. Recognition of Feeling Like a Science Person: Attending Speaker Event
66. Interaction with Learning Assistant: Supportive Relationship
67. Frequency of Interaction with Learning Assistant: Several Times a Week
68. Conversation Initiation with LA: Context-Dependent
69. Impact of Learning Assistants: Increased One-on-One Interaction
70. Impact of Learning Assistants on Self-Perception as a Science Learner: Influence of LA Representation
71. Impact of Interaction with LA on Self-Perception: Teacher's Aide Role
72. Impact of LA Interaction: Constant Availability
73. Memorable Experience with LA: Consistent Support
74. Type of Support Provided by LA: Recurring and Constant

75. Beneficial Support Timing: Outside Class Time
76. Interaction Outside of Class: Messaging for Questions and Study Help
77. Impact on Feeling Like a Science Person: Reinforcing Knowledge and Diversity
78. Perception by LA: Seen as Science Peers
79. Perception by Instructor: Seen as Engaged in Science

Code sorting and grouping

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81. Impact of LA on Feeling Like a Science Person: Inspiration from Learning Assistants - Role Modeling and Confidence Building 11
82. Perceived Impact of LA Support - Recognizing the Supportive Role of LAs 15
83. Impact of LAs on Self-Perception as a Science Learner: – Positive Influence on Identity as a Science Learner 16
84. Positive Course Impact on Science Identity - Preference for Biology 26
85. Impact of Learning Assistants on Perception of Self as a Science Person - Motivational Influence 27
86. Positive Impact of Learning Assistants on Self-Perception as a Science Learner: Influence on Confidence 30
87. Impact of Interaction with Learning Assistants on Self-Perception as a Science Person: Affirmation and Motivation 31
88. Impact on Feeling Like a Science Person: Perception of Self as a Science Person: Evolving Confidence
89. Impact of Learning Assistants on Self-Perception as a Science Person: Uncertain 43
90. Course Impact on Feeling Like a Science Person: Positive Influence 50
91. Impact of Learning Assistants on Classroom Environment: More welcoming 55
92. Impact of Learning Assistants on Perception as a Science Learner: Minimal Impact 56
93. Course Impact on Feeling like a Science Person: Increased Confidence 58
94. Impact of Learning Assistants on Self-Perception as a Science Person: Minimal 62
95. Impact of Learning Assistants: Increased One-on-One Interaction 69
96. Impact of Learning Assistants on Self-Perception as a Science Learner: Influence of LA Representation 70
97. Impact of Interaction with LA on Self-Perception: Teacher's Aide Role 71
98. Impact of LA Interaction: Constant Availability 72
99. Impact on Feeling Like a Science Person: Reinforcing Knowledge and Diversity 77

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- Positive Interaction with Learning Assistant (LA)- Supportive Relationship and Clear Communication 2

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- Interaction with LAs Boosting Confidence in Science: Clear and Non-Condescending Explanation - Supportive Learning Assistant 7
- Engagement with Learning Assistants - Supportive Interactions and Resources 13
- Frequency of Interaction with LAs - Consistent Engagement 14
- Personal Aspiration Inspired by LA: Effect of LA Interaction on Career Aspirations – a desire to become an LA. 17
- Connection to Science Career Goals through Interaction with LA: Connection with Learning Assistant - Personalized Conversations about Career Goals 18
- Sense of Belonging Fostered by Learning Assistant's Supportive Attitude: Supportive and Approachable Interaction with LA 19
- Perception of Self as a Science Person by Learning Assistant: Influence of LA Interaction 23
- Perception by Instructor and Peers - Influence of Interactions 24
- Supportive Relationship with Learning Assistants: Effective Interaction Enhancing Learning Experience- Overcoming Self-Doubt 29
- Impact of Interaction with Learning Assistants on Self-Perception as a Science Person: Affirmation and Motivation 31
- Enhanced Connection and Confidence through Interactions with Learning 32
- Interaction with Learning Assistants: Limited Engagement 40
- Frequency of Interaction with Learning Assistants: Regular Engagement 42
- Impactful Interactions with Learning Assistants: Limited Recall 44
- Frequency of Interaction with Learning Assistants: Regular 53
- Interaction with Learning Assistant: Supportive Relationship 66
- Frequency of Interaction with Learning Assistant: Several Times a Week 67
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- Impact of LA Interaction: Constant Availability 72
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- Interaction with LAs Boosting Confidence in Science: Clear and Non-Condescending Explanation - Supportive Learning Assistant 7
- Perception of Self as a Science Person- Self-Reflection and Peer Recognition 9
- Belonging in Science Community - Sense of Inclusion and Future Engagement 10
- Impact of LA on Feeling Like a Science Person: Inspiration from Learning Assistants - Role Modeling and Confidence Building 11

- Recognition of Feeling like a Science Person through Classroom Activities: Recognition as a Science Person - Validation through Classroom Activities 12
- Impact of LAs on Self-Perception as a Science Learner: – Positive Influence on Identity as a Science Learner 16
- Connection to Science Career Goals through Interaction with LA: Connection with Learning Assistant - Personalized Conversations about Career Goals 18
- Perception of Self as a Science Person by Learning Assistant: Influence of LA Interaction 23
- Sense of Belonging in the Science Community - Facilitated by Science Classes and Associations 25
- Positive Course Impact on Science Identity - Preference for Biology 26
- Impact of Learning Assistants on Perception of Self as a Science Person - Motivational Influence 27
- Recognition of Feeling like a Science Person: Recognition and Encouragement- Positive Feedback Boosting Confidence 28
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- Impact of Interaction with Learning Assistants on Self-Perception as a Science Person: Affirmation and Motivation 31
- Impact on Feeling Like a Science Person: Perception of Self as a Science Person: Evolving Confidence 36
- Perception of Peers: Recognized as a Science Person 38
- Recognition of Feeling Like a Science Person: Group Collaboration 39
- Impact of Learning Assistants on Self-Perception as a Science Person: Uncertain 43
- Perception of Being Seen as a Science Person by Learning Assistants: Equality in Communication 47
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- Course Impact on Feeling Like a Science Person: Positive Influence 50
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- Recognition as a Science Person: Achievement in Assignments 52
- Impact of Learning Assistants on Perception as a Science Learner: Minimal Impact 56
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- Impact of Learning Assistants on Self-Perception as a Science Person: Minimal 62
- Perception of Being Seen as a Science Person by Learning Assistant: Uncertain 63
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- Impact of Learning Assistants on Self-Perception as a Science Learner: Influence of LA Representation 70
- Perception by LA: Seen as Science Peers 78
- Perception by Instructor: Seen as Engaged in Science 79

Support by Learning Assistants

100. Positive Interaction with Learning Assistant (LA)- Supportive Relationship and Clear Communication 2
101. Interaction with LAs Boosting Confidence in Science: Clear and Non-Condescending Explanation - Supportive Learning Assistant 7
102. Beneficial Support Outside of Class - Clarification and Deepening Understanding 8
103. Engagement with Learning Assistants - Supportive Interactions and Resources 13
104. Perceived Impact of LA Support - Recognizing the Supportive Role of LAs 15
105. Sense of Belonging Fostered by Learning Assistant's Supportive Attitude: Supportive and Approachable Interaction with LA 19
106. Type of Support Provided by LA - Academic Guidance and Conceptual Understanding 21
107. Beneficial Timing of LA Support - Effectiveness During Regular Class Time 22
108. Supportive Relationship with Learning Assistants: Effective Interaction Enhancing Learning Experience- Overcoming Self-Doubt 29
109. Enhanced Connection and Confidence through Interactions with Learning Assistants: Continuous Support, Welcoming and Non-judgmental Attitude 32
110. Memorable Experiences with Learning Assistants: Supportive Guidance and Encouragement 33
111. Support Provided by Learning Assistants: Welcoming Environment and Comprehensive Assistance 34
112. Beneficial Support from Learning Assistants: Real-Time Assistance Enhancing 35
113. Description of Learning Assistant Support: Active Assistance 45
114. Beneficial Timing of Learning Assistant Support: In-Class Group Work 46
115. Sense of Belonging with Learning Assistants: Personal and Supportive 57
116. Description of Learning Assistant Support: Balanced Assistance 60
117. Beneficial Timing of Learning Assistant Support: During Activities 61
118. Interaction with Learning Assistant: Supportive Relationship 66
119. Memorable Experience with LA: Consistent Support
120. Type of Support Provided by LA: Recurring and Constant
121. Beneficial Support Timing: Outside Class Time

Theme 1: Impact of LA on Science Identity

6. Inspiration and Role Modeling - Influence of Learning Assistants as Role Models

7. Interaction with LAs Boosting Confidence in Science: Clear and Non-Condescending Explanation - Supportive Learning Assistant
11. Impact of LA on Feeling Like a Science Person: Inspiration from Learning Assistants - Role Modeling and Confidence Building
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27. Impact of Learning Assistants on Perception of Self as a Science Person - Motivational Influence
43. Impact of Learning Assistants on Self-Perception as a Science Person: Uncertain
51. Learning Assistant's Influence on Feeling Like a Science Person: Positive Reinforcement
36. Impact on Feeling Like a Science Person: Perception of Self as a Science Person: Evolving Confidence
30. Positive Impact of Learning Assistants on Self-Perception as a Science Learner: Influence on Confidence
31. Impact of Interaction with Learning Assistants on Self-Perception as a Science Person: Affirmation and Motivation
70. Impact of Learning Assistants on Self-Perception as a Science Learner: Influence of LA Representation
77. Impact on Feeling Like a Science Person: Reinforcing Knowledge and Diversity

Support of LAs

1. Positive Interaction with Learning Assistant (LA)- Supportive Relationship and Clear Communication
7. Interaction with LAs Boosting Confidence in Science: Clear and Non-Condescending Explanation - Supportive Learning Assistant
8. Beneficial Support Outside of Class - Clarification and Deepening Understanding
12. Engagement with Learning Assistants - Supportive Interactions and Resources
15. Perceived Impact of LA Support - Recognizing the Supportive Role of LAs
17. Personal Aspiration Inspired by LA: Effect of LA Interaction on Career Aspirations – a desire to become an LA.
18. Connection to Science Career Goals through Interaction with LA: Connection with Learning Assistant - Personalized Conversations about Career Goals
19. Sense of Belonging Fostered by Learning Assistant's Supportive Attitude: Supportive and Approachable Interaction with LA
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28. Supportive Relationship with Learning Assistants: Effective Interaction Enhancing Learning Experience- Overcoming Self-Doubt
31 Impact of Interaction with Learning Assistants on Self-Perception as a Science Person: Affirmation and Motivation
32. Enhanced Connection and Confidence through Interactions with Learning Assistants: Continuous Support, Welcoming and Non-judgmental Attitude

33. Memorable Experiences with Learning Assistants: Supportive Guidance and Encouragement
34. Support Provided by Learning Assistants: Welcoming Environment and Comprehensive Assistance
35. Beneficial Support from Learning Assistants: Real-Time Assistance Enhancing Learning, Accessibility and Responsiveness of Learning Assistants
45. Description of Learning Assistant Support: Active Assistance
57. Sense of Belonging with Learning Assistants: Personal and Supportive
65. Interaction with Learning Assistant: Supportive Relationship
69. Impact of Learning Assistants: Increased One-on-One Interaction
73. Memorable Experience with LA: Consistent Support
74. Type of Support Provided by LA: Recurring and Constant

Role/Functionality and Interaction of LAs

2. Initiation of Interaction - Role of Learning Assistant in Prompting Discussions
15. Perceived Impact of LA Support - Recognizing the Supportive Role of LAs
66. Interaction with Learning Assistant: Supportive Relationship
69. Impact of Learning Assistants: Increased One-on-One Interaction
70.
71. Impact of Interaction with LA on Self-Perception: Teacher's Aide Role
72. Impact of LA Interaction: Constant Availability
76. Interaction Outside of Class: Messaging for Questions and Study Help

13. Frequency of Interaction with LAs - Consistent Engagement
39. Interaction with Learning Assistants: Limited Engagement
42. Frequency of Interaction with Learning Assistants: Regular Engagement
52. Frequency of Interaction with Learning Assistants: Regular
67. Frequency of Interaction with Learning Assistant: Several Times a Week

22. Beneficial Timing of LA Support - Effectiveness During Regular Class Time
46. Beneficial Timing of Learning Assistant Support: In-Class Group Work
61. Beneficial Timing of Learning Assistant Support: During Activities
75. Beneficial Support Timing: Outside Class Time

Theme 2: Impact of course on science identity

66. Recognition of Feeling Like a Science Person: Attending Speaker Event
    Mary felt like a science person when given the opportunity to attend a speaker event in the building, surrounded by other scientists.
    Quotes: "Probably I felt the most, I guess, science person then and being surrounded by other scientists."
50. Course Impact on Feeling Like a Science Person: Positive Influence (Interesting material)
    Alice feels more like a science person due to the course's interesting material, suggesting that engaging content contributes to her identity as a science enthusiast.
    Quotes: "I'd say more because of how interesting the material is to me."
53. Recognition as a Science Person: Achievement in Assignments

Chris feels recognized as a science person when they are able to conduct additional research beyond the textbook for assignments and receive positive feedback from instructors.

Quotes: " I mean, on some of the assignments like summaries and whatnot we have to do a bit more research on the subjects, and I feel a bit confident when I'm able to find details from other places than just the textbook and whatnot and to get feedback saying that's what they were looking for."

58. Course Impact on Feeling like a Science Person: Increased Confidence

Success in the course has made Chris feel more like a science person and increased their confidence in their scientific abilities.

Quotes: "Just being able to do good in the class makes me feel like more of a science person, I guess." "It's made me a bit more confident in that aspect."

14. Recognition of Feeling like a Science Person through Classroom Activities: Recognition as a Science Person - Validation through Classroom Activities

    Instances where Kris feels recognized as a science person, particularly during group activities or tasks where she demonstrates proficiency in answering questions and actively engaging with the material.

    Quote: "Oh yeah. Well, Dr. Liz, she'll make us do these little breakout groups and then you have this little, you got to fill out this piece of paper with all these questions on there. I'll be feeling good when I actually be knowing the questions and stuff and actually be trying to learn the answer."

55. Impact of Learning Assistants on Classroom Environment: Personal touch

    Chris appreciates the personal touch brought by learning assistants, making the classroom environment feel more welcoming compared to traditional lecture-style classes.

    Quotes: "Most classrooms you don't get that personal touch to it, it's usually just one person teaching the course and they don't have time to interact with every student."

3. Recognition of Feeling Like a Science Person: Peer Teaching and Validation - Sense of Expertise

    Becca's engagement in explaining concepts to peers and feeling empowered when they understand, reinforcing her sense of expertise.

    Example Quote: "So usually when we're in groups and stuff with our LAs and stuff, I feel like a science person when I get to explain it to someone, then they're like, 'Oh, but how does that happen? Or how does that work?'" "Just helping other people learn and better understand it makes me feel good."

40. Recognition of Feeling Like a Science Person: Group Collaboration

    Alice recalls a time during group work on a worksheet in class when she felt like a science person. Despite struggling with social interaction, she felt comfortable and engaged with her group members, contributing to completing the task successfully.

    Quotes: "I guess one time when we were working in a group on a worksheet."

    "The group I was with, I got along with them really well, and we laughed and all that, and then we got the worksheet done."

Manuscript 3: “So Now I Feel Like a Science Person”: A First-Generation Student’s Trajectory in an LA-Supported Science Course

ABSTRACT: Developing a science identity is crucial for students pursuing STEM careers, as it is linked to increased persistence and success. First-generation college students often face unique challenges, such as financial pressures and feelings of isolation, which can hinder their science identity development. The Learning Assistant (LA) model, involving experienced students assisting their peers, has shown promise in enhancing learning outcomes and fostering a sense of belonging. This paper explores the trajectory and developing science identity of a first-generation college student enrolled in an LA-supported introductory biology course over an entire semester using narrative inquiry. Data were collected through three semi-structured interviews at the beginning, mid-semester, and end of the semester. The interviews captured Tea's experiences and identity development, analyzed through thematic coding and chronological analysis. The findings reveal that Tea initially struggled with self-doubt and feelings of not belonging. However, consistent support and encouragement from her LA played a significant role in her mastery experiences and growth mindset in developing a stronger science identity. Over the semester, Tea's confidence grew as she implemented new study strategies and received positive reinforcement from her LA. By the end of the semester, Tea expressed a transformed perception of herself, stating, "So now I feel like a science person." The manuscript highlights the importance of a supportive learning environment as a crucial construct in developing a science identity. This research highlights the need for comprehensive support systems to address the unique challenges faced by FGCS, promoting their success and persistence in STEM fields.

1. Introduction

The development of a science identity is crucial for students pursuing careers in Science, Technology, Engineering, and Mathematics (STEM) fields, as it has been linked to increased persistence and success (Carlone & Johnson, 2007; Hazari et al., 2010; Hosbein & Barbera, 2020). Introductory science courses in college, often deemed gateway courses, are critical for students pursuing STEM fields (Robinson et al., 2019). They provide the foundational concepts required for more specialized and advanced courses in STEM disciplines. Success in these courses can reinforce student's science identity, whereas difficulties can lead to self-doubt and disengagement from the field (Gasiewski et al., 2012). For first-generation college students (FGCS), this development is particularly challenging because they are mostly the first to attend college in their families (Pascarella et al., 2004; Wang, 2014). While FGCS bring unique strengths and perspectives such as resilience, resourcefulness, and strong motivation to succeed to their academic journeys, which can significantly enrich their science identity development, they experience higher attrition rates in introductory science courses compared to their continuing-generation peers (Aruguete, 2017; Stebleton et al., 2014; Thompson, 2021).

Developing a strong science identity can help mitigate the higher attrition rates experienced by FGCS in introductory science courses (Mendez et al., 2022). Also, studies indicate that learning assistants (LA)-supported courses positively impact student engagement and retention, particularly in STEM (Goertzen et al., 2011; Talbot et al., 2015). LAs are experienced students who assist their peers in understanding course material, thereby enhancing learning outcomes and fostering a sense of community within the classroom (Otero et al., 2010). By providing peer support and creating an interactive learning environment, LAs can help mitigate some of the challenges faced by FGCS. However, more research is needed to examine how interactions with LAs influence the development of science identity in FGCS. A well-formed science identity can foster a sense of belonging and self-efficacy, which is crucial for persisting in the face of challenges (Estrada et al., 2011; Hazari et al., 2010; Hosbein & Barbera, 2020). Existing research has primarily addressed general barriers to success in STEM, such as academic preparation and financial constraints, but has not deeply explored the specific science identity formation processes of FGCS. While existing research offers valuable data on science identity changes over a single semester, it often lacks a detailed picture of how, when, and why these identities develop. Recognizing these nuanced moments is critical for understanding the impact of particular classroom practices on identity development. Therefore, a more in-depth exploration of these inflection points within the context of a narrative can reveal the dynamic and evolving nature of science identity, especially for FGCS. Capturing the stories of FGCS is essential to understanding the nuanced processes of identity development by delving into the personal experiences and pivotal moments that shape their science identity.

This study aimed to fill these gaps by exploring the trajectory and evolving science identity of a first-generation college student enrolled in an LA-supported introductory biology course. By identifying critical moments in identity development, this research seeks to provide a deeper understanding of the specific classroom practices that facilitate or hinder science identity growth. Through narrative inquiry, this study will capture the complexities and nuances of identity development, offering valuable insights into how educational experiences and interactions shape the science identities of FGCS.

2. Background

Developing a Science Identity

Identity is a complex construct and is defined and conceptualized in different ways. For example, Gee (2000) describes identity as “being recognized as a certain ‘kind of person,’ in a given context” (p. 99). Nasir and Saxe (2003) state that identities “are not located solely in the individual, but rather are negotiated in social interactions that take form in cultural spaces” (p. 17). Scholars such as Avraamidou (2020) and Lave and Wenger (1991) establish the understanding of identity within a person’s lived experiences. Other scholars view identity as socially constructed components of who we are, including gender identity, race, ethnicity, sexuality, and ability (Torres et al., 2009). It is essential to acknowledge the intricacies of identity and to recognize that identities extend beyond the labels that can be placed on oneself or others. Identities are formed by the environments in which people exist, the people with whom they interact, and the histories that shape the communities to which they belong (Avraamidou, 2020; Rubin, 2007; Urrieta, 2007). For instance, science classrooms in which students reside are governed by unspoken norms and rules regarding who and what is valued; such context impacts the development of students’ science identities (Le et al., 2019).

Science identity broadly refers to people’s thinking of themselves as a science person (Thompson & Jensen-Ryan, 2018) as well as the perception by others as a part of the scientific community (Carlone & Johnson, 2007). Science identity is built through a dynamic, multidimensional process that develops over time and is associated with one's ever-changing social experiences rather than a static state of being (Erikson, 1968; Arnett, 2000). That is, identity is developed over time rather than an innate attribute one has or does not have. The formation of science identity is a complex process influenced by various factors. Faculty mentoring, academic experiences, cohort building, peer mentoring, extra-curricular activities, and social activities have been shown to positively influence students' science identity (Corwin Auchincloss, 2014; Derby, 2006; Holland et al., 2012; Kolenovic et al., 2013). Several studies indicate that these types of experiences enhance success in STEM by improving the way students perceive and engage with science (Carlone, 2004; Carlone & Johnson, 2007; Le et al., 2019; Puente et al., 2021). Given the importance of science identity in retaining students in STEM, particularly those from underrepresented groups, current studies on equity and inclusion in STEM have focused on understanding students' science identity development (McDonald, 2019; Puente et al., 2021).

Puente et al. (2021) examined the development of science identity among high school students. They found that students perceived by their peers as "science people" displayed higher science identity scores than those not recognized as such. Additionally, Latinx and Black students had lower science identities compared to their Asian and White counterparts. Within each ethnic group, females exhibited lower science identity scores than males. The study also identified first-generation status as a predictor of science identity levels, with first-generation students showing lower science identity scores than any other group. Puente et al. linked this lower science identity among first-generation students to their experience of lower recognition as "science people" by others.

Hazari et al. (2010) and Carlone & Johnson (2007) have explored the complex relationships between ethnicity, gender, and science identity, revealing key factors that influence students' perceptions of themselves as scientists. Hazari et al. (2010) found that students with a stronger physics identity are more likely to pursue careers in physics-related fields. They identified several factors that positively influence physics identity, including extracurricular and co-curricular activities, laboratory experiences aligned with students' beliefs, engagement with course material and peers, and frequent encouragement from others to pursue science careers. Importantly, they observed that females generally exhibit lower physics or science identities than males. However, incorporating activities that challenge science stereotypes in the classroom can positively influence the science identity of females without significantly affecting males, suggesting that science identity is fluid and can be shaped by environmental factors and experiences. Carlone & Johnson (2007) examined the science identity development of 15 women of color through their undergraduate and graduate education and into their STEM careers. They found a strong link between external recognition and the participants' science identity levels. External feedback played a crucial role in how participants recognized themselves as scientists. Additionally, the sense of competence, or the ability to succeed in their field, was closely tied to their science identity. Participants who felt successful in their courses or science-related tasks reported a stronger sense of belonging to the science field, reinforcing their identity as scientists.

Academic experiences, such as classroom interactions, have been identified as significant factors that shape one's science identity. Johnson et al. (2022) examined the role of classroom experiences and self-efficacy in shaping science identity among first-year students. The study employed a mixed-methods approach, combining quantitative surveys and qualitative interviews, to comprehensively understand how classroom experiences influence students' perceptions of themselves as science learners. Findings from the quantitative analysis revealed a positive correlation between active learning experiences and science identity. Students who reported engaging in more active learning activities, such as hands-on experiments, group discussions, and problem-solving tasks, tended to have higher levels of science identity. In the qualitative phase of the study, through interviews, students expressed positive interactions with instructors, who provided encouragement and recognized that their contributions played a critical role in fostering a sense of belonging and science identity. The researchers recognized the importance of understanding the factors contributing to science identity formation, as it plays a crucial role in students' long-term interest and motivation in science-related disciplines. The study provides valuable insights into the relationship between classroom experiences, self-efficacy, and science identity among first-year college students. Their findings highlight the significance of incorporating active learning approaches in science courses and fostering a supportive and inclusive learning environment to promote science identity development.

These studies collectively highlight that science identity is not a fixed trait but is influenced by various factors, including gender, ethnicity, engagement in science activities, external recognition, and perceived competence. However, little information still exists about how, when, and why these identities develop, especially for FGCS. FGCS experience the academic world differently from continuing-generation college students. Hence, it is important to understand how participating in a supportive learning environment influences science identity development. By focusing on the detailed narratives and experiences of FGCS, researchers can gain deeper insights into the specific inflection points where science identity shifts occur and identify effective practices for fostering a strong science identity among these students.

3. Theoretical Framing

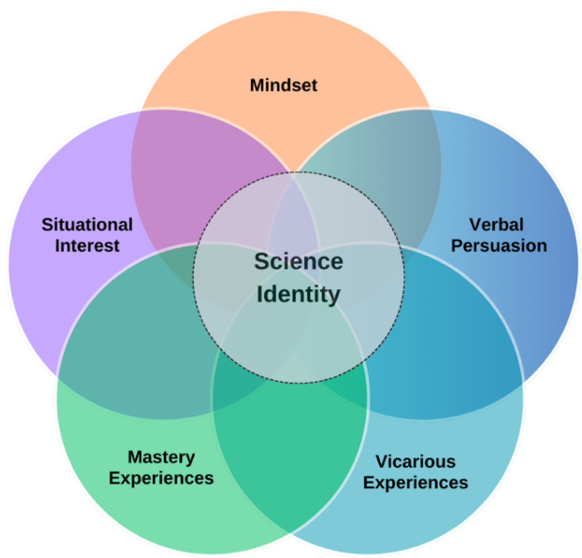
3.1 Operationalized Science Identity (OSI) Framework

The Operationalized Science Identity (OSI) Framework, as introduced by Hosbein & Barbera in 2020, offers a comprehensive approach to understanding what shapes an individual's science identity. According to this framework, five crucial constructs contribute to developing a science identity: mindset, situational interest, verbal persuasion, vicarious experiences, and mastery experiences (Figure 3-1).

Mindset (Dweck, 2006) plays a pivotal role in this framework. It's all about how students perceive their journey to becoming a science person. Some believe that being good at science is an inherent trait, while others think it can be achieved through hard work and determination. The latter group, those with a growth mindset, tend to develop a more robust science identity because they see their abilities as improvable and not fixed.

Figure 3-1

Operationalized Science Identity (OSI) Framework



Situational interest (Hidi & Renniger, 2006; Schiefele, 1991) is defined in stages and revolves around a student's attraction to science within a specific context. This interest can be broken down into two parts: value-related and feeling-related. Value-related interest concerns how personally significant science is to the student, while feeling-related interest deals with the emotions they experience when engaging in scientific activities. Together, these interests shape how students view and relate to science.

Other important constructs are *verbal persuasion* and *vicarious experiences* (Bandura, 1997), which are forms of recognition (Carlone & Johnson, 2007). Verbal persuasion occurs when someone tells a student they are good at science, which can boost their self-efficacy and reinforce their science identity. On the other hand, vicarious experiences involve students observing and appreciating others' success in science. Seeing someone else excel can inspire them and strengthen their self-efficacy.

Finally, mastery experiences (Bandura, 1997) are critical to developing a science identity. These are the moments when students measure their self-efficacy through their successes and failures in specific tasks. For instance, solving a challenging science problem in class can enhance a student's feelings of competence. These positive experiences help build a robust science identity by making students feel capable and accomplished in their scientific endeavors. Together, these five constructs of the OSI Framework provide a detailed understanding of how various factors contribute to developing a strong science identity.

4. Methods

4.1 Narrative Inquiry Methodology

Narrative inquiry is a qualitative research methodology that explores individuals' stories and personal experiences to understand how they make sense of their lives and identities (Clandinin & Connelly, 2000). It focuses on storytelling and personal narratives and offers a valuable approach to exploring lived experiences. Narrative methodology is one of many interpretive approaches used in various fields like sociology, education, and gender studies, and has recently been highlighted for use in chemistry education research (Nardo, 2021), but it is less known compared to case studies or ethnography (McAlpine, 2016). There are three main methodological stances (Elliott, 2005; Pinnegar & Daynes, 2007): 1) Sociocultural- focuses on cultural narratives influencing individual experiences; 2) Naturalist- provides rich descriptions of personal stories about significant issues; 3) Literary- analyzes the language and metaphors used in narratives. Narrative methods can be integrated throughout the research process, from data collection (e.g., interviews, diaries) to data analysis (e.g., narrative analysis, thematic analysis) and reporting (e.g., narrative cameos, thematic summaries).

This manuscript employs narrative inquiry, particularly the naturalist methodological stance. This approach is particularly well-suited for studying identity development, as it allows researchers to capture the complexity and nuance of individual experiences over time. It provides a means to explore how students' identities evolve in response to their educational experiences and interactions, offering an in-depth understanding of how individuals make sense of their experiences and how their identities change over time (Chase, 2005; Clandinin & Connelly, 2000; Creswell, 2007; Riessman, 2008). Its unique feature lies in the chronology of events and people's experiences rather than the recognition of common themes (Riessman, 2008). Narrative inquiry allows for an in-depth exploration of individual experiences and personal stories, providing rich, detailed data that can reveal the complexities of science identity development. One of the limitations of existing research is the lack of detailed insights into the specific inflection points where science identity shifts occur. Narrative inquiry is uniquely positioned to identify and explore these critical moments. Through the collection and analysis of personal narratives, this study can uncover the precise instances and interactions that contribute to significant changes in science identity, providing a more nuanced understanding of the process.

By examining the personal journey of a first-generation student in an LA-supported introductory biology course, this study aims to uncover factors that may influence science identity development and provide insights into effective support mechanisms.

4.2 Study Context

This study was conducted as part of a larger investigation into the science identity development of first-generation college students (FGCS) in learning-assisted supported science classes. Specifically, it took place within the context of a general biology course at a large public university in the southeastern United States. The course was designed with active-learning methods, including clickers, think–pair–share activities, worksheets, and group work, all aimed at enhancing student engagement and understanding. Learning Assistants (LAs), as described by Otero et al. (2010), played a significant role in this setting. A total of eighty-nine students were enrolled in the course, which was supported by six LAs. The class met twice a week for 85 minutes, and weekly quizzes were administered as part of the summative assessment.

The LAs interacted with students during class time to facilitate engagement and learning. During the first two weeks, students had the opportunity to work with and interact with different LAs before selecting a permanent LA to collaborate with for the remainder of the semester. This approach allowed students to find an LA with whom they felt comfortable and supported. In addition to their classroom responsibilities, LAs participated in weekly pedagogical meetings. These sessions provided training on various techniques to offer both psychosocial and learning support to students. This structured support system aimed to create a more inclusive and effective learning environment, particularly beneficial for FGCS navigating the challenges of higher education.

4.3 Study Participant

The sole participant of this study was Tea, a non-traditional, first-generation college student and single mother of two teenage boys, who balanced her academic pursuits with significant family responsibilities. This study focused on Tea's narrative because she demonstrated the most remarkable transformation in her science identity over the course of the semester. Initially, Tea self-identified as a non-science person, but by the end of the semester, she had evolved to confidently self-identify as a science person, showcasing a significant shift in her science identity. Narrative inquiry places participants' voices at the center of the research, empowering them to share their stories and perspectives. This approach is especially important for FGCS, who may often feel marginalized in academic settings. By giving them a platform to articulate their experiences, this study not only contributes to a deeper understanding of their science identity development but also validates and respects their unique contributions and insights.

Tea was a senior working towards her bachelor's degree in psychology with a minor in health and chemistry, and she aspired to attend PA (Physician Assistant) school. Born and raised in a family where no one had graduated from high school or attended college, she was the first in her family to achieve these milestones. For Tea, this accomplishment was not just about personal achievement but was driven by her desire to be a positive example for her siblings, nieces, nephews, and children. She faced limited family support during the college application process, relying instead on financial aid, including Pell Grants. Tea reflected on the financial struggles of being a first-generation college student and the difficulty of balancing her work schedule with on-campus classes. Despite these challenges, Tea maintained a strong sense of faith and exhibited resilience throughout her academic journey. Tea's initial perception of herself as a science person was marked by ambivalence. Although her minor was in science, she did not identify as a science person due to perceived differences in learning speed and articulation compared to her understanding of typical science individuals. Despite this, Tea expressed excitement about specific science subjects and a strong desire to overcome her challenges to pursue her goals. In her biology class, Tea grappled with feelings of belonging, perceiving the class as rushed and feeling uncertain about her comprehension. However, the support of her biology professor, Dr. Elle, and her learning assistant, Ted, played a crucial role in her transformation. Their assistance throughout the semester helped Tea navigate her academic challenges and ultimately develop a strong science identity.

4.4 Data Collection

Tea's journey through her biology course forms the core of this narrative inquiry, focusing on how her science identity evolved over the semester. Data were collected through three semi-structured interviews conducted at distinct points during the semester: the beginning, mid-semester, and end of the semester. These interviews (see Appendix 3A-C) were designed to capture Tea's experiences, perceptions, and identity development as she progressed through the biology course.

Each interview lasted approximately thirty minutes and was held in a quiet, private setting to ensure a comfortable and open environment for conversation. The interviews were designed to be conversational, encouraging Tea to share her experiences and thoughts freely. This approach facilitated a deeper understanding of her journey and the factors influencing her science identity. All interviews were recorded and transcribed for thorough analysis. The data obtained from these interviews provided rich, detailed insights into Tea's evolving science identity, allowing for a comprehensive exploration of the critical moments and interactions that shaped her academic experience. Narrative inquiry offers flexibility in both data collection and analysis, allowing for a more adaptive approach to understanding participants' experiences. This flexibility is particularly valuable in capturing the evolving nature of science identity over time. By conducting multiple interviews at different stages of the semester, the researcher can track the progression of identity development and identify key factors influencing this trajectory.

Trustworthiness

This research was designed to ensure the trustworthiness of the findings by addressing key elements of qualitative research: credibility and transferability (Lincoln & Guba, 1985). To ensure credibility, the study employed strategies such as prolonged engagement and peer debriefing. Conducting multiple interviews over the course of the semester allowed ample time to build trust with the participant and to gain a comprehensive understanding of her evolving science identity. This approach provided a rich, detailed view of her experiences and the factors influencing her identity development. Regular discussions with mentors played a crucial role in maintaining credibility. These peer debriefing sessions provided critical feedback and challenged assumptions, helping to identify and mitigate potential biases. This iterative process of reflection and refinement ensured that the findings accurately represented the participant's experiences and perspectives.

While the primary goal of this study was not generalizability, efforts were made to enhance transferability by providing detailed descriptions of the research context and the participant’s experiences. Through thick description, the study offers rich, contextualized accounts that allow readers to determine the applicability of the findings to other settings.
By carefully documenting the participant's journey, including the specific contexts and interactions that shaped her science identity, the research provides valuable insights that can be

applied to similar educational environments. These detailed narratives enable readers to draw parallels and consider the potential relevance of the findings to their own contexts.

4.5 Data Analysis

The data analysis process followed the principles of narrative inquiry, focusing on the chronological and thematic development of Tea's experiences. The steps involved were:

1. **Familiarization with the Data:** The first step involved thoroughly reading the interview transcripts and additional data sources to understand Tea's experiences and identify preliminary themes. I noted essential experiences pivotal to her science identity development in this step.
2. **Chronological Analysis:** Tea's journey was mapped chronologically, highlighting key phases such as initial hesitation, interactions with LAs, growing confidence, and solidifying science identity. This chronological structure provided a clear framework for the narrative.
3. **Thematic Coding:** The data were coded to identify recurring themes and significant events. Key themes included motivation and aspirations, challenges and support systems, identity evolution, and the impact of first-generation status. Quotes from the transcripts illustrate these themes and add depth to the narrative.
4. **Developing a Narrative:** Reporting narrative research requires balancing detailed individual accounts with broader themes (McAlpine, 2016). A detailed narrative was constructed, integrating the chronological and thematic analyses. This narrative highlighted Tea's evolving science identity and the interplay of various factors influencing her journey. Direct quotes from the interviews were used to bring authenticity and richness to the story.

Research Questions:

This study seeks to answer the following research questions:

- How does Tea's science identity develop over a semester in an LA-supported introductory biology course?
- What challenges does Tea face as a first-generation college student, and how do these challenges impact her science identity?
- What role do Learning Assistants play in the development of Tea's science identity?

5. Findings

Tea's Science Identity Development Trajectory

5.1 Initial Stage

At the beginning of the semester, Tea's perception of her science identity was filled with uncertainty and self-doubt. As a first-generation college student, she faced the dual challenge of navigating college life and tackling a subject she found inherently complex.

5.1.1 Self-Identification as a Non-Science Person

Tea acknowledged that she does not consider herself a science person and expresses fast processing and articulation challenges. Despite this, there is a clear desire and excitement about delving into science fields, particularly biology, with the ultimate goal of graduating and pursuing a Physician Assistant (PA) school. This contrast between her current self-perception and her aspirational goals provides valuable insights into her journey. When asked if she considered herself a science person, she said:

> "No… I want to be a science person, but my brain doesn't... Also, when I think of science people, I think of fast learners. And when you tell them something, they get it right then. I

> am not that person. It takes me a while to articulate what is happening and what is being said. And I process slower than who I think science people are. They process quickly. A and B are done. I'm like A to F."

5.1.2 Perception of a Science Person

Tea described a typical science person as someone extremely smart with a unique way of articulating thoughts, particularly associating them with the medical profession, where individuals exhibit broad thinking abilities and multi-dimensional understanding. She observed that science people, especially doctors, can articulate their thoughts distinctively:

> "A science person? Extremely smart. Someone that understands like... I don't know. When I think of a science person, I think of doctors because they can articulate. Their brain articulates differently than a regular person."

This showcases the intellectual admiration Tea attributes to individuals within the scientific community. She emphasized the importance of broad thinking in the field of science:

> "Their brain articulates differently than a regular person. I remember going up to my biology professor last week, and I was like, 'How do I make myself think differently?' Because she thinks broadly, and so do the student assistants in the class. And I'm like, my brain doesn't do that."

Tea's observation of articulate thinking highlights her acknowledgment of the complexity inherent in the scientific thought process. While she acknowledges these qualities, she also expresses a sense of disparity between her own learning style and what she envisions as typical for science people. Despite pursuing a minor in science, she admits to not fully aligning with the characteristics she associates with science individuals. This divergence, however, doesn't diminish her enthusiasm and dedication to her science studies.

5.1.3 The Role and Impact of Learning Assistant

Tea initially expressed mixed feelings about belonging in her biology class, attributing it to the perceived rushed pace of the class. She felt overwhelmed by the fast pace and intricate content of the biology course:

> "The class is so rushed. I want to say yes [I feel like I belong], but I feel like no, but I want to say yes. The class is just so rushed to where I don't literally know what's going on right now. [I feel] less [of a science person] because I'm just not really getting the guidance that I need."

However, a pivotal moment in Tea's journey came with the interaction of learning assistants (LAs) like Ted. The presence of LAs provided Tea with immediate and accessible support, which was crucial in overcoming her initial barriers. Tea described her experience with Ted as transformative:

> "Amazing. It's the only reason why I'm understanding what I do, a little bit that I do, is because of my learning assistant. And I'm grateful that there was an option to pick your learning assistant and your group people because my learning assistant is Ted, and he's great. Oh, my gosh, he's great. He's clear, he engages."

She recounted a specific incident that highlighted Ted's supportive nature:

> "Even yesterday, he could tell, and he wasn't even standing by me, he wasn't even standing by me at all. But he was down at the bottom of the lecture hall, and he was, like, three rows down. And I was looking at the board, and I had my arm like this [with one hand raised halfway], and I was like, oh, Lord. And I put my hand back up, and I looked at it again, and I was like, all right, I'm not going to say anything. Just let him go past it and I'll just figure it out on my own. And so, I stared at the board a little bit, and then I

> felt somebody looking at me, and he goes, you look like you have a question. And I go, oh. He was like, it's okay. He was like, just tell me, and I can explain it. And I go, I said, I didn't understand nothing you just said. And so, he pointed, he was like, okay, which part of this didn't you understand? And then he was like, you know what? Nope, let's just go through all of it again so you can process it. And I was like, he's so good. And I just appreciated that from him."

Ted's approach made Tea feel included and valued, helping her overcome the fear of asking questions:

> "Ted smiles, and he makes me feel welcome, and doesn't make me feel like an outsider that I don't know this information. He never makes me feel like, oh, my God, this dumb girl. But there are some other learning assistants, and they're just like straight-faced and with this look [give a straight face]... So, I'm grateful for Ted. I'm grateful."

The supportive environment created by Ted played a significant role in helping Tea feel a sense of belonging in the class:

> "Again, Ted is great. He just answers my questions and doesn't look at me with his eyebrows up, like, girl, you're dumb. He doesn't make me feel bad for asking a question over, even if after we just did it."

Reflecting on these initial stages, it was clear that Tea's commitment to her education was driven by a deep sense of responsibility and hope for a better future, both for herself and her family. However, her perception of herself as a science person was still developing. The support and guidance she sought were crucial for her to bridge the gap between her current self-perception and her aspirational identity as a science person.

5.2 Mid-Semester Developments

5.2.1 Self-Identification as a Science Person

By the middle of the semester, Tea's perception of her science identity had undergone a substantial transformation. She began to see herself more confidently as a science person. Reflecting on her journey, Tea shared:

> “I do [see myself as a science person] now. It's because I'm understanding more, and even though the classes are rushed, I still understand most of it, and it's easier for me to understand now because I just have a sense of direction in the structure of the class.”

Reflecting on her evolving perception of herself as a science person, Tea indicated that her learning assistant might now see her as such due to her increased understanding and engagement with the course material. She affirmed,

> "I think he might [see me as a science person]. I think he might now, as opposed to before. And again, that was because I didn't understand anything that was going on, and everything was just hard."

Initially, she struggled to understand and keep up with the fast-paced course. However, over time, she developed a sense of mastery and familiarity with its structure and content.

Tea’s growing confidence was bolstered by the feedback and support from her learning assistants and instructor. She explained some of the factors which contributed to the change in her science identity:

> “First of all, knowing that the tests are not a big grade [referring to the weekly quizzes]. I sent Dr. Elle an email one day, and I asked her, "What are different ways that I can study?" And I even asked Ted in class one day, and I explained to them both what I did. And after I explained it, Ted at first didn't give me anything. And I think I kind of caught

> him off guard, too, because he was kind of just stuck a little bit. But then he was able to give me some information after class. He sent me an email the next morning, it was a book of things that I can do. And then, Dr. Elle sent me an email, and she explained to me it's a lot of information crammed in one week, and you literally really only have that one day in class to go over it because the next following day that you go to class, you have an exam. And so, it's just kind of been beneficial to lay out everything that I have and just go through all of it. After doing the things that Ted helped me to do and then having a little study thing that Dr. Elle does with me, she's even given me information, like side things to do [at] certain times."

Tea's initiative in seeking help from her instructor and learning assistant shows her proactive approach to overcoming challenges. By asking for study tips and additional resources, she took control of her learning process. With these new strategies and supports in place, Tea found herself better equipped to handle the fast pace and dense content of the course. Her improved understanding directly contributed to her growing confidence, making her feel more competent and transforming her self-perception as a science person.

5.2.2 The Role and Impact of Learning Assistant

The relationship and interaction with her learning assistants played a critical role in enhancing Tea's learning experience and self-efficacy. Tea expressed satisfaction with the support provided by her LA, emphasizing their role in clarifying doubts, recognizing her competence, and fostering a supportive learning environment.

5.2.2.1 Recognition of Competence

As the semester progressed, Tea began to experience a shift in her self-perception as a science person, largely due to the positive feedback and encouragement from her LA. Tea recounted an instance where she felt like she was recognized as a science person, and this recognition boosted her confidence:

> "Yeah, with my learning assistant. So, I get very nervous when I'm about to answer a question that is asked because I'm very hesitant on the information. And a long time ago, I used to be that person that's like, "Oh my God, I'm not going to ask that question because I'm going to feel dumb." Now it's more so, "Well, if I get that answer wrong, they're going to ask me why and how I got to it, and sometimes I can explain that."

Tea’s growing self-efficacy was evident as she described her nervousness when answering questions and how the supportive responses from her LA helped her overcome this. This revealed Tea's initial anxiety about participating in class. However, it also shows a shift in her mindset. Initially, she was fearful of getting answers wrong, but with the support of her instructor and her LA, she began to see mistakes as opportunities for learning rather than failures. She continued:

> So here lately, with the extra added studying with Dr. Elle and asking questions in the middle... Like, even one time, I asked a question during the middle of my exam, and I was right, and that was the exam that I got a higher grade on. And he was like, "See, you got it." And just those little words just made me feel like, "Ooh, I got this, I got this, and I can move forward." And so now I try to ask little questions, and Ted is like, "Yeah, that's the right path. Yeah. All right, so give me a little more with that." He doesn't say, "That's right, but..." or "No, that's not it." So, it's just the little words that keep you motivated to do things. And here lately he's just making me feel great about being in science, in class, things like that.

Ted affirmed and praised her for getting a high grade on her quiz. This illustrates the profound impact small affirmations from her learning assistant had on Tea's self-efficacy. The phrase

"Ooh, I got this" signifies a moment of realization and self-assurance that she is capable of understanding and excelling in science. This ongoing encouragement and validation were crucial for Tea, who had previously doubted her abilities.

5.2.2.2 Positive Impact on Self-Efficacy as a Science Learner

Tea recounted a memorable experience during an exam where her learning assistant provided supportive guidance that helped her overcome a challenge and instilled confidence in her abilities:

> "It was that one test that I was telling you about [referring to quiz her LA praised her on] where I got the 6.9 out of 10. And so during exam time, I got stuck on one problem and it was so simple, but I was overthinking it, overlooking it. He [Ted] didn't answer the question for me, but he made me read the question out to him. And as I read the question out, I asked a specific question, and the specific for it was, "Am I overthinking this right here?"
>
> And I didn't even have to really tell him what I was overthinking. And he automatically said, "When you look at everything there, what do you see?" And that right there was just the biggest, "Stop being hard on yourself, you got this." And he literally, at the end of it, he told me, "You got this. Just take your time with it. You're fine. You're going to be fine with it." And then right when I said, "Oh, okay," …. he was like, "See?" And then he walked away. So that was just my... I like Ted. I like Ted a lot…

This story illustrates the personalized support Tea received from her LA. By encouraging her to think through the problem and reassuring her of her capabilities, the LA helped Tea build confidence and develop a more positive self-perception as a science learner.

Further, Tea acknowledged the significant positive impact of her LA on her self-efficacy as a science learner. Their support and encouragement increased her confidence in asking questions and engaging with the learning process:

> I wouldn't have said this before because I didn't really understand what a learning assistant was until I actually started interacting with my learning assistant. They're extremely helpful. And as I said before, sometimes when you're about to ask a question, I kind of am a little hesitant and he'll be like, "No, it's okay. Ask what you're about to ask, because you never know. First of all, somebody else here may have that same question, but you may have heard it differently or understood it differently." So they're just a great impact...

She continued to narrate how interactions with learning assistants were instrumental in affirming her progress and efforts, motivating her to strive for better performance, she said:

> "When you have an extra person that is there motivating you and pushing you and telling you that, 'Yeah, you're on the right track' and things like that, other than just sitting there not having a learning assistant, or no one there to talk to you and answer a quick question because the professor is lecturing. It's so impactful. It's just like, 'All right, I'm doing something right, and I just want to do better, even more than what I'm already doing after this person just told me that I was doing good.'"

Also, Tea described the comprehensive, inclusive, and real-time support provided by her learning assistants, highlighting their willingness to address all questions. She recalled,

> "[Ted is] a great support. Great support. He welcomes everything. He wants all questions no matter what they are, and he's willing to answer them no matter if they sound silly or not… [I interact with Ted] the entire time. Even when she's [Dr. Elle] doing lecture, I

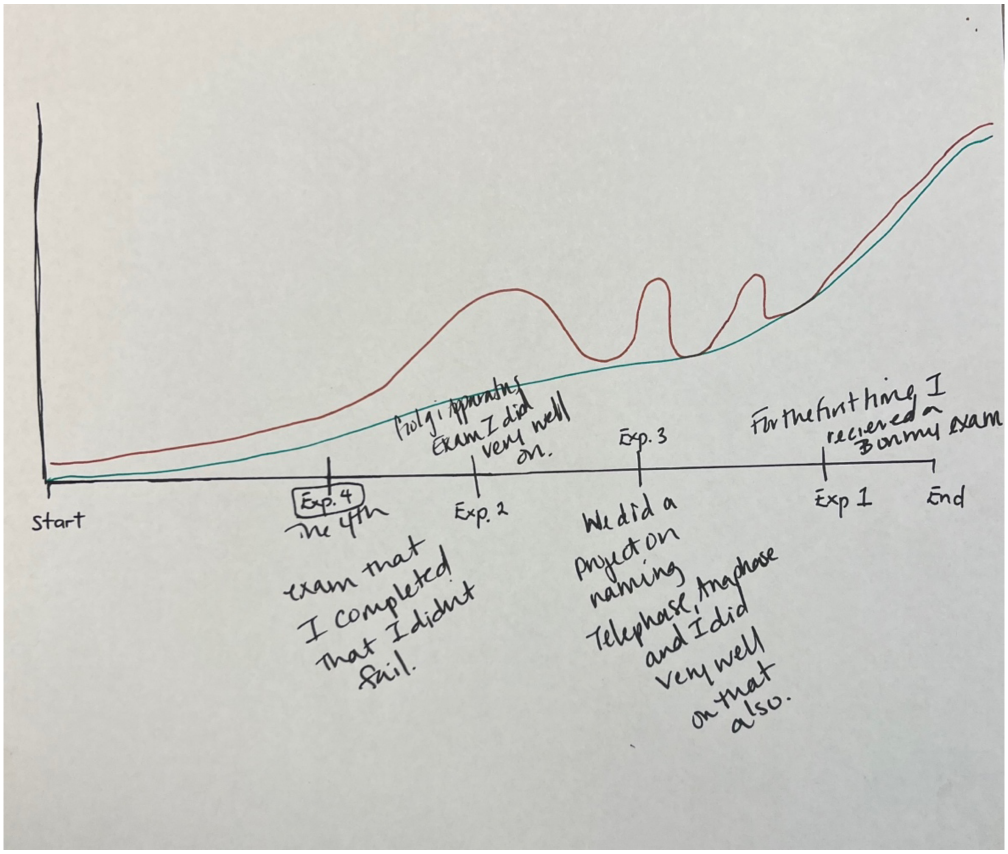
look over at him, and I'm like, "So wait, does she mean this?" And he'll be like, "Yes, yes." And then he'll add his little comments in, too. And it's really good to have that because otherwise I'd be sitting there and I'm like, "All right, well, I'm going to wait for her…to answer my question." and then at that point, I forgot my question... Just the fact that they're always there to answer whatever question. Doesn't matter what it is, doesn't matter what part of class we're in. Whenever we have a question, we can immediately get an answer, so we don't forget our question, and then it's answered immediately… It's hands-on and in real-time. He [Ted] makes me feel more [like a science person] just by being extremely helpful."

5.3 End-of-Semester Reflection

By the end of the semester, Tea's journey toward embracing her science identity was marked by significant milestones and a profound shift in self-perception. The transformation in her confidence and sense of belonging was evident through her reflections and specific experiences she shared during her last interview. She provided a visual illustration (Figure 3-2) of experiences that impacted her science identity (red line) positively over the entire semester. She also depicted her self-efficacy trajectory (green line).

Figure 3-2

Tea's end-of-semester visual illustration



Note: The x-axis represents the timeline of the semester. The y-axis represents change over time.

5.3.1 Overcoming Self-Doubt and Recognizing Competence (Solidifying Science Identity)

One of the pivotal moments for Tea was when she received a B on her exam. This achievement was a significant turning point that significantly impacted her perception of herself as a science person. Tea recounted:

> "I know this last exam had me feeling like a science person [smiling] because I got a B, and I was excited because I worked very hard to get that B. All my tests have been C's, all of them, not one have been an A or a B. So, this last one really made me feel that way. Only because the material was different and a little bit more understandable."

This captures Tea's joy and the sense of accomplishment she felt after receiving her first B. It wasn't just the grade that mattered, but the validation of her hard work and improved understanding of the material. Tea further explained how this success was the culmination of discovering effective study methods and understanding her learning preferences:

> "It took a whole semester for me to actually understand how I study and how I learn. And it's always different for every semester because different knowledge, different techniques, different teachers, different things. But what I noticed was that I don't do well with online books or things like that, but I'm good with notes. And so it was the way that I used my notes and actually just stopped at certain times, stopped using notes, anything, and just read the question out, and then read it again just to make sure that I understood what was being said to me, so I can go back in my notes and find it. So I, literally, for that exam, almost yelled in front of the class. [Getting a B made me feel] more of a science person.

She attributed her ability to understand more of the content to seeing herself as a science person; she said,

> [understanding the content] more so on my own terms because the class is extremely fast. So, nine times out of the 10, she [Dr. Elle] lost me in the first five minutes. So, more of it is going back and looking at my notes, and yeah. Just knowing more of the material, just doing more and understanding more makes me feel like more of a science person, you know what I mean? Because if I don't know much of the information, I don't feel great about it. So I don't feel like... It almost is like, "Oh, well you don't really know much of the material, so how can you be a science person if you don't know the material?"

Although Tea continued to struggle with the fast pace of the class, understanding how she learned best helped her focus her study efforts more effectively. The process she describes—

pausing, rereading questions, and then consulting her notes—demonstrates a strategic approach to learning that allowed her to grasp the material better and perform well on her exams.

5.3.2 Sense of Belonging and Participation

Tea's sense of belonging was further solidified through group activities and projects. She described how involvement in these projects made her feel a sense of belonging in the class. She recalled:

> "It'd be experience three. And that's where the telophase and anaphase and things like that. Because I was able to answer questions, [and] group discussions, I knew things, I was able to help out with the group project and stuff like that. That day, it was five of us. And I was able to help. Even with I think it was experience two. Yeah, experience two. Same thing [answering questions and group discussions] happened in the group. And those things [project details], I remember those things, so I didn't feel awkward or like, 'Oh, I don't want to answer a question, or I don't want to raise my hand, or I don't want to say anything because it might be wrong.' And at those times, I don't feel like I belong. But when I knew some of the material and some of the answers, it made me feel like I belonged more. So it made me want to answer more."

This highlights Tea's growing self-efficacy in active participation in group projects. By answering questions and contributing to discussions, she felt knowledgeable and capable, reinforcing her sense of belonging. The specific mention of understanding complex concepts like telophase and anaphase indicates that she was not just participating but doing so with a solid grasp of the material, which further boosted her confidence.

5.3.3 Trajectory of Self-Efficacy and Science Identity

Tea’s trajectory of her science identity (depicted by the red line in Figure 3-2) was marked by fluctuations. Her trajectory was not linear; it had its ups and downs, but overall, she felt more like a science person by the end of the semester. She recounted:

> “I would say it [my science identity] like this [started really low], but then I would [say it went up] like this. And then, here [a little beyond mid-semester]. I want to think I feel like there was a little bit of a hump and dip here too. **And so now I feel like a science person**…it fluctuated around these exams because I was just confused with my life.”

Despite moments of confusion and self-doubt, her overall trend was towards a stronger identification as a science person. The "humps and dips" she mentioned correspond to the challenges and setbacks she faced (discussed in the next section), but her persistence led to a positive outcome. Although her science identity had more fluctuations, her sense of self-efficacy was steady during that period.

Similar to her science identity, Tea’s self-efficacy (depicted by the green line in Figure 3-2) started really low and grew steadily over the semester. She described her initial feelings of ‘I can do this’ (that is self-efficacy) at the start of the semester. She recalled:

> “[It] started extremely low. When I started out in the semester, it was terrible. I didn't feel like I could do it. Didn't feel smart, didn't feel like I belonged in a class, not for real. And it really wasn't until that fourth exam that made me feel like, 'Oh, okay, maybe I know a little something or maybe this is going well.' And then it just literally started to go up a little bit. But then I got a four out of... What's it, 4.5 out of 10 on one of the exams again. So it dipped a little bit and then it went up, it shot up. And it shot up for... It was two

different times I got a six, and then I got a 6.5 out of 10. And then, this last time, I got an eight out of 10. Finally. All that hard work."

Tea's description of starting the semester with low confidence highlights the initial challenges she faced. However, the fourth exam was a turning point for her (Exp. 4), where she began to see the possibility of success. She then experienced moments of doubt, particularly after receiving low scores. This reflects the non-linear nature of Tea's journey. Despite setbacks, her overall progress was positive. Each success reinforced her self-efficacy and science identity, showing her hard work was paying off.

5.4 Navigating External Stressors

Throughout the semester, Tea faced numerous external factors that significantly influenced her academic journey and self-perception as a science person. These stressors stemmed from various aspects of her life, including work, personal responsibilities, and challenges in other classes.

5.4.1 Impact of work and personal responsibilities

Tea described the myriad external pressures she was under, contributing to fluctuations in her science identity. She recounted,

> "Honestly, it was a lot of different things. Honestly, I can't even say that it was the class. I think it was other things, like my other classes and work. I went through very hard stress at work recently. That's why I was like, I'm even surprised that I even got a B, but I know that was God just showing me, 'Don't give up.' But work has been extremely stressful and life. House and stuff have been stressful. So I think those things. But it was more life stuff, like getting bills paid because I have to be here, and I don't have a husband, or boyfriend or anything like that."

This illustrates how external life stressors, such as work and financial pressures, compounded Tea's academic challenges. Balancing these responsibilities while maintaining her studies significantly affected her overall well-being and academic performance.

5.4.2 Impact of Other Classes on Tea's Science Identity

Tea's experience in her other science class, in particular, profoundly impacted her science identity and sense of self-efficacy. She recounted the discouraging interactions and lack of support from her other professor:

> "And then having another professor tell me that she can't tutor me, or she's not that helpful, it was just taking stress on me. So yeah, just different stuff. So it's really not the [biology] class, it's my other, it's my [other] class. And when that started making me feel some type of way, I just got frustrated about just almost everything and it just... And then being told when you ask about the exam and stuff like that, and she [her other professor] tells you, "No matter what grade you get, you're still not going to get a B in the class [the other science class]." And then I'm just like... So now I'm sad... I don't know, it's just a bunch of emotions,"

The lack of support and rigid structure in her other science class starkly contrasted with her biology class, where she found more flexibility and encouragement:

> "For biology, there are ways to get extra credit. There are ways to bump up your grade. There are different opportunities that are given if you get extensions for homework assignments because life happens, people get sick, and things like that. And for my [other science class] ... I'm sorry [with teary eyes], my eye is burning… [she continued] …In biology, you have notes... and I love the fact that we have notes that we can look over just

real quick just to bring up a remembrance of something, you don't have that in [my other science class] …and so there's just no leeway in [the other science class]"

Tea's frustration with the lack of flexibility in her other science class contributed to a cycle of stress and self-doubt, which at times affected her motivation in her biology class:

> "So yes, [the other science class] has impacted... And I'm going to be honest with you, it almost makes me not even want to attend next year, next semester. And I know that I'm at the end, and I just want to finish. At one time, I was so frustrated with [the other science class] that it made me not even want to put any more effort into biology. So it was just like, it's just a cycle. And for biology, there are ways to get extra credit... But for my [other science class], you have no extension for anything... And it's been extremely stressful to be able to feel like a science person or any type of person because you want to feel good in all your courses. And then if one course is beating you down, it's almost like, 'Well, dang'…"

Despite these challenges, Tea's determination was evident. She acknowledged the difficulties but remained committed to her goals. She concluded,

> "But again, we're adults, so we just got to do what we got to do and keep it pushing…. and I'm not expecting any handouts. I just need some help. Just some help. And I haven't gotten that from the [other science class] …So yeah. Sorry. That was a little long-winded."

These external factors significantly influenced Tea's science identity and feelings of belonging. The supportive environment in her biology class, contrasted with the rigidity and lack of support in her other science class, highlighted how different teaching approaches and class structures can impact a student's self-efficacy and identity. Tea's reflections reveal the emotional and psychological toll that academic pressures and external stressors can take on first-generation college students.

6. Discussion and Implications

This study aimed to explore and understand the trajectory and developing science identity of a first-generation college student enrolled in an LA-supported introductory biology course over an entire semester. Tea's journey illustrates the initial challenges first-generation students face in an introductory STEM course, including self-doubt and lack of self-efficacy in their abilities. The findings show a clear growth trajectory in Tea's science identity, facilitated by consistent support and encouragement from her LA and instructor. This aligns with the OSI Framework, which identifies mastery experiences as crucial for developing a strong science identity. Tea's gradual improvement and increasing self-efficacy reflect the importance of providing opportunities for students to experience success in their academic endeavors. The findings also highlight the significance of mindset in science identity development. Tea's transition from self-identifying as a non-science person to embracing a science identity highlights the transformative power of a growth mindset encouraged by positive reinforcement. According to the OSI Framework, a growth mindset helps students view their abilities as improvable through effort and persistence, evident in Tea's evolving self-perception throughout the semester.

The study highlights the crucial role of LAs in providing immediate and accessible support, significantly impacting first-generation students' self-efficacy and academic performance. Research has shown that peer-assisted learning models like the LA model can enhance student engagement and achievement, particularly in STEM education (Goertzen et al., 2011; Talbot et al., 2015). In the case of Tea, her interactions with her LA, Ted, were transformative. Ted's proactive engagement and personalized assistance were pivotal in helping

Tea overcome initial self-doubt and confusion. This personalized support aligns with verbal persuasion and vicarious experiences as key constructs for developing a strong science identity (Hosbein & Barbera, 2020). Tea's narrative highlights how Ted's encouragement and immediate feedback helped her feel competent and confident in her scientific abilities, fostering her science identity.

LAs play a significant role in creating an inclusive classroom environment, essential for mitigating feelings of isolation and imposter syndrome often experienced by first-generation students. The literature indicates that first-generation students frequently struggle with feelings of not belonging and self-doubt (Stebleton et al., 2014). By providing consistent and relatable peer support, LAs help foster a sense of community and belonging within the classroom. Tea's experiences with Ted illustrate how LAs can make students feel welcomed and valued, reducing feelings of alienation. This sense of belonging is crucial as it directly influences students' self-efficacy and willingness to engage in class activities. The positive reinforcement and approachable demeanor of LAs like Ted make a significant difference in helping students like Tea see themselves as capable and belonging in the scientific community.

Tea's experience as a single mother juggling family responsibilities, work, and academic pursuits reflects the broader challenges many first-generation students face. These external stressors significantly impact students' academic performance and, consequently, their science identity development. The literature indicates that first-generation students often face financial pressures, familial responsibilities, and the need to balance work and study, creating additional stress and barriers to success (Engle & Tinto, 2008; Pascarella et al., 2004). The findings suggest that educational institutions need to consider these external stressors and provide flexible support systems to accommodate diverse student needs. For instance, offering flexible deadlines using a framework such as Universal Design for Learning (Rose, 2000; Rose & Meyer, 2002), providing access to on-campus childcare, and creating financial aid packages that address the unique needs of first-generation students can help mitigate these challenges.

The contrast between the supportive environment in Tea's biology class and the rigidity in her other science class highlights the variability in teaching approaches and their impact on student confidence. While Tea's biology class, supported by LAs, provided a flexible and encouraging learning environment, her other science class was characterized by a lack of support and rigid policies. This discrepancy significantly affected her confidence and overall academic experience. The literature suggests that supportive teaching practices, such as those exemplified by the LA model, are crucial for fostering a positive learning environment and enhancing student persistence in STEM fields (Goertzen et al., 2011; Sellami et al., 2017). Consistent application of supportive teaching practices across all courses is essential to ensure holistic student support and success.

The detailed accounts of Ted's interactions with Tea demonstrate the effectiveness of proactive and personalized support in enhancing student learning and confidence. Encouraging LAs and instructors to adopt similar approaches can help create more supportive and effective learning environments. This aligns with the OSI Framework's emphasis on verbal persuasion and mastery experiences, highlighting the importance of feedback and encouragement in developing a strong science identity. The positive impact of flexible course structures in the biology class, such as opportunities for extra credit and extensions, contrasts sharply with the rigid structure of Tea's other science class. This suggests that incorporating flexibility and understanding in course policies can significantly benefit first-generation students who may face unique challenges to enhance their academic success and science identity development.

7. Conclusion

In this study, the development of science identity in Tea, a first-generation college student, was explored within an LA-supported introductory biology course. Throughout the semester, Tea faced the typical challenges that FGCS face, including balancing academic responsibilities with personal and family obligations, alongside financial pressures and a lack of familial guidance. These challenges often led to feelings of isolation and imposter syndrome, impacting her academic performance and self-efficacy. The LA model showed evidence as an effective approach to support students like Tea. The presence of her LA, Ted, was instrumental in providing peer support and creating a learning environment that fostered science identity development.

Supportive and flexible teaching practices played a critical role in enhancing Tea's persistence in her science course. This significantly influenced her science identity development, transforming her from a student filled with uncertainty to one with growing confidence. The biology class, characterized by flexible deadlines, extra credit opportunities, and immediate feedback from LAs, significantly contributed to her sense of belonging and academic confidence. In contrast, the rigid structure of her other science courses often exacerbated her stress and self-doubt.

In conclusion, this study highlighted the importance of a supportive and welcoming learning environment in developing a positive science identity for a first-generation college student. By understanding and addressing the unique challenges of FGCS, educational institutions can create more inclusive environments that promote success and persistence in STEM fields. Tea's journey provided valuable insights into effective support mechanisms provided by an LA-supported course for helping first-generation students navigate their academic paths and achieve their goals.

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Appendix 3-A

First Interview Protocol

This first set of questions addresses first-generation college student identity and will help us to understand the unique experiences first-generation college students have.

3. What does it mean to you to be a first-generation college student?
4. Has being a first-generation college student impacted your college experience so far?
    3. If yes, how?
5. What motivated you to pursue a college degree?
6. How did your family support or hinder you when you were applying and accepted to colleges?
    3. Did you rely on others to support you during this time?
        3. If yes, who and how did they support you?
7. What challenges have you faced in college so far?
8. What resources have been the most helpful to you in navigating college so far?
9. How have you managed to balance your academic and social responsibilities?
10. Has your college experience been different from what you had expected?
    3. If yes, how?
11. What has been your proudest moment as a college student?
12. What has been the most valuable lesson you have learned in college so far?
13. What advice would you give to other college students?
14. What would you like to see in your classroom to better support you as a college student?
15. What would you like to see universities do to better support college students?

This next set of questions addresses science identity and belonging.

16. How would you describe a typical science person?
17. Do you consider yourself a science person?
    3. Why or why not?
18. What inspired you to choose [their major] [science, technology, engineering, or math]?
19. What do you think it takes to be successful in STEM fields?
20. What do you think will be the most important skills you need to develop in order to pursue a career in STEM?
21. Do you feel like you belong in your [CHEM 1110/BIOL 1110] class?
    3. Why or Why not?
22. Is there anything about the course that has made you feel like more or less of a science person?

This question will help us to understand the impact of the LAs on identity

23. Describe your experience with your LA so far.
24. How have the learning assistants helped you feel like more or less of a science person?

Appendix 3-B

Second Interview Protocol

Let's talk a bit about your class context (General Chemistry/Biology)

2. What was your motivation for taking this course?
   ii. What are your goals for this class?
3. How confident are you that you can understand science in class?
   ii. How confident are you that you can understand science outside of class?
4. Do you value the content you're learning in this class? *How so?*
5. Tell me about a time when you felt confident with the material.
6. Do you enjoy learning *about science (*Chemistry/Biology) in this class?
   ii. Do you enjoy learning science outside of this class?
7. Has this course made you interested in learning more about science?
   Probe: *In what ways?*
8. Have you had specific experiences that you can recall where you feel like you've been recognized as a science person?
   ii. Tell me about a time (in this course) you've felt like a science person.

The next set of questions will focus on your relationship with the learning assistants.

9. Tell me about your *relationship and* interaction with the Learning Assistants in this class.
   ii. How often do you interact with your LA?
   iii. What does the conversation initiation with your LA look like?
10. Can you share your experiences in LA-supported science classes? What stands out to you about these classes?
11. Does your interaction with your LAs impact how you see yourself as a science person?
    ii.(If No) Does it impact your confidence in seeing yourself as a science person if you wanted to?
12. In your opinion, do LAs (learning assistants) have an impact on how students perceive themselves as science learners? If so, how?
13. Can you recall any specific interactions or experiences with LAs that made you feel more connected to or confident in science?
14. What made you feel a sense of belonging when interacting with the LA
15. What helped you feel like a science person (sense of belonging) in this course
16. Tell me about a memorable experience you've had with your LA.
17. How would you describe what kind of support your LA provides?
18. When do you find the support of your LA most beneficial, during regular class time or "study hours"? Why?

Science person

19. In our last interview, you defined a science person as _______. How do you define a science person now?
    ii. How has this changed?
20. Do you think your LA sees you as a science person?

ii. Do you think your instructor sees you as a science person?
iii. Do your friends or peers see you as a science person?
iv. Do you see yourself as a science-person?

21. What is it about science that interests you?
22. Why is science worth pursuing as a major/career?
23. Did you have role models or supporters who helped shape your interest in science?
24. Do you feel that you are part of a science community? How?
25. What has helped you persist in science?

First Generation Status Follow up

26. How would you describe stereotypical first-generation students.
27. Besides your first-generation status, are there other social identities that impact your experiences in your classroom, or in science in general? (such as race, gender, sexual identity, disability status, etc.")

Appendix 3-C

Third Interview Protocol

Hi, thank you for joining me for our third and last interview.

The first two questions will be about comparing your classes with LAs and those without.

1. How does having LAs in your Chemistry/Biology class differ from other science classes you don't have LAs?
2. Would you have preferred to have LAs in those classes, or it doesn't matter?
    a. Why or why not?

I will be asking for some visual illustrations, that's because I'm looking for a more detailed and nuanced understanding of your experiences or perspectives. Be as creative as you want.

3. Think about your experiences over the semester. Write out **four** experiences (things that stood out to you the most) that you recall that were related to you feeling like a science person or not.
4. Can you describe one of these moments in more detail and how that impacted you as a science person?
5. Can you describe one of these moments in more detail and how that impacted your sense of belonging? (where? science community or the classroom).
6. **(in green)** Draw a line that depicts your emotions or feelings of 'I can do this' over the semester.
7. **(in red)** Draw a line that depicts the trajectory of your identity as a science person.

Peer Mentoring

8. Why do you think your professor invited LAs into her classroom? What do you think she wanted to accomplish?
9. How does your LA provide support when you encounter challenges or difficulties in your coursework? Can you share any specific examples of their support?
10. What qualities or actions make LAs effective in helping you overcome academic challenges in your classroom?
11. Do LAs play a role in connecting you with the broader STEM community? If so, can you describe how they facilitate this connection?
12. Have you been involved in any STEM-related activities, groups, or events you learned about through your interactions with Learning Assistants? Please share your experiences.
13. How do your LAs encourage your interest and participation in STEM beyond the classroom? Can you provide any examples of their efforts in this regard?

Conclusion

In this dissertation, we investigated the science identity development of FGCS in LA-supported science classes. This research aimed to uncover the complex and multifaceted processes through which FGCS come to see themselves as "science people" and how various elements of the educational environment influence this identity development. By conducting three interrelated studies, we explored the initial perceptions and descriptions of what it means to be a "science person," examined the impact of LA-supported learning environments on FGCS's science identity, and traced the science identity development of an individual FGCS over a semester. The research findings highlight the crucial role of supportive educational environments, the importance of formal recognition within the scientific community, and the transformative impact of Learning Assistants. By integrating identity theory and operationalized science identity framework within an interpretivist paradigm, this dissertation offers an understanding of the personal and contextual factors that influence science identity development among FGCS.

In the following sections, the key findings from each study are synthesized, their implications for practice and research are discussed, and recommendations are offered for educators and institutions aiming to support FGCS in STEM fields. Additionally, directions for future research are outlined to build on this work and further enhance our understanding of science identity development.

Summary of Findings

Manuscript 1: Exploring Science Identity Among First-Generation College Students

This study identified three major themes in the science identity of first-generation college students (FGCS): Personal Science Identity Traits, Positional Science Identity, and Participatory

Science Identity. These themes align with Gee's (2000) identity theory, which includes Nature-identity (N-identity), Institution-identity (I-identity), and Affinity-identity (A-identity), respectively. FGCS perceived a "science person" as someone with intrinsic interest and passion for science who holds formal scientific roles and actively participates in scientific communities. The findings suggest that while FGCS have a broad and inclusive view of what it means to be a "science person," they may struggle to see themselves in these roles without explicit support and validation from their academic institutions.

Manuscript 2: The Impact of LA-Supported Science Learning Environment on FGCS's Science Identity

This study explored how FGCS perceive their science identity development in Learning Assistant (LA)-supported science classes. It revealed that vicarious experiences, verbal recognition, and mastery experiences enhanced FGCS's science identity. Key factors within the learning environment that contribute to positive science identity development include collaborative group work, peer teaching, engaging course material, and a supportive classroom atmosphere. The findings emphasize the critical role of LAs in fostering a welcoming and inclusive environment that supports FGCS in developing a strong science identity.

Manuscript 3: A First-Generation Student's Trajectory in an LA-Supported Science Course

The third study followed the science identity development of Tea, a first-generation student, over a semester in an LA-supported introductory biology course. Tea's journey highlighted initial challenges, such as self-doubt and feelings of isolation, which were mitigated through consistent support and encouragement from her LA. The study emphasized the importance of mastery experiences, verbal persuasion, and a growth mindset in fostering science identity. The flexible and supportive learning environment in her biology class contributed to her developing self-efficacy and science identity.

Connections Among the Three Manuscripts

The findings from the three manuscripts offer a comprehensive and interconnected view of science identity development among first-generation college students (FGCS) in STEM courses. Each study, while distinct in its perspective, collectively contributes to a nuanced understanding of how science identity evolves, particularly under the influence of LAs.

The connection among the three manuscripts lies in the evolution of science identity from a fixed, innate perspective to a more dynamic, growth-oriented mindset. Manuscript 1 sets the stage by identifying the initial nature-identity perspective among participants. It revealed that FGCS initially described a "science person" through the lens of nature-identity, viewing scientific capability as an inherent trait. Participants often believed that being good at science was something innate, rather than a skill that could be developed. This mindset posed a significant barrier to their self-identification as science people. Manuscript 2 explores the mechanisms through which LAs influence this perspective, highlighting their role in challenging stereotypes and boosting self-efficacy. Manuscript 3 provides a concrete example of this transformation through Tea's journey, illustrating how LAs and mastery experiences can significantly shift a student's science identity. For example, in manuscript 3, Tea initially described a science person using nature-identity, perceiving them as inherently smart and fundamentally different. This view was encapsulated in her statement, "Someone extremely smart, their brain articulates differently than a regular person." However, by the middle of the semester, her perception of her science identity had undergone a substantial transformation. The presence of LAs provided Tea with immediate and accessible support, which was crucial in overcoming her initial barriers. These interactions facilitated a shift in her self-perception, moving away from the fixed notion of innate ability to recognize her potential to develop as a science person.

Similarly, findings in Manuscript 2 were also highlighted in Manuscript 3, the roles of LAs in providing psychosocial support, verbal recognition, supportive guidance, and facilitating mastery experiences, which boosted participants' self-efficacy and science identity. In Manuscript 3, Tea initially struggled with self-doubt and did not see herself fitting into formal scientific roles until she received consistent support and encouragement from her LA. This support helped her to gradually see herself as a "science person" and aspire to formal scientific roles, indicating the importance of institutional recognition in science identity development. The study highlights the crucial role of LAs in providing immediate and accessible support, impacting first-generation students' self-efficacy and academic performance. Research has shown that peer-assisted learning models like the LA model can enhance student engagement and achievement, particularly in STEM education (Goertzen et al., 2011; Talbot et al., 2015). In the case of Tea, her interactions with her LA, Ted, were transformative. Ted's proactive engagement and personalized assistance were pivotal in helping Tea overcome initial self-doubt and confusion. This personalized support aligns with verbal persuasion and vicarious experiences as key constructs for developing a strong science identity (Carlone & Johnson (2007; Hosbein & Barbera, 2020).

The cumulative findings highlight the critical role of supportive educational practices, such as the integration of LAs, in fostering a growth mindset and enhancing science identity among FGCS. By challenging preconceived notions about scientific ability and providing targeted support, LAs help students recognize their potential and develop a robust science identity.

Implications for Practice

The findings from these three manuscripts provide valuable insights for educators and policymakers aiming to create more inclusive and supportive learning environments for first-generation college students (FGCS) in STEM disciplines. The implications for practice can be categorized into three key areas: addressing perceptions of a science person, enhancing the role of Learning Assistants (LAs), and fostering mastery experiences.

Addressing Perceptions of a Science Person- FGCS often enter STEM courses with preconceived notions about what it means to be a science person, typically viewing it as an inherent trait. This perception can either serve as a strength or a barrier in their self-identification as science individuals. For some, the belief in inherent scientific ability may bolster confidence if they see themselves as naturally talented. However, for many FGCS, this perception acts as a significant barrier, leading to self-doubt and the belief that they are not "born" to be scientists.

It is crucial for educators to create learning environments that challenge the notion of science identity as an innate trait. Instead, they should emphasize that scientific skills and knowledge can be developed through effort and perseverance. By promoting a growth mindset, educators can help FGCS understand that becoming a science person is achievable for anyone who is willing to work hard and persist through challenges. This shift in perception can significantly enhance FGCS's confidence and motivation in STEM fields.

Enhancing the Role of Learning Assistants- Learning Assistants (LAs) play a pivotal role in shaping the science identities of FGCS by providing vicarious experiences and verbal persuasion. These interactions are critical in helping students see themselves as capable scientists. LAs serve as relatable role models who can demonstrate that scientific success is not solely the result of inherent talent but also of dedication and hard work.

To maximize the positive impact of LAs, it is essential to develop comprehensive training programs that emphasize their role in challenging stereotypes and providing verbal recognition and support. LAs should be trained to recognize the unique challenges faced by FGCS and to offer encouragement and constructive feedback that reinforces a growth mindset. By actively engaging with students and providing consistent verbal affirmation, LAs can help FGCS overcome self-doubt and build a stronger, more positive science identity.

Fostering Mastery Experiences- The findings highlight the significant impact of mastery experiences on the science identity development of FGCS. Throughout the semester, mastery experiences—such as successfully completing challenging assignments, performing well on exams, and effectively engaging in scientific experiments—were shown to be highly influential in shaping a student's confidence and self-perception as a science person.

Educators should prioritize creating opportunities for FGCS to experience mastery in their STEM courses. This involves designing coursework that includes achievable challenges, providing timely and constructive feedback, and celebrating students' successes. By facilitating mastery experiences, educators can help students build a sense of competence and confidence in their scientific abilities. These positive experiences reinforce the belief that they are capable science people, further strengthening their science identity.

Implications for Research

The findings from the three manuscripts offer valuable insights into the development of science identity among first-generation college students (FGCS) and highlight several areas where future research could further advance our understanding. Two key areas for future research include examining the perception of innate traits in FGCS and conducting longitudinal studies on the long-term impact of different constructs of the science identity framework.

Exploring the Perception of Innate Traits Among FGCS

One of the key findings from the current study is the prevalent perception among these FGCS that being a "science person" is an innate trait. Future research should investigate whether this perception is unique to FGCS or if it is also common among other student populations. Understanding why FGCS might hold this belief more strongly than their peers is crucial. Possible factors to explore include:

- Cultural and Societal Influences: Investigate how cultural backgrounds and societal messages contribute to the belief in innate scientific ability among FGCS. This might involve examining the role of family expectations, cultural narratives about intelligence, and exposure to role models in science.
- Psychological Factors**:** Examine the psychological aspects that might lead FGCS to perceive scientific ability as innate. This could include studies on self-efficacy, stereotype threat, and the impact of academic setbacks on students' beliefs about their capabilities.

Longitudinal Studies on Science Identity Constructs

While the current studies provide a snapshot of how science identity develops over a single semester, there is a need for longitudinal research to understand the long-term impact of different constructs of the science identity framework on FGCS. Such studies could address several important questions:

- Sustained Impact of LAs: Investigate the long-term effects of Learning Assistants on FGCS's science identity. Do the positive influences observed in the short term continue to benefit students throughout their academic careers and into their professional lives?

- Evolution of Science Identity: Track FGCS over several years to observe how their science identity evolves. What constructs (e.g., verbal recognition, mastery experiences, vicarious experiences) remain influential, and how do new experiences in advanced courses or research opportunities shape their identities?

Conclusion

This dissertation aimed to investigate the science identity development of FGCS in an LA-supported introductory science class. The journey of FGCS in developing a science identity is complex and multifaceted. This collection of studies provides a comprehensive exploration of science identity development among FGCS within science classes, highlighting the dynamic interplay between perceptions, support systems, and educational practices. While each manuscript approached the topic from a distinct angle, their findings collectively contribute to a nuanced understanding of how science identities are formed, challenged, and transformed. These manuscripts collectively illustrate that with the right support and educational practices, FGCS can overcome initial barriers and develop a robust science identity. By promoting a growth mindset, leveraging the supportive role of Learning Assistants, and emphasizing mastery experiences, educators can significantly enhance the science identity development of FGCS.

References: Conclusion

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