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Abstract

This study examined the role of science identity in a two-year upper-division research training program that prepares diverse undergraduate students for a research career. Using the annual year-end student evaluation data, we examined whether science identity is a predictor or an outcome of learning that enhances career preparation in biomedical research. Results showed that science identity is a predictor of learning in our trainees. In general, students with stronger science identity at the end of Year 2 reported having acquired more research skills and experiences through the program. This finding demonstrates that science identity makes learning research skills meaningful and purposeful. Preliminary analyses also showed that the levels of science identity did not differ between Years 1 and 2. In fact, science identity approached the maximum possible scores in both years. These findings imply that the training program could have succeeded in bolstering participants' science identity early by the end of the first year. Our findings do not rule out the possibility that science identity is both a predictor and an outcome of learning, depending on the specific contexts of learning as well as learners' specific developmental phases. Further studies are needed to systematically test these and other possibilities.

Introduction

In the 2019-2020 Committee on Equal Opportunities in Science and Engineering (CEOSE) Biennial Report to Congress (National Science Foundation [NSF], 2021), the CEOSE asserted:

> Today's focus on inclusiveness is about the intellectual opportunities to address systemic issues of 'ism' and biases and to remove barriers related to being overlooked, undercounted or simply missing. More specifically, CEOSE is calling attention to the need for more diverse scientific leadership, more attention to the economic advantage of belongingness in STEM, and increased attention on the removal of social and cultural barriers (p. 11).

As the employment in STEM occupations continues to grow rapidly (Cover et al., 2011; Jelks & Crain, 2020; NSF, 2021; United States, 2017), an effort is urgently sought to systematically address issues of "ism" and remove social and cultural barriers for STEM participation. Doing so helps (1) students from minoritized and/or economically disadvantaged backgrounds build a strong sense of belonging in STEM, (2) colleges retain underrepresented students in the field once they become interested in STEM, and (3) professional fields produce a strong and diverse STEM workforce (Eisenhart & Allen, 2020; Jelks & Crain, 2020; Lock et al., 2019). To secure the diverse workforce, it is essential to promote and ensure STEM participation and persistence by historically underrepresented groups of students (Chelberg & Bosman, 2019). As underscored by the NSF (2022), science and technology have never been more important to the nation: "Society is confronted by a growing set of challenges that call for the insights that science and engineering can provide (p. 9)." The integration of diverse perspectives in the field of sciences will reinforce the U.S. capacity to meet domestic needs, retain its international competitiveness, and accommodate ever-increasing challenges and complexities in today's world.

In recent years, quite a few researchers have examined psychological factors that could positively impact students' engagement and attainment in STEM and decisions to pursue STEM career. One of the prominent findings stipulates that having a solid science identity counters the negative stereotypes that discourage students from marginalized groups from participating in STEM. When strong science identity is cultivated, students from those groups are empowered and their sense of belonging in STEM is promoted (Hudson et al., 2018). As science identity develops, individuals: (1) enjoy strong sense of competence and belonging in STEM; (2) persistently perform well in STEM, even in the face of hardships; (3) come to believe that they are a "science person" and be recognized as such by others; and (4) become committed to pursue STEM careers (Carlone & Johnson, 2007; Hazari et al., 2017; Stets et al., 2017; Syed et al., 2019).

Research has shown that science identity significantly explains science achievement and engagement of minoritized students (Gholson & Wilkes, 2017). For instance, Estrada et al. (2018) found that students from underrepresented minority groups are more likely to persist in STEM if they become identified with the sciences. Chen et al. (2021) indicated that science identity fosters science achievement particularly among first-generation minority students. A study by Garcia et al. (2020) also concluded that science identity could help marginalized students continue investing in STEM. Particularly, Black students in their study eagerly transferred to a four-year university as STEM majors after doing well in science courses at a community college, internalizing science identity, and deciding to pursue additional work in STEM. Thus, nourishing a strong science identity within a diverse group of students could be one important path to promote racial equity in science and to build a more diverse, robust, and healthy STEM workforce.

Identity is a psychosocial concept that reflects a perception of a self within a given context and it could fluctuate depending on the specific contexts where the individual resides (Wenger-Trayner, 2008). In that sense, science identity represents individuals' perceptions of themselves within a specific context where science is learned and performed. Then, the contexts where science is learned and performed would determine how science identity develops and to what degree it increases or decreases, and therefore predict the direction and magnitude in the growth of science identity. Extant research indicates that when learners develop science identity, it also demonstrates who the learners aspire to become. As described by Chen and Wei (2020), science identity is "students' perceptions of who they are, what they believe they are capable of, and what they want to do and become with regard to science."

Regarding the relationship between science learning and science identity, studies have reported that successful learning and attainment in science bolstered the learners' senses of belonging and competence and thereby solidified their science identity (Carlone & Johnson, 2007; Hernandez et al., 2018b; Hudson et al., 2018; Lock et al., 2019; Robinson et al., 2018). In this context, science identity is an outcome of successful learning. However, another line of research has demonstrated that science identity fostered persistence, retention, engagement, and aspiration in science among minoritized students (Chen et al., 2021; Estrada et al., 2018; Garcia et al., 2020; Gholson & Wilkes, 2017). In this latter context, science identity is a predictor of further learning, persistence, and engagement in science. Taken together, science identity might have a bi-directional relationship with learning, such that science identity is not only an outcome of successful learning in science (i.e., development of research skills) but also a predictor of further learning and commitment. Both aspects of science identity, i.e., either a predictor or an outcome of learning/attainment, are crucial for educators who strive to build and implement intentional and effective educational programs aimed at developing scientists from diverse backgrounds. However, educators would benefit greatly if it is known whether science identity predicts further learning and growth or is an outcome of learning science within their specific STEM training programs. If such a direction is revealed, training programs can use this knowledge to prepare increasingly more meaningful contexts of learning where students could successfully link science identity with their learning, professional growth, and career goals in STEM fields. To specify the direction, this study examined whether science identity is a predictor or an outcome of learning research skills within a training program that was designed to prepare minoritized undergraduate students for research careers.

Current Study

Research Training Programs for Underrepresented Student Groups

A variety of STEM research training programs have targeted undergraduate students from historically underrepresented groups, and have successfully promoted science identity and STEM engagement for those students (Asempapa et al., 2021; Camacho et al., 2021; Carpi et al., 2017; Hernandez et al., 2018a,b; Hudson et al., 2018; Odera et al., 2015; Trott et al., 2020). Mentored learning programs (e.g., faculty research and fieldwork) successfully retained non-Asian American minority students in STEM (Jelks & Crain, 2020). Quality mentorship and research experiences during the undergraduates' Junior and Senior years enabled participants from underrepresented minority groups to identify with science and persist in the science field (Hernandez et al., 2018b).

Research training programs developed through the National Institutes of Health (NIH) Building Infrastructure Leading to Diversity (BUILD) initiative also involved programmatic training of undergraduate students in research to enhance and solidify the health-related workforce. The BUILD initiative led to the creation of the Diversity Program Consortium that includes 10 BUILD Programs from minority-serving institutions nationwide. These institutions were charged with developing and testing innovative health-related research training programs for undergraduate students. Together these programs would establish a sustainable pipeline from undergraduate to graduate education to support NIH's goals of diversifying the nation's biomedical research workforce by engaging and retaining students from diverse backgrounds in research. The BUILD student training programs provide well-designed activities that integrate academic advising, tutoring, career advice, counseling, research training and mentoring, and were able to sustain students' interest in biomedical research career throughout their college experience (e.g., Camacho et al., 2021; Foroozesh et al., 2017; Kingsford et al., 2022; Vu et al., in press). For instance, early exposure to research through an intensive 1-year research program for lower division students led to development of science interest and science skills (e.g., gains in writing, oral presentation, and data analysis) for both underrepresented and non-underrepresented undergraduate sophomores (Kingsford et al., 2022). In addition to the endeavors that are shared by multiple sites, each BUILD Program also determined its own unique approach or emphasis, whose foci have encompassed such areas as community health and social justice guided by critical race theory (Camacho et al., 2021; Saetermoe et al., 2017), mitigation of stereotype threat through microaffirmation (Estrada et al., 2019), or an entrepreneurial model for research training (Kamangar et al., 2017).

Training Program Examined in This Study

The present study used student training data from the California State University, Long Beach (CSULB) BUILD Program. At the time of the award, CSULB was designated as a Hispanic-Serving and Asian American Native American and Pacific Islander-Serving institution. Of its approximately 34,000 undergraduate students, 44% are from Hispanic/Latino background, 20% Asian American, 16% White, and 15% were from other ethnic races (African-American, American Indian, etc.). The primary goal of the CSULB BUILD Program is to foster career preparation in behavioral and biomedical science research among undergraduate students, especially those from underrepresented groups. The program's major component is a two-year upper division training called the Scholars Program that aims to assist participants' career preparation in research.

The Scholars Program consists of: (1) participation in a research training learning community, (2) courses taken from an intensive, deliberate research curriculum, (3) professional development activities, and (4) faculty mentored research (see Vu et al., in press, for description of the program philosophy and details). The Scholars Program strives to foster students' sense of belonging in BUILD and in the field of behavioral and biomedical sciences by creating a cohort-based learning community in which student trainees participate during the two years of the program. Many of the activities in the CSULB BUILD Program are closely aligned with ongoing endeavors in the other nine BUILD sites, but what makes the CSULB BUILD Program stand out from other BUILD Programs includes:

(1) its relevance and training across a broad range of disciplines, and

(2) its strong research curriculum that helps trainees solidify their research-related knowledge and skills through courses taken in their majors as well as courses developed for the BUILD Program's research curriculum that focus on developing critical research-related skills (e.g., literature review, data collection and analyses, presentation skills), essentials of grant and manuscript writing, and Responsive Conduct of Research (for details, see Taing et al., 2022).

In relation to the first element, i.e., a broad range of disciplines, this BUILD Program provides training to students in traditional biomedical disciplines such as biology, biochemistry and chemistry, in other biomedical disciplines such as biomedical and chemical engineering, and in behavioral science disciplines such as health science, kinesiology, linguistics, nutritional science, sociology and psychology.

The cohort-based learning community and mentored research are the two pillars within the two-year Scholars Program of the CSULB BUILD Program. Although the pillars are distinct, the components of the pillars closely intertwine and reinforce the effects of one another. In the learning community, Scholars acquire knowledge and skills that guide robust research. The knowledge and skills cultivated in the learning community are applied, tested, and consolidated in the mentored research whose rigor would intensify over the course of two years. The learning community provides the student trainees with the multi-layered system of support and guidance, which involves interactions with BUILD training directors, near-peer graduate student mentors (see Abeywardana et al., 2020), and faculty research mentors.

As Scholars apply knowledge and skills that are acquired in the research curriculum onto the faculty mentored research, they also prepare multiple research presentations and research reports as part of the graded requirements for the learning community. The Scholar trainees are also given the opportunity to participate in discipline-specific skill development workshops (e.g., statistics, assays, 3-D printing) and GRE preparation workshops. What is beneficial for the trainees is that for all of these activities in the Scholars Program, the trainees can seek feedback, guidance, and support from the program’s training directors and near-peer graduate student mentors as well as their faculty research mentors. Program data and evaluation data demonstrated that over the two-year training, students showed growth in their understanding of research (both as a career path and in terms of research skills: writing, presentation skills, and data analysis; Vu et al., in press). Moreover, the gains were similar for all Scholars regardless of their academic disciplines or underrepresented group status.

The Scholars Program starts with an 8-week program, titled the Summer Undergraduate Research Gateway to Excellence (SURGE). The SURGE component plays a critical role in cultivating scholars’ science identity because students are introduced to research and the pathway to a Ph.D. during the SURGE. Moreover, the SURGE concludes with a celebration where Scholars present their research projects in front of their family members. The involvement of family members provides an important opportunity for Scholars to solidify a network of social support. As demonstrated by researchers, social support from family members, peers, and teachers is a primary factor that helps minoritized students commit to a STEM field (Alshahrani et al., 2018), and others’ recognition of the learner as a science person is an essential ingredient in the development of sound science identity (Kalender et al., 2019; Le et al., 2019).

During the first year in the program after the SURGE, Scholar trainees attend a national student research conference, which again reinforces the undergraduate researchers’ science identity. Scholars are required to apply for a summer research experience (SRE) at an R1 university or other research-intensive organization for their second summer in the program. This SRE allows them to experience what it would be like to conduct research as a graduate student early on. The culminating experience of the Scholars Program is applying to graduate schools in their second year so the trainees could continue embodying the types of knowledge, skills, and dispositions that are expected of a researcher who nicely represents the field as a competent science person.

Goals of This Study

Using the CSULB BUILD Scholars Program as the context of the present investigation, we attempted to expand our knowledge about science identity that Scholars cultivate and enact on during the two years of the Scholars Program. Specifically, the major goal of this study was to reveal the roles that science identity plays in science learning, specifically whether science identity predicts or is an outcome of learning research skills. The two major research questions in this study are as shown below:

> *Research Question 1:* Is students' learning of research skills, as measured at the end of the two-year training program, predicted by science identity that Scholars report at the end of the first year and at the end of the second year of the program?
>
> *Research Question 2:* Is science identity, as measured at the end of the two-year training program, predicted by the learning of research skills measured at the end of the first year and at the end of the second year of the program?

Before these two questions were examined, we first tested if we could establish a condition that justifies our planned analyses to address the two major research questions. Namely, first we tested if science identity measured at the end of Year 1 and Year 2 and science learning measured at the end of Year 1 and Year 2 are empirically distinct constructs. As noted earlier, it was expected that the results from this research would help BUILD and other training programs provide more meaningful and purposeful contexts where undergraduate students from diverse backgrounds can successfully link science identity with their learning as they advance career preparation in STEM research.

Methods

Participants

The analytical sample consisted of 66 participants (n = 45 females; n = 21 males) who completed the two-year BUILD Scholars Program and took evaluation surveys at the end of both Year 1 and Year 2 of the program. About half (51.5%) of the participants were from the biomedical track consisting of majors in the natural sciences (e.g., biology, chemistry, biochemistry) and engineering (e.g., biomedical, chemical, electrical). The other half (48.5%) were from the behavioral track consisting of majors in social sciences (e.g., psychology, linguistics, international studies) and health and human services (e.g., health science, nutrition and dietetics, kinesiology).

In terms of ethnicity, 43.9% self-identified as Hispanic or Latinx. The largest self-identified racial group was Asian (34.8%), followed by White (27.3%). About 6.1% self-identified as Black or African American, 3.0% as American Indian or Alaskan Native, and 4.5% as more than one race. The rest (24.3%) did not identify their race. One half of our sample (50.0%) were from underrepresented minority groups for race and ethnicity, 69.7% were eligible for financial aid, and 36.4% were first generation college students. The bivariate distributions of the participants are summarized in Table 1. As indicated with the Chi-Square tests reported in Table 1, only gender interacted with students' track, with a significantly higher proportion of males within the biomedical track as compared to the behavioral track.

Table 1. Bivariate Distribution of the Participants

Variables		Track			Chi-Square
		Biomedical	Behavioral	Total	
Gender	Male	18	3	21	14.42***
	Female	16	29	45	
Minority Status	Yes	15	18	33	.97
	No	19	14	33	
First-Generation College Students	Yes	10	14	24	1.47
	No	24	18	42	
Financial Aid Eligibility	Yes	21	25	46	2.09
	No	13	7	20	

Note: *** - Significant at the .001 level.

Data Sources

The student data used in the present analyses were obtained from two sources: the program data and evaluation data. The program data included students' demographic (gender, race and ethnicity), financial aid, and academic (major and first-generation college student status) information that were obtained from students' application forms and institutional research data. The evaluation data consisted of the Learning Community evaluation survey administered at the end of each year of the Scholars Program and the annual evaluation surveys administered independently by the Coordination and Evaluation Center (CEC) at UCLA, the NIH-funded evaluation group that supports evaluation of the ten BUILD sites in the Diversity Program Consortium. All survey data were collected in accordance with approved Institutional Review Board protocols.

Measures

Science Identity

Scholar trainee's science identity was measured with three items from a 5-item measure developed by Estrada et al. (2011), as shown below. Estrada et al. (2011) demonstrated that five items of science identity (including the particular three items included in the present study) had high internal consistency (alpha = .86). The five items utilized by Estrada et al. (2011) were: "I have a strong sense of belonging to the community of scientists," "I derive great personal satisfaction from working on a team that is doing important research," "I have come to think of myself as a 'scientist'," "I feel like I belong in the field of science," and "the daily work of a scientist is appealing to me."

The CEC survey included four of these five items, excluding the last item. In addition, the second item which was included in the CEC survey was dropped in our analyses to ensure strong internal consistency of the science identity measure. For instance, the alpha coefficient for four items including the particular item was .80 for four Year 2 items, which was substantially lower than the alpha coefficient for three items when the particular item was excluded (i.e.., alpha =.88 for three Year 2 items). The three items retained were:

Indicate to what extent the following statements are true of you (5-point Likert-like scale, where 1 = Strongly Disagree and 5 = Strongly Agree):

1. I have a strong sense of belonging to a community of scientists.
2. I have come to think of myself as a scientist.
3. I feel like I belong in the field of science.

Perceived Learning: Career Preparation in the Learning Community

Participants' perceived learning in the program to promote research career preparation was measured with seven items, as shown below (unvalidated). These items were generated by the program evaluator for the purpose of evaluating trainees' experience of the Scholars Program Learning Community.

Please rate how much you agree with the following statements (1 = Strongly Disagree and 6 = Strongly Agree):

1. Learning Community clarified for me which field of study I want to pursue.
2. Learning Community has prepared me for graduate school.
3. Learning Community clarified research career steps.
4. Learning Community helped me develop scientific research project ideas.
5. Learning Community helped me understand research-related ethical issues.
6. Learning Community has prepared me to effectively communicate scientific information to different audiences.
7. Learning Community has contributed to my professional development.

Analysis Plan

All analyses were conducted utilizing the SPSS program. To examine whether Year 1 and Year 2 measures of science identity and Year 1 and Year 2 measures of science learning form four distinct constructs, we carried out a factor analysis. The three items of science identity as well as seven items of learning to promote career preparation in STEM research measured in Year 1 and Year 2 were included in the factor analysis. If four distinct factors were identified, the results would justify our plan to compute two composite scores of science identity (i.e., the sums of scores over three items of science identity obtained each year) and two composite scores of science learning (i.e., the sums of scores over the seven items related to career preparation obtained each year).

After the confirmation of the four constructs, we examined their correlations and compared means of the composites from each year to better understand the nature of their interrelationships. Then, to address Research Questions 1 and 2, a series of regression analyses was conducted. For Research Question 1, Year 2 perceived learning composite score was entered as a dependent variable, and Year 1 and Year 2 composite scores of science identity, as predictors. For Research Question 2, we reversed the dependent and predictor variables. In this regression analysis Year 2 science identity composite score was entered as the dependent variable and Year 1 and Year 2 composite scores of perceived learning were predictor variables.

Results

Factor Analysis of Year 1 and Year 2 Science Identity and Science Learning Measures

To examine the factor structure of Year 1 and Year 2 measures of science identity and science learning, an exploratory factor analysis was conducted, with six Year 1 and Year 2 items of science identity (three items per year) and fourteen Year 1 and Year 2 items of perceived learning (seven items per year). After entering all 20 items, factors were extracted with Principal Axis Factoring and the extracted factors were rotated using Equamax with Kaiser Normalization. The results showed strong divergence across items loading onto four distinct factors. These factors separated the science identity and learning items from each other and across the two time points. As shown in Table 2, Factor 1 was comprised of the seven Year 1 items of perceived learning and explained 33.22% of the variance. Factor 2 involved the Year 2 items of perceived learning, which explained additional 26.75% of the variance. Factor 3 was comprised of the three Year 1 items of science identity and explained additional 13.71% of the variance. Factor 4 was associated with the three Year 2 items of science identity, and additional 5.59% of the variance was explained by Factor 4. With all four factors, 79.27% of the variance was explained. Four separate reliability analyses were conducted to further examine how well the items loaded onto each factor held together as a measure.

The results demonstrated high levels of internal consistency among items associated with each of the four factors. For the two science identity factors, the alpha coefficients were .88 for the three Year 1 items and .88 for the three Year 2 items, demonstrating solid reliability. For two perceived learning factors, the alpha coefficients were .96 for the seven Year 1 items and .96 for the seven Year 2 items, demonstrating excellent reliability.

Table 2. Rotated Factor Matrix with Factor Loadings

Items	Factor			
	1	2	3	4
Y1_Learning Community has contributed to my professional development.	**0.94**	-0.03	0.03	-0.12
Y1_Learning Community has prepared me to effectively communicate scientific information to different audiences.	**0.93**	-0.19	-0.02	-0.20
Y1_Learning Community clarified research career steps.	**0.92**	-0.13	-0.12	0.02
Y1_Learning Community has prepared me for graduate school.	**0.87**	-0.01	0.05	-0.23
Y1_Learning Community helped me develop scientific research project ideas.	**0.84**	-0.02	-0.12	0.08
Y1_Learning Community helped me understand research-related ethical issues.	**0.84**	0.01	-0.10	-0.15
Y1_Learning Community clarified for me which field of study I want to pursue.	**0.81**	0.32	-0.06	-0.03
Y2_Learning Community helped me understand research-related ethical issues.	0.04	**0.90**	0.08	0.06
Y2_Learning Community has prepared me to effectively communicate	0.04	**0.90**	0.18	0.06

Items	Factor 1	2	3	4
scientific information to different audiences.				
Y2_Learning Community has contributed to my professional development.	0.07	**0.89**	0.20	0.00
Y2_Learning Community clarified research career steps.	-0.08	**0.88**	0.03	0.25
Y2_Learning Community clarified for me which field of study I want to pursue.	-0.08	**0.87**	0.20	0.11
Y2_Learning Community has prepared me for graduate school.	0.06	**0.85**	0.23	0.23
Y2_Learning Community helped me develop scientific research project ideas.	-0.15	**0.79**	-0.16	0.10
Y1_Science Identity: I feel like I belong in the field of science.	-0.10	-0.01	**0.88**	0.26
Y1_Science Identity: I have come to think of myself as a scientist.	0.03	0.12	**0.82**	0.23
Y1_Science Identity: I have strong sense of belonging to the community of scientists.	-0.07	0.15	**0.73**	0.22
Y2_Science Identity: I have strong sense of belonging to the community of scientists.	-0.07	0.02	0.20	**0.92**
Y2_Science Identity: I feel like I belong in the field of science.	-0.15	0.24	0.27	**0.75**
Y2_Science Identity: I have come to think of myself as a scientist.	-0.04	0.06	0.31	**0.74**

Note: Loadings larger than .40 are in bold.

With the results indicating that four constructs were distinct, we proceeded to compute the four composite scores for Year 1 Science Identity, Year 2 Science Identity, Year 1 Perceived Learning, and Year 2 Perceived Learning (see Table 3 for descriptive statistics of the composite scores). To further understand the relationships among the obtained composite scores, we carried out two separate paired-samples t-tests and examined the correlations of the corresponding Year 1 and Year 2 measures for each construct. The results of the paired-samples t-test of the Science Identity scores revealed that the Year 1 and Year 2 mean values do not significantly differ [$t(64) = .92$, $p > .05$]. However, the paired-samples t-test of the Perceived Learning scores revealed that the Year 2 mean value was significantly higher than the Year 1 mean value [$t(59) = 2.25$, $p < .05$]. The correlation analysis showed that the Year 1 and Year 2 Science Identity composite scores were positively and significantly correlated with each other [$r = .47$, $p < .001$], whereas the Year 1 and Year 2 Perceived Learning composite scores were not [$r = -.13$, $p > .05$].

Table 3. Ranges, Means and Standard Deviations of Composite Scores

Construct	Possible Score Range	Composite Score Range	*M*	*SD*
Science Identity- Y1	3-15	6-15	12.67	2.03
Science Identity- Y2	3-15	6-15	12.91	2.15
Perceived Learning- Y1	7-42	14-42	31.31	8.05
Perceived Learning- Y2	7-42	17-42	34.27	7.31

Testing Research Questions 1 and 2

After confirming the appropriateness of treating the science identity and learning measures of Year 1 and Year 2 as separate but interrelated constructs, we proceeded to run analyses to test the two research questions utilizing the composite scores. To address Research Questions 1 and 2, two regression analyses were conducted. In both analyses, two independent variables (from Year 1 and Year 2) were simultaneously entered. In the first regression analysis, Year 2 Perceived Learning composite score was the criterion variable and Year 1 and Year 2 Science Identity composite scores were the predictors. In the second regression analysis, Year 2 Science Identity composite score was the criterion variable and Year 1 and Year 2 Perceived Learning composite scores were the predictors. The results from the two regression analyses are summarized in Table 4.

Table 4. Two Multiple Regression Analyses

Variables	B	*SE* B	β
Analysis 1 (DV: Year 2 Perceived Learning)			
Year 1 Science Identity	.08	.49	.02
Year 2 Science Identity	1.01	.46	.31*
Analysis 2 (DV: Year 2 Science Identity)			
Year 1 Perceived Learning	-.04	.04	-.14
Year 2 Perceived Learning	.07	.04	.23

Note: * Significant at the .05 level

As described in Table 4, in Analysis 1, Year 2 Science Identity was a significant predictor of Year 2 Perceived Learning; however, Year 1 Science Identity was not a significant predictor. The overall regression model resulted from Analysis 1 was significant [R2 = .10, F (2,60) = 3.37, p < .05]. In the second analysis, neither Year 1 Perceived Learning nor Year 2 Perceived Learning was a significant predictor of Year 2 Science Identity.

Discussion

The present study examined the longitudinal and concurrent interrelationships between science identity and learning for underrepresented minority students participating in a two-year upper-division research training program. The analyses of the psychometric properties of the measures that assess science identity and perceived learning of research skills demonstrated that Year 1 and Year 2 science identity and Year 1 and Year 2 perceived learning are separate entities, with two factors consisting of the Year 1 and Year 2 science identity items, and two other factors consisting of the Year 1 and Year 2 perceived learning items. The Year 1 composite score of science identity positively and significantly correlated with Year 2 composite score of science identity at r = .47. Importantly, our findings suggest that science identity may not change significantly from Year 1 to Year 2. Indeed, the mean composite score of science identity measured at the end of Year 1 (M = 12.67) was already approaching the maximum possible score of 15, suggesting a possible ceiling effect. In addition, Year 2 science identity measure did not significantly differ from the corresponding Year 1 measure. Given that science identity was measured at the end of each year, this might reflect the situation where Scholar trainees had already developed high levels of science identity by the end of Year 1, either from earlier science-related experiences prior to the Scholars Program or during the first year in the Scholars Program probably largely due to the intensive SURGE summer component as our prior study implied (Vu et al., in press). This could then imply that the Scholars Program was quite successful in cultivating science identity among its participants from early phases in the program or succeeded in maintaining science identity that Scholars brought into the program. Additionally, results from the second paired-samples t-test revealed that trainees' ratings of their learning in the learning community at the end of the second year were significantly higher than those at the end of the first year, suggesting that the Scholar trainees continued to learn research knowledge and skills well into their second year in the training program. This finding could indicate another set of success in the Scholars Program, as it appears that the program effectively advanced participants' learning to prepare them for careers as research scientists during the courses of two years in the Scholars Program.

In relation to the major goal of this study, which was to expand our understanding about the roles that science identity plays in one's learning, the results revealed that science identity is a predictor (rather than an outcome) of students' learning of research skills when this particular undergraduate research training program was concerned. This finding is intriguing and significant as it might suggest that it is important for training programs to develop sound science identity that enables participants to continually learn. As discussed earlier, however, it is still probable that science identity and learning might grow concurrently while maintaining bi-directional and dynamic relationships with each other, where science identity could be both a predictor of learning and an outcome of learning over time, depending on: (1) the specific contexts where learners carry out their learning of research skills or conduct science-related performances, as well as (2) the specific developmental phases where the learners are located. If it is so, the findings in the present study are applicable only to the contexts of learning and students' developmental phases that were observed in the particular BUILD Scholars program that we examined in the present study. It remains highly probable that new contexts of learning to which the Scholar trainees proceed after the Scholars Program might require more advanced learning of highly sophisticated research skills. In such contexts, our Scholars' science identity could be at least temporarily diminished even though they already had high levels of science identity at the end of the Scholars program. After the Scholars acquire and embody necessary knowledge and highly advanced skills, their science identity then could be bolstered and re-solidified. Thus the trajectory of growth of science identity may not even be linear as it can ebb and flow, reflecting their developmental stage. Future studies are strongly needed to systematically examine those possibilities. Also needed is the systematic studies that investigate specific factors that help learners persistently develop, solidify and intensify their science identity, and specific manners where those factors positively impact learners' science identity.

Particularly in the present BUILD Scholars Program, more in-depth analyses are needed to understand exactly what enabled Scholars to attain high levels of science identity by the end of Year 1. As noted earlier, such investigation should carefully examine Scholars' science-related experiences prior to BUILD, experiences during the program including the SURGE, contexts of learning that were present throughout Year 1 of the Scholars Program (e.g., environment and programs to foster participants' sense of belonging in the program and sciences, multi-layered system of mentoring), and others, and how each relates to Scholar trainees' science identity.

Importantly, in relation to the development of science identity, limitations in this study also call for a series of robust future studies. First, future studies should examine how well the various information typically gathered from student applications to training programs such as academic performance, science interests, and letters of recommendation predict growth in science identity and learning. Findings from these studies can inform the application and selection processes of student training programs. Second, in relation to operationalization of science identity, the present study operationalized science identity only with items that assessed learners' own perceptions. However, as argued by many researchers, science identity is solidified when others recognize individuals as a science person (Carlone & Johnson, 2007; Hernandez et al., 2018b; Hudson et al., 2018; Lock et al., 2019; Robinson et al., 2018). If it is so, for future research, it is also important to include more extensive items that measure science identity, involving ratings provided by others, e.g., family members, teachers, and peers, as well as how science identity is harmonious or conflicted with other important identities of the students such as being a person of color, a son/daughter, and a person of faith. It is possible that science identity would relate with the trainees' learning of research skills in a different manner, if perceptions by others or coherence with other personal identities are also integrated in the operationalization of science identity.

Thus, continued efforts are strongly needed to further solidify our understanding about science identity and its relationship with the learning to promote research skills. However, our finding depicting that science identity predicts learning of research skills nicely mirrors the argument conceptualizing science identity as a landscape of becoming (Avraamidow, 2020; Avraamidow & Schwartz, 2021). As maintained by the author, "a key goal of science identity research is to contribute to an understanding of how science identity might serve in making science learning meaningful and purposeful" (Avraamidow, 2020, p. 326). In this sense, our findings suggest that science identity has indeed made learning in the Scholars Program to advance research career preparation meaningful and purposeful. The finding is important as it reveals one possible way to link science identity with productive career preparation in STEM research.

Conclusion

Findings from this study significantly contributes to our knowledge about how science identity relates to one type of STEM learning among undergraduate students from underrepresented backgrounds. It appears that students who embody high levels of science identity are able to benefit more from their learning for advancing their career preparation in behavioral and biomedical research. The findings provide important implications to guide future educational practices in research training programs similar to this BUILD Scholars Program and confirm our efforts to help trainees develop a strong science identity throughout the program. Based on the results obtained in the present study demonstrating that science identity predicts one's learning of research skills, program directors should reflect on the specific conditions in the Scholars Program in relation to their relationships with students' sense of belonging and identifications with the science field throughout the program.

In the present study, experiences in the learning community as well as special components in the program such as the SURGE program during the initial summer and summer research experiences during the second summer could have been crucial components that successfully bolstered Scholars' science identity. However, to understand how strong science identity develops in the program, it would be useful to approach current and past trainees who developed high levels of solid science identity within the two-year program to learn about their experiences in the Scholars Program that helped them strongly identify with science. Additionally, as discussed earlier, the possibility still remains where science identity and learning maintain a dynamic system of bi-directional relationships. Thus, there is a need to continue investigating this possibility in the future.

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