Evidence for Professional Conceptualization in Science as an Important Component of Science Identity

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ABSTRACT
Experience in research facilitates development of science identity and encourages undergraduate student persistence along the pathway to careers in science, technology, engineering, and math (STEM). Participation in authentic research can foster identity development by influencing a sense of belonging, recognition, interest, and performance and competence in science. We examine science identity in a group of five community college women in marine science during a 2-year study in which students participated in a research experience. We used interviews, surveys, identity artifacts, and significant circles before and after the research experience in a thematic analysis to explore identities and examine their intentions, interests, perspectives, and aspirations for a future career. Participation in research provided opportunities for students to gain conceptual understanding of themselves and their abilities in science as well as explore and clarify their professional interests. This work builds upon our current understanding by providing evidence that conceptualization of career trajectories and self as a science professional is an important component of identity. Exploring career options and developing professional conceptualization are critical components in science research experiences and warrants additional study to understand the role of professional conceptualization in shaping student trajectories in STEM.

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INTRODUCTION
The loss of students from science, technology, engineering, and math (STEM) disciplines along the educational pathway, particularly at critical decision points (i.e., the "leaky STEM pipeline") forms the basis of national strategies to increase the STEM workforce by fostering student persistence (Blickenstaff, 2005; Allen-Ramdial and Campbell, 2014; Cannady *et al.*, 2014; Lykkegaard and Ulriksen, 2019). However, research in the past decade challenges the leaky pipeline as an appropriate model for understanding individual variation in student experiences and motivations for pursuing a career in science (Metcalf, 2010; Cannady *et al.*, 2014). The generalized nature of the linear view of an individual's journey through science homogenizes the complexities in choices made along the pathway of STEM and masks contextual information of student identity and cultural and social influences (Maltese *et al.*, 2014; Lykkegaard and Ulriksen, 2019). Because educational and career choices are complex and the movement of students in and out of STEM fields is dynamic, it is important to view student pathways in science through a lens that acknowledges individual experiences.

Student perceptions of themselves in science fields and as scientists influence their desire to pursue STEM careers (Chemers *et al.*, 2011; Wang and Degol, 2013; Robinson *et al.*, 2019). The development of students' sense of themselves in science—their science identities—is complex, nuanced, and intersectional, influenced by intrinsic and extrinsic factors (Carlone and Johnson, 2007; Kim and Sinatra, 2018;

Avraamidou, 2020; Hazari *et al.*, 2020). Previous research has demonstrated that science identity can have a significant influence on learner decisions to persist in STEM fields (Merolla and Serpe, 2013; Stets *et al.*, 2017; Robinson *et al.*, 2018, 2019), and it can therefore directly inform strategies for facilitating persistence in science. Carlone and Johnson's (2007) framework of science identity describes student performance (i.e., demonstration of scientific knowledge to others), recognition (i.e., recognition by self and others as a science person), and competence (i.e., having scientific knowledge and motivation to understand the world scientifically) as significant factors shaping science identity. Hazari and colleagues (2010) further expanded on this framework by including interest (i.e., desire and curiosity to think about and understand science) as an important component of identity development in physics high school students. This framework further emphasizes that constructs of science identity are important to consider in the context of interplay with personal (i.e., individual characteristics and experiences) and social identity (i.e., shared experiences with others or community; Hazari *et al.*, 2010). A combined construct of performance/competence as well as interest and recognition influenced the development of math and physics identities in first-year undergraduate students (Godwin *et al.*, 2016). Further work by Trujillo and Tanner (2014) discussed the importance of a sense of belonging (i.e., the feeling of being part of a community) to a student's experience in science, and Ong and colleagues (2018) demonstrated that facilitating a sense of belonging is critical for underrepresented groups. These constructs are examined in recent work by Hazari and colleagues (2020) in which the authors' findings and previous work provide evidence for four constructs contributing to identity development: interest, recognition, sense of belonging, and performance/competence. Further, gender plays an important role in science identity development, and it is critical to understanding factors that influence science identity development for women, an underrepresented group in science (Carlone and Johnson, 2007; Hazari *et al.*, 2010; Rainey *et al.*, 2018).

Science identity development is a process, and science identities are not fixed—rather, identity is variable over time and unlikely to remain constant, especially during undergraduate education, when student identity beliefs can be solidified or destabilized due to positive or negative experiences in course work or research experiences (Robinson *et al.*, 2018, 2019). Therefore, longitudinal studies that characterize and describe student identities as they progress through their educational journeys are necessary. In this study, we examine student science identity based on the theoretical framework of Hazari *et al.* (2020) for a group of women attending community college in marine science during and after participation in a research experience. We approach this group case study research by using tools that provide in-depth exploration of student identities and examine their intentions, interests, and aspirations in science by looking beyond linear pipeline trajectories and exploring their desires for creating a future in science.

Positive and supportive early undergraduate experiences can facilitate development of salient science identities and encourage student persistence along the pathway to a career in science (Lopatto, 2004, 2010; Hunter *et al.*, 2007; Hazari *et al.*, 2010). Undergraduate education institutions that offer early research experiences, active-learning environments, and opportunities for students to experience membership in science communities have achieved success in increasing student persistence and broadening participation in STEM (National Academies of Sciences Engineering and Medicine, 2017). Specifically, research experiences allow students to gain practical and academic skills while interacting with a research mentor and provide a space for students to explore professional activities associated with their career interests (Russell *et al.*, 2007; Schultz *et al.*, 2011). Engaging in research allows students to strengthen views of themselves as scientists, learn science content and practices, and understand how science is done outside university courses (Linn *et al.*, 2015). Gaining skills and practice in science in these ways can influence how students view their performance and competence in science, two key components of science identity (Carlone and Johnson, 2007; Godwin *et al.*, 2016; Hazari *et al.*, 2020). Research experiences can also provide opportunities for students to explore their interests in science disciplines and evaluate their options to pursue scientific careers (Lopatto, 2004; Russell *et al.*, 2007; Sadler and Mckinney, 2010). Through the lens of the "persistence framework" developed by Graham *et al.* (2013), student learning and identification as a scientist generates confidence and motivation to continue in science pathways. Within this framework, undergraduate education institutions that offer early research experiences and active-learning environments and provide opportunities for students to experience membership in learning communities have achieved measurable success in increasing student persistence in science by supporting student identity development (Graham *et al.*, 2013). Preparation for research, expectations of the experience, level of involvement in research, laboratory atmosphere, and quality of mentorship strongly influence whether students experience positive gains during research experiences (Taraban and Logue, 2012; Wilson *et al.*, 2013; Cooper *et al.*, 2019). For women in science, supportive and positive mentorship from more senior women in science can have positive effects on science persistence by strengthening science identity development (Stout *et al.*, 2011; Hernandez *et al.*, 2017). Because the outcomes of research experiences are highly individualized, it is critical to evaluate the role of research experiences in science identity development and student career trajectories across a diverse range of interests, institutions, educational pathways, and backgrounds.

Students of underrepresented cultural, racial, and gender groups in science are more likely to encounter obstacles and experience social stigma in their pursuit of careers and development of their science identities (Carlone and Johnson, 2007; Lopatto, 2007; Hurtado *et al.*, 2009; Robinson *et al.*, 2018, 2019; Vincent-Ruz and Schunn, 2018). Community colleges (i.e., 2-year colleges or associate's colleges) are particularly important institutions for serving underrepresented groups in science. Compared with 4-year universities, community colleges offer lower tuition, open admissions, and flexible schedules and can be located close to home communities, serving a higher proportion of underrepresented groups in science, first-generation college students, low-income families, and adults returning to education (Ma and Baum, 2016; Hewlett, 2018). Of undergraduate students pursuing education and careers in science, 47% choose to study at community colleges during their education (National Science Board, 2018).

TABLE 1. Description of study participants at the beginning of the study

Student	Community college campus	Age	Ethnicity	Year in school	Degree track	Previous research experience	Gender
Allison	Kapi‘olani Community College	19	Asian American, Japanese	2	Life Science	Yes	Female
Kate	Leeward Community College	48	American Indian, Asian American	2	Geology and geophysics	No	Female
Nancy	Leeward Community College	20	American Indian, Hispanic/Latino	3	Marine biology	No	Female
Hannah	Kapi‘olani Community College	29	White/Caucasian	4	Natural resources	Yes	Female
Julie	Honolulu Community College	20	White/Caucasian	3	Natural and biological science	No	Female

Although community college students represent an important component of the potential future professional field in science, there is a lack of authentic research opportunities available to community college students because of limited resources, faculty and student preparation, incompatible faculty models, and isolation from scientific networks (Hewlett, 2018). Programs that support student science identity development and provide opportunity for engagement in research may encourage persistence in STEM for students from underrepresented groups (Stets *et al.*, 2017), and it is therefore important to understand how research experiences influence science identity development at institutions that serve these populations, such as community colleges.

We investigated the influence of participating in an authentic marine science research experience on the development of student science identities and career intentions in a group of community college students. In this study, we asked, “What factors are important for science identity development in community college students and how does participation in a research experience influence science identities and career intentions?” We approached this question from the theoretical framework of science identity described by Hazari *et al.* (2020) and applied this framework to understand the experiences of a group of community college women in Hawai‘i, USA, during a 2-year study. Students in this study participated in a two-semester authentic research experience in a marine biology laboratory at the Hawai‘i Institute of Marine Biology (HIMB). Throughout the two-semester research experience and for 1 year following their participation, we used surveys, interviews, significant circles, and identity artifacts to gather information on student experiences in the research experience and their science identities and career intentions. We used a qualitative thematic analysis approach to understand how theoretical constructs of science identity apply in the context of the individual experiences and career intentions of this group of community college women. This approach provides an opportunity to examine the science identity and experiences of these women with rich detail and explore the relationship between participating in a research experience and their own science career intentions.

METHODS

Study Participants and Researchers

A.S.H. served as the research experience mentor for all students and conducted the primary data analysis and writing of the article. A.S.H. is a woman in the sciences and conducted this work within a marine biology research dissertation on coral physiology and ecology. All research activities were approved by the University of Hawai‘i Human Studies Institutional Review Board with data de-identification and informed consent. Participants are described in this study using pseudonyms. Students attending community colleges on O‘ahu, Hawai‘i, in scientific degree programs were eligible to participate in this study, and no previous research experience was required. A.S.H. contacted prospective student participants with the opportunity to participate in this research experience during the Spring and Summer 2017 semesters through Listserv emails and presentations during science classes at O‘ahu community colleges. Students contacted A.S.H. by email to apply for participation. Six students emailed to apply to participate in the research experience, one male and five female students in total. However, after the first week of the research experience the male participant could no longer participate due to scheduling conflicts. Therefore, the student group that participated in this study consisted of five female participants from three different community college campuses in Hawai‘i. Participant ages ranged from 20 to 48 years old in their second, third, or fourth year in postsecondary education. Participant descriptions are summarized in Table 1. All students were enrolled in a science degree track (e.g., biological sciences, natural resources, geology) during the study and expressed an interest in pursuing a science-related career at the start of the research experience, including “marine biologist,” “ocean engineering,” “research in a lab,” “marine research and education,” and “working with animals.”

Research Experience

The first two semesters of this study encompassed the research experience, and we conducted follow-up data collection with students for three subsequent semesters (Figure 1). Participation in the research experience was based on each student’s course schedule and other commitments. During the first semester (Fall 2017, semester 1) of the research experience, students became familiar with the research environment at HIMB. Students assisted with general laboratory and coral biology research activities, including coral species identification, measuring coral survivorship and growth, maintaining tank systems, and reading scientific literature. Throughout semester 1, the research mentor prompted students to brainstorm and identify topics of interest for their independent research projects to be conducted in the second semester.

During the second semester (Spring 2018, semester 2) of the research experience, students designed and conducted research projects in coral biology. To create a collaborative research environment, the research mentor provided a framework research project in coral biology from which students could conduct specific projects branching from the larger project. Students assisted with all aspects of research project setup and maintenance of

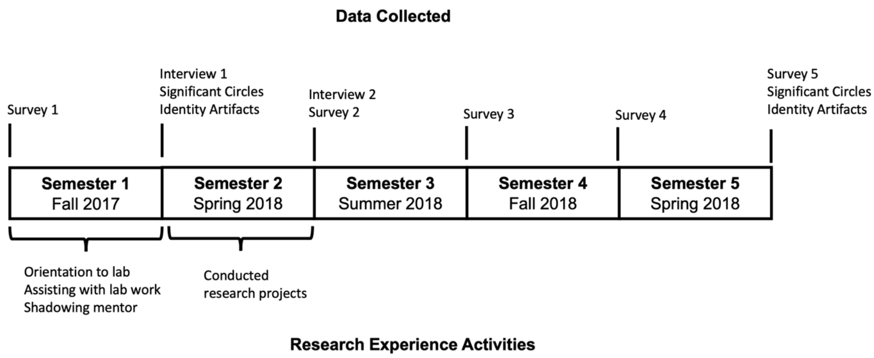

FIGURE 1. Timeline of data collection and research experience activities. The research experience was conducted in semesters 1 and 2 of this study. We conducted interviews before (interview 1) and after (interview 2) the research experience. Additionally, students responded to surveys before (survey 1) and after (survey 2) the experience. After the two-semester research experience, students were contacted at the end of each subsequent semester (semesters 3–5) to complete follow-up data collection (surveys 3–5). Surveys, interviews, significant circles, and identity artifacts were used as sources of data in this study.

corals in the experiment. In this project, corals were exposed to high-temperature treatments, and students monitored their reproduction, growth, and survivorship. From this framework, students had the opportunity to design a project of their choice, with the option to work either in small teams or independently to conduct their research projects in coral biology. Two of the five students chose to work together to conduct their research, while the other three students worked independently due to a lack of overlap in their availability and schedule of work at HIMB. Students designed and conducted the following projects:

1. Hannah and Allison: Survivorship of coral larvae from parents exposed to high temperature
2. Kate: Settlement aggregation behavior of coral larvae
3. Nancy: Reproductive timing of corals exposed to high temperature
4. Julie: Settlement substrate choice of coral larvae

During semester 2, students collected data for their individual projects and assisted with data collection and maintenance of corals in the large collaborative project. Activities associated with research and data collection included photographing and analyzing mortality and pigmentation of coral colonies, collecting larvae, counting survivorship, measuring coral growth and larval settlement, monitoring coral reproduction, feeding corals, recording temperature, and cleaning tanks. All activities and data were recorded in laboratory and student notebooks. Students designed and planned their research projects during the first 2 weeks of semester 2 and conducted research and collected data for the following 8 weeks. At the end of semester 2, students analyzed data and presented their results at a gathering of all students, the research mentor, and an HIMB faculty member. At this gathering, students presented the conclusions of their projects and what they learned during the research experience. Students provided all notes, data, and presentations and were provided with gift cards upon completion of their final project presentations. After completion of the research experience, students were contacted to complete follow-up surveys at the end of the Summer 2018, Fall 2018, and Spring 2019 semesters (semesters 3, 4, and 5, respectively; described in *Data Collection* below).

Data Collection

Data collection during the study is visualized in Figure 1. Students were provided with gift cards upon completion of each interview and survey in this study, and all students in this study completed all stages of data collection. We chose to use four types of data collection to learn about student experiences through multiple perspectives: interviews, surveys, significant circles, and identity artifacts.

Interviews. At the start of semester 1, students completed an interview (interview 1) in which we asked students a predetermined set of questions in a semistructured format allowing for further discussion and exploration of ideas and topics. Interview questions focused on the students' science identities, science interests, personal and social influences, perceived performance and competence in science, and degree and career trajectories (Supplemental Table 1). At the end of semester 2, students completed a final semistructured interview (interview 2). These final interviews included additional questions on student experiences during the research experience (e.g., triumphs and challenges in their projects, learning experiences), students' science identities, science interests, personal and social influences, perceived performance and competence in science, and degree and career trajectories (Supplemental Table 1). Interviews were conducted for approximately 45–60 minutes and were audio-recorded, transcribed, and de-identified for analysis.

Surveys. At the start of semester 1, students completed an initial written self-reporting survey (survey 1) based on previously published and validated surveys (Lopatto, 2004; Cole, 2012) with questions on students' science identities, science interests, personal and social influences, perceived performance and competence in science, and degree and career trajectories (Supplemental Table 1). Students repeated these surveys at the end of semester 2 (survey 2). These surveys contained statements that students rated on a scale from one to nine to indicate agreement. For example, one item in the survey states, "I am interested in pursuing a science career," with a response of "1" indicating that they "completely disagree" and a response of "9" indicating that they "completely agree." During the follow-up period after the research experience, we contacted students by email to complete an abbreviated version of self-reporting surveys at the end of semesters 3, 4, and 5 (surveys 3, 4, and 5, respectively). In these follow-up surveys, we asked students to report their degree progress as well as any research, employment, or volunteer activities in science undertaken since the research experience. We also asked students to report personal and professional impacts of the research experience and reflect on skills learned during the research experience (Supplemental Table 1).

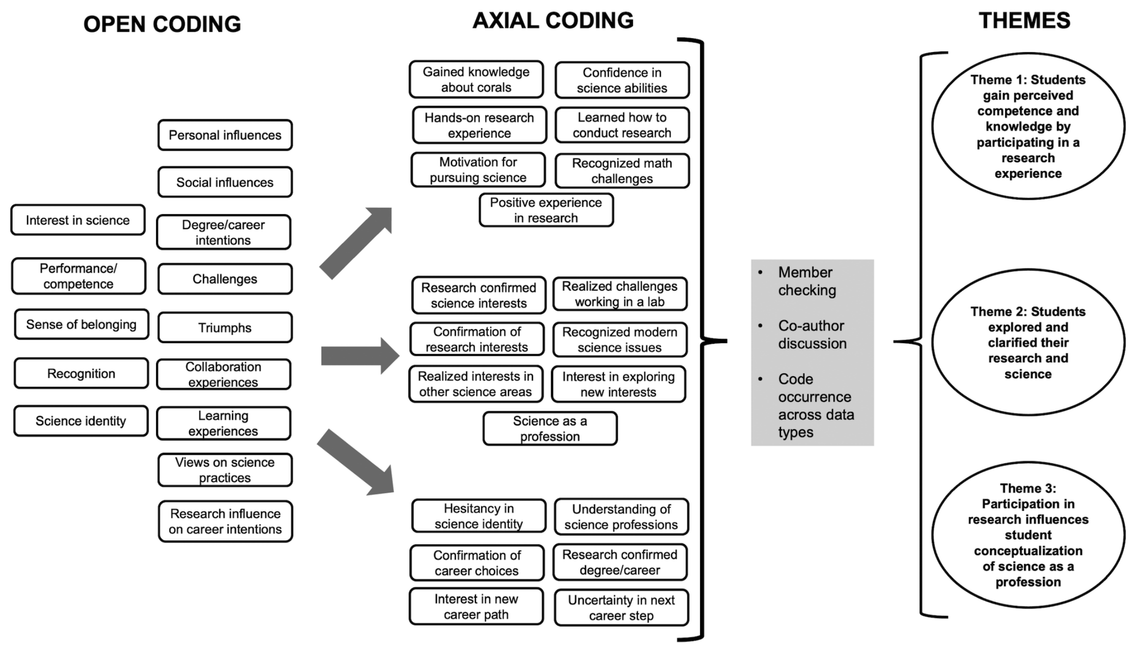

FIGURE 2. Coding tree for qualitative data analysis in this study. Codes were applied to data acquired through surveys, interviews, identity artifacts, and significant circles. Data were open coded (left column) for components of student identity, degree/career intentions, and statements about the research experience. These codes were then assigned to categories that drew connections between open codes (i.e., axial coding; middle column). Axial codes were then used to identify emergent themes (right column). This study used member checking, coauthor discussion, and code occurrence across data types to ensure validity and reliability (gray box).

Significant Circles and Identity Artifacts. During interview 1, we discussed two additional sources of data: significant circles and identity artifacts (Supplemental Table 1). Before the interviews, we provided students with instructions on completing a significant circle (as described by Moll *et al.*, 2013) and selecting an identity artifact (as described by Leander, 2002). Significant circles were a single-page drawing or representation of the objects, activities, people, institutions, and hobbies that were most important to each student both in the context of their scientific interests and their lives in general. Significant circles provided information on social and personal influences and context for student experiences and trajectories in science. Identity artifacts in this study were physical items chosen by each student that they felt represented who they are as scientists, which provided an additional view of the students' science identities. In the final follow-up survey (survey 5), students were asked to provide a new significant circle and describe a new science identity artifact along with a written description of these items (Supplemental Table 1).

Data Analysis

We explored and analyzed data in NVIVO 12 software (v. 12.5.0) and Microsoft Excel (v. 16.33) using a qualitative thematic analysis framework to provide a description of the experiences of these five students (Braun and Clarke, 2006). Interview transcripts, survey responses, significant circles, and identity artifacts collected over the course of the five-semester study were used as data sources in this study (Figure 1). The coding tree in Figure 2 presents a representation of the coding workflow used in this study. Student responses were first open coded by one researcher (A.S.H.) according to the four primary aspects of student science identity as described in the theoretical framework used in this study (Hazari *et al.*, 2020): interest in science, performance/competence, sense of belonging, and recognition and direct statements on student science identity. A.S.H. then coded data for "personal influences" and "social influences" to understand personal and social context for student experiences and identities as described by Hazari *et al.* (2010). Additionally, responses were coded as "degree/career intentions" for statements that described student goals and intentions for their degrees and career interests. To examine student experiences during the research experience, statements were also coded for "challenges," "triumphs," "collaboration experiences," "learning experiences," and "views on science practices" that students described based on their experiences with the research activities. Finally, data were coded as "research experience influences on degree/career intentions" for student responses about the influence of participation in a research experience on their degrees and career goals and interests.

These coded responses were then examined and organized into axial codes that draw connections between open codes (Figure 2). For example, statements coded for both "performance/competence" and "science identity" (e.g., "I need more experience to become a scientist") resulted in axial codes such as "hesitancy in science identity" or "science as a profession." In addition, statements open coded for "research influence on career intentions" resulted in axial codes such as "research confirmed degree/career" and "interest in new career path" (Figure 2). To ensure reliability and validity at open and axial coding stages of data analysis, we checked biases, confirmed code categories, and validated coding through coauthor discussion. Specifically, A.S.H. conducted open coding in stages and presented coded data to coauthors. The author team then discussed the validity of code categories and revised and repeated the coding process as necessary. This process was repeated during the axial coding phase. Viewing the open- and axial-coding processes through multiple author perspectives across disciplines and career stages allowed for checking of biases in coding.

Following axial coding, A.S.H. identified emergent themes from these codes, which were then discussed with coauthors to evaluate evidence (Figure 2). Following author team discussions, emergent themes were evaluated and revised in an iterative process. Further, our data analysis process to identify themes facilitated member-checking validation through consensus between data types. We [1] conducted member checking of identity artifacts and significant circles by discussing these items with students through interviews and follow-up email correspondence, and [2] follow-up surveys included repeated questions from previous interviews and surveys to provide member checking. By recording student responses to repeated questions at each stage of data collection, we were able to track consistency and variation in student responses across this study. For example, in each interview and follow-up survey, we asked each student, "Do you consider yourself as a scientist?" Student responses to this question across the five-semester period of this study allowed us to use member checking to examine consistency and detect variation in responses that played a critical role in the development of themes in this study. We also used code occurrence across data types to ensure reliability in the development of themes. For coded responses to be considered in the development of a theme, code categories needed to be present in at least three sources of data (e.g., present in interviews 1 and 2 as well as a survey; present in two follow-up surveys and interview 2; present in interview 1, one follow-up survey, and a significant circle). Coauthor discussion, member checking, and code occurrence across data types ensured reliability and validity in the development of themes through data analysis in this study (Figure 2).

Participant Descriptions

Five women participated in this study, all of whom were attending community colleges in science degree programs (Table 1). For all five students, social (e.g., family, community, employment) and personal influences (e.g., personal interests, hobbies) played important roles in shaping students' education journeys. First, Allison was pursuing a life science degree and in her second year enrolled at a community college during this study. Her interest in science was inspired by interacting with the environment and oceans through outdoor recreation and surfing. When surfing, "there are spots I usually go to and every time I paddle out I see [coral] growing, or see that it died and I always wondered, 'why is that'?" (interview 1). Music was also an important component of Allison's significant circle, and she considered music as an additional career goal (interview 1, survey 5). Family, health, personal growth, and happiness were also key features of Allison's significant circle. Allison chose to participate in the research experience in this study to explore her interests in science, gain experience in research, and learn more about career options (interviews 1 and 2).

Kate was in her second year at a community college pursuing a geology and geophysics degree. Kate was returning to school at age 48, and scientific research was a key component of her significant circle. Before attending community college in Hawai'i, Kate and her family moved frequently, and she worked in business to support her family (interview 1). However, she decided to return to school, because "I really like marine biology and just keep going back to it." Her interest in science started at a young age when she "wanted to know something that nobody could answer, so I would have to look it up" and enjoyed observation of the natural world (interview 1). Knowledge and research, family, friends, and art were also important components of her significant circles. Kate participated in the research experience to have the opportunity to do research in marine science (interview 1).

Nancy was enrolled in her third year of community college, pursuing a degree in marine biology. While attending school, she worked in retail, saying, "It's something I have to do, but I don't like it" (interview 1). Her interest in science started at a young age as a fascination with the ocean, and she "knew what I wanted to do for my future—something related to the ocean because I love it so much" (interview 1). After moving to Hawai'i and snorkeling on coral reefs, she decided to pursue a degree in marine biology at a Hawai'i community college. Family was Nancy's "support system" and "supported everything I've done as far as school" (interview 1). Her friends and school were included at the center of her significant circle. Nancy chose to participate in the research experience in this study due to her interest in corals and desire to learn more about coral reefs (interview 1).

Hannah was in her fourth year at a community college pursuing a natural resources degree during this study. Hannah grew up in Hawai'i and placed "home" and "family" at the center of her significant circle, which she expressed as the foundation of her interest in science and career goals to "combine science, education, and the community" (interview 1). Although at first, she "didn't know that you could do science as a way to be outdoors doing work," she participated in internships and summer courses in science and was "excited to find opportunities to do marine science in Hawai'i" (interview 1). In addition to family and home, health and happiness were also at the center of Hannah's significant circle. Hannah participated in this study to gain experience in research, pursue an opportunity to study corals, and explore career options (interview 1).

Julie was enrolled in her third year of education at a community college in natural and biological sciences during this study. Her interest in science is due to her love of animals, and she expressed desire to use science to take better care of the planet (interview 1). Julie identified as an artist, but she was concerned about the financial implications of a career in art and decided to pursue a science degree (interview 1); her education decisions were also affected by her family moving frequently (interview 1). Family and religion were key aspects of Julie's significant circle. Julie participated in the research experience to engage in research and interact with the environment (interview 1).

RESULTS

Three emergent themes were identified from thematic analysis of student responses in interviews, surveys, significant circles, and identity artifacts (Figure 2). We explore each theme as it relates to the student group and highlight nuances in these themes for the unique perspectives of the students in this study. In the first theme, we describe how participating in a research experience provided beneficial opportunities for students to both gain perceived competence and increase understanding of their own limitations. In the second theme, we describe how students both confirmed and clarified their science and research interests during the research experience. Finally, in the third theme, we use embedded case studies for each student to demonstrate how participation in a research experience influenced their conceptualizations of themselves as science professionals.

Theme 1: Students Gained Perceived Competence and Understanding of Their Limitations by Participating in a Research Experience

By participating in the research experience, students gained perceived knowledge, skills, and competence in scientific research and gained understanding and awareness of ways in which they are currently limited in science knowledge or skills. Both gaining research competence and gaining understanding of self-limitations are beneficial outcomes of participation in research as one develops an understanding of who they are in science, pathways to improve science knowledge and skills, and one's vision of one's future self in science.

These gains were reported at the conclusion of the research experience (interview 2) as well as in follow-up surveys. Specifically, students reported gains in discipline-specific knowledge of corals and coral reefs (Supplemental Table 2) and knowledge of the process of research and science practices (Supplemental Table 3). For example, Hannah said, "I had little to no confidence in working with corals before the research experience. Learning about corals paired with hands-on research led me to ask more in-depth questions" (survey 4). Allison also expressed that "working amongst professionals in the field and hearing their conversations about how difficult the grant process is and the reality of corals was eye-opening" (survey 5), and Kate learned "the different steps in an experiment and the importance of a supporting community" (survey 5). These responses highlight that conducting research and working with a research mentor in coral biology provided clear opportunities for students to learn about corals by designing experiments, collecting data, reading scientific literature, and making personal observations in the laboratory and in the field. Learning about marine biology, specifically coral biology, in a hands-on, authentic research environment was particularly influential and enhanced student confidence and ability to communicate about corals. Hannah said that she learned "how to digest, summarize, and discuss scientific literature with scientists, colleagues, and professors" and that "through this practice I became more comfortable talking about these topics" (survey 5). Julie reported that she was "better at making inferences about the data collected" (survey 5), and Nancy "learned more lab skills and more knowledge about corals" (interview 2). Additional sample quotes illustrating student gains in discipline-specific knowledge of corals are shown in Supplemental Table 2. Students also gained knowledge and understanding in the practices of science by conducting their own research projects. For example, Hannah learned that science "is never linear … it's a big web … you're always going to go back and forth and be able to be flexible" (interview 2). These responses show that students reported increased understanding of scientific practices, including how to set up and conduct an experiment, collect data, practice observation, and experience the process of scientific research, and gained perspectives on how research is conducted in an authentic laboratory space. Further quotes exemplifying gains in understanding of science practices are shown in Supplemental Table 3.

Participation in a research experience also provided valuable opportunities for students to gain knowledge and awareness concerning the ways they are currently limited in science and perceptions of themselves as future science professionals. First, students identified limitations in science-related math skills. At the completion of the research experience, all students reported difficulty with and/or dislike of math and data analysis related to their science research experience (Supplemental Table 4). In follow-up surveys after the research experience, students continued to identify data analysis, technology, statistical analyses, writing, and communication as skills they would still like to develop, illustrating an understanding of both their own challenges and aspirational goals in scientific research. Two students specifically stated in interview 2 that they "love everything about science except math" (Nancy) or that they are "good at everything in research except math" (Kate). Students also said in interview 2 that they "had a hard time with [graphs]" (Allison) and difficulty in "data analysis and knowing what statistics to use" (Hannah) and that "math and equations" are challenging (Julie). Although students identified math and data analysis as a limitation, they expressed awareness of the importance of understanding this content. Nancy, for example, said, "When I decided to do this major, I said, you know, you're going to have to do a lot of math. That is one thing I completely dislike, but I love it enough to conquer that" (interview 1). Along with math and statistics, writing the final scientific report at the end of the research experience was a task that presented a challenge to the students. Students had difficulty "finding sources to support my data and incorporate them" (Kate, interview 2), expressing that they needed to "work on writing papers" (Julie, interview 2) and that writing an independent research paper was challenging (Hannah, interview 2). Additional sample quotes illustrating student recognition of challenges in these areas are presented in Supplemental Table 4.

In addition, participation in research provided an opportunity for students to evaluate their perceptions of themselves as future science professionals. Gains in knowledge and competence in scientific research are important components of the students' science identities. All students in this study identified as a person of science during interviews and in survey responses, including discussion of student identity artifacts (Table 2). Further, the identity artifacts chosen by students at the end of the experience particularly highlight the role of gaining knowledge and experience in science on their science identities. For example, Julie said,

> I bought a shirt from HIMB and I think it represents me as a scientist better than anything else I have. The shirt reminds me of how I went out and got this internship by myself and how I traveled outside my comfort zone. I also had to be the one to motivate myself and get things done. I feel like working at HIMB really helped me to grow, not only as a scientist, but as a young adult. It pushed me to grow in ways that nothing else would've. I am so thankful for the opportunity I was afforded, and I will keep my shirt as a treasured keep-sake.

TABLE 2. Student identify artifacts, descriptions of why these objects were chosen, and the objects' connections to student science identities

Student	Identity artifact (start)	Identity artifact (end)	Description
Allison	Snorkel and mask	Photograph from reef diving	Allison expressed a desire to explore the natural world and influential experiences on coral reefs shaped her journey in science.
Kate	Conglomerate rock	Microscope	Kate recognized the processes of her own scientific development and valued gaining knowledge.
Julie	Zoo T-shirt	HIMB T-shirt	Julie expressed an interest in working with animals and recognized the influence of a research experience on her scientific interests.
Hannah	Photograph of family	Her brain	Hannah described the importance of home and family to her goals and valued gaining knowledge through research.
Nancy	Piece of a coral	Her research on corals	Nancy cited her love of the ocean and corals as motivation for her goals and valued conducting research.

Julie's identity artifact at the end of the experience shows the strong influence of the experience on her growth and identity as a scientist. Hannah expressed the value of knowledge gained during the research experience by identifying her "brain" as her identity artifact, reporting, "the expanse of knowledge I've acquired just in the past few years amazes me of the capabilities of our bodies, and what enables me to pursue science." Further, Nancy chose her "own research" from the research experience as her identity artifact, demonstrating the connection between corals and learning about reefs to her identity as a scientist. Kate chose a "microscope" as her identity artifact after the research experience, because she valued "gaining specific knowledge" through science.

Although students expressed identification as a person of science as illustrated by their identity artifacts and responses during interviews, they also expressed hesitancy in describing their identities as scientists, particularly after participating in research, due to perceived limitations in their competence and performance in science. Their responses demonstrate expressions of their conceptualizations of themselves as future science professionals. Specifically, we found that student descriptions of science identity were often paired with statements about performance and competence in science. In interview 1, Julie said, "I think anybody who is curious about the world is a scientist … Yeah [I would call myself a scientist]," but in interview 2, she said, "I am a junior scientist, I feel like [scientists] at least have an associate's or some experience," indicating that she was hesitant in calling herself a scientist in a professional context due to a perception that she needed a more advanced degree to be a professional scientist. Hannah also called herself an "aspiring scientist," (interview 2) and although she said, "[I] would like to call myself a scientist," she was "not at the PhD level, but I think I fit along the lines of a scientist because I'm curious and I want to know about life" (interview 2), exhibiting another example of student perception that acquiring a more advanced degree is required to identify as a professional scientist. In interview 1, Nancy said that she "loves science because I want to contribute to what is or isn't known and the ocean needs to be paid more attention to protect it" and that she is "learning to be a scientist and practicing being a scientist by doing research." After the research experience, Nancy said, "I am hesitant to call myself a scientist, but I do," stating that she would "need more practice to be more confident in calling myself a scientist" (interview 2). Allison also said that she "is an aspiring scientist" in interview 1 and described herself in this same way in interview 2, because "the basic foundation of knowledge is still not there" and "biology is a hole in my knowledge." Although students' sense of themselves as scientists due to their interest in science and the process of discovery persisted throughout the course of the research experience, the common use of qualifiers such as "learning," "junior," "practicing," or "aspiring" when describing their science identities in interview 2 is indicative of participants recognizing multiple forms and layers of science identity. Specifically, participants began to describe themselves as aspiring professional scientists, but not yet "professional scientists." Importantly, the responses of students following the research experience included the use of these qualifiers to describe their perceptions of themselves as professional scientists. These students expressed a need to gain more experience, knowledge, competence, or professional credentials to consider themselves science professionals. Exposure to authentic research in a space in which they interacted with other science professionals provided an opportunity for students to reflect upon what it means to do science *and* their understanding of what it means to become a professional in science.

Theme 2: Students Explored and Clarified Their Interests in Research and Science

Students expressed confirmation and clarification of their interests resulting from participation in the research experience. Allison said that the research experience "made me realize my passion for marine ecosystems" (interview 2) and that conducting research "sparked an interest in ensuring support to work on environmental mitigations" (survey 4). Hannah said, "it helped me realize passionate interests and that I would like to work in a field of conservation/restoration of reefs" (survey 4) and expressed that she "reached a lot of goals that I didn't know I had until we were actually doing it [in the research experience] and I kept thinking this is what I've been working towards" (interview 2). In a follow-up survey (survey 5), Hannah wrote that she "was self-conscious of my age and upbringing being different from others and felt out of place in science, this internship helped me listen to my gut and heart and to have a purpose with the ocean." Nancy also wrote in survey 3, "This was a confirmation that this is what I want to do because I love the ocean and learning more about corals. It's been inspiring for me." Nancy also said that she "wants to do marine biology with an emphasis in coral biology" (interview 2) after the research experience and her interest in coral biology increased (survey 4). Kate knew that she "wanted to do geology or geophysics but I wasn't sure what part I wanted, but because of this internship I want to do marine geology" (interview 2). In survey 5, Kate wrote that "doing research helped me realize I want to do a career in research." Participating in the research experience "reinvigorated" Julie's "love for science and conservation," and she "learned not to be intimidated by research" (surveys 3 and 4).

In addition to confirming and increasing their interest in research and marine science, students also clarified their interests and recognized aspects of science that did not align with their goals for working in the sciences. Although students were interested in marine science, some found that laboratory research did not align with their interests and instead recognized a need to explore alternative career paths. During the research experience, Julie experienced a critical period of exploration and reflection of her interests in science and reported in interview 2 after the experience,

> It definitely made me feel more confident in my ability to do research and stuff, but I definitely want to be more involved in like animal studies, that kind of thing. I feel like this is not exactly what I want to do. Do you know, that helped, like, me determine that I was, like, nope, this is not exactly what I want to do, I want to do something more involved. So that was good.

Julie's response illustrates the value of participating in research to clarify her interests in science. By participating in a research laboratory environment, she learned that she did not want to work in that environment in her future career and instead would like to work with "large animals" (survey 4). Allison expressed a similar perspective after the research experience, reporting in survey 5,

> The research process was extremely interesting for me, but I realized that I could not see myself in a lab for my future career. Also, working amongst professionals in the field and hearing their conversations about how difficult the grant process is and the reality of the corals was eye-opening.

By engaging in research, Allison learned that laboratory research was not the way she desired to explore science and instead became interested in environmental planning, because she "realized the bigger problems and where major changes need to be made for corals" and "wanted to give a stronger voice to environmental issues" (interview 2, survey 4). This experience was influential for Allison, because she was "at a point where I have to choose and there are a lot of choices for [my future]" (interview 2). Hannah expressed uncertainty in how laboratory research fit within her goals and interests in science, saying in interview 2, "I don't know if I like research or would be a person that will be a researcher full time, I'm not up to that level yet. I'm not trying to put pressure on myself and just keep my options open."

Overall, participation in a research experience provided opportunities for students to both confirm and increase their interests in science and also provided important learning experiences that helped to clarify their interests in career pathways.

Theme 3: Participation in Research Influenced Student Conceptualization of Themselves as Science Professionals

Participation in a research experience provided an opportunity for gains in students' perceived performance and competence in science and allowed students to explore and identify their interests in science (theme 1). Further, participation in the research experience allowed students to explore and develop greater understanding and clarification of their individual scientific interests (theme 2). However, students had outstanding questions and uncertainties about their conceptualizations of themselves as future science professionals and their career trajectories (i.e., professional conceptualization). Importantly, we found that students were actively considering their career options while participating in the research experience, and exposure to a research environment provided an opportunity for students to reflect upon their career interests and directions as they related to the research experience. For some students, these opportunities strengthened their conceptualizations of themselves as science professionals and helped them narrow and focus their views of their career trajectories. For others, participation in research and reflection on their experiences opened their conceptualizations of themselves as science professionals in spaces outside laboratory science and shifted their conceptualizations of themselves in science careers. Here, we describe evidence through embedded case studies that participation in the research experience provided opportunities for students to reflect upon and develop their conceptualizations of themselves as future science professionals.

Kate and Nancy: Research Experience Facilitated Focusing of Career Interests. Kate and Nancy both demonstrated that participation in the research experience confirmed and strengthened their conceptualizations of themselves as researchers and their career goals to conduct research science. First, Kate was interested in pursuing a career in research at the start of the research experience (Table 3). When asked what her ideal career would be, she responded, "I would set up my own lab and research something that I am passionate about," reflecting her passion for science, solving problems, and asking questions (significant circle, interview 1). In her life, she explored her interests across science fields, because she "likes doing research but wasn't sure what field" and said that her "original plan was to get into geology and geophysics for money" due to family and financial obligations (interview 1). Exploring her interests in research and gaining authentic experience in science increased Kate's interest in marine science research (as described in themes 1 and 2), and after the research experience, she said, "Because of the research experience I want to do marine geology" (interview 2). In survey 2, Kate also shared that she possessed characteristics highly similar to those of scientists, expressed high interest in pursuing a science degree and career, and considered herself to be similar to a professional scientist. Her responses demonstrate that she felt confident in her science identity and benefited from participating in the research experience to narrow her career interests and develop her conceptualization of her desired profession in science. At the end of the study, she said, "Without the research experience, I would not have thought about how oceans are affected by corals" and that she was "directed to marine geology because of the research experience by narrowing my interests and thinking about how

TABLE 3. Student-reported intended career trajectories collected through surveys and interviews

Student	Intended career path			Trajectory of intentions
	Start of research experience	End of research experience	End of study	
Allison	Environmental sciences	Ocean engineering	Environmental planning	Shift
Kate	Research in a laboratory	Marine geology	Marine geology	Focusing
Julie	Work with animals at a zoo	Work with animals and integrate art	Zoologist/wildlife conservation	Shift and focusing
Hannah	Connecting science, education, and communities	Ocean education and research	Biologist working in conservation and community education	Shift and focusing
Nancy	Marine biology	Coral biology	Coral biology	Focusing

corals affect the ocean" (survey 5). Participation in the research experience strengthened Kate's conceptualization of herself as a science professional and helped her focus her interests in pursuing a research career focused on marine geology.

Nancy experienced similar focusing of her goals by participating in research and said that "research is the ultimate goal for me, that's what I have always wanted to do so I am trying to make that happen" (interview 1). Participating in the research experience further provided an opportunity for Nancy to gain experience and confirm her conceptualization of herself as a researcher in marine biology. In interview 2, Nancy said, "the research experience was a confirmation of what I want to do because I love the ocean" and that she focused her interests in biology to have "an emphasis on coral biology." After the research experience, she responded that she considered herself a science person and similar to a professional in science (survey 2). At the end of the study, she also expressed a high ability to visualize a science career (survey 5). Participating in the research experience provided opportunities for her to increase her interest in research and to network with professionals in science, which provided an avenue for her to interact with scientists in her desired field (survey 5). Nancy's responses during this study demonstrate that participating in a research experience helped her confirm her interests and visualization of herself as a researcher.

Allison: Research Experience Was an Opportunity to Explore Career Options and Shift Professional Interests. At the beginning of the research experience, Allison expressed that she was "always thinking about how my actions will affect my future" (significant circle, interview 1). In the context of her career interests, she knew that she wanted to pursue a career in environmental sciences in a job that would allow her to "grow, learn, and constantly change" (interview 1). However, she did not know if "doing something in the lab or for a long time is the right thing" (interview 1) and that she "didn't have people that were professional in science growing up, so I don't really know what I would do as a job" (interview 1). Following the research experience, she expressed interest in ocean engineering and exploring advanced degrees in this area (interview 2), saying, "I'm at a point where I need to choose a path" and that getting experience in research was important at this point in her science journey (interview 2). She expressed uncertainty in her future career path after the research experience (interview 2) but began to gain clarity in jobs that she would like to explore, saying "when I think about a job I feel like ocean engineering is more what I want to do as an ultimate goal, but there are a lot of choices and it is hard to decide on a path" (interview 2). At this point in her education, Allison's statements demonstrate that although she has high interest and motivation to pursue a career in science, she experienced uncertainty in the career pathways available to her that fit her conceptualization of herself as a scientist and opened new possibilities and spaces to consider for her career trajectory. At the end of the study, Allison expressed a shift in her career goal toward environmental planning, following reflection upon her experiences in the program (Table 3). In survey 5, she wrote that the "eye-opening" experience of working with science professionals during the research experience and gaining experience in the laboratory deepened her skills and interest in marine science (as described in themes 1 and 2). Based on this experience, she realized that the "hard work of researchers is not met by higher powers dealing with environmental issues, sparking an interest in environmental planning to ensure support to those working on mitigations" (survey 4), demonstrating the strong influence of reflecting on her research experience on her career goals and motivations. At the end of the study, she reported a high rating of her similarity to a science person and high confidence in her ability to visualize a professional science career (survey 5). Allison's responses during the study illustrate that gaining experience in science and research during a period of uncertainty and exploration in her career interests influenced her conceptualization of herself as a scientist and provided opportunities for her to explore her career interests.

Julie: Research Experience Confirmed Interest in Careers Outside the Laboratory and Provided Opportunities to Reflect on Professional Interests. At the start of the research experience, Julie's goal was to work at a zoo and find ways to incorporate her interests in art (e.g., taking photographs of animals, drawing animated animals for media; Table 3), but she was uncertain if there was a career that would match these interests (interviews 1 and 2). Participating in this research experience helped her gain experience in science and provided an opportunity for her to evaluate whether laboratory research was an appropriate match for her interests and goals. She found that "this isn't exactly what I want to do" (as described in themes 1 and 2). Although she realized that her interests lie outside the laboratory environment, the research experience provided an opportunity for her to evaluate her conceptualization of herself in science professions. She said, "It helped me be not so intimidated by research, you think science is white coats in a room with expensive equipment—research is going into the field and seeing how things work" (interview 2). After the research experience, she planned to work as a teaching assistant and gain more experience through internships or working at a zoo, having a continued desire to combine art and animals in her career through photography or similar activities (interview 2). At the end of the study, Julie said that the research experience "helped pinpoint which career I wanted to pursue and gave me hope … I became more excited about research and working with larger animals" and identified wildlife conservation and zoology as career interests (Table 3; survey 5). The trajectory of her career goals throughout the study illustrates both shifts in and focus on her professional interests—she experienced simultaneous shifts in and focus on her interests in working with animals and integrating art to zoology and wildlife conservation (Table 3). Although she recognized herself as a science person on surveys, she was moderately confident in her ability to visualize a science career (survey 5). Julie gained understanding of her interests and of professions in science during the research experience and developed her conceptualization of herself in science fields. Importantly, Julie's experience highlights that students need access to experiences that allow them to explore a wide range of career options outside our traditional understanding of what careers in science are.

Hannah: Navigating Career Opportunities and Exploring Professional Interests through a Research Experience. Hannah's motivations and interests for her science career were built on her desire to work with communities and connect science and education in her home in Hawai'i (significant circle, interview 1; Table 3). Although she was passionate about her motivations and interests, Hannah was uncertain about professional career options available to her. She said in interview 2, "I don't know if there is a job description out there already for me, I don't know the options that are out there so I think it's about learning what is possible—I try not to stress about it but it's on my mind all the time."

Her journey in science was "a process" in which she followed a pathway of her interests that led from one opportunity to another and led to a community of science mentors and peers that helped her feel "confident and supported in science" (interview 1). This statement illustrates that a sense of belonging in her home community was important to Hannah in addition to the sense of belonging and support acquired from a community of science mentors and peers (significant circle, interview 1). Participating in the research experience allowed her to gain authentic experience in a research environment, explore her interests, and gain skills (as described in themes 1 and 2). After the research experience, Hannah expressed that she was still exploring her career options. She stated in interview 2, "I think I want to get into education but I'm not sure exactly where, but I definitely want to work in education with the ocean. In addition to education I want to be able to somehow do research but not the PhD route, I'm still trying to figure it out."

This statement illustrates that Hannah confirmed and focused her desire to pursue a professional career that has connections to the ocean but was still working to understand what her options are in this field. In surveys, she reported high interest in pursuing a science degree and career, and after the research experience, she responded that she was more confident in when comparing herself to a professional in science (surveys 1 and 2). At the end of the study, Hannah reported plans to take a year off after obtaining her degree to work in the field of management or biology and take part in internships or other research experiences in Hawai'i to further clarify her career goals and learn about professional opportunities available to her (survey 5). Participating in the research experience, she wrote, confirmed that she "wants to work with corals after the internship and realized my passion for field work and management and reef conservation," demonstrating a focus on her career interests in science while she was still experiencing shifts in her interests at the intersections of education, science, and community (survey 4; Table 3). She also expressed a high rating of herself as a science person and ability to visualize a professional career in science (survey 5) and further developed her conceptualization of herself as a scientist at the intersection of research, education, and community. Hannah's responses during this study demonstrate that participation in research was beneficial to gain perspectives on one aspect of her career interests in research and further develop her conceptualization of herself as a science professional, which aligned with her desire to integrate science, education, and communities.

These embedded case studies of individual student experiences demonstrate that student conceptualizations of themselves as science professionals and where they fit within the available science career options play a critical role in the choices, interests, and goals of these students as they continue their education in the sciences. Shifts in and focus on their career goals because of gaining experience, knowledge, and an understanding of professions in science highlight the nonlinear, complex, and nuanced nature of student career trajectories in the sciences. Participation in research experiences provides opportunities for students to gain knowledge and understanding while also considering and reflecting upon their conceptualizations of themselves as future science professionals and exploring potential career pathways. Although participation in research allows for gains in science understanding and exploration of interests, students require additional support and experiences that help them explore career pathways and expand their views of science careers aligned with their conceptualizations of themselves as science professionals.

DISCUSSION

Participation in a research experience provided a space and opportunities for students to gain knowledge and understanding of themselves and their abilities in science. This study provides evidence that an individual's sense of self as a science professional, considered here as professional conceptualization, is an important component of science identity for the community college students involved in this study. Participation in a research experience can influence student science identity by providing opportunities for learning and practice in science and experiences to confirm and clarify their interests in science and science career pathways. Further, student interests and motivations for science inform their career choices and conceptualizations of themselves as professionals in science. First, we describe the implications of these findings for our understanding of performance/competence and interest in the development of science identity. We then explore the implications of student conceptualizations of themselves as science professionals.

Participation in a Research Experience Fostered Development of Student Competence Beliefs and Exploration of Their Interests in Science

The results of this study demonstrate the importance of performance/competence and interest in science as constructs in science identity development, as described in previous frameworks (Carlone and Johnson, 2007; Godwin *et al.*, 2016; Stets *et al.*, 2017; Hazari *et al.*, 2010, 2020), and exemplify the value that research experiences hold in science education. Students reported learning content knowledge and skills by conducting scientific research and gaining understanding of the process of science, which have been demonstrated as positive outcomes of undergraduate student participation in research (Hunter *et al.*, 2007; Lopatto, 2007, 2010; Sadler and Mckinney, 2010; Linn *et al.*, 2015). An important component of this knowledge and exploration was an increased understanding of their current limitations in science, particularly in challenges associated with related math and data analysis skills for the students in this study. Student ability and confidence in mathematics is important for analyzing and reporting data that they collect in their research and success in science (Elliott *et al.*, 2001; Furner and Kumar, 2007). However, perceived challenges associated with mathematics, which may be influenced by poor previous achievement in math, low perceived ability in math, competitive testing environments, or negative prior experiences in math (Zeidner, 1991; Foley *et al.*, 2017), can have negative influence on student interest and persistence in science (Ahmed, 2018; Chipman *et al.*, 1992; Foley *et al.*, 2017). These effects may be experienced at a higher rate by women students due to implicit gender stereotypes associated with performance in math (Smeding, 2012). Learning to analyze, write, and present data that they themselves collected could provide important motivation for learning these critical science skills and can influence career intentions (Cameron *et al.*, 2020). Further, acknowledging and discussing challenges during student experiences in science may help students to overcome difficulties and encourage instructors and mentors to develop individualized learning plans (Jackson and Seiler, 2018). We suggest that research experiences include explicit and supportive learning experiences in conceptual and practical application of statistics and analysis and regular, constructive feedback from mentors as students develop these skills.

In addition to gains in knowledge and skills, participation in research provides an opportunity for students to explore and clarify their interests in science as those interests pertain to their degrees and career intentions, presenting an opportunity for students to foster their conceptualizations of themselves as scientists. Involvement in research allows students to “try out” potential career paths and, through reflection, can confirm or clarify their interests (Lopatto, 2004; Hunter *et al.*, 2007; Sadler and Mckinney, 2010; Taraban and Logue, 2012). Recognition that research in a scientific laboratory does not fit within one’s goals and is not aligned with one’s science aspirations should be considered a positive outcome of reflection for students as they work to clarify and define their science identities through challenging moments. Indeed, previous research has shown that identity can be strengthened and developed by challenging experiences, in which students examine the relevance of their experiences and learning to their values and goals (Trede *et al.*, 2012).

Designing science experiences such that students are provided with support to strengthen their performance/competence beliefs and explore their interests can positively influence their confidence and identification in science (Godwin *et al.*, 2016; Hazari *et al.*, 2020; Deemer *et al.*, 2021). This work supports the influence of performance/competence as a construct of science identity, as demonstrated in previous work (Carlone and Johnson, 2007; Godwin *et al.*, 2016; Hazari *et al.*, 2020), and points to the role of this construct in also shaping the foundation for students to conceptualize their identities as professionals in science. In this study, statements regarding limitations in perceived performance and competence and statements of science identity were often co-occurring, highlighting the influence of this construct on student views of themselves as scientists. For example, students responded that they were “aspiring,” “junior,” or “learning” scientists and that further education and practice would be required to feel as though they were truly scientists. This pairing of statements regarding perceived competence and performance in the fields of science with statements regarding their conceptualization of skills and credentials required for their careers of interest sets important context for the formation of their identities as future science professionals. Because community colleges serve underrepresented groups in science and those who pursue science through nontraditional pathways (e.g., “latecomers”), it is particularly important to strengthen the resources and support for these institutions to provide research experiences that build student perceptions of their competence and performance in science and foster development of their science identities (Jackson and Seiler, 2018). In classroom environments, course-based research experiences leverage the positive impacts of research and a collaborative peer environment to encourage persistence in science fields (Eagan *et al.*, 2013; Rodenbusch *et al.*, 2016). We suggest that course-based research experiences could facilitate opportunities for community college students to explore and reflect upon their conceptualizations of themselves as science professionals by incorporating activities such as career exploration, job shadowing, journaling, and discussion with both peers and science role models.

Reflection on these experiences and perspectives facilitated by mentors can provide a space for students to actively challenge their conceptualizations of science and evaluate how participation in science resonates and matches with their goals, interests, and aspirations. Reflection on experiences is an important component of learning and identity development and helps individuals recognize barriers and challenges in their own learning (Dyer and Taylor, 2012; Linn *et al.*, 2015; Huvard *et al.*, 2020) and is a dynamic and lifelong process (Trede *et al.*, 2012). In this study, for example, Julie exemplifies the positive impacts of reflection, during which she realized that working in a laboratory was not aligned with her interests, which helped her clarify her aspirations for a future career. To provide formative opportunities for reflection, research mentors can encourage students to think critically about their learning and career goals through frequent check-in conversations, regular meetings, and journaling (Chemers *et al.*, 2011; Wilson *et al.*, 2013; Allen-Ramdial and Campbell, 2014; Linn *et al.*, 2015). Employing individualized approaches to student mentorship and career exploration (i.e., individual learning plans; Hamilton, 2009) may help research mentors augment these practices to

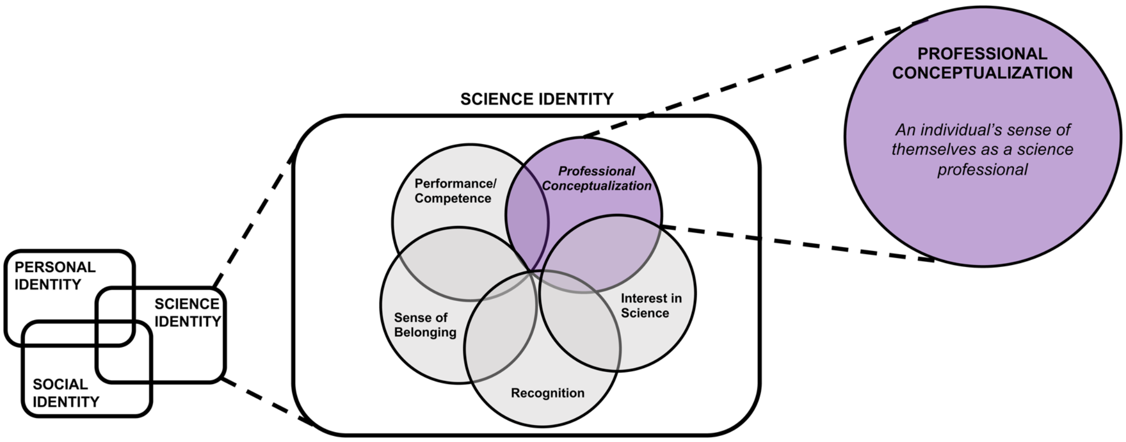

FIGURE 3. Professional Conceptualization definition to "individuals' sense of themselves as science professionals"—should be considered and further studied as an important component of science identity.

encourage productive outcomes for all students, especially those undergoing exploration of their career interests and goals (Linn *et al.*, 2015).

Conceptualization of Self as a Science Professional Is an Important Component of Student Science Identity

This work builds upon our understanding of science identity development by providing evidence for conceptualization of self in science professions as an important component of identity in this group of community college women (Figure 3). Engaging with science through a research experience influenced their science identity development by providing a space to evaluate and reflect on their interests in science and professional pathways. These interests and motivations in science further informed their career goals, aspirations, and intentions and their conceptualizations of themselves as professionals in science. Viewing professional conceptualization—a student's sense of being a professional in science—as an important component of science identity requires considering not only the student's present sense of self in science, but perceptions of a future self in the science professions (Figure 3).

As students progress through education and become closer to a point at which they must choose a career pathway or acquire a professional position, developing an understanding of career interests, goals, and expectations is an important step toward a career postgraduation. Rather than a linear pipeline, science career trajectories are complex, variable, and involve dynamic movement (Metcalf, 2010; Cannady *et al.*, 2014; Lykkegaard and Ulriksen, 2019), and identity influences choices (Vincent-Ruz and Schunn, 2018). It is important for students to explore science and try new experiences to reflect upon how these experiences resonate with each individual as they develop their identities in science. As students gain more experience in science and learn about professional pathways available to them, these experiences may provide opportunities for reflection and clarification of their interests.

In this study, career aspirations, hopes, and goals were linked to how individuals view themselves as science professionals. For example, in this study, Allison gained new perspectives on how scientific research fit within her personal and professional goals and shifted her interests to pursuing environmental policy and management to positively impact conservation of ecosystems. Julie became less intimidated by the research space, but also realized that laboratory research was not well aligned with her interests and goals, deciding to pursue wildlife conservation and zoology. Based on the results of this study, it is important to consider the context of career aspirations and intentions in the development of science identity and facilitate exploration of professional spaces in science education beyond traditional frameworks of research science. As stated by Dall'Alba (2009, p. 34), "Learning to become a professional involves not only what we know and can do, but also who we are (becoming)." The results of this study exemplify this statement—students' views of their future careers were not only influenced by their skills and knowledge (i.e., perceived competence), but also by their understanding of what they would like their future careers to be within the careers traditionally made available to them. While this study demonstrates participation in research influenced students' sense of themselves as future science professionals, additional research should investigate the influence of research experiences on students' perceptions of science as a discipline.

During research experiences, mentors and institutions can explicitly provide exposure to career exploration through career panels with representatives of diverse backgrounds and opportunities for professional networking and job shadowing and by facilitating experiences in research facilities at different institution types (e.g., academic, nonprofit, government). For example, in this study, Hannah said that she was unsure what types of careers would be a good fit for her and that it was difficult to learn about the options available. We recommend that research mentors ask students about their career interests and tailor their research experience to allow them to explore their interests and actively reflect on how these experiences relate to their expectations. Building these experiences within a collaborative environment with peers and mentors can encourage professional science socialization, which facilitates a sense of belonging in science careers (Carlone and Johnson, 2007; Hazari *et al.*, 2020). Effective fostering of professional conceptualization may be particularly influential in guiding students toward not just degrees in science, but careers in science. Shaping and development of students' conceptualizations of themselves as professionals in science may provide a key foundation for professional science identity. Professional identity, as defined by Trede *et al.*, (2012, p. 374), is built by the "attitudes, beliefs, and standards which support the professional role and development of identity as a member of the profession with understanding of responsibility of being a professional" and is intersectional with social and personal identities. Professional identity development has been discussed in certain fields, including social, health, and computer sciences. For example, Joynes (2018) showed that senior professionals in the health and social sciences are more certain in their professional identity than more junior professionals. In counseling professions, confidence-building experiences positively impact professional identity (Moss *et al.*, 2014), and in computer science, participation in professional development and community activities shape professional identity (Kapoor and Gardner-McCune, 2019). One study in geosciences found that mentoring strengthened participant professional identities and intentions to persist in science and that this support was particularly important for women (Hernandez *et al.*, 2017). While struggling to develop one's sense of professional self has been previously documented for postdoctoral scholars (Hudson *et al.*, 2018) and faculty (Brownell and Tanner, 2012), it is less described for undergraduate students in science early in their educations (Hernandez *et al.*, 2017). Because identity formation is an important influence for student motivation and persistence in science (Graham *et al.*, 2013), future work should continue to explore the role of professional identity in shaping career intentions for postsecondary students. In this study, we present evidence that participation in research provides opportunities for students to develop their sense of self as science professionals, and additional work should thoroughly examine how professional identity is built from this foundational conceptualization of self in science.

This study explored identity development in a group of women in science, and it is important to consider social factors that may influence the development of their science identities and perspectives that they bring into the research space. Women in science are more likely to experience situations in which issues of gender, race, and ethnicity negatively influence and disrupt one's perception of belonging and recognition as a professional in science (Brickhouse and Potter, 2001; Carlone and Johnson, 2007; Williams and George-Jackson, 2014; Rainey *et al.*, 2018; Vincent-Ruz and Schunn, 2018; Bodnar *et al.*, 2020). Across a variety of disciplines (including health professions, information technology, and science), a tangible understanding of self as a professional can foster students' confidence in their career trajectories and enhance their visions of themselves as future science professionals (Hunter *et al.*, 2007; Moss *et al.*, 2014; Joynes, 2018). Prevailing uncertainty in this aspect of identity throughout undergraduate education may negatively impact student persistence in science later in their educations or professional training. Even in science careers where women are not underrepresented, such as nursing, conflicts and disruptions in professional identity and conceptualization can lead to career exit (Worthington *et al.*, 2013). It is therefore particularly important to develop science experiences and immersive research opportunities that foster the development of professional conceptualization for women students in science fields. The results of this work highlight the impact of providing research experiences for women in science and for students pursuing education at institutions such as community colleges that serve underrepresented groups in science (Ma and Baum, 2016; Hewlett, 2018).

Engaging in research provides a space for students to work with mentors and role models in the field (Hernandez *et al.*, 2018) and experience professional socialization (Hunter *et al.*, 2007). Students benefit from being matched with mentors of the same race and gender (Blake-Beard *et al.*, 2011). Women in science benefit from supportive and positive mentors who are women in science, which can influence their identity development and encourage persistence in science (Stout *et al.*, 2011; Hernandez *et al.*, 2017). In this study, Allison said that she had difficulty envisioning a career in science, because she lacked role models in careers that interested her. Therefore, providing opportunities for students to interact with science professionals across a range of career types can support students as they learn about their professional options (Trede *et al.*, 2012).

Although not major components of identity expressed by students in this study, there were responses that point to the role of belonging and recognition in shaping their perspectives. For example, Hannah expressed a strong sense of belonging in her home community and expressed the importance of connections with others in the science program at her community college as important in her science pathway. In the surveys, we asked students about the importance of recognition by others and whether others recognized them as a science person and, generally, students strongly agreed. In other studies, these components play important roles in science identity development (Trujillo and Tanner, 2014; Godwin *et al.*, 2016; Rainey *et al.*, 2018; Vincent-Ruz and Schunn, 2018; Avraamidou, 2020; Hazari *et al.*, 2020). Additional work should explore the influence of belonging and recognition in community college student groups, as the educational structure of these institutions differs from that of 4-year universities (Ma and Baum, 2016; Hewlett, 2018).

In this study, we found that performance/competence statements were paired with identity statements, such that students expressed limitation in adopting an identity as a "scientist" due to perceived lack of skills, knowledge, and education and training. Therefore, students' perceptions of the skills and qualifications necessary for building their conceptualizations of professions in science could influence their beliefs about their own competence required to succeed in those career pathways (Carlone and Johnson, 2007; Hazari *et al.*, 2010, 2020; Godwin *et al.*, 2016; Robinson *et al.*, 2018). It is important to consider conceptualization of self as a science professional as a component of science identity and provide opportunities for students to explore career pathways well matched to their skills, interests, and goals in science.

Implications and Next Steps

The purpose of this study was to explore the experiences of these individuals. Due to the individualized nature of this approach, we recognize the limitations in expanding these findings to broad populations. To fully understand the complex processes of science identity development, it is important to employ research through both individualized and larger quantitative discovery approaches. Our findings are based on student self-reported data, and future work would be strengthened by direct measurement of gains in knowledge and skills, as well as longitudinal research on actualized career pathways. This study is also limited by participant self-selection biases, because the students who participated in the research experience chose to seek out and apply for participation. Although understanding the perspectives of these five women provides a richer awareness of factors influencing their goals and trajectories in science, students in this study began the research experience with high interests and motivations for science, and we therefore cannot apply these conclusions to prospective science or non-science students. Further, the responses of the five community college students in this study provide important perspectives on the experiences in science that students from these institutions experience. Therefore, future studies should examine and compare differences in science experiences between students attending community college and those attending 4-year universities.

This work provides evidence that professional conceptualization is an important component of science identity development based on this study of a group of community college women. The results of this research suggest that fostering development of professional conceptualization is a critical component in providing and designing experiences in science that build students' sense of themselves as future professionals in science. By giving students more opportunity to explore, network, and interact with professionals in science and expand the range of their professional conceptualization, research experiences can help build student confidence in career choices and clarify career interests and goals. Future work should further investigate the role of professional conceptualization in science identity development across education levels. It is important to understand critical points during educational pathways at which students begin to form and develop their conceptualization of science professions and how this affects their career intentions and choices. To facilitate development of professional conceptualizations that positively impact student persistence in science, it is also necessary to understand how social structures, institutions, and experiences in science shape student perceptions of science professions. Research experiences are particularly well suited to help students develop an understanding of professional pathways in science, and it is important to increase resources to allow for students to access these experiences in community colleges. Further research should characterize aspects of research experiences that influence student views of themselves in their future careers.

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