Understanding Mentoring Style of Mentors and Science Identity Formation in Historically Excluded Undergraduate Students in Natural History Collections

Jeanette Pirlo (✉ jpirlo@flmnh.ufl.edu)

University of Florida

Research Article

Keywords: Science Identity, Mentorship, HEGs, Qualitative Analysis, Phenomenology, Natural History Collections, Museums, STEM, Minority, Historically Excluded Groups

Posted Date: January 14th, 2022

DOI: <https://doi.org/10.21203/rs.3.rs-1248699/v1>

License: This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Abstract

Background: Science identity formation is integral to the transformation from a student to a member of the STEM workforce. However, the formation of a student's science identity is affected by various factors such as support from mentors and community members, the student's perception of their peers' acceptance of them, as well as the student's own perception of their role in research. The aim of this study is to investigate mentors' understanding of science identity formation, their mentoring style, and if it is effective when working with students from historically excluded populations. A phenomenological approach was used to conduct this study. Structured interviews were conducted with natural history collections faculty members of various backgrounds and career levels.

Results: Three themes emerged that contribute to science identity formation through mentoring: 1. Factors for science identity formation; 2. Mentorship among different career stages, and 3. Defining own mentoring style. Predominantly, participants realized that their own experience as a mentee shapes how they approach mentoring.

Conclusions: Although this study describes the mentee's science identity formation from the mentor's point of view, the study's participants realized the importance they play in a student's science identity formation, and that mindful mentoring is necessary for success when engaging historically excluded groups in the STEM workforce.

Background

Science, Technology, Engineering, and Mathematics (STEM) careers drive innovation and competitiveness between countries through the production of new ideas and technology. However, there is a lack of workers in some STEM careers in the United States (Xue and Larson 2015). Within these burgeoning fields, there is a disproportionate number of males versus females, and an even greater disproportion of white workers in STEM compared to underrepresented minorities (Ovink and Veazey 2011, Sassler et al. 2017). These disparate values extend into STEM majors at the undergraduate and graduate levels (Blair 2011, Carlone and Johnson 2007, Mussey 2009, Wilker 2017). A large volume of literature examines potential drivers for this inequality, with more recent articles testing programs that can broaden diversity, equity, and inclusion through completion, from college through a professional career. Mentors, and their mentoring style, specifically, affect and develop science identity in underrepresented minorities (Aikens et al. 2017, Ovink and Veazey 2011, Thiry and Larsen 2011). Experiences in STEM can be applied to a myriad of careers including working within natural history collections and museum spaces as skills learned in STEM fields can inform research in these areas.

Natural history collections hold a trove of treasures ranging from fossils to the stories of how specimens were collected. These aspects of collections provide vital information about a specimen, but most importantly, increase our understanding of life on earth over time. As natural history research keeps pace with modern technology, broader questions are being answered

Historically excluded groups (HEG) are people that do not fit the cis white male stereotypes that make up the vast majority of STEM fields. HEGs includes diverse groups of gender, gender identity, race, ability differences, class, sexual orientation, etc. (Berry 2021). It is important to recognize that by combining these groups under one acronym does not acknowledge the intersectionality within these groups. HEGs are more likely to seek advanced degrees in education and business, than in STEM (Bell 2008, Jensen et al. 2021). Still, through programs specific for HEG students, more are persevering through to the completion of a STEM degree (Ikuma et al. 2019). All of the studies that have tracked retention in STEM show that the concept of science identity plays a crucial role in completion and persistence into STEM careers.

Science identity (SI) is defined by White et al. (2019) as who the student is, what the student is capable of doing, and what the student aspires to do and become as it relates to science. SI is essential in the transformation from a student of STEM to a worker in a field of STEM. For example, a first-generation Latino undergraduate STEM student will see themselves as a student majoring in marine biology, but once in the workforce, they might see themselves as a marine biologist. However, identifying as a scientist is more complicated than receiving a degree in the field. SI is based not only on the individual's perception of themselves, but also on how they think those influential players in the field view them (Carlone and Johnson 2007, White et al. 2019). Developing one's SI takes advising from trusted mentors, validation and support from a community, and experience within the field. Nevertheless, HEG students face multiple barriers as they navigate through a STEM career (Guy & Boards 2019, Marin-Spiotta et al. 2020, Skrentny & Lewis 2021).

STEM degrees are not easily attained. Core courses like calculus, chemistry, and biology are designed explicitly to "weed-out" students that are unable to keep up with the rigor of the material. Unfortunately, HEG students are less prepared to excel in a demanding STEM curriculum when they arrive at college than their majority counterparts (Perna et al. 2009). Along with these weed-out courses, Ovink and Veazey (2011) point out the need for advisors, community support, and experience as vital for the development of SI and the completion of a STEM degree. Using an intervention, or bridge program specifically designed to address academics, socialization in academic communities, networking, and a safe space to practice new skills via undergraduate research for historically excluded groups, Ovink and Veazey (2011) shed light on the importance of institutions investing in enriching students' cultural and social capital to develop their SI. These results are corroborated by Carlone and Johnson's (2007) findings on the critical experiences that women of color defined as being formative in the creation of their SI. Through interviews, participants described the importance of recognition from external valued members of their STEM field as one of the significant contributors to SI, along with pre-college experiences, family support, mentor encouragement, intrinsic motivation and perseverance, and being a part of a small and supportive community (Carlone and Johnson 2007). Therefore, to develop a strong SI, HEGs need to be competent in their field, trust in their performance, and feel recognized by other scientists in their field. To build these components, HEGs need access to trusted mentors that can help them navigate the new experiences of undergraduate work, a community of peers, and an opportunity to develop new skills through undergraduate research (Carlone and Johnson 2007, Ovink and Veazey 2011).

Another critical factor in the development of science identity and perseverance to completion is through community involvement (Chemers et al. 2011, Hendricks et al. 1996). Participants in the study by Hendricks et al. (1996) described that much of their determination to succeed in their academic career, stemmed from a calling and obligation to serve their community and society in general. Contributions to their community is often seen as a way to give back, either by righting inequalities, providing services previously unavailable, or some other reason (Hendricks et al. 1996, Jensen et al. 2021). Chemers et al. (2011) take it a step further by demonstrating the importance of belonging to different types of communities, not just childhood communities, but STEM communities, and the participation in them. These alternate communities include professional scientific conferences and other group events that build a participant's network, as well as a sense of community. Successful undergraduate programs supporting HEG students in STEM must also include opportunities for students to attend scientific conferences and connections to networks external of their home institution.

Securing one's science identity is determined by several factors: (1) accepting oneself as a scientist; (2) feeling like other respected scientists in one's field view them as a scientist; (3) having confidence in one's use of relevant scientific vocabulary; and (4) having confidence in one's knowledge of a specific field (Carlone and Johnson 2007). Mentors must be aware of the components that make up science identity. This can be achieved by understanding their own path to their SI and fostering SI growth within their mentees. Fostering this growth, however, can be challenging when working with HEGs. Oftentimes, HEG students are unaware of what questions to ask or are even uncomfortable asking for help (Riccitelli 2015, Zambrana et al. 2015). Mentors must be able to anticipate potential questions in a manner that does not belittle the mentee and push them away from asking for assistance. In the best-case scenario, mentors also need to understand the needs and attributes of success as described above.

Studies have shown that science identity formation for HEGs is based on several factors. Therefore, it is crucial for undergraduate programs that look to broaden representation via HEG participation in research to understand that SI formation is multi-faceted and requires a true and honest commitment from the mentors involved. Unfortunately, with the national push to increase representation within STEM, either from funding agencies like the National Science Foundation (NSF 2017), or other sources, many HEG students are being targeted on the basis of the "historically excluded" label that they bring, and not provided with adequate mentoring to aid in retention, and eventual integration into the STEM workforce (Zambrana et al. 2015). A lack of understanding by mentors of the factors that aid in the formation of science identity of underrepresented minority undergraduate students can negatively impact the very demographic they seek to boost.

The purpose of this study is to examine mentors' understanding of their mentoring style, how their personal science identity was formed, and how they affect their mentees' SI formation and long-term retention in STEM. Data collected from these interviews were used to identify themes that contribute to researchers' understanding of the type of mentoring style that fosters science identity formation in HEGs. By understanding their own process in attaining their science identity, and the type of mentoring that was effective in fostering their own growth, mentors can be better prepared in aiding HEG students in

internship programs designed to increase representation within STEM fields. By basing this study on the theoretical framework put forth by Brown et al. (2005) and improved upon by Carlone and Johnson (2007), interviewees of this study were asked to discuss what they believe is important for forming a solid science identity, and how their mentoring style fosters that growth. Specifically, this study aimed to answer the questions: (1) What do mentors think is important for science identity formation? (2) What were the important moments that mentors experienced in their own science identity formation? (3) How has their mentorship experience influenced their personal mentoring style?

Results

Three themes emerged that contribute to science identity formation through mentoring: 1. Factors for science identity formation; 2. Mentorship among different career stages, and 3. Defining own mentoring style. Each participant highlighted challenges that they faced as they developed their personal science identity, experiences while mentees, and how they used their personal experiences to provide better mentorship for the students they work with.

Theme 1: Factors for Science Identity Formation

The first theme that emerged was the different factors that each interviewed participant viewed as important for forming science identity (SI). This theme relates specifically to the participants' own understanding of their SI formation, and their experience watching their mentees form their SI. Each participant agreed that a student must be able to "see themselves in a position in order to make the leap from being a student to be a researcher or actual scientist." This can be achieved by having access to "role models that look like you, sound like you, that may have something in common with you." Each participant spoke of the importance of hands-on experience, working in groups, and having

"room for exploration to see what a person likes, letting students explore new skills and problem solve, and having supportive parents that allow students to freely explore their interest."

One important comment was made by an interviewee pertaining to working with women and the importance of "seeing [other] women who are academics and raising a family" because it made them realize they could have a fulfilling academic career, as well as a family. The research participants, without exposure to the literature during the interview process, summarized the findings in the literature (Carlone and Johnson 2007, Ovink and Veazey 2011).

Theme 2: Mentorship Among Different Career Stages

The second emergent theme was the difference in how the participants in each career stage, i.e., established career professionals, mid-career professionals, and early career professional, viewed the mentorship that they received as students. Established career professionals discussed how their advisors did not leave them with positive experiences, "No one thought of mentoring in the manner in which we do

now. My graduate mentor was very hands-off.” Early career professionals view their time with their mentors in a much more positive light. One participant described an event in which their:

“Mentor was someone who treated me and taught me about equality, I ended up with two course preps or something, while all the other students only had one. And I was a first year, so why was I getting all of this extra work. So, when she found out, I have never seen such a fury on someone’s face as they walked down the hallway, like I just walked out and then just closed the door. But the fact that, she saw that an inequality was happening in the department, and she stood up for me...she knew that it wasn’t okay, and she caused a big stink about it, and we got it rearranged and fixed, so I didn’t have too much more work. I think it’s very important to know someone is there to advocate for you and take care of you if you need support in that regard, or if you are uncertain, like maybe you feel like something’s a little unfair, but you can’t quite figure it out, having someone with experience be there and fight for you really buoyed my understanding of what a good mentor is.”

Interestingly enough, mid-career professional saw a blend in this regard. A participant of this study discussed how they “[were] driven crazy all the time. My advisor just didn’t have the time” to mentor them, but that their fellow graduate students were there to help when they had a minor question. The participant went on to discuss, however, how their advisor was available when they needed him the most:

“Left to my own devices...when I was in grad school, I got myself into all sorts of hot water politically with people because I was just an eager, interested person who was very unaware of the norms of academia and in terms of, especially, the sort of hierarchical power structure among academics and especially outside of this country, and it was very helpful to have an advisor who, even though was very hands off most of the time, when needed, would step in and do whatever he could to, you know, fix whatever was happening.”

This theme is supported by the idea of transferring social capital from the mentor to the mentee (Carlone and Johnson 2007, Ovink and Veazey 2011). Mentees often are unaware of what questions to ask because they do not know the culture or are unaware of a specific topic. Mentors are meant, not only to shepherd their mentee through a research project, but to also make them aware of the culture of their field, when a situation is unfair, or simply, to provide a lending hand when a student does not know where to go next with their research.

Theme 3: Defining Own Mentoring Style

The final theme that emerged from this study was how the participants defined their mentoring style based on their experiences with their own mentors. They all discussed how they used their negative mentoring experiences as catalysts for how they would, in turn, mentor their own students. They touched upon how they “needed to fail to know how to succeed” as well as how a:

“hands-off approach made me want to be more hands-on with my students but allowing them room to fail and problem solve on their own, knowing I was available when they were ready to ask for help.”

The study participants describe how each mentee is different and requires a different approach. Knowing what the students' goals are, a mentor can tailor their mentoring approach to better foster and encourage the student.

Along the same vein, another participant discussed their induction into mentorship and how they used their experience to become a better mentor:

"When I first started graduate school, nobody taught me how to mentor. So, I sort of modeled it from what I saw in my mentor. I didn't like some of what he did, he never complimented me, he only told you when you weren't doing a good job. So, I consciously try to compliment my students when they are doing a good job and encourage them."

By building trust and communication, mentors can foster growth within their students, which is imperative to HEG students. Not feeling supported or receiving enough communication from their mentors can often times leave HEG students feeling like they do not belong in research (Carlone and Johnson 2007, Ovink and Veazey 2011, White et al. 2019). However, one participant mentioned the importance of learning from their mentors, and how to advocate for themselves, an important skill for HEGs as they are faced with a multitude of barriers:

"I had to learn to self-advocate. I was disappointed that my advisor did not advocate for me, but I had to learn how to do it myself. I realized that I have to teach my students how to advocate for themselves, like my advisor did for me during my masters, and then help them through advocating for themselves like my advisor did during my PhD, but maybe take a more hands on approach than he did. I was very nervous and anxious, and had I known he was supportive and an active participant in the wings, my anxiety would have been lessened knowing I had help if I needed it."

Successful mentorship, and the eventual formation of a science identity in underrepresented minority students, requires several factors: a commitment from the mentors to increase representation of HEG in STEM, understand how SI is formed by understanding their own experience and their students, and realizing that the mentorship they experienced as students informs and defines their own mentorship style (Fig 1).

Discussion

This study sought to answer: (1) what mentors' thought is important for science identity formation? (2) What were the important moments that mentors experienced in their own science identity formation? (3) How has their mentorship experience influenced their personal mentoring style? The emergent themes answered these questions, as well as provided an opportunity for study participants to reflect on their own journey from a student to becoming a museum professional. As mentors work with HEGs, it is vital to keep the following in mind:

Theme 1: Factors for Science Identity Formation

This theme is important when working with historically excluded groups of students because many may not be fully certain of their interests if they have had little exposure to a natural history collection field. Exposure to various careers, from curator, to collections manager, to someone who digitizes collections broadens the mentee's understanding of potential employment within NHCs. Additionally, this exposure demonstrates the collaboration that occurs among collections, and the types of skills and research questions that can stem from broad collaborations. Providing HEGs with the resources to share with their home community will help them create a supportive structure from those that care for them. Community support may in turn develop into a stronger interest in natural history within that community.

Theme 2: Mentorship during different career stages

This is an important theme to keep in mind when working with HEG students because oftentimes they are unaware there is a problem or are concerned to ask for help in order to not be seen as inadequate. Having near-peer mentors like graduate students and post-doctoral fellows working alongside mentees will increase a HEGs' confidence in themselves by exposing them to the language and culture of research in natural history collections. Near-peer mentors allow HEGs to experiment with using scientific language as well as creates a supportive atmosphere for asking questions. Mid- and senior career professionals can be perceived as authority figures. Recognizing one's own career stage, and mentees' potential perception of oneself may help bridge generational gaps. As a mentor continues to move along through their career will change how they approach mentorship, but by providing a supportive and inviting atmosphere in their approach, their mentoring relationships with HEGs should continue to have positive growth.

Theme 3: Defining own mentoring style

Finally, mentoring style should be fluid and adaptable to each situation and mentee. Mentoring style can be shared with mentees. Collaboratively, mentors and mentees should work together to find a style that achieves the research and supports the goals established within the partnership. It is important to invite the mentees to bring their full self into the partnership, and to build trust through positive and constructive feedback. Communication and trust in a mentor are key for successful mentoring relationships. Trust and communication build on the mentor's awareness of their own SI formation, how they affect SI formation of their mentees, as well as adapting their mentoring style for each mentee and situation especially as mentors progress through their career.

Limitations

The objective of this study was to understand how participants viewed their influence as a mentor on the formation of science identity in their mentees. However, there are limitations to this study and are important to keep in mind when reading the findings. The study includes interviews from six mentors, representing various stages of their career, from early career professionals to established career professionals. Unfortunately, the study is limited in the number of professionals represented in each bin with two representing early career, one representing mid-career, and three representing established career professionals. Also, and most importantly, the ethnic and racial diversity of the study participants did not

at all represent the demographic of the students that would be their mentees, neither did the make-up of gender identification. It is important to have a representative sample of mentors that reflect the mentee demographics. Unfortunately, the number of faculty from historically excluded groups does not represent the student demographics and is even more limited when working with faculty from one institution.

Students from historically excluded groups experience mentorship from mostly white individuals, and, at times, are unwilling to ask questions for clarification due to the fear of being labeled as not qualified enough for a research position. This can lead the mentee to criticize how mentors view their mentorship style as effective only because they may be uncomfortable advocating for themselves. This bias is considered as the implications of this study are discussed.

Implications for Mentors

The implication that mentors can draw from this study is that the formation of science identity in the majority of students is complex, as demonstrated by their responses to the interview questions. Therefore, it is even more complicated for HEGs because there are barriers present that the mentors may not have experienced and cannot foresee, or barriers that the mentees may not be comfortable sharing or even aware are present. Mentorship is not solely provided by the primary advisor, but also from other members in the lab and oftentimes other faculty advisors. If mentors take a minute to examine how they arrived at a specific point in their career, and the sum of the experiences that led them to that point, they can provide a more informed and supportive mentorship experience for HEGs, fostering an opportunity for growth and formation of their science identity (Hund et al. 2018, Johnson et al. 2021).

Implications for Mentees

The implications that mentees can draw from this study is that many mentors are not yet up to speed on the needs of HEGs. Both the mentor and the mentee must have patience, understanding for the other side, and trust that they can communicate their problems or concerns. Mentees must recognize that their mentors may not be their primary advisor, but also fellow students in the lab will serve as near-peer mentors. Without a solid foundation built on trust and communication, gained through hands-on experience and observation, HEGs may be unable to advocate for themselves.

Conclusion

Science identities developed by HEGs are not fixed but fluid and can be bolstered or shaken based on how mentors view and interact with their mentees. Academic professionals are intuitively aware of the importance of mindful mentorship and how that affects the retention of students within natural history collections but may not have been explicitly informed of the terminology, literature, or developing best practices. As we build more inclusive spaces in natural history collections, it is imperative for mentors to seek training designed specifically for working with students from historically excluded groups, increasing their awareness of potential barriers for their students' success. Communication also plays a major role in building trust between the mentor and mentee. This study demonstrates that mentors

understand, at least subconsciously the importance of trust and support needed to build their mentees' science identity. This focus on mindful mentoring is based on the mentors' own experience while forming their science identity, and their experiences inform their own mentorship style.

Methods

Curators and collections managers from natural history collections were interviewed to determine the factors that influenced the formation of science identity (SI). Questions relating to SI formation were asked during an interview of six participants currently serving as curators or collections managers in research-focused natural history collections in the U.S.. These interviews were designed to clarify specific factors that are necessary for the mentors to understand their role in SI formation of students of historically excluded groups.

Participants

Participants of this study met the following criteria, i.e., they : a) are currently employed in a natural history collection in the United States, b) are currently employed as a curator or collections manager position, c) have agreed to serve as a mentor for undergraduate students from historically excluded groups in the iDigBio-Summer Internship Program (iDB-SIP) offered through the Florida Museum of Natural History (FM) at the University of Florida (UF), and d) have had at least five (5) years' experience working as a mentor with undergraduate students. Six participants were selected for this study (Table 1). They were categorized into one of three career stages: 1) Early-Career Professional, 2) Mid-Career Professional, or 3) Established Professional. These career stages are defined as: early-career professionals are researchers that received their PhD within the last 7 years (Lumpkin 2014); mid-career professionals are researchers that have up to 10 years of after receiving tenured (Hall 2002); while established professionals are researchers that have over 10 years in their tenured position (Trower 2011).

The first individual that was interviewed is a white female-identifying individual in her sixties. Having published over 400 scientific papers, she has also served as a mentor for more than 30 undergraduate students within her lab, a third of which she characterizes as HEGs. She currently serves as Curator for a top research institution in the United States and is defined by this study as an established professional.

The second individual interviewed is a white male-identifying individual in his seventies. He has published over 200 scientific papers and has served as a mentor for over 100 undergraduate students, a fifth of which he characterizes as HEGs. He currently serves as Curator for a top research institution in the United States and is defined by this study as an established professional.

The third individual interviewed is an African American female-identifying individual in her sixties. She has published nearly 70 scientific papers and has served as a mentor for 100 undergraduate students, half of which she characterizes as HEGs. She currently serves as Curator at a top research institution in the United States and is defined by this study as an established professional.

The fourth individual interviewed is a white male-identifying individual in his forties. He has published nearly 200 scientific papers and has served as a mentor for at least 20 undergraduate students, half of which he characterizes as HEGs. He currently serves as Associate Curator for a top research institution in the United States and is defined by this study as a mid-career professional.

The fifth individual interviewed is a white female-identifying individual in her thirties. She has published nearly 50 scientific papers and has served as a mentor for 20 undergraduate students, half of which she characterizes as HEGs. She currently serves as Collections Manager at a top research institution in the United States and is defined by this study as an early career professional.

The sixth individual interviewed is a white male-identifying individual in his thirties. He has published nearly 10 scientific papers and has served as a mentor for 7 undergraduate students, three quarters of which he characterizes as HEGs. He currently serves as Collections Manager at a top research institution in the United States and is defined by this study as an early career professional.

Table 1. Summary of Study Participants

Participant	Career Stage	Number of Undergraduate Students	% HEG
1	Established	30	33%
2	Established	100	20%
3	Established	100	50%
4	Mid-Career	20	50%
5	Early Career	20	50%
6	Early Career	7	75%

Table depicts participants’ career stage, number of undergraduate students mentored throughout their career, and their estimate for how many of those students can be characterized as students from historically excluded groups.

Data Collection

The mentors selected for this study all have extensive experience working with undergraduate students and have shown a commitment to working specifically with students from historically excluded groups. These factors are important to the study because their attitudes and understanding of science identity formation and their mentoring style can be tracked throughout the length of the iDB-SIP, for which they have agreed to serve as mentors, in an effort to broaden representation in natural history collections. The

initial year of iDB-SIP will take place at the FM and UF, expanding to other natural history collections across the United States in subsequent years. The mentors interviewed for this study will provide a baseline of understanding how to select good mentors at our partnering institutions, and the professional development that these partnering mentors will need to receive to provide effective and supportive mentoring to HEG undergraduates in their collections. This baseline is described in the results.

All of the participants of this study were interviewed for the length of approximately 1 hour. These interviews (See Supplement Material for interview protocol) explored common themes relating to mentorship, science identity formation, and personal mentoring style. Interview questions were designed to first create a baseline of the mentors' experience with undergraduate students. The participants were also asked to define, to the best of their understanding, the factors necessary to develop one's science identity based on the theoretical framework of Carlone and Johnson (2007). A discussion of different mentoring styles was also included in the interview, and the participants were asked to define their own mentoring style. The interview protocol was validated prior to administration by Dr. Linda Serby of the University of Florida, College of Education, an expert on mentoring and mentoring best practices. The interviews were recorded via the Zoom platform (Zoom Video Communications Inc. 2016), and the recorded transcriptions were compared to the audio recordings to ensure accuracy. The interviews were then coded to find emergent themes related to science identity formation and mentoring style.

Data Analysis

Using techniques to code and theme the data, the responses of the interviews with six mentors were analyzed, line by line, to examine the factors that contribute to mentors' understanding of their own mentoring style and how that may affect the formation of science identity in undergraduate students from historically excluded groups. Eclectic coding (Saldaña 2015), which employs several types of coding including: in vivo, attribute, emotional, and descriptive coding, was used in this study, as it lends itself to many forms of data. The codes were noted in the margin of the Word document and are included in a master list. This list was then placed in a table, allowing for easy examination of all transcripts at once.

The codes were compared between the six transcripts and similar codes across the columns were noted; themes based on their similarity were created. Themes, as defined by Saldaña (2015) are "outcomes of coding, categorization, and analytic reflection." By following this protocol, the raw data (transcribed interviews) and the codes were used to produce three themes that best represent the interview data. Select quotes from the interviews that best define the theme were selected. These themes and quotes were compared with the prior literature to determine if the findings were similar or different from existing research. The themes chosen for the final project most clearly answer the research questions: What do mentors think is important for science identity formation? What were the important moments that mentors experienced in their own science identity formation? How has their mentorship experience influenced their personal mentoring style?

Abbreviations

FM: Florida Museum of Natural History

iDB-SIP: iDigBio-Summer Internship Program

SI: Science Identity

STEM: Science, Technology, Engineering, Mathematics

HEG(s): students from Historically Excluded Groups

UF: University of Florida

Declarations

Availability of Data and Material – Interview protocols are available in the Supplemental Material accompanying this submission. Data collected during this study is available upon request from corresponding author.

Competing Interest – Author declares no competing interests.

Funding - This study was supported through the NSF award DGE 1842473 (GRFP) and DBI-1547229. This study is approved under IRB202000022 through the University of Florida.

Author Contributions – Jeanette Pirlo was the sole author of this manuscript and completed all aspects of the described study from design, implementation, analysis, and write-up. This study is a portion of her dissertation research.

Acknowledgements: The author wishes to thank Bruce MacFadden, Megan Ennes, Carmi Thompson and the anonymous reviewers for their detailed and helpful suggestions given throughout the review and revision process. She would also like to thank Dr. Linda Serby for her suggestions during the development and validation of the interview protocol. Finally, thank you to the participants of the study. It's through their candor and openness that we can work to make natural history collections a more inclusive and equitable space.

References

1. Aikens, M. L., Robertson, M. M., Sadselia, S., Watkins, K., Evans, M., Runyon, C. R., Eby, L. T., and Dolan, E. L. (2017). Race and gender differences in undergraduate research mentoring structures and

- research outcomes. *CBE—Life Sciences Education*, 16(2), ar34.
2. Bell, N. (2008). Graduate enrollment and degrees: 1997 to 2007. Council of Graduate Schools: Office of Research and Policy Analysis.
 3. Berry III, R. Q. (2021). 2021 Founders Lecture: Examining Mathematics Education Reforms' Impact on Historically Excluded Learners. *Investigations in Mathematics Learning*, 1-14.
 4. Blair, T. P. (2011). *Exploring factors affecting success and persistence of underrepresented minorities in undergraduate science, technology, engineering, and mathematics (STEM) majors* (Doctoral dissertation, Capella University).
 5. Brown, B. A., Reveles, J. M., and Kelly, G. J. (2005). Scientific literacy and discursive identity: A theoretical framework for understanding science learning. *Science Education*, 89(5), 779-802.
 6. Carlone, H. B., and Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, 44(8), 1187-1218.
 7. Chemers, M. M., Zurbriggen, E. L., Syed, M., Goza, B. K., and Bearman, S. (2011). The role of efficacy and identity in science career commitment among underrepresented minority students, *Journal of Social Issues*, 67, 469–491.
 8. Chenail, R. J. (1995) Presenting qualitative data. *The Qualitative Report*, 2(3), 1-9.
 9. Guy, B., & Boards, A. (2019). A seat at the table: Exploring the experiences of underrepresented minority women in STEM graduate programs. *Journal of prevention & intervention in the community*, 47(4), 354-365.
 10. Hall, D. T. (2002). *Careers in and out of organizations*. Sage.
 11. Hendricks, A. D., Smith, K., Caplow, J. H., and Donaldson, J. F. (1996). A grounded theory approach to determining the factors related to the persistence of minority students in professional programs. *Innovative Higher Education*, 21(2), 113-126.
 12. Hund, A. K., Churchill, A. C., Faist, A. M., Havrilla, C. A., Love Stowell, S. M., McCreery, H. F., Ng, J., Pinzone C. A., & Scordato, E. S. (2018). Transforming mentorship in STEM by training scientists to be better leaders. *Ecology and evolution*, 8(20), 9962-9974.
 13. Ikuma, L. H., Steele, A., Dann, S., Adio, O., and Waggenpack Jr, W. N. (2019). Large-scale student programs increase persistence in STEM fields in a public university setting. *Journal of Engineering Education*, 108(1), 57-81.
 14. Jensen, A. J., Bombaci, S. P., Gigliotti, L. C., Harris, S. N., Marneweck, C. J., Muthersbaugh, M. S., Newman, B. A., Rodrigues, S. L., Saldo, E. A., Shute, K. E., Titus, K. L., Williams, A. L., Yu, S. W., & Jachowski, D. S. (2021). Attracting Diverse Students to Field Experiences Requires Adequate Pay, Flexibility, and Inclusion. *BioScience*.
 15. Johnson, M. O., Fuchs, J. D., Sterling, L., Saucedo, J. A., Saag, M. S., Fernandez, A., Evans, C. H., & Gandhi, M. (2021). A mentor training workshop focused on fostering diversity engenders lasting impact on mentoring techniques: results of a long-term evaluation. *Journal of Clinical and Translational Science*, 5(1).

16. Lumpkin, A. (2014, April). The role of organizational culture on and career stages of faculty. In *The Educational Forum* (Vol. 78, No. 2, pp. 196-205). Taylor & Francis Group.
- 17.
18. Ovink, S. M., and Veazey, B. D. (2011). More than “getting us through:” A case study in cultural capital enrichment of underrepresented minority undergraduates. *Research in higher education*, 52(4), 370-394.
19. Marín-Spiotta, E., Barnes, R. T., Berhe, A. A., Hastings, M. G., Mattheis, A., Schneider, B., & Williams, B. M. (2020). Hostile climates are barriers to diversifying the geosciences. *Advances in Geosciences*, 53, 117-127.
20. Mussey, S. S. (2009). *Navigating the transition to college: First-generation undergraduates negotiate identities and search for success in STEM and non-STEM fields* (Doctoral dissertation, UC San Diego).
21. [NSF] National Science Foundation. (2017). Dear Colleague Letter: Announcement of an effort to expand the INCLUDES National Networks (NSF 17-111). Accessed 10 August 2020 at: www.nsf.gov/pubs/2017/nsf17111/nsf17111.jsp
22. Perna, L., Lundy-Wagner, V., Drezner, N. D., Gasman, M., Yoon, S., Bose, E., and Gary, S. (2009). The contribution of HBCUS to the preparation of African American women for stem careers: A case study. *Research in Higher Education*, 50(1), 1–23.
23. Riccitelli, M. (2015). *Science Identity's Influence on Community College Students' Engagement, Persistence, and Performance in Biology*. (Doctoral dissertation, Northcentral University).
24. Saldaña, J. (2015). *The coding manual for qualitative researchers* (3rd Edition). Los Angeles: Sage.
25. Sassler, S., Glass, J., Levitte, Y., and Michelmores, K. M. (2017). The missing women in STEM? Assessing gender differentials in the factors associated with transition to first jobs. *Social Science Research*, 63, 192-208.
26. Skrentny, J. D., & Lewis, K. (2021). Beyond the “STEM Pipeline”: Expertise, Careers, and Lifelong Learning. *Minerva*, 1-28.
27. Thiry, H., and Laursen, S. L. (2011). The role of student-advisor interactions in apprenticing undergraduate researchers into a scientific community of practice. *Journal of Science Education and Technology*, 20(6), 771-784.
28. Trower, C. A. (2011). Senior faculty satisfaction: Perceptions of associate and full professors at seven public research universities. *TIAA-CREF Institute Research Dialogue*, 101, 1-15.
29. White, A. M., DeCuir-Gunby, J. T., and Kim, S. (2019). A mixed methods exploration of the relationships between the racial identity, science identity, science self-efficacy, and science achievement of African American students at HBCUs. *Contemporary Educational Psychology*, 57, 54-71.
30. Wilker, J. C. (2017). *Women in STEM: The effect of undergraduate research on persistence*. (Doctoral dissertation, Walden University).

31. Xue, Y., and Larson, R. C. (2015). STEM crisis or STEM surplus? Yes and yes. *Monthly labor review*, 2015.
32. Zambrana, R. E., Ray, R., Espino, M. M., Castro, C., Douthirt Cohen, B., and Eliason, J. (2015). "Don't leave us behind" The importance of mentoring for underrepresented minority faculty. *American Educational Research Journal*, 52(1), 40-72.
33. Zoom Video Communications Inc. (2016). Security guide. Zoom Video Communications Inc. Retrieved from <https://d24cgw3uvb9a9h.cloudfront.net/static/81625/doc/Zoom-Security-WhitePaper.pdf>

Figures

Image not available with this version

Figure 1

Contributing factors to the formation of science identity in historically excluded groups of students (HEGs). The progression necessary to encouraging the development of science identity in HEGs must include a commitment by the mentor to increase representation in their field, and is achieved by defining their own mentoring style, understanding how their own experiences as a mentee shaped their science identity and mentoring style, and understanding science identity formation.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [PIRLOSIFormationSuppMaterial.docx](#)