Received: 22 September 2022 | Revised: 18 May 2023 | Accepted: 20 August 2023

DOI: 10.1002/tea.21902

RESEARCH ARTICLE

JRST | WILEY

Are there any "science people" in undergraduate health science courses? Assessing science identity among pre-nursing and pre-allied health students in a community college setting

Heather Perkins[1] | **Emily A. Royse**[2] | **Sara Cooper**[3] | **Jennifer D. Kurushima**[4] | **Jeffrey N. Schinske**[3]

[1]Department of Psychological and Brain Sciences, Indiana University, Bloomington, Indiana, USA

[2]Natural and Physical Sciences Department, Aims Community College, Greeley, Colorado, USA

[3]Biology Department, Foothill College, Los Altos Hills, California, USA

[4]Biology Department, Evergreen Valley College, San Jose, California, USA

Correspondence
Heather Perkins, Department of Psychological and Brain Sciences, Indiana University, Bloomington, IN 47405, USA.
Email: hlperkin@iu.edu

Funding information
National Science Foundation, Grant/Award Number: 1730130

Abstract

Science identity, or one's sense of recognition and competence as a scientist, is an invaluable tool for predicting student persistence and success, but is understudied among undergraduates completing preparatory work for later studies in medicine, nursing, and allied health ("pre-health career students"). In the United States, pre-health career students make up approximately half of all biology students and, as professionals, play important roles in caring for an aging, increasingly diverse population, managing the ongoing effects of a pandemic, and navigating socio-political shifts in public attitudes toward science and evidence-based medicine. Pre-health career students are also often members of groups marginalized and minoritized in STEM education, and generally complete their degrees in community college settings, which are chronically under-resourced and understudied. Understanding these students' science identities is thus a matter of social justice and increasingly important to public health in the United States. We examined science identity and engagement among community college biology students using two scales established and validated for use with STEM students attending four-year institutions. Exploratory and confirmatory factor analysis were used on two sub-samples drawn from the pool of 846 participants to confirm that the factor structures functioned as planned among the new population. Science identity values were then compared between pre-health career students (pre-nursing and pre-allied health) and other groups. Pre-health career students generally reported interest and performance/competence on par with their traditional STEM, pre-med, and pre-dentistry peers, challenging popular assumptions about these students' interests and abilities. However, they also reported significantly lower recognition than traditional STEM and pre-med/dentistry students. The implications for public health, researchers, and faculty are discussed.

KEYWORDS

career goals, community college, factor analysis, pre-nursing and allied health, science identity, undergraduate students

1 | INTRODUCTION

Think of your most recent interactions with health professionals. Perhaps that would include a nurse assisting with your vaccinations, a radiologic technician preparing you for medical imaging, a dental hygienist cleaning your teeth, or a respiratory therapist testing your lung capacity after an infection. You might or might not have thought of those health professionals as "scientists," but all of them navigated extensive sequences of science courses in preparation for their careers. The question of science identity—whether one identifies as a scientist and is seen as such by others—is thus of increasing interest among those working with pre-health career students. Given that aspects of students' science identities often predict success and science literacy in science courses (see below) we propose the following question: to what extent do healthcare professionals see themselves as science people during their undergraduate academic preparation?

1.1 | Theoretical framework

Science identity refers to the degree to which an individual identifies as a scientist or science person. There are various ways of conceptualizing and operationalizing identity. In this study, we use the disciplinary role identity framework. This framework draws from role identity theory (focusing on the internal processes of identity, such as an individual's thoughts and feelings about themselves or how they make sense of their experiences; Stets & Serpe, 2013) and studies of students and professionals to examine identity across an array of STEM domains (Dou & Cian, 2022). The framework originated from Carlone and Johnson's (2007) study of 15 successful female scientists of color, which identified three components of science identity (recognition, performance, and competence). Further studies in physics linked science identity to student career goals and intrinsic fulfillment (Hazari et al., 2010). These results prompted a wave of work examining the relationship between STEM identities and academic achievement (e.g., see Close et al., 2014; Dou et al., 2019; Patrick & Prybutok, 2018). Science identity has subsequently become an invaluable tool for understanding commitment to and belonging in science majors (Camacho et al., 2021; Patrick & Prybutok, 2018; Robinson et al., 2019).

Many of the foundational studies in the field took place within engineering and provided validity evidence for the disciplinary role identity framework, ultimately linking engineering identity to a number of outcomes of interest (Godwin, 2016). This included engineering practices, intentions to persist, degree progression, classroom belonging, ontological beliefs, and an array of non-cognitive factors like self-control, test anxiety, motivation, and personality (e.g., see Borrego et al., 2018; Choe et al., 2019; Godwin & Lee, 2017; Schar et al., 2017; Scheidt et al., 2019; Verdín et al., 2018; Verdín & Godwin, 2018). Over time, this framework was finalized into a model of science identity composed of three sub-constructs (Godwin et al., 2013; Gray et al., 2018; Hazari et al., 2010; Patrick & Prybutok, 2018). All three sub-constructs (performance/competence, interest, and recognition) play important roles in the development of science identity. Since we focus on two scales in this study, both addressing aspects of disciplinary role identity, we refer to the measure developed from the above framework (Godwin, 2016) as the "PCIR scale" (i.e., an abbreviation representing its three sub-constructs). This distinguishes it from the second scale, the Student Assessment of Learning Gains (SALG), discussed later.

1.1.1 | Performance/competence (PC) in the PCIR scale

Performance/competence is closely linked to the construct of self-efficacy, which has long been associated with beliefs about goal achievement and career choice (Vincent-Ruz & Schunn, 2018). Measures of performance/competence ask students to evaluate their success in tasks relevant to their chosen domain, such as performing a scientific analysis, writing a scientific paper, or performing well on a science exam (Godwin, 2016; Hazari et al., 2010). Whether students believe they are capable of performing in their field is a key factor in their ability to identify themselves as legitimate participants in their chosen domain (Marsh, Hau, & Kong, 2002). Research suggests that performance/competence mediates the relationship between interest and science identity (Hazari et al., 2020). This suggests students evaluate their interest and ability in tandem and base their decisions about their career tracks on both personal interest and anticipated success. The current sub-scale of the PCIR focusing on performance/competence provides several items that ask about understanding of scientific concepts and exams ("I can do well on exams relating to scientific concepts and ideas"). This could be problematic for certain students (e.g., pre-healthcare students) who may not view themselves or their future professions as "scientific" due to messaging from professionals and society at large. Evaluating items from other scales alongside the PCIR might therefore lead to a more robust measure of performance/competence that is more relatable for pre-healthcare students.

1.1.2 | Interest (I) in the PCIR scale

Interest has been extensively studied as a driving factor in students' selection of major and their engagement with their studies (Godwin et al., 2013; Potvin et al., 2009; Hazari et al., 2010; Semsar et al., 2011; Aschbacher et al., 2010). It is often considered the first step in building science identity, and many studies of science outreach programs highlight the importance of interest and fascination (Bonnette et al., 2019; Krapp & Prenzel, 2011; Potvin & Hazni, 2014). Measuring students' science interest can provide insight into what draws them to the field and what sustains their engagement during periods of difficulty. However, the current interest component of the PCIR scale is rather brief (often comprising only two or three items) and general (e.g., "I enjoy learning new scientific concepts and ideas"). Other studies have used more complex measures of interest, such as the science fascination scale (Bonnette et al., 2019) that asks about interest, curiosity, and mastery, and the CLASS-Bio scale (Semsar et al., 2011) that asks about real world connections, interest, problem-solving, and conceptual connections. Given current limitations of the interest component of the PCIR, opportunities exist to leverage other scales with more elaborate interest components to supplement the PCIR.

1.1.3 | Recognition (R) in the PCIR scale

Recognition is students' sense of whether they are recognized as a scientist by important others, such as parents, peers, instructors, and professionals in the field (Godwin, 2016; Hazari et al., 2010). It is a robust predictor of success among the sub-constructs of science identity (Cwik & Singh, 2022; Hughes et al., 2021; Jackson et al., 2019; Zimmerman, 2021), perhaps owing to the central role of recognition in the navigation of one's role identities. In role identity theory, recognition is experienced via a feedback loop of reflected appraisal and self-conception (Stets & Serpe, 2013). Reflected appraisals (feedback about the self from others) are compared to one's desired self-conception (e.g., being a scientist). When reflected appraisals and self-concept are congruent, the message is one of successful identification and belonging; when they are incongruent, the message is that adjustment is needed. As a result, recognition plays an important role in whether students feel that their science identities are validated. Previous work suggests that recognition can be particularly meaningful for students with marginalized identities (Carlone & Johnson, 2007; Avraamidou, 2021; Espinosa, 2011; Rodriguez et al., 2019; Starr et al., 2020). A strength of the current PCIR scale is that it asks about recognition from multiple sources, including family, instructors, and peers, thus assessing recognition through professional socialization, such as that experienced by nursing students (Dinmohammadi et al., 2013), and through familial and community cultural wealth (Yosso, 2005).

1.1.4 | An opportunity to expand upon the PCIR using the student assessment of learning gains

In biology education, the Student Assessment of Learning Gains (SALG) has frequently been used to assess elements of science identity (such as performance/competence, or self-efficacy, and interest). The SALG was originally created to measure the effects of curricular change in chemistry classrooms from a variety of institutions (including research universities, liberal arts colleges, community colleges, and historically black colleges; Seymour et al., 2000) and has come to be used in biology as a self-report measure of students' learning gains. For example, it has been used to examine the effects of curriculum changes in health science classrooms (Finn et al., 2017; Wolf et al., 2015; FitzPatrick et al., 2011) and in interdisciplinary classrooms that focus on specific real-world issues (Donaldson et al., 2019; Kosal et al., 2010; Weaver et al., 2018). It has also been used to make group comparisons of learning gains (i.e., whether the class has accomplished its goal of increasing students' education relative to their starting point; Tight, 2021) in a range of STEM classrooms (Luckie et al., 2013; Ojennus, 2016; Willoughby & Metz, 2009).

Traditional uses of the SALG have focused on the subscales asking about students' experiences with class and lab activities, their use of classroom resources, and the development of their science skills, with a focus on connecting classroom content to real-world issues (Seymour et al., 2000). Although the scale was not originally developed to measure science identity, it nonetheless mirrors two aspects from the PCIR: performance/competence (perceived ability to succeed in areas related to major) and interest (engagement and enthusiasm for the topic). Validity work with the SALG has generally focused on aspects of content, criterion, and construct validity, such as whether students' scores on the SALG mirror their demonstrated understanding of chemistry concepts (Gutwill-Wise, 2001). Thus, evaluating the SALG alongside the PCIR to assess science identity opens the potential to: (1), identify a new instrument for measuring science identity, and (2) increase our understanding of how science identity relates to perceived learning gains and academic performance. As described next, we aimed to investigate these issues among a unique, important, and understudied student group: pre-nursing and pre-allied health students.

1.2 | The gap in the science identity literature surrounding pre-nursing & pre-allied health students

Nursing and allied health (NAH) students are a critically understudied group despite the important roles they play in STEM education and in the healthcare system (Demo et al., 2015). While professions included under the "allied health" umbrella differ by organization and nation (Demo et al., 2015), allied health in the United States encompasses several healthcare related fields, excluding medicine, nursing, pharmacy, and dentistry (Institute of Medicine (US) Committee to Study the Role of Allied Health Personnel, 1989). Thus, allied health includes fields as diverse as respiratory therapy, nutrition, radiology technology, paramedics, kinesiology, dental hygiene, and many others (ASAHP, 2020). This immense range of NAH career tracks showcases the critical importance of these professionals in the healthcare system. There is currently an urgent need for more NAH professionals, as evidenced by the projection that "more registered nurse jobs will be available through 2022 than any other profession in the United States" (Haddad et al., 2023, p. 1). This brings into focus the importance of the pre-NAH training pathway and the potential for associations between science identity and student success throughout that pathway.

While a limited amount of research has examined science identity among pre-medical students (Dou et al., 2021), to our knowledge, no prior studies have investigated science identity among students aspiring toward NAH careers with sufficient sample sizes to assess internal validity of the scales or compare identity across career goals. Given the potential for science identity to predict student success in this context (Royse et al., 2020) and the dire need to recruit and retain more NAH professionals, this represents a critical gap in the literature. Previous work theorizes that science identity and science literacy are linked, with inequities in identity and literacy linked to inequities in participation and access (Johnson, 2012). Merely engaging in the practice of science will not create literacy without some identification with science (Johnson, 2016). Investigations of science identity in pre-NAH settings could therefore lead to interventions that support NAH professionals' science literacy and ultimately perhaps their sense of engagement with research-based medical recommendations.

1.2.1 | The debate over whether pre-healthcare career students are "STEM students"

Though levels of interest in STEM among pre-healthcare undergraduates resemble those of other STEM students, there is ongoing debate as to whether these students should be classified as science majors (Dou et al., 2021). Healthcare professionals are also not consistently described as STEM professionals by various national and educational organizations (National Science Board, 2014). This uncertainty about the status of healthcare students in comparison to other STEM students impacts the perceived importance of science in pre-health students' college classes. For pre-health students, undergraduate science courses are often viewed as gatekeepers to accessing clinical training, with clinical training representing what the students will most directly apply in their careers (McVicar et al., 2014). Consequently, the presumed use of science knowledge by health professionals differs from the uses of a research scientist, with the practices of healthcare resembling applied science more than basic science. Indeed, health professionals often feel unequipped to pursue research as a part of their careers (Borkowski et al., 2016; Upton & Upton, 2006). This lack of research self-efficacy is evident during undergraduate training as well, since students may operationalize the significance of pursuing healthcare careers differently than pursuing research-oriented STEM careers (Hsu et al., 2009).

Despite the debate as to how practitioners should be classified, we view pre-NAH students as STEM students. Prior to entering NAH programs, these students take sequences of prerequisite STEM courses that can match the breadth and intensity of the undergraduate work completed by science majors. These courses often include sequences in general biology, chemistry, anatomy and physiology, and microbiology (McVicar et al., 2014; Scott et al., 1995). However, pre-NAH students are not always considered STEM students by their institutions and by themselves. They often struggle with the content both during and after enrollment in these courses (McVicar et al., 2015), and graduates report that they perceive their bioscience knowledge to be insufficient when entering the workforce (Davis, 2010). Recommendations regarding the content students should learn in these courses are conflicting, with some advocating for research-based practices in line with other science majors (Ballen et al., 2017; Dou et al., 2021) and others suggesting that further integration with clinical practice could better prepare these students for their careers (Larcombe & Dick, 2003). This conflict between basic and applied science perceptions in health education contributes to a context-dependent spectrum of views about the relevance of learning biosciences for clinical practice (Larcombe & Dick, 2003).

In consideration of the above, fully supporting pre-NAH students through their extensive sequences of STEM prerequisites will likely require a better understanding of their science identities. This includes investigations into what pre-NAH students' science identities are, how they compare to their peers aspiring to enter other STEM careers, and the potential sources and consequences of these differences.

1.3 | The importance of the community college context

As noted above, existing measures and methodologies for studying science identity are not well tested in pre-NAH settings. These measures are even less robustly examined in community college contexts. This is a significant oversight, as community colleges sit at the center of pre-NAH education and are on the frontlines of efforts surrounding diversity and equity in higher education.

1.3.1 | Diverse student populations at community colleges might respond in unique ways on science identity measures

In the United States, community colleges serve students during their early undergraduate careers as they seek associate's degrees, complete professional training and certifications (e.g., nursing school), or prepare to transfer to 4-year colleges and universities. Community college students make up close to 40% of all undergraduates in the United States (American Association of Community Colleges, 2023), with most biology majors completing some of their training at community colleges (Foley et al., 2020). Most students from backgrounds minoritized and marginalized in higher education attend community colleges (U.S. Department of Education et al., 2021).

Comparisons between four-year colleges and universities and community colleges reveal differences between the student populations. For instance, community college students are more likely to have real-world experience and to hold part- or full-time jobs while also attending school (Radwin et al., 2018), and to have additional roles as caregivers or parents (Gallup, 2020; Reed et al., 2021). Compared to four-year students, they are more often nontraditional students, navigating new settings and cultures with differing stores of capital and support to guide them (RTI International, 2019; Sáenz et al., 2018). Community college students are also more likely to belong to groups targeted by racial violence and exclusion, which provides unique perspectives and challenges in academia (Ma & Baum, 2016; Phillippe, 2016). Many community college students are the first in their families to attend college (hereafter "first-generation students") who report strong ties and responsibilities to their families and communities of origin. Such students tend to value practical, hands-on knowledge that contributes to their upward mobility and their ability to uplift others (Covarrubias et al., 2019; Smith & Lucena, 2016).

Like other students, community college students experience struggles and adversity in the pursuit of their degrees and need to have their belonging in academia and STEM validated (Acevedo et al., 2021; Rodriguez et al., 2019). This need is compounded by the fact that community colleges are often stigmatized as "less than" when compared to four-year institutions, but also ameliorated by the unique advantages provided by community colleges such as local community support, small hands-on classes, and individual mentorship (Shaw et al., 2019).

Given these differences, previous research about science identity may not extend seamlessly to community college science students. For instance, belonging interventions that increase the pass rate for minority students with low science identity in four-year institutions (Chen et al., 2021) have required adaptation for use with community college students (Patterson Silver Wolf et al., 2017; Patterson Silver Wolf et al., 2019). Confirming that widely used measures of science identity function in new populations is an important step in bringing lessons learned from one context to another.

1.3.2 | The central role of community colleges in pre-NAH education

Community colleges play a critical role in the academic preparation of NAH professionals. Health science majors make up the largest proportion of associate degrees awarded in the United States (National Center for Education Statistics, 2014). NAH students, in particular, are especially likely to complete academic preparation at community colleges, with one study finding that 62% of allied health professionals attended community colleges (Frogner & Skillman, 2016). However, community college teaching and learning is understudied, with less than 6% of biology education research publications featuring community college faculty authors or community college study contexts (Creech et al., 2022). While there is significant research exploring the success and identity of biology students at four-year institutions, there is little research investigating the science identity of community college biology students. As community college students often come from identities that have been marginalized and minoritized in higher education, studying and supporting this population might also hold promise for efforts to address issues of inequity and disparity in healthcare by increasing diversity and empowering oppressed groups (Greenwood et al., 2020; Institute of Medicine, 2003).

1.4 | Study purpose and research questions

In summary, science identity is an important component of student success, with links to academic and affective outcomes such as GPA, self-efficacy, interest, and many others (Li et al., 2020; Verdín, 2021). Despite ongoing debate about their classification as STEM or STEM-adjacent, we view pre-NAH students as science students. Their science identities are understudied, but potentially linked to outcomes of individual and public importance. Collecting validity evidence for existing measures of science identity in community college pre-NAH settings, and examining science identity variables among students with varying pre-NAH interests, are important first steps in studying and supporting community college students aspiring to healthcare careers. To this end, this study begins to explore two broad research questions that address the gaps in the literature established above:

1. How do PCIR and SALG items function for community college biology students?
2. What is the state of science identity among community college biology students, with a specific focus on those pursuing NAH careers?

We address these questions by examining the internal structure of the PCIR and SALG instruments in a community college serving a diverse population of biology learners. We then compare students' composite scores for identity constructs based on student career goals.

2 | METHODS

Below we describe our strategies for addressing our research questions, including our study context, measurements, approaches to data collection, and analyses.

2.1 | Participants and institutional context

Participants were drawn from four biology courses at a diverse west coast community college. Data were collected from 846 participants from said courses over four quarters (see Table 1 for more information). Students were asked to complete a department-administered survey at the beginning and ending of each quarter in exchange for extra credit. Students from 12 sections of four biology courses (an introductory course for biology majors, $n = 51$, an introductory course for nonmajors, $n = 222$, an anatomy and physiology course, $n = 419$, and a microbiology course, $n = 136$) participated in multiple rounds of data collection. For this analysis, only responses from students' first participation timepoint were used (e.g., a student who participated in the survey for their introductory course and then one of the more advanced options was only included once, as an introductory student).

2.2 | Procedure

2.2.1 | Collection of PCIR and SALG data for research question 1

Data were collected from biology students at the beginning and ending of each quarter through participation in a voluntary, anonymous, extra-credit survey (only beginning-of-course responses were used for these analyses). The surveys asked participants to respond to 11 items from the previously introduced PCIR measure on a 5-point Likert scale (see Appendix 1 for the full list of items). As part of the department's evaluation procedures, students also responded to items from the Student Assessment of their Learning Gains (Seymour et al., 2000) and about their course experiences, content knowledge, and previous science experiences. Students' current course, gender, and race/ethnicity were obtained from institutional records and linked to survey responses before they were anonymized for analysis. For the full list of items in this survey, refer to Appendix 1.

2.2.2 | Collection and categorization of career interest data for research question 2

Students were additionally asked about their future career goals in the survey. A list of 21 potential career goals, based on programs offered by the college, and two "other" write-ins ("other: health/science" and "other: non-health/science"), were presented for students to choose from. To create categories for our analyses, information from two sources (the National Center for Education Statistics and the National Science Board) were used to cluster the career goals into larger groups. Initially, the full list of response options was consolidated into specific careers with Classification of Instructional Programs (CIP) codes associated with educational programs leading to those careers (e.g., dentist, dental hygienist, mental health counselor; National Center for Education Statistics, 2021). This created three career goal categories: health ($n = 597$), non-science and engineering ($n = 107$), and STEM ($n = 11$). We also consolidated the career goals into STEM careers ($n = 11$), non-STEM careers ($n = 44$), or S&E-related careers (i.e., science and engineering-related careers that require substantial science course loads but are not STEM fields, including health careers; $n = 660$; National Science Board, 2014).

TABLE 1 Demographic information from biology sample.

	All courses		F001A		F010		F040		F041	
Race/Ethnicty	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**
Asian: East Asian (e.g., Chinese, Japanese, Korean)	114	14%	13	25%	28	13%	50	12%	20	15%
Asian: Filipinx	87	10%	2	4%	15	7%	48	11%	20	15%
Asian: South Asian (e.g., Asian Indian, Thai)	50	6%	10	20%	6	3%	26	6%	8	6%
Asian: Southeast Asian (e.g., Vietnamese, Cambodian)	130	15%	8	16%	18	8%	75	18%	25	18%
Biracial	15	2%	1	2%	8	4%	5	1%	1	1%
Black & Indigenous	22	3%	0	0%	9	4%	10	2%	3	2%
Hispanic and Latino/a (e.g., Central American, Chicanx)	210	25%	5	10%	76	34%	100	24%	27	20%
Middle Eastern (e.g., North African, Lebanese)	34	4%	1	2%	10	5%	20	5%	3	2%
No response	16	2%	1	2%	6	3%	7	2%	2	1%
White	163	19%	10	20%	46	21%	78	19%	27	20%
Total	841		51		222		419		136	
Sex and/or Gender[a]										
Female	591	70%	37	73%	159	72%	297	71%	97	71%
Male	236	28%	14	27%	63	28%	120	29%	39	29%
Nonbinary	2	0%	0	0%	0	0%	2	0%	0	0%
Total	841		51		222		419		136	

[a]This information was drawn from institutional records that only offered binary M/F options. In later waves of data collection a nonbinary option was added. 12 students did not provide responses.

To break down the large health/S&E-related blocks into categories relevant to our current analysis, we used information from two additional sources: a list of STEM disciplines created by the Higher Education Research Institute at UCLA and a list of job titles and allied health fields from a study of allied health personnel (Higher Education Research Institute at UCLA, 2021; Institute of Medicine (US) Committee to Study the Role of Allied Health Personal, 1989). This allowed us to separate this group into three smaller groups (pre-allied health, $n = 263$), pre-nursing ($n = 271$), other health (e.g., pre-medicine/dentistry, $n = 82$), and veterinary studies (including assistants and technologists; $n = 63$). We also recategorized the counseling career goal from non-S&E to STEM, based on information from the previously cited sources. Students who selected from the "other" options and provided write-ins ($n = 122$) were sorted into these categories when possible or categorized as 'not applicable' ($n = 11$). For the full list of career goals and career goal categories, refer to Table 2.

2.3 | Analysis

2.3.1 | Internal structure validity

We conducted an exploratory factor analysis (EFA) to explore the factor structure and a confirmatory factor analysis (CFA) to confirm the results from the EFA. Given the previous validation work done with the PCIR scale, it would have been defensible to skip the EFA for the PCIR items. However, we decided to follow the entire process to gain a more comprehensive understanding of how the items were performing in the new population before confirming the fit indices with CFA and ensuring the accuracy of the assessment. To conduct this EFA/CFA analysis, we first screened the sample for outliers to remove participants with non-normative scores that could exert undue influence on the distribution and thus distort any inferential statistics

TABLE 2 Career goal categories and original response options/write-ins.

Career goal categories	Original response options & write-ins	Count	Percentage
Allied Health	Dental Assisting/Dental Hygiene, Dietician/Nutrition, EMS/EMT/Paramedic, Kinesiology/Sports Medicine/Athletic Training, Occupational Therapy, Physical Therapy, Physician Assistant, Radiology, Respiratory Therapy, Speech Therapy	288	32.91%
Nursing	Nursing	272	31.09%
Non-STEM	Social Work, Education, Art, Business, Communications	45	5.14%
Other Health	Public Health, Dentist, Medical School, Pharmacy Technologist, Pharmicist	88	10.06%
Veterinary Studies	Veterinary Assitant, Veterinary Technology	65	7.43%
STEM	Counseling, Biologist, Biomedical Researchers, Engineering, Chemistry, Psychology	66	8.01%
Not Applicable	Item Unanswered or Miscellaneous Response Provided (e.g., "college student" or "something that involves physics or a product designer")	51	5.83%

(Tabachnick & Fidell, 2007). While it's important not to drop participants cavalierly, it's also important to ensure that the data is reflective of the population. To do this we checked the skew and kurtosis scores of the raw items to identify problematic items (with skew or kurtosis greater than +2 or less than −2). Four items were identified, and we used QQ-plots to identify and remove outlying individuals producing non-normative distributions ($n = 7$). Once this was done, the participants were randomly assigned to a learning sample for the EFA ($n = 416$) or a testing sample for the CFA ($n = 430$). The R package *nFactors* (Raiche et al., 2020) was used to determine the ideal number of factors through scree plot and parallel analysis, and the proposed model was tested using an ML estimator (as the data was normally distributed) with a 0.3 cutoff to separate cross-loading items. When a satisfactory solution was identified using EFA, the *lavaan* (Rosseel, 2012) package was used to test the proposed model on new cases (using a robust ML estimator). Per recommendations from the literature, analysis of 4 indices were used to determine adequate fit for the EFA and CFA; CFI and TLI scores were considered acceptable if above 0.90 and ideal if above 0.95, while RMSEA and SRMR scores used a 0.10 cutoff (Brown & Moore, 2012; Hu & Bentler, 1999). If model fit is poor, review of correlated residuals will also be used to identify overlapping items for removal, with residuals above 0.1 considered indicative of overlap and poor model parsimony.

2.3.2 | Relationships between science identity and career goals

Once the underlying factors were identified and confirmed, multivariate outliers (individuals with strange combinations of scores on two or more variables; Tabachnick & Fidell, 2007) were screened using Mahalanobis' distance (Leys et al., 2018) and ANOVA and Kruskal–Wallis tests were used to compare aspects of science identity across career goal categories. Recently ANOVA tests have come under fire as the de-facto test for mean comparisons, due to their frequent use on data that do not meet their assumptions (Boisgontier & Cheval, 2016). Kruskal–Wallis tests are a non-parametric alternative to ANOVAs with similar interpretations but have less power when used on normal data, and thus are used as an alternative when the normality assumption of an ANOVA is not met (Hecke, 2012). Thus for each dependent variable, the normality of the distribution for each career goal category was tested (using QQ plots), and if the data were non-normal, the categories were compared using Kruskal–Wallis tests. If the data were normal, the homogeneity of variance was tested using Bartlett and Levene's tests, and if the tests were significant (indicating that variance differed across categories), the analysis shifted again to use Kruskal–Wallis tests. Only if the data was normal and the variances homogenous were one-way ANOVAs used to compare the dependent variables across career goal categories. Given the number of comparisons being made, a more conservative p-value (0.01) was used to help prevent Type I error. In the event of significant ANOVA or Kruskal–Wallis tests, pairwise comparisons are conducted using Tukey's range test (ANOVA) or Dunn's test (Kruskal–Wallis).

3 | RESULTS

Below we discuss our findings stemming from our investigations of Research Question 1 (How do the PCIR and SALG items function for community college biology students?) and Research Question 2 (What is the state of science identity among community college biology students, with a specific focus on those pursuing NAH careers?).

3.1 | Research question 1, finding 1: PCIR Internal structure reveals 3 identity related scales, consistent between our community college setting & prior studies

Univariate normality for the PCIR was confirmed by analysis of skew and kurtosis, with all items falling within traditional cutoffs of −2/+2 (Tabachnick & Fidell, 2007). Mahalanobis' distance was also calculated for the group of raw items, and observations outside the 99th percentile were dropped ($n = 81$; Leys et al., 2018). Two of the PCIR items were measures of general science identity and were expected to cross-load across all factors, as science identity is expected to be a higher-order variable. Cross-loading items can "blur" the factors of an EFA and cause further cross-loading among other variables, and so they were not included in the EFA but were added back in for the CFA. For the PCIR items, analysis of a scree plot and parallel analysis recommended two to three factors. The first iteration of the EFA identified a cross-loading item ("Others ask me for help with scientific concepts and ideas"). We decided it was cross-loading because it asks about performance/competence as filtered through the lens of recognition, and so we dropped the item from further analysis. A second item ("I can overcome setbacks") was cross-loading at a low level on the performance/competence and recognition items, but it was below the 0.4 cutoff used in the literature (Tabachnick & Fidell, 2007) and we kept it in the analysis.

The final 11-item measure was consistent with previous work, the three-factor solution (using a promax rotation) showing a clear structure with items loading together as expected (refer to Table 3 for factor loadings). As with the EFA, the CFA (using the 11-item, three-factor solution identified by the EFA) indicated that the PCIR items were operating as expected within the new population (CFI = 0.98, TLI = 0.97, RMSEA = 0.06, SRMR = 0.04; refer to Table 4 for

TABLE 3 EFA factor loadings of PCIR scale items.

	EFA		
Item text	**Recognition**	**Performance/ competence**	**Interest**
My family members see me as a "science person"	0.755		
My instructors see me as a "science person"	0.796		
My peers see me as a "science person"	0.943		
I understand scientific concepts I have previously studied		0.612	
I am confident that I can understand scientific concepts that I learn in class		0.866	
I am confident that I can understand scientific concepts and ideas outside of class		0.801	
I can do well on exams relating to scientific concepts and ideas		0.811	
I enjoy learning new scientific concepts and ideas			0.684
I am interested in learning more about science and scientific concepts			1.045

Note: Factor loadings below 0.3 (the cutoff used in the analysis) are not reported. All items preceded by the stem: "Indicate to what extent do you agree or disagree with each of the following statements."

TABLE 4 CFA factor loadings and error variance of PCIR scale items.

Item text	Std. factor loading				Std. error variance			
	General	Recognition	Performance/ competence	Interest	General	Recognition	Performance/ competence	Interest
In the past few months, I have really felt like a "science person"	0.744				0.466			
I see myself as a "science person"	0.938				0.120			
My family members see me as a "science person"		0.759				0.424		
My instructors see me as a "science person"		0.776				0.398		
My peers see me as a "science person"		0.866				0.251		
I understand scientific concepts I have previously studied			0.813				0.339	
I am confident that I can understand scientific concepts that I learn in class			0.843				0.290	
I am confident that I can understand scientific concepts and ideas outside of class			0.834				0.304	
I can do well on exams relating to scientific concepts and ideas			0.746				0.443	
I enjoy learning new scientific concepts and ideas				0.927				0.140
I am interested in learning more about science and scientific concepts				0.906				0.180

All items preceded by the stem: "Indicate to what extent do you agree or disagree with each of the following statements." CFA Goodness of Fit: df(24), X^2 = 53.42, CFI = 0.99, TLI = 0.98, RMSEA = 0.05, SRMR = 0.03.

factor loadings and error variances). CFI and TLI scores are considered acceptable if above 0.90 and ideal if above 0.95, while RMSEA and SRMR scores are good if below 0.10 (Brown & Moore, 2012; Hu & Bentler, 1999). Cronbach's alpha for the four sub-scales ranged from acceptable to excellent: general, $\alpha = 0.86$; recognition, $\alpha = 0.93$; performance/competence, $\alpha = 0.90$; and interest, $\alpha = 0.73$.

3.2 | Research question 1, finding 2: SALG Internal structure reveals 4 scales related to performance/competence, interest, applications, & content connections

The SALG items were analyzed using the same procedure from the PCIR items. The 23 items administered to students were subjected to three waves of EFA to identify a coherent factor structure that minimized cross-loading, all using a promax rotation and a 0.4 cutoff. Analysis of the first scree plot suggested a four-factor solution, and five items loaded below the 0.4 cutoff or cross-loaded consistently across the different solutions. These items were dropped and a second EFA was run, also with a four-factor solution. One item still failed to load, and so a final four-factor solution of 17 items was tested and considered final (refer to Table 5 for the final factor loadings). Ultimately, there were six items dropped from this scale. Two of these items asked about confidence in understanding and succeeding in the class ("presently, I am confident that I understand this subject," and "presently, I am confident that I can succeed in this subject"), and so it is logical that the factor structure would be unclear given the different classes and levels of preparation within the sample. Three items also focused on aspects of communication and help-seeking within the classroom ("presently, I can prepare and give oral presentations," "presently, I can work effectively with others," and "presently, I am willing to seek help from others (teachers, peers, TA) when working on academic problems"). The unclear loadings suggest that these items constitute a new factor, one without sufficient definition to function on its own. The last item ("presently, I am comfortable working with complex ideas") cross-loaded on three factors that came to be labeled verbal performance/competence, science applications, and content connections, suggesting that the current item is too vague to help discriminate between related latent constructs.

The first CFA with the 17-item, four-factor model produced mediocre fit indices (CFI = 0.92, TLI = 0.91, RMSEA = 0.08, SRMR = 0.05). Five items with the highest correlated residuals were removed in waves, with the revised models re-tested until the fit indices and residuals suggested a good-fitting solution had been reached. The final model consisted of 13 items, with good fit indices (CFI = 0.96, TLI = 0.95, RMSEA = 0.07, SRMR = 0.04) and only one item with residuals above the 0.1 cutoff (refer to Table 6 for the final model and loadings). The four subscales produced by this solution were labeled verbal performance/competence (e.g., "Presently, I can recognize a sound argument and appropriate use of evidence"), ongoing interest (e.g., "Presently, I am interested in discussing this subject area with friends or family"), science applications (e.g., "Presently, I am in the habit of connecting key ideas I learn in my classes with other knowledge"), and content connections (e.g., "Presently, I understand how studying this subject can help to address real world issues"). Cronbach's alpha for the four sub-scales ranged from acceptable to excellent: verbal performance/competence, $\alpha = 0.83$; ongoing interest, $\alpha = 0.87$; science applications, $\alpha = 0.94$; and content connections, $\alpha = 0.90$.

TABLE 5 EFA factor loadings of SALG scale items.

Item text	EFA			
	VerbalPerf/comp	Ongoing interest	Science applications	Content connections
Find academic articles relevant to a particular problem in professional journals or elsewhere[b]	0.591			
Critically read articles about issues raised in class[b]	0.713			
Identify patterns in data[b]	0.76			
Recognize a sound argument and appropriate use of evidence[b]	0.851			
Develop a logical argument[b]	0.784			
Write documents in discipline-appropriate style and format[b]	0.635			
Enthusiastic about this subject[c]		0.849		
Interested in discussing this subject area with friends or family[c]		0.826		
Interested in taking additional classes in this subject[c]		0.833		
Interested in pursuing a science career[c]		0.682		
Connecting key ideas I learn in my classes with other knowledge[d]			0.708	
Applying what I learn in classes to other situations[d]			0.841	
Using systematic reasoning in my approach to problems[d]			0.744	
Using a critical approach when analyzing data and arguments in my daily life[d]			0.658	
How ideas and concepts we will explore in this class will relate to those that I have encountered in other classes within this subject area[a]				0.766
How ideas and concepts we will explore in this class relate to those that I have encountered in classes outside of this subject area[a]				0.935
How studying this subject can help to address real world issues[a]				0.566

Note: Factor loadings below 0.3 (the cutoff used in the analysis) are not reported.
[a]Items preceded by the stem: "Presently, I Understand…."
[b]Items preceded by the stem: "Presently, I Can…."
[c]Items preceded by the stem: "Presently, I Am…."
[d]Items preceded by the stem: "Presently, I Am in the Habit Of…."

TABLE 6 CFA factor loadings and error variance of SALG scale items.

Item text	Std. factor loading				Std. error variance			
	VerbalPerf/comp	Ongoing interest	Science app.	Content Conn.	VerbalPerf/comp	Ongoing interest	Science app.	Content Conn.
Identify patterns in data[b]	0.638				0.593			
Recognize a sound argument and appropriate use of evidence[b]	0.943				0.111			
Develop a logical argument[b]	0.706				0.502			
Enthusiastic about this subject[c]		0.829				0.312		
Interested in discussing this subject area with friends or family[c]		0.801				0.358		
Interested in taking additional classes in this subject[c]		0.81				0.343		
Interested in pursuing a science career[c]		0.659				0.566		
Connecting key ideas I learn in my classes with other knowledge[d]			0.877				0.231	
Applying what I learn in classes to other situations[d]			0.841				0.294	
Using systematic reasoning in my approach to problems[d]			0.729				0.469	
How ideas and concepts we will explore in this class will relate to those that I have encountered in other classes within this subject area[a]				0.829				0.313
How ideas and concepts we will explore in this class relate to those that I have encountered in classes outside of this subject area[a]				0.857				0.265
How studying this subject can help to address real world issues[a]				0.62				0.616

Note: CFA Goodness of Fit: df(24), X^2 = 53.42, CFI = 0.99, TLI = 0.98, RMSEA = 0.05, SRMR = 0.03.

[a]Items preceded by the stem: "Presently, I Understand…."

[b]Items preceded by the stem: "Presently, I Can…."

[c]Items preceded by the stem: "Presently, I Am…."

[d]Items preceded by the stem: "Presently, I Am in the Habit Of…."

3.3 | Research question 2, finding 1: Pre-NAH Students report higher levels of general science identity than non-STEM students

Students were grouped according to their career goals and their science identity scores (general, recognition, performance/competence, and interest) were compared. A Kruskal–Wallis test was used to compare general science identity across the seven career goal groups, $H(5) = 23.3$, $p = < 0.001$, $\acute{\eta}^2 = 0.03$. Further analysis with Dunn's test revealed that pre-nursing and pre-allied health students did not differ significantly from each other ($p = 0.750$). Pre-nursing and pre-allied health groups reported significantly higher general science identity than students in the non-STEM group ($p < 0.001$ and $p = 0.002$, respectively), as did students in the STEM group ($p < 0.001$) and other health (e.g., pre-med/pre-dental) group ($p < 0.001$; refer to Figure 1 for full results).

3.4 | Research question 2, finding 2: Pre-NAH Students report higher levels of recognition than non-STEM students, but lower levels than pre-medicine/dentistry students

Next, a one-way ANOVA was used to compare science identity recognition across the career goal groups, $F(5,676) = 8.56$, $p < 0.001$, $\acute{\eta}^2_p = 0.06$. Contrasts with Tukey's HSD correction indicated that

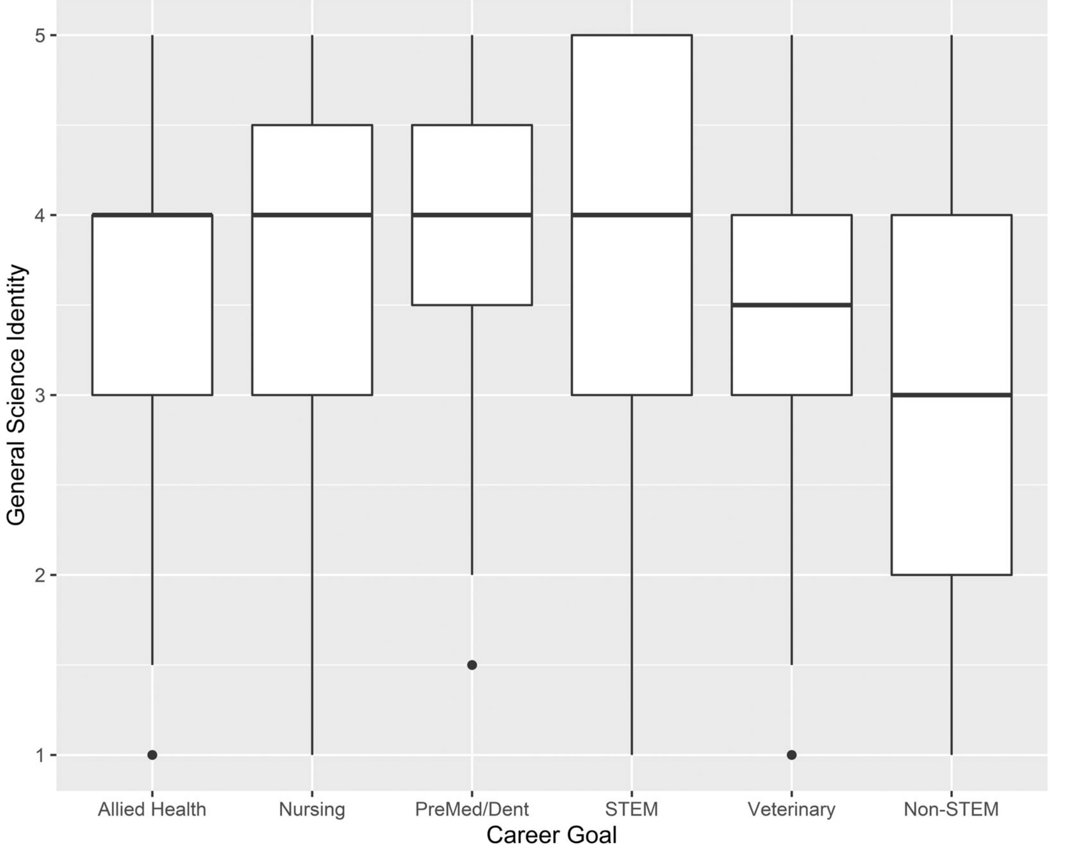

FIGURE 1 Differences in general science identity by career goal.

pre-nursing and pre-allied health groups did not differ significantly from each other ($p = 0.986$), but that they were significantly lower in recognition than the other health group ($p = 0.004$ and $p < 0.001$, respectively). They were, however, higher than the non-STEM and veterinary groups (refer to Figure 2 for full results). Science identity performance/competence was also compared using a one-way ANOVA, $F(5,676) = 3.68$, $p = 0.003$, $\acute{\eta}^2_p = 0.03$. Once again, contrasts indicated the nursing and allied health groups did not differ significantly from each other ($p = 0.999$). This time, they also did not differ significantly from the other career groups (refer to Figure 3 for full results). Lastly, a Kruskal–Wallis test was used to compare science identity interest across the seven groups, $H(5) = 14.50$, $p = 0.013$, $\acute{\eta}^2 = 0.01$. Nursing and allied health students did not differ from each other ($p = 0.999$) or any other groups (refer to Figure 4 for full results).

3.5 | Research question 2, finding 3: Pre-NAH Students report lower levels of verbal performance/competence than pre-medicine/dentistry students

An ANOVA was used to examine differences in verbal performance/competence, $F(5,675) = 5.07$, $p < 0.001$, $\acute{\eta}^2_p = 0.04$ (refer to Figure 5 for full results). Pre-nursing and pre-allied health

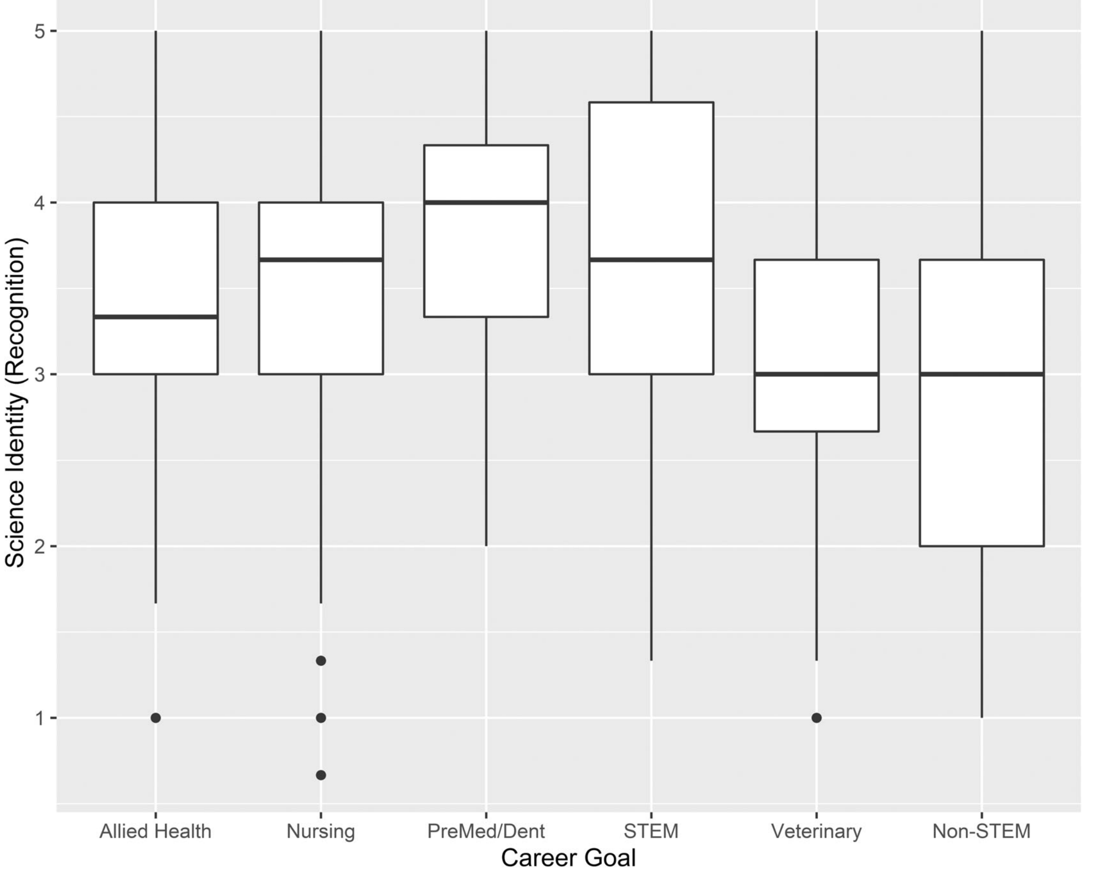

FIGURE 2 Differences in science identity recognition by career goal.

students did not differ significantly from each other ($p = 0.947$), but both groups were lower than other health students ($p = 0.001$ and $p = 0.009$, respectively). Veterinary students also scored lower in verbal performance/competence than other health students ($p = 0.001$).

3.6 | Research question 2, finding 4: Pre-NAH Students report higher levels of ongoing interest in comparison to all other groups

Differences in ongoing interest were examined using a Kruskal–Wallis test, $H(5) = 43.7$, $p < 0.001$, $\acute{\eta}^2 = 0.05$ (refer to Figure 6 for full results). Once again, students within the pre-NAH group did not differ significantly ($p = 0.744$). Both pre-nursing ($p < 0.001$) and pre-allied health ($p < 0.001$) students scored higher in ongoing interest than non-STEM students, as did other health ($p < 0.001$), STEM ($p < 0.001$), and veterinary ($p = 0.001$) students.

An ANOVA of students' science applications did not find any significant differences between groups, $F(5,675) = 1.68$, $p = 0.138$. Similarly, an ANOVA testing for differences in content connections across groups, $F(5,675) = 2.61$, $p = 0.024$, $\acute{\eta}^2_p = 0.02$, did not meet our threshold for statistical significance ($p < 0.01$).

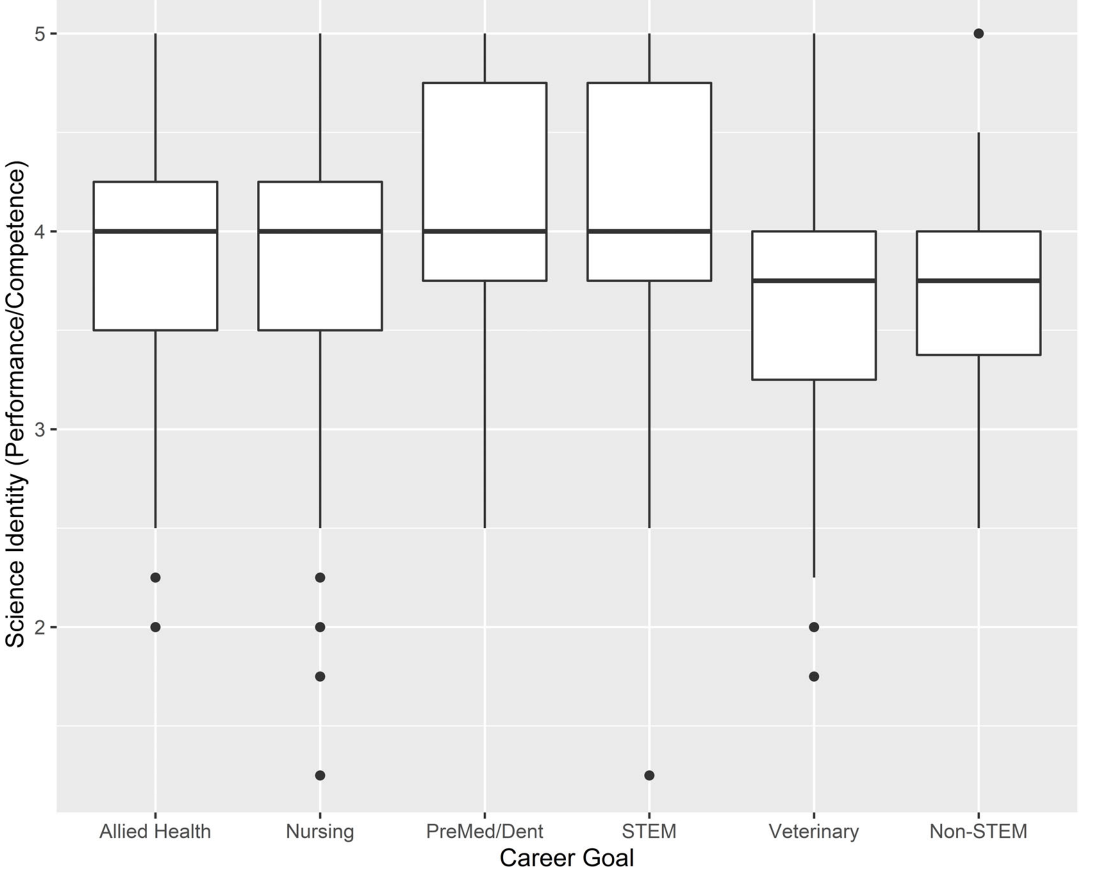

FIGURE 3 Differences in science identity performance/competence by career goal.

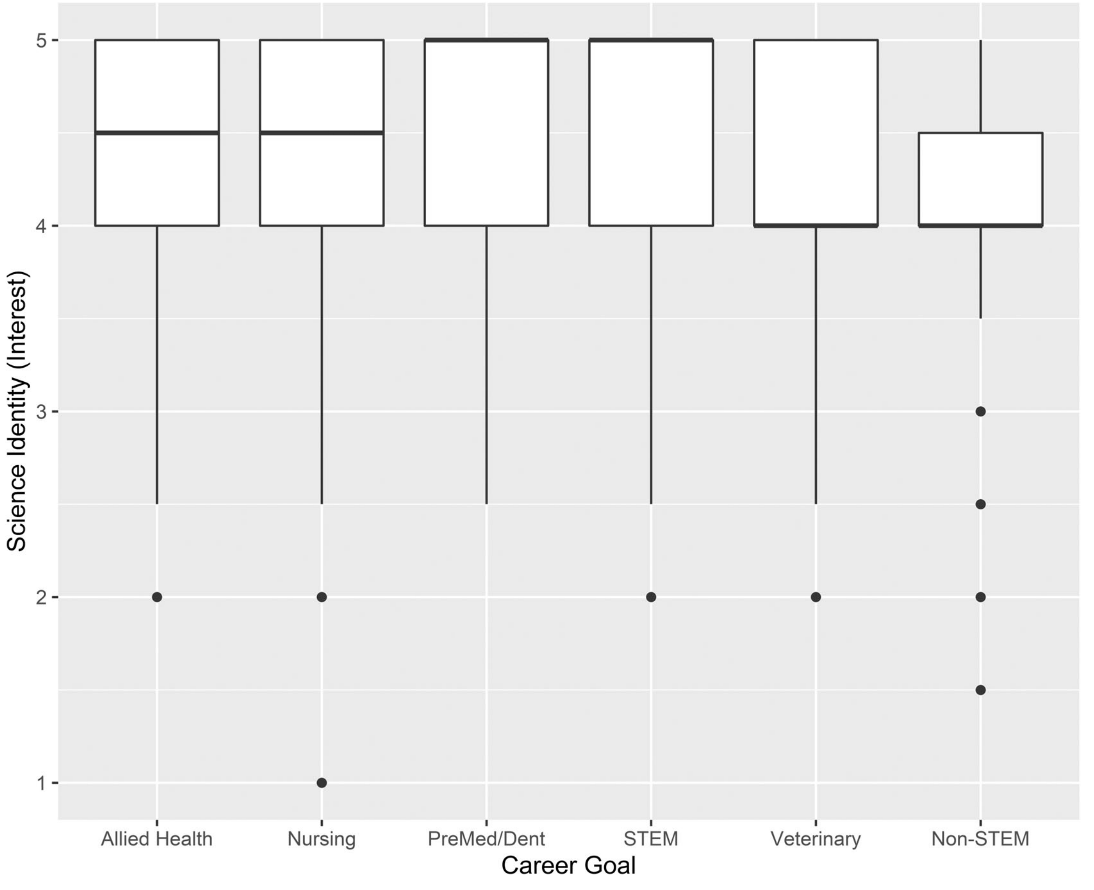

FIGURE 4 Differences in science identity interest by career goal.

4 | DISCUSSION

Science identity is entwined with science learning, as being and doing go hand in hand. Though prior work suggested pre-NAH students' science identities might predict academic outcomes (Royse et al., 2020), these measures had not previously been validated in biology or community college contexts. Assessing science identity in this population is important, as science identity is implicated in STEM retention and persistence in STEM fields. How then do students aspiring to NAH careers view themselves in relation to science?

4.1 | The PCIR and SALG instruments represent promising tools for investigating science identity in community college biology contexts

Current calls in biology education research emphasize establishing the validity of psychometrics in biology contexts (Lo et al., 2019; Reeves & Marbach-Ad, 2016), a task for which factor analysis is particularly well-suited (Knekta et al., 2019; Ballen & Salehi, 2021). Our first research question asked whether the science identity of community college students in prerequisite biology courses could be measured using the tools developed in other STEM fields. We found that

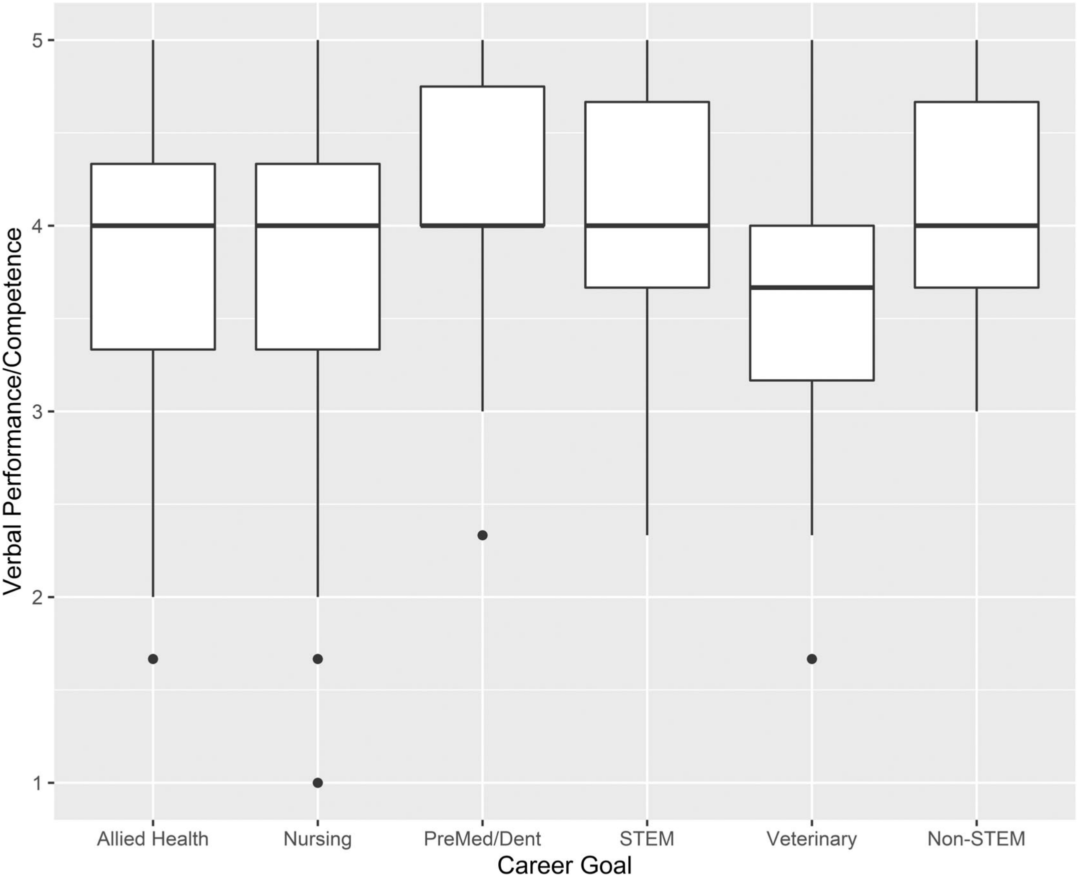

FIGURE 5 Differences in verbal performance/competence by career goal.

the PCIR and SALG scales function as intended for students in biology courses in community college contexts, including course sequences with large enrollments of students with healthcare career aspirations. Analyses of the internal structure of the PCIR suggested three science identity scales in line with studies of the instrument in other contexts.

One item ("I can overcome setbacks I encounter when studying and practicing science") did show some minor cross-loading that has not been previously reported in validity analyses of the scale (Godwin et al., 2013; Scheidt et al., 2018). This may be due to the inclusion of the phrase "practicing science" in this item, which does not appear in other performance/competence items that instead focus on "understanding." This short phrase and the resultant cross-loading may be due to the complex network of ideas that makes up the divide between understanding science, practicing science, practicing medicine, and being recognized as a scientist by others. Studies of students' views of scientists have long indicated a focus on "doing science," such as by conducting experiments or using scientific equipment (Chambers, 1983; Gormally & Inghram, 2021), and the practice of being a scientist is considered separate from the practice of being a student who learns about science from a teacher (Alkaher & Dolan, 2014). Although future work will be needed, we hypothesize that this item was cross-loading in our analysis due to the range of courses students were enrolled in, which results in students having different amount of research experience and different definitions of "practicing" science. However, the

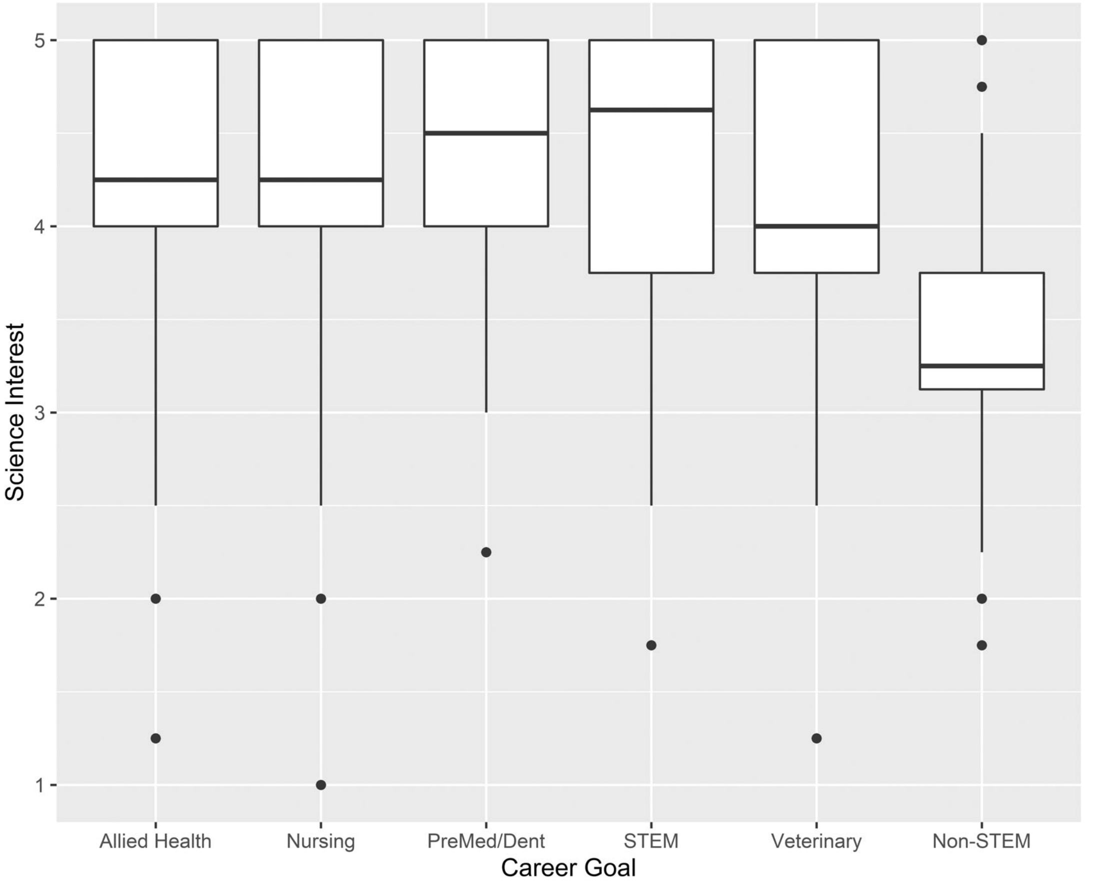

FIGURE 6 Differences in engaged interest by career goal.

cross-loading of this item was small (loading on the recognition factor was below the 0.4 cutoff commonly used in the literature; Tabachnick & Fidell, 2007) and as such we retained the item in our scale. Altogether, these results suggest that the PCIR is a viable candidate for future studies that assess community college biology science identity and its relationships with other variables of interest, such as academic outcomes or persistence into desired careers.

In addition to the PCIR, the SALG was also subjected to factor analysis, and although it was not designed to measure identity, its measurement of learning gains allows for closer examination of two aspects of the PCIR (performance/competence and interest). These items have been previously used in studies of pre-NAH students, with examinations of validity and reliability focusing on external and face validity rather than assessment of the factor structure (Frawley et al., 2019; Redmond et al., 2018; Seymour et al., 2000). Our analysis suggests that streamlining the number of items allows for a cleaner factor structure (e.g., prevents noise and better captures the latent variables). This shortened version of the SALG is thus a viable measurement of students' verbal performance/competence, their ongoing interest in the subject matter, and their perceived ability to think scientifically and connect ideas. This evidence also suggests that this scale functions well alongside the established PCIR scale of science identity. The additional interest items provide a middle ground between the sparse interest measure of the PCIR and more robust measures of science interest (as seen in Knekta, Chatzikyriakidou, & McCartney, 2020).

It also allows for insight into different "types" of performance/competence. Combining the PCIR and SALG items could allow researchers to differentiate between an overall measure of science competence, verbal performance/competence, competence in scientific thinking, and competence in learning and connecting ideas.

While the collection of validity evidence is always ongoing and occurs in the context of specific studies, our findings suggest that combining the PCIR and SALG is a potentially fruitful way to measure science identity in pre-NAH students. The dropped items are not without value, however, and researchers should be judicious regarding which items to include, particularly if the scale is being used with new populations. There is also the possibility that dropping these items changes the nature of the scale substantially so that previous validity work no longer applies. Future work is needed to gather additional validity evidence and confirm that the scale is functioning as intended.

4.2 | Science identity for pre-NAH students was generally similar to STEM/medical students and higher than non-STEM students

Our findings illustrate how pre-NAH, pre-medical/dental students, non-STEM, and STEM students perceive their science identities. We used students' reported career goals to categorize students into six groups for our comparisons, three of which were health-focused: nursing, allied health, and other health (a group consisting mainly of pre-medical school and pre-dentistry students). Overall, our results indicate that pre-nursing and pre-allied health students perform similarly on all aspects of the PCIR and SALG, but differ from other pre-health students. These findings challenge some conventional assumptions about nursing and allied health students, such as the idea that nursing students share more in common with pre-med students and are thus higher in the "hierarchy" of the health sciences. They also suggest that, despite the differences in nursing and allied health professions—such as different educational and licensing requirements, and professional roles with varying levels of independence and autonomy (Weiss, 1989)—the two groups are more alike in science identity than other student groups.

When compared to the other student groups, pre-NAH students sometimes have scores higher than their non-STEM peers (occasionally including veterinary students) and lower than their other health and STEM peers. For instance, measures of general science identity and ongoing interest saw pre-NAH, STEM, and other health students with similar scores that were all significantly higher than those in the non-STEM group. However, measures of recognition and verbal performance/competence found that pre-NAH students were lower than other health students. In other measures, such as general performance/competence, broad interest, content connections, and science applications, pre-NAH students did not differ significantly from the other groups either positively or negatively. One challenge we faced when exploring potential differences between students based on career aspirations was how to categorize students with veterinary technology career aspirations, as it is not a STEM field or a health sciences career. However, our findings suggest that categorizing these students independently of health sciences and STEM students is warranted, because their science identity scores often more closely resemble those of non-STEM students. This finding has potential implications for educators working with veterinary students and further validates the need to disaggregate in studies of STEM students, rather than treating them as homogenous populations.

Overall, our findings suggest that pre-NAH students' science identities are similar to STEM and Pre-Medical/Dentistry students with the exception of lower recognition and lower verbal performance/competence. These differences may be due to the mixed messages they receive about the importance of science to their education and future careers. Previous work with pre-NAH students highlights the importance of learning science for academic success, but little emphasis is placed on practicing science, either as a student or a professional (Ralph et al., 2017). This contrasts them with pre-med and traditional STEM students, whose scores in our analysis were generally similar. These students are encouraged to engage in research even as undergraduates, and if they pursue graduate school, often extensively focus on research (Beatty et al., 2021). This results in some populations of students who are encouraged early in their educational careers to think of themselves as scientists and producers of knowledge, rather than as “mere” students who are required to know information for a test (Knekta, Chatzikyriakidou, & McCartney, 2020). This has clear implications for recognition—as pre-NAH students are clearly not recognized as scientists—but also for performance/competence, as these students are not given the opportunity to develop their competence. This explanation is supported by the mixed findings around performance/competence in this study; the performance/competence measure from the PCIR found no differences between pre-NAH and pre-Med/Dentistry students, while the performance/competence measure from the SALG did. Closer examination of the items reveals that they focus on different aspects of mastery, with the PCIR items focusing on understanding concepts and performing on exams, while the SALG items focus on arguments and the use of evidence.

Minoritization and marginalization may also play a role in these differences. Pre-NAH and other health/STEM student populations differ across several significant demographics, such as race, ethnicity, and gender. A well-established body of work discusses the messages that women and students of color receive about their perceived incompetence and lack of belonging in STEM (Master & Meltzoff, 2020). Despite these negative messages, students of color (and women of color in particular) maintain strong interest in STEM, and those who pursue STEM majors fight to persist and succeed, often pioneering new spaces and navigating distinctly hostile and/or apathetic spaces to do so (Carlone & Johnson, 2007). For instance, previous work with women and students of color suggests that they engage transformatively with their STEM curriculum, focusing on the applied, communal, and humanistic aspects of STEM to carve out new spaces that recognize and validate their experiences and their drive to give back to their communities and families of origin (Diekman et al., 2011). Furthermore, work with minority women in engineering found that interest was linked to intentions to persist when recognition and belonging did not, and that the role of interest was much stronger for minority women than majority women (Verdín, 2021). In comparison to STEM students, the lower recognition and perceived performance/competence and high rates of interest in pre-NAH students may thus be part of a larger pattern among women and students of color in STEM rather than a trait specific to pre-NAH education itself. However, we must note that we are including this observation as a potential implication that requires exploration in future work, as our current sample does not have sufficient power to analyze the interaction of career goal and race/ethnicity on science identity.

4.3 | Potential implications for faculty & researchers

Our results have the potential to influence life science educators (Table 7) and biology education researchers (Table 8) in numerous ways. It might be tempting to focus exclusively on perceived “deficits” in science identity recognition among pre-NAH students. However, we see the

TABLE 7 Implications for teaching.

Possible implications for pre-NAH educators	Examples
Build upon pre-NAH students' interests in science and scientific concepts	Explore teaching and learning models that connect course content to relatable applications outside of class (Kassirer, 2010; Malau-Aduli et al., 2013; Pugh et al., 2017)· Consider goal congruity frameworks to align student interests and pre-NAH course content (Diekman et al., 2011)· Pre-assess student interests related to course content and craft related learning experiences
Provide opportunities for pre-NAH students to feel recognized as scientists	Incorporate interventions such as Scientist Spotlights (Schinske et al., 2016; https://scientistspotlights.org/) to highlight relatable scientists· Include authentic research activities as part of pre-NAH lab courses (e.g., Adkins-Jablonsky et al., 2021; Muth & Caplan, 2020)
Structure courses to foster growth in perceived performance and competence in science	Consider interventions aimed at enhancing self efficacy (Rittmayer & Beier, 2008) and growth mindset (Hacisalihoglu et al., 2020; Yeager & Dweck, 2020)
Attend to identity and belongingness across the spectrum of clinical career goals	Feature applications of course content in fields like veterinary technology, in addition to traditional pre-NAH fields

TABLE 8 Implications & future directions for researchers.

Possible Implications & Future Directions for Biology Education Researchers
Consider during study design and intervention development that pre-NAH students might exhibit distinct science identity profiles compared to other biology students
Disaggregate pre-NAH student data based on career goals to account for potential differing identities and experiences
Include SALG "interest" items with PCIR to strengthen the interest scale
Explore the utility of PCIR and SALG scales for predicting success in pre-NAH courses and persistence in NAH career tracks
Compare science identity of pre-NAH students across 4-year and 2-year institutions
Develop and evaluate interventions to support science identity development in pre-NAH contexts
Further explore pre-NAH student science identities, and in particular the nuances of student interest, through qualitative studies

relatively robust interest in science and scientific concepts among pre-NAH students as a potential avenue for building off of under-recognized strengths among these students. This warrants further investigation by researchers and attention from educators. We suspect this interest is not based on traditional perceptions of the pre-NAH curriculum, such as an interest in the perception of pre-NAH courses as emphasizing memorization of hundreds of structures/terms. How, then, can we identify the sources of the "interest" pre-NAH students report? And how can we leverage pre-NAH students' interest to promote student success and equitable outcomes? Future work might explore whether students' interests stem from communal goals, or the interest in using knowledge and skills from class to help others (Diekman et al., 2011). Researchers could apply a goal congruity perspective to investigate this possibility (Diekman et al., 2011). Further, frameworks like Teaching for Transformative Experiences in Science (Pugh et al., 2017) or case-based teaching (Kassirer, 2010; Malau-Aduli et al., 2013) might guide instructors to paths for connecting content with the existing real-world interests of students.

Despite pre-NAH students' apparent interest in science, our results imply that classes and institutions have not always provided pathways for pre-NAH students to see themselves as scientists to the same degree as other biology students. This raises the question; whose science identity is considered important in life science education? Given the relationships between science identity and student success (see Introduction) and the importance of pre-NAH course success in persistence toward important clinical careers, educators might be motivated to attend more closely to the science identities of pre-NAH students. In terms of research, future work might examine how pre-NAH students define scientists and how they respond to items from the PCIR and SALG, perhaps using think-alouds or other forms of cognitive interviewing. Regarding classroom activities and practices, numerous interventions developed and tested in STEM courses outside of pre-NAH contexts might prove useful for pre-NAH educators and researchers (Table 7). Perhaps most importantly, we hope this study generates interest in exploring the experiences, assets, and needs of pre-NAH students, particularly in community college environments. This often-overlooked segment of life science students comprises a sizable proportion of the undergraduate biology student body and includes critical future health professionals with the potential to address persistent health inequities.

4.4 | Limitations

Our conclusions are limited by the scope of our sample and the nature of the constructs we examined. Although factor analyses can reveal much about how participants respond to items, validity and reliability of a measure can only be demonstrated through holistic examination of the scale's items as contextualized by the population being studied. Our results build upon previous examinations of the PCIR and SALG's validity to argue for their use in this population, but whether a scale is "valid" should always be determined on a case-by-case, study-by-study basis. In short, our factor analyses provide evidence for the validity of the items for the analysis in this paper and suggest they will function well in future studies with this population, but this suggestion should always be tested.

Furthermore, while our sample was representative of a diverse community college setting, we did not analyze demographic data in this study. Although our student population and sample are highly diverse, we still lacked the power to examine the interactions of race/ethnicity and career goal across all cells. Future work should examine these student factors in community college and biology contexts more meaningfully to add to the critical corpus of research literature examining science identity for students with marginalized identities. Additionally, our study is limited by the static measurement of dynamic constructs and factors. Since our sample reported their career goals at the beginning of the semester, our sample may not be reflective of the science identities of more advanced pre-NAH students. Future work can examine the lifespan of students' career goals, how these goals evolve over time, and what experiences promote change versus persistence on career trajectories.

5 | CONCLUSIONS

Biology prerequisites in pre-NAH curricula serve as vital points-of-entry between healthcare careers and science literacy development. We posit that, especially in community college contexts, a critical line of inquiry is to ask: what can an instructor do to support learning via science identity development? As students become "science people" in biology prerequisite courses, their sense of recognition, competence, and interest may follow them into diverse health careers. Interventions that foster the recognition of students as science people, both as a sense of self and contextually within their communities, can start with recognition from science instructors in these courses. Instructors can also provide structured opportunities for metacognitive reflection so students can engage with science identity and how it relates to their personal development. Additionally, instructors can increase equity in their classrooms by examining students' perceptions of their performance/competence (i.e., self-efficacy), identifying potential barriers and sources of difference in those perceptions, and creating initiatives to dismantle identified barriers. We recommend that future work in pedagogical design centers students' interest in the classroom, as our data suggest that may be a strength in pre-NAH student populations. Our work provides evidence that, to evaluate the impact of such practices on science identity development, future studies can use the PCIR and SALG in combination as robust measures of science identity to paint a better picture of how it exists in a spectrum of students and how it changes over time in pre-NAH courses. Further, these measures may help evaluate causality and identify mechanisms to support student science identity in future work, providing insight into supporting students in these important contexts.

ACKNOWLEDGMENTS

We extend our appreciation to Elaine Kuo, Ben Kaliczak, Doreen Finkelstein, Amy Edwards, Anna Alderkamp, Connie La, Guido Bordignon, Karen Erickson, Karen Moody, Leif Palleson, Melissa Jacobs, Melissa Ko, Neha Arora, Nirmal Gosavi, and Parisa Mousavi Shafaei for their assistance with survey administration and data collection. This project was supported by CC Bio INSITES, which receives funding from the National Science Foundation (Grant 1730130) and meeting services from the Howard Hughes Medical Institute.

ORCID

Heather Perkins https://orcid.org/0000-0002-8757-0545

REFERENCES

Acevedo, N., Nunez-Rivera, S., Casas, Y., Cruz, E., & Rivera, P. (2021). Enacting spiritual activism to develop a sense of belonging: Latina community college students choosing and persisting in STEM. *Journal of Women and Gender in Higher Education*, *14*, 1–20.

Adkins-Jablonsky, S. J., Arnold, E., Rock, R., Gray, R., & Morris, J. J. (2021). Agar art: A CURE for the microbiology laboratory. *Journal of Microbiology & Biology Education*, *22*(2), e00121.

Alkaher, I., & Dolan, E. L. (2014). Integrating research into undergraduate courses. In *Research based undergraduate science teaching* (pp. 403–434).

American Association of Community Colleges. (2023). Community college fast facts. Accessed April 7, 23, from https://www.aacc.nche.edu/research-trends/fast-facts/

ASAHP. (2020). Association of Schools Advancing Health Professions website. Accessed February 24, 2022, from https://www.asahp.org/what-is

Aschbacher, P. R., Li, E., & Roth, E. J. (2010). Is science me? High school students' identities, participation and aspirations in science, engineering, and medicine. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, *47*(5), 564–582.

Avraamidou, L. (2021). Identities in/out of physics and the politics of recognition. *Journal of Research in Science Teaching*, *59*(1), 58–94. https://doi.org/10.1002/tea.21721

Ballen, C. J., Blum, J. E., Brownell, S., Hebert, S., Hewlett, J., Klein, J. R., McDonald, E. A., Monti, D. L., Nold, S. C., Slemmons, K. E., Soneral, P. A. G., & Cotner, S. (2017). A call to develop course-based undergraduate research experiences (CUREs) for nonmajors courses. *CBE—Life sciences. Education*, *16*(2), 1–7. https://doi.org/10.1187/cbe.16-12-0352

Ballen, C. J., & Salehi, S. (2021). Mediation analysis in discipline-based education research using structural equation modeling: Beyond "What Works" to understand how it works, and for whom. *Journal of Microbiology & Biology Education*, *22*(2), e00108–e00121. https://doi.org/10.1128/jmbe.00108-21

Beatty, A. E., Ballen, C. J., Driessen, E. P., Schwartz, T. S., & Graze, R. M. (2021). Addressing the unique qualities of upper-level biology course-based undergraduate research experiences through the integration of skill-building. *Integrative and Comparative Biology.*, *61*, 981–991.

Boisgontier, M. P., & Cheval, B. (2016). The anova to mixed model transition. *Neuroscience & Biobehavioral Reviews*, *68*, 1004–1005.

Bonnette, R. N., Crowley, K., & Schunn, C. D. (2019). Falling in love and staying in love with science: Ongoing informal science experiences support fascination for all children. *International Journal of Science Education*, *41*(12), 1626–1643. https://doi.org/10.1080/09500693.2019.1623431

Borkowski, D., McKinstry, C., Cotchett, M., Williams, C., & Haines, T. (2016). Research culture in allied health: A systematic review. *Australian Journal of Primary Health*, *22*(4), 294–303. https://doi.org/10.1071/PY15122

Borrego, M., Patrick, A., Martins, L., & Kendall, M. (2018). A new scale for measuring engineering identity in undergraduates. *ASEE Annual Conference & Exposition* https://peer.asee.org/31558.pdf

Brown, T. A., & Moore, M. T. (2012). Confirmatory factor analysis. In R. H. Hoyle (Ed.), *Handbook of structural equation modeling* (pp. 361–379). The Guilford Press.

Camacho, T. C., Vasquez-Salgado, Y., Chavira, G., Boyns, D., Appelrouth, S., Saetermoe, C., & Khachikian, C. (2021). Science identity among Latinx students in the biomedical sciences: The role of a critical race theory–informed undergraduate research experience. *CBE—Life Sciences Education*, *20*(2), 1–10.

Carlone, H. B., & 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.

Chambers, D. W. (1983). Stereotypic images of the scientist: The draw-a-scientist test. *Science Education*, *67*(2), 255–265. https://doi.org/10.1002/sce.3730670213

Chen, S., Binning, K. R., Manke, K. J., Brady, S. T., McGreevy, E. M., Betancur, L., Limeri, L. B., & Kaufmann, N. (2021). Am I a science person? A strong science identity bolsters minority students' sense of belonging and performance in college. *Personality and Social Psychology Bulletin*, *47*(4), 593–606. https://doi.org/10.1177/0146167220936480

Choe, N. H., Martins, L. L., Borrego, M., & Kendall, M. R. (2019). Professional aspects of engineering: Improving prediction of undergraduates' engineering identity. *Journal of Professional Issues in Engineering Education and Practice*, *145*(3), 04019006. https://doi.org/10.1061/(ASCE)EI.1943-5541.0000413

Close, E. W., Conn, J., & Close, H. G. (2014). Learning assistants' development of physics (teacher) identity. 2013 PERC proceedings. https://doi.org/10.1119/perc.2013.pr.010

Covarrubias, R., Valle, I., Laiduc, G., & Azmitia, M. (2019). "You never become fully independent": Family roles and independence in first-generation college students. *Journal of Adolescent Research*, *34*(4), 381–410.

Creech, C., Just, J., Hammarlund, S., Rolle, C. E., Gonsar, N. Y., Olson, A., … Cotner, S. (2022). Evaluating the representation of community colleges in biology education research publications following a call to action. *CBE—Life sciences. Education*, *21*(4), ar67.

Cwik, S., & Singh, C. (2022). Not feeling recognized as a physics person by instructors and teaching assistants is correlated with female students' lower grades. *Physical Review Physics Education Research*, *18*(1), 010138. https://doi.org/10.1103/PhysRevPhysEducRes.18.010138

Davis, G. M. (2010). What is provided and what the registered nurse needs—Bioscience learning through the pre-registration curriculum. *Nurse Education Today*, *30*(8), 707–712. https://doi.org/10.1016/j.nedt.2010.01.008

Demo, D. H., Fry, D., Devine, N., & Butler, A. (2015). A call for action: Advocating for increased funding for the allied health professions. *Journal of Allied Health*, *44*(1), 57–62.

Diekman, A. B., Clark, E. K., Johnston, A. M., Brown, E. R., & Steinberg, M. (2011). Malleability in communal goals and beliefs influences attraction to stem careers: Evidence for a goal congruity perspective. *Journal of Personality and Social Psychology*, *101*(5), 902–918. https://doi.org/10.1037/a0025199

Dinmohammadi, M., Peyrovi, H., & Mehrdad, N. (2013). Concept analysis of professional socialization in nursing. *Nursing Forum*, *48*(1), 26–34. https://doi.org/10.1111/nuf.12006

Donaldson, N. L., Felzien, L. K., Marvin, M. C., Cielocha, J. J., & Shapiro, T. (2019). Development of an interdisciplinary conceptual conservation of energy theme for use in undergraduate physics, chemistry, and biology courses. *American Journal of Physics*, *87*(7), 527–534.

Dou, R., & Cian, H. (2022). Constructing STEM identity: An expanded structural model for STEM identity research. *Journal of Research in Science Teaching*, *59*(3), 458–490. https://doi.org/10.1002/tea.21734

Dou, R., Cian, H., & Espinosa-Suarez, V. (2021). Undergraduate STEM majors on and off the pre-med/health track: A STEM identity perspective. *CBE Life Sciences Education*, *20*(2), 1–12. https://doi.org/10.1187/cbe.20-12-0281

Dou, R., Hazari, Z., Dabney, K., Sonnert, G., & Sadler, P. (2019). Early informal STEM experiences and STEM identity: The importance of talking science. *Science Education*, *103*(3), 623–637. https://doi.org/10.1002/sce.21499

Espinosa, L. (2011). Pipelines and pathways: Women of color in undergraduate STEM Majors and the college experiences that contribute to persistence. *Harvard Educational Review*, *81*(2), 209–241. https://doi.org/10.17763/haer.81.2.92315ww157656k3u

Finn, K. E., FitzPatrick, K., & Yan, Z. (2017). Integrating lecture and laboratory in health sciences courses improves student satisfaction and performance. *Journal of College Science Teaching*, *47*(1), 66.

FitzPatrick, K. A., Finn, K. E., & Campisi, J. (2011). Effect of personal response systems on student perception and academic performance in courses in a health sciences curriculum. *Advances in Physiology Education*, *35*(3), 280–289.

Foley, D., Milan, L., & Hamrick, K. (2020). National Center for Science and Engineering Statistics (NCSES). The increasing role of community colleges among Bachelor's degree recipients: Findings from the 2019 National Survey of college graduates. NSF 21–309. Alexandria, VA: National Science Foundation. Available from https://ncses.nsf.gov/pubs/nsf21309/

Frawley, T., Carroll, L., Casey, M., Davies, C., Durning, J., Halligan, P., Joye, R., Redmond, C., & Fealy, G. (2019). Evaluation of a national training programme to support engagement in mental health services: Learning enablers and learning gains. *Journal of Psychiatric and Mental Health Nursing*, *26*, 323–336. https://doi.org/10.1111/jpm.12535

Frogner, B. K., & Skillman, S. M. (2016). Pathways to middle-skill allied health care occupations. *Issues in Science and Technology*, *33*(1), 52.

Gallup & Lumina Foundation. (2020). State of the student experience: Fall 2020 higher education during disruption. Retrieved from https://www.gallup.com/education/327485/state-of-the-student-experience-fall-2020.aspx

Godwin, A., Potvin, G., Hazari, Z., & Lock, R. (2013). Understanding engineering identity through structural equation modeling. In *In 2013 IEEE Frontiers in education conference (FIE)* (pp. 50–56). IEEE.

Godwin, A., & Lee, W. (2017). A cross-sectional study of engineering identity during undergraduate education. ASEE Annual Conference & Exposition. https://docs.lib.purdue.edu/enepubs/13

Godwin, A. (2016). *The development of a measure of engineering identity*. In ASEE 2016 Annual Conference & Exposition.

Gormally, C., & Inghram, R. (2021). Goggles and white lab coats: Students' perspectives on scientists and the continued need to challenge stereotypes. *Journal of Microbiology & Biology Education*, *22*(1), ev22i1.2273. https://doi.org/10.1128/jmbe.v22i1.2273

Gray, C. A., Tuchscherer, R., & Gray, R. (2018). The challenges and affordances of engineering identity as an analytical lens. In ASEE Annual Conference proceedings.

Greenwood, B. N., Hardeman, R. R., Huang, L., & Sojourner, A. (2020). Physician–patient racial concordance and disparities in birthing mortality for newborns. *Proceedings of the National Academy of Sciences*, *117*(35), 21194–21200.

Gutwill-Wise, J. P. (2001). The impact of active and context-based learning in introductory chemistry courses: An early evaluation of the modular approach. *Journal of Chemical Education*, *78*(5), 684.

Hacisalihoglu, G., Stephens, D., Stephens, S., Johnson, L., & Edington, M. (2020). Enhancing undergraduate student success in STEM fields through growth-mindset and grit. *Education Sciences*, *10*(10), 279.

Haddad, L. M., Annamaraju, P., & Toney-Butler, T. J. (2023). Nursing Shortage. [Updated 2023 Feb 13]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing. Available from https://www.ncbi.nlm.nih.gov/books/NBK493175/

Hazari, Z., Chari, D., Potvin, G., & Brewe, E. (2020). The context dependence of physics identity: Examining the role of performance/competence, recognition, interest, and sense of belonging for lower and upper female physics undergraduates. *Journal of Research in Science Teaching*, *57*(10), 1583–1607.

Hazari, Z., Sonnert, G., Sadler, P. M., & Shanahan, M. C. (2010). Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: A gender study. *Journal of Research in Science Teaching*, *47*(8), 978–1003.

Hecke, T. V. (2012). Power study of anova versus Kruskal-Wallis test. *Journal of Statistics and Management Systems*, *15*(2–3), 241–247.

Higher Education Research Institute at UCLA. (2021). *STEM disciplines*. HERI Faculty Survey Retrived from https://heri.ucla.edu/heri-faculty-survey/

Hsu, P. L., Roth, W. M., Marshall, A., & Guenette, F. (2009). To be or not to be? Discursive resources for (Dis-) identifying with science-related careers. *Journal of Research in Science Teaching*, *46*(10), 1114–1136. https://doi.org/10.1002/tea.20352

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, *6*(1), 1–55.

Hughes, R., Schellinger, J., & Roberts, K. (2021). The role of recognition in disciplinary identity for girls. *Journal of Research in Science Teaching*, *58*(3), 420–455. https://doi.org/10.1002/tea.21665

Institute of Medicine (US) Committee to Study the Role of Allied Health Personnel. (1989). *Allied health services: Avoiding crises*. National Academies Press (US).

Institute of Medicine (US) Committee to Study the Role of Allied Health Personnel. (1989). *What does "allied health" mean? From allied health services: Avoiding crises*. National Academies Press (US) Available from https://www.ncbi.nlm.nih.gov/books/NBK218850/

Institute of Medicine. (2003). *Unequal treatment: Confronting racial and ethnic disparities in health care*. The National Academies Press. https://doi.org/10.17226/12875

Jackson, M. C., Leal, C. C., Zambrano, J., & Thoman, D. B. (2019). Talking about science interests: The importance of social recognition when students talk about their interests in STEM. *Social Psychology of Education*, *22*(1), 149–167. https://doi.org/10.1007/s11218-018-9469-3

Johnson, A. (2012). Consequential validity and science identity research. In *Identity construction and science education research* (pp. 173–188). Brill Sense.

Johnson, W. R. (2016). Why engaging in the practices of science is not enough to achieve scientific literacy. *The American Biology Teacher*, *78*(5), 370–375.

Kassirer, J. P. (2010). Teaching clinical reasoning: Case-based and coached. *Academic Medicine*, *85*(7), 1118–1124.

Knekta, E., Chatzikyriakidou, K., & McCartney, M. (2020). Evaluation of a questionnaire measuring university students' sense of belonging to and involvement in a biology department. *CBE—Life Sciences Education*, *19*(3), 1–14.

Knekta, E., Runyon, C., & Eddy, S. (2019). One size Doesn't fit all: Using factor analysis to gather validity evidence when using surveys in your research. *CBE—Life Sciences Education*, *18*(1), 1–17. https://doi.org/10.1187/cbe.18-04-0064

Kosal, E., Lawrence, C., & Austin, R. (2010). Integrating biology, chemistry, and mathematics to evaluate global water problems. *Journal of College Science Teaching*, *40*(1), 41–47.

Krapp, A., & Prenzel, M. (2011). Research on interest in science: Theories, methods, and findings. *International Journal of Science Education*, *33*(1), 27–50. https://doi.org/10.1080/09500693.2010.518645

Larcombe, J., & Dick, J. (2003). Who is best qualified to teach bioscience to nurses? *Nursing Standard*, *17*(51), 38–44. https://doi.org/10.7748/ns2003.09.17.51.38.c3451

Leys, C., Klein, O., Dominicy, Y., & Ley, C. (2018). Detecting multivariate outliers: Use a robust variant of the mahalanobis distance. *Journal of Experimental Social Psychology*, *74*, 150–156.

Li, Y., Whitcomb, K., & Singh, C. (2020). How perception of being recognized or not recognized by instructors as a "physics person" impacts male and female Students' Self-efficacy and performance. *The Physics Teacher*, *58*(7), 484–487.

Lo, S. M., Gardner, G. E., Reid, J., Napoleon-Fanis, V., Carroll, P., Smith, E., & Sato, B. K. (2019). Prevailing questions and methodologies in biology education research: A longitudinal analysis of research in CBE-life sciences education and at the society for the advancement of biology education research. *CBE life Sciences Education*, *18*(1), ar9. https://doi.org/10.1187/cbe.18-08-0164

Luckie, D. B., Rivkin, A. M., Aubry, J. R., Marengo, B. J., Creech, L. R., & Sweeder, R. D. (2013). Verbal final exam in introductory biology yields gains in student content knowledge and longitudinal performance. CBE—Life sciences. *Education*, *12*(3), 515–529.

Ma, J., & Baum, S. (2016). Trends in community colleges: Enrollment, prices, student debt, and completion. *College Board Research Brief*, *4*, 1–23.

Malau-Aduli, B. S., Lee, A. Y., Cooling, N., Catchpole, M., Jose, M., & Turner, R. (2013). Retention of knowledge and perceived relevance of basic sciences in an integrated case-based learning (CBL) curriculum. *BMC Medical Education*, *13*(1), 1–8.

Marsh, H. W., Hau, K.-T., & Kong, C.-K. (2002). Multilevel causal ordering of academic self-concept and achievement: Influence of language of instruction (English compared with Chinese) for Hong Kong students. *American Educational Research Journal*, *39*(3), 727–763. https://doi.org/10.3102/00028312039003727

Master, A., & Meltzoff, A. N. (2020). Cultural stereotypes and sense of belonging contribute to gender gaps in STEM. *International Journal of Gender, Science and Technology*, *12*(1), 152–198.

McVicar, A., Andrew, S., & Kemble, R. (2014). Biosciences within the pre-registration (pre-requisite) curriculum: An integrative literature review of curriculum interventions 1990-2012. *Nurse Education Today*, *34*(4), 560–568. https://doi.org/10.1016/j.nedt.2013.08.012

McVicar, A., Andrew, S., & Kemble, R. (2015). The 'bioscience problem' for nursing students: An integrative review of published evaluations of year 1 bioscience, and proposed directions for curriculum development. *Nurse Education Today*, *35*(3), 500–509. https://doi.org/10.1016/J.NEDT.2014.11.003

Muth, T. R., & Caplan, A. J. (2020). Microbiomes for all. *Frontiers in Microbiology*, *11*, 593472.

National Center for Education Statistics. (2021). *CIP User Site*. The Classification of Instructional Programs Available from [https://nces.ed.gov/ipeds/cipcode/resources.aspx?y=56]

National Center for Science and Engineering Statistics (NCSES). (2014). *Women, minorities, and persons with disabilities in science and engineering*. National Science Foundation Available from https://ncses.nsf.gov/pubs/nsf21321

National Science Board. (2014). Science and engineering indicators. Available from https://www.nsf.gov/statistics/seind14/

Ojennus, D. D. (2016). Assessment of learning gains in a flipped biochemistry classroom. *Biochemistry and Molecular Biology Education*, *44*(1), 20–27.

Patrick, A. D., & Prybutok, A. N. (2018). Predicting persistence in engineering through an engineering identity scale. *International Journal of Engineering Education*, *34*(2a), 351–363.

Patterson Silver Wolf, D. A., Perkins, J., Butler-Barnes, S. T., & Walker, T. A., Jr. (2017). Social belonging and college retention: Results from a quasi-experimental pilot study. *Journal of College Student Development*, *58*(5), 777–782.

Patterson Silver Wolf, D. A., Taylor, F., Maguin, E., & Asher BlackDeer, A. (2019). You are college material—You belong: An underrepresented minority student retention intervention without deception. *Journal of College Student Retention: Research, Theory & Practice*, *23*(3), 507–522.

Phillippe, K. (2016). *Minority students in STEM: Diverse pathways in STEM programs for minority students are necessary to increase degree completion*. American Association of Community Colleges Retrieved from https://www.aacc.nche.edu/wp-content/uploads/2017/09/DataPoints_No22.pdf

Potvin, P., & Hasni, A. (2014). Interest, motivation and attitude towards science and technology at K-12 levels: A systematic review of 12 years of educational research. *Studies in Science Education*, *50*(1), 85–129. https://doi.org/10.1080/03057267.2014.881626

Potvin, G., Tai, R., & Sadler, P. (2009). The difference between engineering and science students: Comparing backgrounds and high school experiences. In 2009 Annual Conference & Exposition. (pp. 14–1202).

Pugh, K. J., Bergstrom, C. M., Heddy, B. C., & Krob, K. E. (2017). Supporting deep engagement: The teaching for transformative experiences in science (TTES) model. *The Journal of Experimental Education*, *85*(4), 629–657.

Radwin, D., Conzelmann, J. G., Nunnery, A., Lacy, T. A., Wu, J., Lew, S., Wine, J., & Siegel, P. (2018). *2015–16 National Postsecondary Student aid Study (NPSAS: 16): Student financial aid estimates for 2015–16. First look. NCES 2018–466*. National Center for Education Statistics.

Raiche, G., Magis, D., & Raiche, M. G. (2020). Package 'nFactors'. *Repository CRAN*, 1–58.

Ralph, N., Birks, M., Cant, R., Chun Tie, Y., & Hillman, E. (2017). How should science be taught to nurses? Preferences of registered nurses and science teaching academics. *Collegian (Royal College of Nursing, Australia)*, *24*(6), 585–591. https://doi.org/10.1016/j.colegn.2017.01.004

Redmond, C., Davies, C., Halligan, P., Joye, R., Carroll, L., & Frawley, T. (2018). Nursing and midwifery students' perception of learning enablers and gains in the first semester of their BSc programmes: A cross sectional study. *Nurse Education Today*, *65*, 242–249. https://doi.org/10.1016/j.nedt.2018.03.010

Reed, S., Grosz, M., Kurlaender, M., & Cooper, S. (2021). *A portrait of student parents in the California community colleges: A new analysis of financial aid seekers with dependent children*. The Center for Community College Leadership and Research, UC Davis https://education.ucdavis.edu/sites/main/files/wheelhouse_research_brief_vol_6_no_2_v2.pdf

Reeves, T. D., & Marbach-Ad, G. (2016). Contemporary test validity in theory and practice: A primer for discipline-based education researchers. CBE life sciences. *Education*, *15*(1), 1–9. https://doi.org/10.1187/cbe.15-08-0183

Rittmayer, A. D., & Beier, M. E. (2008). Overview: Self-efficacy in STEM. *Swe-Awe Casee Overviews*, *1*(3), 12.

Robinson, K. A., Perez, T., Carmel, J. H., & Linnenbrink-Garcia, L. (2019). Science identity development trajectories in a gateway college chemistry course: Predictors and relations to achievement and STEM pursuit. *Contemporary Educational Psychology*, *56*, 180–192.

Rodriguez, S., Jordan, A., Doran, E., & Sáenz, V. (2019). Latino men & community college environments: Understanding how belonging, validation, and resources shape experience. *Journal of Applied Research in the Community College*, *26*(1), 1–14.

Rosseel, Y. (2012). Lavaan: An R package for structural equation modeling and more. Version 0.5–12 (BETA). *Journal of Statistical Software*, *48*(2), 1–36.

Royse, E. A., Sutton, E., Peffer, M. E., & Holt, E. A. (2020). The anatomy of persistence: Remediation and science identity perceptions in undergraduate anatomy and physiology. *International Journal of Higher Education*, *9*(5), 283–299.

RTI International. (2019). *First-generation college students: Demographic characteristics and postsecondary enrollment*. NASPA Retrieved from https://firstgen.naspa.org/files/dmfile/FactSheet-01.pdf

Sáenz, V. B., García-Louis, C., Drake, A. P., & Guida, T. (2018). Leveraging their family capital: How Latino males successfully navigate the community college. *Community College Review*, *46*(1), 40–61.

Schar, M., Pink, S. L., Powers, K., Piedra, A., Torres, S. A., Chew, K. J., & Sheppard, S. (2017). Classroom belonging and student performance in the introductory engineering classroom. *ASEE Annual Conference & Exposition*. https://peer.asee.org/28034.pdf

Scheidt, M., Godwin, A., Senkpeil, R. R., Ge, J. S., Chen, J., Self, B. P., Widmann, J. M., & Berger, E. J. (2018). Validity evidence for the SUCCESS survey: Measuring non-cognitive and affective traits of engineering and computing students. In 2018 ASEE Annual Conference & Exposition.

Scheidt, M., Senkpeil, R., Chen, J., Godwin, A., & Berger, E. (2019). SAT does not spell success: How non-cognitive factors can explain variance in the GPA of undergraduate engineering and computer science students. *Proceedings - Frontiers in Education Conference, FIE, 2018-October*. https://doi.org/10.1109/FIE.2018.8658989

Schinske, J. N., Perkins, H., Snyder, A., & Wyer, M. (2016). Scientist spotlight homework assignments shift students' stereotypes of scientists and enhance science identity in a diverse introductory science class. *CBE—Life Sciences Education*, *15*(3), 1–18.

Scott, A. H., Chase, L. M., Lefkowitz, R., Morton-Rias, D., Chambers, C., Joe, J., Holmes, G., & Bloomberg, S. (1995). A national survey of admissions criteria and processes in selected allied health professions. In. *Journal of Allied Health*, *24*(2), 95–107. https://europepmc.org/article/med/7642442

Semsar, K., Knight, J. K., Birol, G., & Smith, M. K. (2011). The Colorado Learning Attitudes about Science Survey (CLASS) for use in biology. *CBE—Life Sciences Education*, *10*(3), 268–278. https://doi.org/10.1187/cbe.10-10-0133

Seymour, E., Wiese, D., Hunter, A., & Daffinrud, S. M. (2000). Creating a better mousetrap: On-line student assessment of their learning gains. National Meeting of the American Chemical Society (pp. 1-40).

Shaw, S. T., Spink, K., & Chin-Newman, C. (2019). “Do I really belong here?”: The stigma of being a community college transfer student at a four-year university. *Community College Journal of Research and Practice*, *43*(9), 657–660.

Smith, J. M., & Lucena, J. C. (2016). Invisible innovators: How low-income, first-generation students use their funds of knowledge to belong in engineering. *Engineering Studies*, *8*(1), 1–26.

Starr, C. R., Hunter, L., Dunkin, R., Honig, S., Palomino, R., & Leaper, C. (2020). Engaging in science practices in classrooms predicts increases in undergraduates' STEM motivation, identity, and achievement: A short-term longitudinal study. *Journal of Research in Science Teaching*, *57*(7), 1093–1118.

Stets, J. E., & Serpe, R. T. (2013). Identity theory. In *Handbook of social psychology* (pp. 31–60). Springer.

Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics* (Vol. 5, pp. 481–498). Pearson.

Tight, M. (2021). Existing research on learning gain in higher education. In *Learning gain in higher education*. Emerald Publishing Limited.

U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS). (2021). Student Enrollment: How many students enroll in postsecondary institutions annually? 12-month Enrollment component 2019-20 provisional data. Retrieved from https://nces.ed.gov/ipeds/TrendGenerator/app/build-table/2/2?cid=1

Upton, D., & Upton, P. (2006). Knowledge and use of evidence-based practice by allied health and health science professionals in the United Kingdom. *Journal of Allied Health*, *35*(3), 127–133.

Verdín, D. (2021). The power of interest: Minoritized women's interest in engineering fosters persistence beliefs beyond belongingness and engineering identity. *International Journal of STEM Education*, *8*(1), 1–19.

Verdín, D., Godwin, A., & Ross, M. (2018). STEM roles: How Students' ontological perspectives facilitate STEM identities. *Journal of Pre-College Engineering Education*, *8*, 31–48. https://doi.org/10.7771/2157-9288.1167

Verdín, D., & Godwin, A. (2018). First-generation college students identifying as future engineers. *American Educational Research Association.* https://docs.lib.purdue.edu/enegs/79

Vincent-Ruz, P., & Schunn, C. D. (2018). The nature of science identity and its role as the driver of student choices. *International Journal of STEM Education*, *5*(1), 1–12.

Weaver, A. J., Haak, N. J., Molt, L., & Cannon, A. R. (2018). Let's do the twist: Pairing interdisciplinary collaborative teaching, and hands-on and service learning opportunities, to spread awareness of communication sciences and disorders. *Perspectives of the ASHA Special Interest Groups*, *3*(10), 27–44.

Weiss, E. H. (1989). Committee to Study the Role of Allied Health Personnel, Institute of Medicine, Allied Health Services: Avoiding crises, National Academy Press, 2101 Constitution Avenue, NW, Washington, DC 20418 (1989), 344 pp., softcover, $29.95., ISBN: 0-309-03896-0.

Willoughby, S. D., & Metz, A. (2009). Exploring gender differences with different gain calculations in astronomy and biology. *American Journal of Physics*, *77*(7), 651–657.

Wolf, A. M., Liachovitzky, C., & Abdullahi, A. S. (2015). Active learning improves student performance in a respiratory physiology lab. *Journal of Curriculum and Teaching*, *4*(1), 19–29.

Yeager, D. S., & Dweck, C. S. (2020). What can be learned from growth mindset controversies? *American Psychologist*, *75*(9), 1269–1284.

Yosso, T. J. (2005). Whose culture has capital? A critical race theory discussion of community cultural wealth. *Race Ethnicity and Education*, *8*(1), 69–91. https://doi.org/10.1080/1361332052000341006

Zimmerman, H. T. (2012). Participating in science at home: Recognition work and learning in biology. *Journal of Research in Science Teaching*, *49*(5), 597–630.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Perkins, H., Royse, E. A., Cooper, S., Kurushima, J. D., & Schinske, J. N. (2023). Are there any "science people" in undergraduate health science courses? Assessing science identity among pre-nursing and pre-allied health students in a community college setting. *Journal of Research in Science Teaching*, 1–35. https://doi.org/10.1002/tea.21902