www.ijres.net

What Predicts Undergraduate Students' Decision to Pursue a Career in Biomedical/Behavioral Research within an Upper-Division Research Training Program? A Study of Trainees' Science Identity and Educational Outcomes

Hiromi Masunaga
California State University Long Beach, U.S.A.

Chi-Ah Chun
California State University Long Beach, U.S.A.

Kim-Phuong L. Vu
California State University Long Beach, U.S.A.

To cite this article:

Masunaga, H., Chun, C. -A., & Vu, K.-P.L (2023). What predicts undergraduate students' decision to pursue a career in biomedical/behavioral research within an upper-division research training program? A study of trainees' science identity and educational outcomes. *International Journal of Research in Education and Science (IJRES), 9*(4), 920-936. https://doi.org/10.46328/ijres.3238

IJRES International Journal of Research in Education and Science
2023, Vol. 9, No. 4, 920-936 https://doi.org/10.46328/ijres.3238

What Predicts Undergraduate Students' Decision to Pursue a Career in Biomedical/Behavioral Research within an Upper-Division Research Training Program? A Study of Trainees' Science Identity and Educational Outcomes

Hiromi Masunaga, Chi-Ah Chun, Kim-Phuong L. Vu

Article Info

Article History

Received:
06 May 2023
Accepted:
21 September 2023

Keywords

Science identity
Undergraduate research
Biomedical research training
Diverse students

Abstract

This study examined how science identity and positive educational outcomes relate to student trainees' decision to pursue a research career in health-related sciences, within the context of a two-year research training program that prepares diverse undergraduate students for a research career. In analyses using the evaluation data, science identity and one of the positive educational outcomes significantly predicted trainees' decision to pursue a research career in biomedical and behavioral sciences. In general, students with stronger science identity and interest in pursuing research in academia exhibited a firmer decision to pursue a research career in sciences. In a separate analysis that examined the associations between the trainees' decision to pursue a health-related research career and their underrepresented minority identities, gender, and disciplinary track, results revealed that: (1) the interaction between trainees' disciplinary track (i.e., biomedical vs. behavioral sciences) and their total number of underrepresented minority status was associated with their decision to pursue a research career, but (2) the gender x disciplinary track interaction was not. Emphasizing the need for supporting diverse undergraduate trainees to solidify their science identity and prepare them for a research career in academia, we discuss implications of our findings for research training programs with similar aims.

Introduction

> *As estimated by the U.S. Bureau of Labor, 'employment is projected to increase by 11.5 million over the 2016–26 decade.' Of this projected growth, the top ten fastest growing occupations fall under the STEM career umbrella. Developing and preparing the future citizenry and workforce then falls into the hands of teachers, administrators, and the nation* (Avendano et al., 2019, p. 69).

To develop a workforce equipped for handling large-scale societal problems, educators, administrators, and the nation must first resolve a historical issue in STEM, the persistent underrepresentation by minoritized individuals. Ensuring opportunities for STEM participation for all is a matter of social justice (Chelberg & Bosman, 2019; Eisenhart & Allen, 2020; Jelks & Crain, 2020; Lock et al., 2019). Society is confronted by "a growing set of challenges that call for the insights that science and engineering can provide" (NSF, 2020, p. 9). The insights from

science and engineering have particularly driven technological innovation and heightened health benefits. When minoritized individuals are well integrated in the STEM workforce, we will be able to recognize and respond to various perspectives impacting technology, health, and other needs that are prevalent in today's diverse societies (Kricorian et al., 2020).

Unfortunately, the STEM workforce in the U.S. continues to fall very short of being able to tap into this potential wealth of insight and information (Fry et al, 2021: Holman et al, 2018; Ong et al., 2018). In analyzing recent trends in the STEM career participation, the National Center for Science and Engineering Statistics (NCSES) (2023) highlighted that despite recent improvement, gender and racial/ethnic identities still persistently interact to impact career participation in the U.S.: (a) In 2020, women earned 66% of bachelor's degrees in social and behavioral sciences but only 26% in mathematics and computer sciences and 24% in engineering; (b) In 2021, Hispanic and Black workers accounted for 10% and 8% of the college-educated workforce in science and engineering, respectively, although Hispanic and Black workers accounted for 15% and 9% of the total STEM workforce, respectively; and (c) In 2021, women made up 51% of the college-educated labor force, but their representation was as low as 29% when the college-educated labor force in science and engineering occupations was concerned. According to another report (NCSES, 2021), in 2019, Hispanic women represented only 2% of STEM occupations for the college-educated workforce, while the corresponding percentage was 6.5% for their male counterparts.

To advance more equitable access to innovations in STEM, the U.S. must promptly remove social and cultural barriers for STEM participation. One way to remove these barriers is to provide early interventions that introduce students to research careers (Kingsford et al., 2022) and provide intensive research training to those students to make them competitive for entry into Ph.D. programs (Vu et al., 2023). However, for students to persist in research training programs and pursue graduate studies, they need to develop and maintain a strong science identity (Carlone & Johnson, 2007; Estrada et al., 2011, 2018). Examining psychological factors, such as science identity, is important because even high-ability students switch majors from a STEM area to a non-STEM area due in part to their perceptions that they lack competence and skills that are essential for being successful in the STEM field (McDonald et al., 2019; Webb et al, 2002).

Science Identity

An effort to foster STEM participation for all must proceed hand in hand with an effort to retain those who become affiliated with the field. Researchers have reported that well-designed, intentional educational activities and programs promote student persistence in educational settings, in general (Koch et al., 2019), and minority students' persistence and engagement in science, in particular (Asempapa et al., 2021; Camacho et al., 2021; Carpi et al., 2017; Davis & McIntosh, 2020; Esparza et al., 2020; Hernandez et al., 2018a,b; Hudson et al., 2018; Ikuma et al., 2019; Koch et al., 2019; Odera et al., 2015; Trott et al., 2020). For instance, in a program that targeted undergraduate juniors and seniors from underrepresented minority groups, quality mentorship and hands-on research experiences helped students identify with science and persist in the field (Hernandez et al., 2018b). An after-school STEM curriculum encouraged African American and Hispanic teenage, female students to stay in

STEM fields and develop STEM career plans (Koch et al., 2019). Currently, there is a national consortium of undergraduate research training programs that aims to enhance the diversity of the nation's health-related research workforce by strengthening career aspiration and interest in health-related research in underrepresented minority students. These programs have achieved their shared goal of preparing diverse trainees for health-related careers (e.g., Camacho et al., 2021; Foroozesh et al., 2017; Kingsford et al., 2022; Saetermoe, et al., 2017; Vu et al., 2023).

At an individual level, studies have investigated psychological factors that are associated with students' success in those educational activities and programs. Their findings indicated that students from diverse backgrounds commit to STEM when they embody a solid science identity. According to Carlone and Johnson (2007), a strong science identity emerges when learners become confident about (a) understanding science concepts (competence), (b) demonstrating science-related skills (performance), and (c) being regarded by others, particularly by those in the field of science, that they perform science-related tasks well (recognition). When learners solidify such confidence, they build a sense of belonging in STEM and come to see themselves as a "science person" (Carlone & Johnson, 2007; Hazari et al., 2017; Hudson et al., 2018; Robinson et al, 2018; Stets et al. 2017; Syed et al., 2019).

Studies have shown that a strong science identity (a) predicts science achievement and engagement of underrepresented students, including first-generation college students (Chen et al., 2021; Gholson & Wilkes, 2017); (b) helps those students persist in STEM (Estrada et al., 2011, 2018; Jelks & Crain, 2020); and (c) empowers African American community college students to persist as STEM majors at a four-year university (García et al., 2019). Thus, a more diverse, robust, and healthy STEM workforce could emerge when students from diverse backgrounds build a solid science identity. When individuals feel increasingly more connected with the culture of science and build more confidence in their science abilities, they come to select career options that are aligned with their interests and skills in science (Eccles, 2009; Oyserman, 2015). Moreover, students with a sound science identity would persist in STEM, as the science identity would fuel their efforts to succeed in the field (McDonald et al., 2019). According to the model of career self-management (e.g., Lent & Brown, 2013; Lent et al, 1994), individuals actualize career decision by learning and building self-efficacy and outcome expectations, and then setting career goals, making actions, and ultimately attaining the goals. Attaining career goals is easier if personal and contextual factors support the learners' efforts, and a sound science identity positively affects their self-efficacy and outcome expectations (Byars-Winston & Rogers, 2019).

Since science identity promotes science achievement, interest, motivation, engagement, persistence, as well as career interest and career goals in science, educators would benefit if they understood the mechanisms underlying the development of a solid science identity. In that light, McDonald et al. (2019) presented a simple but informative model that describes how science identity is cultivated. The model posits that science identity is solidified as learners merge two different states of identities: that is, (1) the current state (i.e., actual identity) and (2) the potential state (i.e., designated identity, possible self, or the image of STEM professionals). When the overlap between the actual identity and the designated identity is substantial, an individual has acquired a solid science identity, whereas when the overlap remains minimal, the individual has a weak science identity. In relation

to processes where the two states of identities are merged, McDonald et al. (2019) contended that the two identities become aligned by way of educational choices, efforts, and outcomes that would unite the two identities. This simple model is useful as it reveals how a science identity is cultivated.

However, this model does not explain if and how the magnitude of science identity changes when the two identities are increasingly more aligned while being supported by important educational opportunities, efforts, choices, and outcomes. Moreover, the model does not describe the roles that science identity and educational choices/outcomes would play in predicting science-related outcomes in a larger context (e.g., learning, persistence, career decision). In other words, we do not know if both science identity and educational choices/outcomes predict science-related outcomes, or if educational choices/outcomes would not directly predict science-related outcomes as their effects could be reflected in more solidified science identity. Hence, this study was designed to expand our knowledge in these areas.

Specifically, we set our goals in this study to examine: (a) how students who attained positive outcomes from pivotal educational choices (i.e., being accepted into a graduate program) and efforts (i.e., attain a high cumulative GPA) and developed distinct preferences for research within academia differed from their counterparts who did not attain those outcomes, in relation to the magnitude of science identity, (b) if both science identity and pivotal educational outcomes predict the undergraduate students' career aspirations, and (c) how undergraduate participants' minoritized identities (e.g., racial/ethnic identities, financial background), gender, and field of studies interact to impact their decision to pursue a research career in biomedical or behavioral sciences. We defined educational outcomes to be pivotal, if they closely influence the plausibility of them attaining their goal to pursue a research career in biomedical and behavioral sciences. Unique characteristics of our sample helped us test the last goal.

This study used data from trainees in an upper-division research training program targeting underrepresented students, which provided an ideal context for an examination of how trainees' minoritized identities relate to their decision to participate in the STEM workforce. The student trainees were from two disciplinary tracks: (1) behavioral sciences and (2) biomedical sciences. Having the data on the trainees' gender, underrepresented minority status, and disciplinary track enabled an investigation of how those variables interacted to influence student trainees' decision to pursue a research career in biomedical and behavioral sciences. We hypothesized that (a) trainees who attained positive educational outcomes (i.e., high cumulative GPA, acceptance to a graduate program, and/or interest in conducting research in academia) will report stronger (higher levels of) science identity as compared to their peers who did not attain the same outcomes, (b) both science identity and trainees' pivotal educational outcomes will independently predict trainee's decision to pursue a research career in biomedical and behavioral sciences, and (c) trainees' background variables including disciplinary track, gender, and minority status will interact to impact their career decision in the research training program that we examined, in alignment with the persistent trends in the U.S. workforce. We expected that the findings from the present study would have direct implications for undergraduate research training programs, as they strive to cultivate and sustain their trainees' interests in research careers in biomedical and behavioral sciences and their commitment and actions to help them attain careers in those areas.

Current Study

The present study used student training data from a federally funded, large scale undergraduate research training program at a Hispanic- and Asian American Native American and Pacific Islander-Serving university, located in the western United States. The university has approximately 34,000 undergraduate students involving Hispanic/Latino (44%), Asian (20%), White (16%), and African-American, American Indian and others (15%). The primary goal of the training program called the Scholars Program is to promote trainees' career preparation in health-related research fields via a cohort-based learning community and engagement in faculty mentored research (see Vu et al., 2023, for more details). Throughout the two-year program, Scholars acquire extensive research-related knowledge and skills in a learning community, and apply, test and consolidate their knowledge and skills in faculty mentored research.

Moreover, to foster the development of a culturally congruent science identity during the learning community, trainees participate in activities designed to help them foster growth mindset and explore the meaning of being a scientist for themselves, their families and communities, and the broader scientific communities. Trainees are also given opportunities to learn from role models about what it would be like to be a scientist, as part of their research labs/groups or in other venues such as professional conferences. In this vein, the program invites underrepresented minority scientists as colloquium speakers who not only present their research but also share with trainees their personal journey on how they became scientists and what obstacles they had to overcome and how. Trainees also attend minority student focused research conferences such as the annual meetings for the Society for Advancement of Chicanos/Hispanics and Native Americans in Sciences (SACNAS) and the Annual Biomedical Research Conference for Minoritized Students (ABRCMS). These conferences offer inspirational speakers as well as professional development workshops designed to build resilience for underrepresented minority students and strengthen their identification with the sciences. Scholars also apply for and participate in a summer research experience (SRE) at an R1 or other research-intensive organization during the summer between their junior and senior years to widen and solidify their learning. The culminating experience is applying to graduate schools where their graduate training would continue solidifying their knowledge, skills, and dispositions that would help them grow into an independent, competent researcher in their respective health-related field. For all activities throughout the two-year program, Scholar trainees can seek feedback, guidance, and support from the program training directors, faculty research mentors, and near-peer graduate student mentors (for details about near peer mentoring, see Abeywardana et al., 2020).

The Scholars Program has two additional features. First, as mentioned earlier, the program was designed to accommodate a broad range of health-related disciplines, including (a) traditional biomedical disciplines such as biology, biochemistry and chemistry, and biomedical and chemical engineering, and (b) behavioral sciences such as health science, kinesiology, linguistics, nutritional science, sociology and psychology. Second, the program utilizes a strong research curriculum encompassing courses in student majors and program-specific courses to solidify knowledge and skills in such critical areas as literature review, data collection/analyses, presentation skills, grant and manuscript writing, and Responsible Conduct of Research (for more details, see Taing et al., 2022).

Method

Participants

The analytical sample consisted of 97 participants (n = 65 females; 31 males; 1 nonbinary) who completed the two-year Scholars program and took the end-of-program survey (n = 37 for the 2016-2018 cohort, n =28 for the 2017-2019 cohort, and n =32 for the 2018-2020 cohort). Although the sample size of 97 was on a smaller side, it should be noted that the Scholars program has achieved sizable cohorts considering the nature of the federally funded two-year training program. The Scholars program has welcomed 45-50 students per year, as compared to the MARC U-STAR program, which averaged 11 students across universities in 2013 (3-21 students per cohort; Hall et al., 2016). Although our analytical sample involved three cohorts of Scholars, the rates of annual survey completion reduced our sample size to 97. In our analytical sample, there was only one trainee whose gender was coded nonbinary. As there were not enough participants to form a third category alongside male and female in the gender variable, all analyses were conducted after removing the data of the trainee whose gender was nonbinary from the dataset. This provided us with the analytical sample of 96 Scholars. About half (51.0%) of them were from departments in the natural sciences (e.g., biology, chemistry, biochemistry) and engineering (e.g., biomedical, chemical, electrical), also known as the biomedical track. The other half (49.0%) were from departments in social sciences (e.g., psychology, linguistics, international studies) and health sciences (e.g., health science, nutrition and dietetics, kinesiology), also known as the behavioral track. About half (51.0%) were also from underrepresented minority groups for race and ethnicity (i.e., non-Asian or non-White); 76.0% were eligible for financial aid, and 38.5% were first generation students. In relation to ethnicity, more specifically, about two-fifths (42.7%) self-identified as Hispanic or Latinx. The largest self-identified racial group was Asian (32.3%), followed by White (27.1%). About 7.3% self-identified as Black or African American, 3.1% as American Indian or Alaskan Native, and 8.3% as more than one race. The remaining twenty-one participants (21.9%) did not indicate their race; however, all of them self-identified as Hispanic or Latinx for ethnicity.

Data Sources

The end-of-program data were obtained from two sources: (a) a program evaluation survey administered at the end of the two-year Scholars program by an internal evaluation team and (b) an annual evaluation survey administered independently by an external evaluation team. All survey data were collected in accordance with approved Institutional Review Board protocols. Students' gender (female = 1, male = 0) and disciplinary track (biomedical = 1, behavioral = 0) were recorded based on the program record. The following are the other specific measures analyzed in the present study.

Underrepresented Minority (URM) Identities

Students' information for the total count of underrepresented minority (URM) status was obtained from their applications to the Scholars Program. The total count of the URM status was the sum of: Race/ethnicity (historically underrepresented minority = 1, non-minority = 0), financial aid eligibility (yes = 1, no = 0), and first-generation college students (yes = 1, no = 0), with a range of the total score being between 0 and 3. Higher scores

indicated more accumulated underrepresented minority identities.

Pivotal Educational Outcomes

Students' pivotal educational outcomes were measured using three indicators – cumulative GPA, preference for research setting, and graduate school acceptance. Students' cumulative GPA at the end of the senior year was retrieved from the institutional research and analytics office. Preference for research setting that students came to internalize was measured using two items from the program evaluation survey on a 6-point Likert-type scale:

Indicate how likely are you to: (6-point Likert-like scale, where 1 = Extremely Unlikely and 6 = Extremely Likely):

1. Pursue a research career in Academia.
2. Pursue a research career outside Academia.

Finally, the data on the graduate school acceptance was obtained from the program record which specified whether the Scholars were accepted into a master's or doctoral program (yes = 1, no = 0).

Science Identity

Scholar trainee's science identity was measured with three items from a 5-item measure developed by Estrada et al. (2011). The five items of science identity by Estrada et al. (2011) consisted of: "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." Those five items had high internal consistency (alpha = .86).

The annual evaluation survey in the Scholars program included four of these five items, excluding the last item. However, in our prior study, we decided to drop the second item in the evaluation survey as well to ensure strong internal consistency of the science identity measure (Masunaga et al., 2023). The alpha coefficient for four items including the second item was .80, which was substantially lower than the alpha coefficient for three items when that particular item was excluded (i.e.., alpha =.88). Reflecting these findings, the following three items were retained and analyzed in the present study:

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.

As the evaluation survey was conducted annually, two sets of three-item Science Identity measures were available in our analytical sample as well, which consisted of Year 1 and Year 2 measures. However, this study exclusively utilized the items measured at the end of the program (i.e., Year 2 measure) because Year 2 measure is reflective of Scholars' entire experiences within the two-year program. Analyses in our prior study revealed a positive but

modest correlation between Year 1 and Year 2 Science Identity composite scores (i.e., sum of three-item scores) [r = .47, p <.001], suggesting that the overlap between Year 1 and Year 2 Science Identity remained low (Masunaga et al., 2023).

Decision to Pursue a Research Career in Biomedical/Behavioral Sciences

A measure on a 6-point Likert-type scale from the annual evaluation survey was used to determine Scholar's decision to pursue a research career in biomedical/behavioral sciences.

> Indicate how likely you are (6-point Likert-like scale, where 1 = Definitely No and 6 = Definitely Yes): Will you pursue a science-related research career?

Results

Descriptive Statistics

For total count of the URM status, within our analytical sample of 96 participants, 16 Scholars (16.7%) did not meet any of the URM status categories (i.e., score of 0), 27 students (28.1%) each had either the score of 1 or the score of 2, and 26 students (27.1%) had the score of 3 that signified that they were from underrepresented racial/ethnic groups, from families where no other members had attended the college, and eligible for financial aid. Table 1 summarizes descriptive information of the total URM count, cumulative GPA at the end of the senior year, interest in research in academia or non-academia, and Science Identity.

Table 1. Descriptive Statistics

Variable	*M*	*SD*	Range	*alpha*
Total URM Count	1.66	1.05	0 – 3	n/a
Cumulative GPA	3.50	0.29	2.80 – 4.00	n/a
Interest in research in academia	4.48	1.13	1 – 6	n/a
Interest in research in non-academia	4.54	1.33	1 – 6	n/a
Science Identity	12.77	2.39	3.00 – 15.00	.92

When responding to the question "Will you pursue a science-related research career?", 64 Scholars (67.4%) selected "Definitely Yes," along with 25 Scholars for "Probably Yes" and six Scholars for "Uncertain." To avoid having a category with insufficient respondents, two lower categories (i.e., Probably Yes and Uncertain) were combined to form a new category with 31 respondents (32.6%). Thus, a dichotomous variable was formed to indicate students' decision to pursue a research career, involving two groups, i.e., those who would definitely pursue a research career in health-related fields, and those who would probably do so or were not certain about their career choice.

Participants' Characteristics

To foster our understanding about the characteristics of our analytical sample, two independent-samples t-tests

and one chi-square analysis were conducted to examine how Scholars' background variables, including URM identities, gender, and disciplinary track, related to each other. The t-tests were carried out including total count of the URM status as the dependent variable and gender and disciplinary track (biomedical vs. behavioral sciences) as grouping variables, and the chi-square analysis tested the relationship between gender and track. As seen in Table 2, neither disciplinary track nor gender was significantly related with the total URM count. However, gender and disciplinary track were significantly associated (see Table 3). In line with the persistent trends in sciences (e.g., NCSES, 2021; 2023), the females were more prevalent in the behavioral track than in the biomedical track, whereas significantly more males were prevalent in the biomedical track, as compared with the behavioral track.

Table 2. t-tests with Total URM Count as Dependent Variable

Grouping Variables		*M*	*SD*	*t(94)*	p-value
1. Track	Behavioral	1.81	1.04	1.39	.167
	Biomedical	1.51	1.06		
2. Gender	Male	1.35	1.11	-1.96	.053
	Female	1.80	1.00		

Table 3. Chi-Square between Disciplinary Track and Gender

		Track				
		Behavioral n (%)	Biomedical n (%)	Total n (%)	Chi-Square	p-value
Gender	Male	5 (16.1%)	26 (83.9%)	31 (100.0%)	19.75	< .001
	Female	42 (64.6%)	23 (35.4%)	65 (100.0%)		
	Total	47 (49.0%)	49 (51.0%)	96 (100.0%)		

Testing Research Question 1

To test our first research question, an independent-samples t-test was conducted to examine how the levels of Science Identity differed between those who attained a pivotal outcome from their educational choice (i.e., being accepted into a graduate program) and their counterparts who failed to attain the positive outcome. Out of 96 Scholars, 42 (43.8%) were accepted into a Ph.D. program and 42 (43.8%) were accepted into a Master's program, where those who were accepted into a Master's program largely differed from those who were accepted to a Ph.D. program. When Master's programs and Ph.D. programs were combined, 71 trainees (74.0%) successfully gained acceptance into a graduate program.

The t-test results indicated that student trainees' Science Identity did not differ between the two groups (see Table 4). Namely, acceptance into a graduate program, or a successful outcome from pivotal educational choices/efforts, did not influence the magnitude of Science Identity. Thus, the results from this analysis did not support our first hypothesis that trainees who attained positive educational outcomes will report stronger (i.e., higher levels of) science identity as compared to their peers who did not attain the same outcomes.

Table 4. t-tests on the Magnitude of Science Identity

Grouping Variables		*M*	*SD*	*t(94)*	p-value
Accepted to a Graduate Program	No	12.92	2.61	0.36	.719
	Yes	12.72	2.32		

A correlation analysis was also conducted to examine how the other two educational outcomes (1. Cumulative GPA and 2. Preferences in conducting research either in academia or non-academia) were related to Science Identity. Correlation coefficients and their significance are reported in Table 5. Out of three variables in this analysis (i.e., GPA, Interest in research in academia, and Interest in research in non-academia), only trainees' interest in research in academia was significantly but weakly correlated with Science Identity (r=.22). It is seen that the data minimally support our hypothesis that higher levels of interest in research within academia, instead of non-academia, is associated with a stronger science identity.

Table 5. Correlation with Science Identity

	1	2	3	4
1. GPA	1.00			
2. Interest in Research in Academia	-.06	1.00		
3. Interest in Research in Non-Academia	-.13	.08	1.00	
4. Science Identity	-.16	.22*	.07	1.00

Note: * significant at the .05 level (2-tailed).

Testing Research Questions 2 and 3 in a Hierarchical Logistic Regression Analysis

A hierarchical logistic regression analysis was performed to test the remaining two research questions. The dichotomous dependent variable in the logistic regression analysis was derived from trainees' responses to the question "Will you pursue a science-related research career?" (i.e., either "uncertain/probably yes" or "definitely yes"). Table 6 shows the results from the two blocks/models and reports the unstandardized beta coefficients and odds ratios for each model. Model 1 tested our research question pertinent to the impact of interactions among trainees' minoritized identities (i.e., total URM count), gender, and disciplinary track onto their decision to pursue a science-related research career. Model 2 examined how Scholars' Science Identity and pivotal outcomes from their educational choices and efforts (i.e., being accepted into a graduate program, cumulative GPA at the end of the program, and preferences related to research in academia or non-academia) predicted their decision to pursue a research career in health-related fields, after controlling for the impacts from the interactions among student trainees' minoritized identities, gender, and disciplinary track.

In Model 1, an interaction between disciplinary track and total URM count significantly predicted trainees' decision to pursue a research career. This finding supported our hypothesis, whereas the impacts from the two other interactions were not significant, contrary to our prediction. The odds ratio of 0.59, which is less than 1, for the interaction between track and total URM count indicated that student trainees from the biomedical track (coded as 1) who belonged to more URM status categories were less likely to decide to pursue a research career in

biomedical/behavioral sciences as compared with their counterparts, including those from the behavioral track with equivalent levels of URM status.

Model 2, or a comprehensive model in the analysis, tested if the pivotal educational outcome variables and Science Identity predicted science career decision above and beyond the predictors in Model 1. Results of Model 2 showed that the log odds of decision to pursue a science-related research career are positively and significantly related with both interest in research in academia and Science Identity, when holding the other variables in the model constant. The positive signs of the *B* coefficients for both interest in research in academia and Science Identity indicated that stronger preference in conducting research in academia and higher levels of science identity were associated with firmer decision to pursue a research career in biomedical and behavioral sciences. Thus, the results from Model 2 supported our second hypothesis that both science identity and trainees' pivotal educational outcomes will independently predict trainee's decision to pursue a research career in biomedical and behavioral sciences. The final model, which posited interest in research in academia and Science Identity as significant predictors of Scholars' decision to pursue a science-related research career, explained about 30% of the variance in the dependent variable (Nagelkerke R^2 = .306), and accurately classified 72.6% of participants into their observed groups.

Table 6. Logistic Regression Analysis Predicting Science Career Decision

	Model 1		**Model 2**	
Predictor	*B*	Exp(B)	*B*	Exp (B)
Constant	1.21	-	0.70	-
Gender * Track	0.76	2.13	0.24	1.27
Gender * URM Total Count	0.00	1.00	-0.24	0.79
Track * URM Total Count	-0.52**	0.59	-0.41	0.66
Accepted into a Graduate Program			-0.64	0.53
Cumulative GPA			-1.56	0.21
Interest in Research in Academia			0.44*	1.55
Interest in Research in Non-Academia			0.16	1.18
Science Identity			0.28*	1.32
Chi-square	7.81		23.56**	
	df = 3, p = .05		df = 8, p < .01	
Nagelkerke R Square	0.110		0.306	

Discussion

The results from this study revealed some important characteristics of science identity. First, the results from a logistic regression analysis showed that when entered side by side in the analysis, both Science Identity and outcome from a pivotal educational choice (i.e., preference in research within academia, but not in non-academia) independently predicted Scholars' commitment to pursue a research career in biomedical or behavioral sciences. Cumulative GPA or acceptance into a graduate program were not significant predictors. This finding would

suggest that in their effort to help students persist in science and ultimately decide to pursue a research career therein, research training programs should build an intensive and intentional program where student trainees are guided well to cultivate and maintain science identity and supported well to build a strong interest in research particularly in academia. As described by McDonald et al. (2019), educational outcomes could influence the development of a science identity; however, our results showed that they could also impact trainees' career decision. It is possible that non-significant results of cumulative GPA and acceptance into a graduate program are ascribable to the unique characteristics of our analytical sample where the range of cumulative GPA was rather restricted, with the mean GPA of 3.50, and 74% of the trainees were accepted into a graduate program upon the completion of the Scholars program. In a future study that could afford a larger sample, the educational outcome variables with wider variances should be identified and analyzed to solidify the examination of how outcomes from educational choices and efforts impact trainees' decision to pursue a science-related research career.

In relation to the nature of science identity, an additional intriguing finding was reported in Table 4, which showed that the magnitude of science identity did not differ between those who were accepted into a graduate program and their counterparts who were not accepted into a graduate program. This result might suggest that solidifying a science identity does not necessarily proceed hand in hand with the enhancement of its magnitude. However, future studies are needed to systematically investigate what factors might influence changes in the magnitude of science identity, and once again to examine group differences on science identity involving a grouping variable that more widely distribute trainees into different categories (i.e., instead of 74% of participants being accepted into a graduate program, as in our present analysis). In addition, as argued by McDonald et al. (2019), (a) identity is a dynamic entity that is constantly shaped and reshaped under the influence from social contexts and educational opportunities, and so (b) a measure of science identity reflects one's science identity at the very moment when the measurement is obtained. If it is so, the relationship between pivotal outcomes of educational choices/efforts and the magnitude of a science identity could be analyzed best if science identity is measured immediately after pivotal outcomes are obtained based on one's educational choices/efforts. As such, we would not be able to make a firm conclusion about the relationships between educational outcomes and the levels of a science identity without considering how social contexts or educational opportunities could have impacted trainees' science identity between the time when they were accepted into graduate programs and at the time when the end-of-program surveys addressed trainees' perceptions about their science identity. Furthermore, science identity was operationalized with three items that mainly assessed respondents' sense of belonging in the field of science in the present study. The results could have been different if science identity was operationally defined with a measure that directly addressed the overlap between the trainees' actual identity and designated identity, as conceptualized by McDonald et al. (2019).

The present study's findings also illuminate how trainees might make career decision at the intersections of their URM and other identities. As seen in Table 6, student trainees from the biomedical track that also belong to more URM groups were less likely to decide to pursue a research career as compared to their behavioral counterpart. This finding signifies a need for targeted interventions to support students who bring in an accumulated URM status, especially in the biomedical track. However, the other two interactions (i.e., gender x track, gender x total URM count) did not significantly predict trainees' career aspirations. The non-significant impact of the gender x

track interaction leads to many thoughts, especially given that our analytical sample had more males in the biomedical track as compared to the behavioral track, and more females in the behavioral field than in the biomedical field (See Table 3). The non-significant impact from the gender x track interaction onto trainees' career decision might imply that the research training program was able to mitigate potential negative impacts from the gender x track interaction. However, before drawing further implications, future studies should carefully examine exactly what elements and activities in a research training program might help trainees from diverse backgrounds solidify science identity and decision to pursue a research career in health-related fields.

Finally, some limitations in the present study also call for a series of further research. For the present study, we analyzed data from trainees who completed the two-year program in 2018, 2019, and 2020 in the spring semesters. Data analyzed were trainees' responses to the surveys administered at the end of the two-year research training program. Although some survey items used in the present study were collected at multiple data collection points, not all participants completed all survey items, and the sample size and variables available for the analyses were substantially reduced when repeated measure analyses were conducted. In future analyses, it would be ideal if student growth could be examined along a longer continuum of time (i.e., from the beginning of Year 1 to the end of Year 2 of the program) with longitudinal data analyses that allow us to test how the construct and variables involved in this study develop over time. It is our future goal to gather data on survey items that are assessed in both Year 1 and Year 2, so we could conduct longitudinal investigations.

Conclusion

This study revealed that both science identity and a pivotal outcome from educational choices/efforts predicted student trainees' decision to pursue a science-related research career. Students who embody stronger science identity made firmer decision to pursue a research career in biomedical or behavioral sciences, and those who developed more intense interest in research in academia made stronger decision to pursue a research career in sciences. This finding could guide future educational practices within research training programs similar to the present study's training program. Especially, the findings signify our continuing effort to provide our diverse undergraduate trainees with well-designed learning opportunities where they could solidify their science identity, prepare for research especially in academia, and prepare for a research career in their relevant STEM fields. Such efforts could also be impactful in attaining our ultimate goal to cultivate a diverse STEM workforce. As demonstrated in our analytical sample derived from the two-year upper-division research training program targeting minoritized students, the interactions between trainees' minoritized identities and gender and between their gender and disciplinary track did not strongly impact their decision to pursue a research career in biomedical and behavioral sciences. Our findings might illuminate one possible type of training programs that could increase STEM participation by females and those who were historically underrepresented in the field.

Acknowledgements

This work was supported by the National Institute of General Medical Sciences of the National Institutes of Health under Award Numbers UL1GM118979, TL4GM118980, and RL5GM118978. The content is solely the

responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health. We thank Ashley Colbern for her assistance with the compilation of data from our program surveys and the HERI surveys.

References

Asempapa, R. S., Morales, A. W., & Agili, S. S. (2021). A quantitative analysis of a customized peer mentoring program with STEM underrepresented students. *Journal of Research in STEM Education, 7*(1), 1–20. https://doi.org/10.51355/jstem.2021.94

Abeywardana, S. U., Velasco, S., Hall, N., Dillon, J., & Chun, C.-A. (2020). Near-peer mentoring in an undergraduate research training program at a large master's comprehensive institution. *Understanding Interventions, 11*(1): The Use and Impact of NIH-fueled Resources for Mentoring—Reports from the Field, 12477.

Avendano, L., Renteria, J., Kwon, S., & Hamdan, K. (2019). Bringing equity to underserved communities through STEM education: Implications for leadership development. *Journal of Educational Administration and History, 51*(1), 66–82. https://doi.org/10.1080/00220620.2018.1532397

Byars-Winston, A., & Rogers, J. G. (2019). Testing intersectionality of race/ethnicity × gender in a social–cognitive career theory model with science identity. *Journal of Counseling Psychology, 66*(1), 30–44. https://doi.org/10.1037/cou0000309

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), ar23. https://doi.org/10.1187/cbe.19-06-0124

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, 44*(8), 1187–1218. https://doi.org/10.1002/tea.20237

Carpi, A. Ronan, D. M., Falconer, H. M., & Lents, N. H. (2017). Cultivating minority scientists: Undergraduate research increases self-efficacy and career ambitions for underrepresented students in STEM. *Journal of Research in Science Teaching, 54*(2), 169–194. https://doi.org/10.1002/tea.21341

Chelberg, K., & Bosman, L. (2019). The role of faculty mentoring in improving retention and completion rates for historically underrepresented STEM students. *International Journal of Higher Education, 8*(2), 39–48. https://doi.org/10.5430/ijhe.v8n2p39

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 & Social Psychology Bulletin, 47*(4), 593–606.

Davis, J, & McIntosh A. K. (2020). Culturally responsive mentoring and instruction for middle school Black boys in STEM programs. *Journal of African-American Males in Education, 11*(2).

Eccles, J. (2009). Who am I and what am I going to do with my life? Personal and collective identities as motivators of action. *Educational Psychologist, 44*(2), 78–89. https://doi.org/10.1080/00461520902832368

Eisenhart, M., & Allen, C. D. (2020). Addressing underrepresentation of young women of color in engineering and computing through the lens of sociocultural theory. *Cultural Studies of Science Education, 15*(3), 793–824. https://doi.org/10.1007/s11422-020-09976-6

Esparza, D., Wagler, A. E., & Olimpo, J. T. (2020). Characterization of instructor and student behaviors in CURE and Non-CURE learning environments: Impacts on student motivation, science identity development, and perceptions of the laboratory experience. *CBE—Life Sciences Education, 19*(1), ar10.

Estrada, M., Hernandez, P. R., & Schultz, P. W. (2018). A longitudinal study of how quality mentorship and research experience integrate underrepresented minorities into STEM careers. *CBE–Life Sciences Education, 17*(1), ar9–. https://doi.org/10.1187/cbe.17-04-0066

Estrada, M., Woodcock, A., Hernandez, P. R., & Schultz, P. W. (2011). Toward a model of social influence that explains minority student integration into the scientific community. *Journal of Educational Psychology, 103*(1), 206–222. https://doi.org/10.1037/a0020743

Foroozesh, M., Giguette, M., Morgan, K., Johanson, K., D'Amour, G., Coston, T., & Wilkins-Green, C. (2017). Building integrated pathways to independence for diverse biomedical researchers: Project Pathways, the BUILD program at Xavier University of Louisiana. *BMC Proceedings, 11*(S12), 28.

Fry, R., Kennedy, B., & Funk, C. (2021, April 1). *STEM jobs see uneven progress in increasing gender, racial and ethnic diversity.* https://www.pewresearch.org/science/2021/04/01/stem-jobs-see-uneven-progress-in-increasing-gender-racial-and-ethnic-diversity/

García, H. A., Hotchkins, B. K., & McNaughtan, J. (2019). "Why Not?": How STEM identity development promotes Black transfer and transition. *The Journal of Negro Education, 88*(3), 343–357.

Gholson, M. L., & Wilkes, C. E. (2017). (Mis)Taken identities: Reclaiming identities of the "Collective Black" in Mathematics education research through an exercise in Black specificity. *Review of Research in Education, 41*(1), 228–252. https://doi.org/10.3102/0091732X16686950

Hall, A. K., Miklos, A., Oh, A., & Gaillard, S. D. (2016). *Educational outcomes from the Maximizing Access to Research Careers Undergraduate Student Training in Academic Research (MARC U-STAR) Program.* Retrieved from https://www.nigms.nih.gov/News/reports/Documents/MARC-paper031416.pdf.

Hazari, Z., Brewe, E., Goertzen, R. M., & Hodapp, T. (2017). The importance of high school Physics teachers for female students' Physics identity and persistence. *The Physics Teacher, 55*(2), 96–99.

Hernandez, P. R., Hopkins, P. D., Masters, K., Holland, L., Mei, B. M., Richards-Babb, M., Quedado, K., & Shook, N. J. (2018a). Student integration into STEM careers and culture: A longitudinal examination of summer faculty mentors and project ownership. *CBE—Life Sciences Education, 17*(3), ar50–ar50. https://doi.org/10.1187/cbe.18-02-0022

Hernandez, P. Woodcock, A., Estrada, M., & Schultz, P. W. (2018b). Undergraduate research experiences broaden diversity in the scientific workforce. *Bioscience, 68*(3), 204–211. https://doi.org/10.1093/biosci/bix163

Holman, L., Stuart-Fox, D., & Hauser, C. E. (2018). The gender gap in science: How long until women are equally represented? *PLOS Biology, 16*(4), e2004956. https://doi.org/10.1371/journal.pbio.2004956

Hudson, T. D., Haley, K. J., Jaeger, A. J., Mitchall, A., Dinin, A., & Dunstan, S. B. (2018). Becoming a legitimate scientist: Science identity of postdocs in STEM fields. *Review of Higher Education, 41*(4), 607–639. https://doi.org/10.1353/rhe.2018.0027

Ikuma, L. H., Steele, A., Dann, S., Adio, O., & Waggenspack, W. N. (2019). Large-scale student programs

increase persistence in STEM fields in a public university setting. *Journal of Engineering Education, 108*(1), 57–81. https://doi.org/10.1002/jee.20244

Jelks, S. M. R., & Crain, A. M. (2020). Sticking with STEM: Understanding STEM career persistence among STEM bachelor's degree holders. *The Journal of Higher Education, 91*(5), 805–831.

Kingsford, L., Mendoza, R., Dillon, J., Chun, C.-A., & Vu, K.-P. L. (2022). Broadening and diversifying the behavioral and biomedical research workforce through early access to an undergraduate research training program. *Understanding Interventions, 13*(2), 1-24.

Koch, M., Lundh, P., & Harris, C. J. (2019). Investigating STEM support and persistence among urban teenage African American and Latina Girls across settings. *Urban Education, 54*(2), 243–273.

Kricorian, K., Seu, M., Lopez, D., Ureta, E., & Equils, O. (2020). Factors influencing participation of underrepresented students in STEM fields: Matched mentors and mindsets. *International Journal of STEM Education, 7*(1), 16. https://doi.org/10.1186/s40594-020-00219-2

Lent, R. W., & Brown, S. D. (2013). Social cognitive model of career self-management: Toward a unifying view of adaptive career behavior across the life span. *Journal of Counseling Psychology, 60*(4), 557–568.

Lent, R. W., Brown, S. D., & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice, and performance. *Journal of Vocational Behavior, 45*(1), 79 –122.

Lock, R. M., Hazari, Z., & Potvin, G. (2019). Impact of out-of-class science and engineering activities on Physics identity and career intentions. Physical Review *Physics Education Research, 15*(2), 020137. https://doi.org/10.1103/PhysRevPhysEducRes.15.020137

Masunaga, H., Chun, C.-A., & Vu, K.-P. L. (2023). Is science identity a predictor or an outcome of learning research skills? Analyses of evaluation data from a training program to enhance research career preparation of diverse undergraduate students. *International Journal of Research in Education and Science (IJRES), 9*(2), 266-282. https://doi.org/10.46328/ijres.3029

McDonald, M. M., Zeigler-Hill, V., Vrabel, J. K., & Escobar, M. (2019). A single-item measure for assessing STEM identity. *Frontiers in Education 4*, 1-15. https://doi.org/10.3389/feduc.2019.00078.

National Science Foundation (NSF). (2020). *Learning the world in discovery and innovation, STEM talent development and the delivery of benefits from research. NSF Strategic Plan for Fiscal Years 2022-2026.* https://www.nsf.gov/pubs/2022/nsf22068/nsf22068.pdf

National Center for Science and Engineering Statistics (NCSES) (2021). *Women, minorities and persons with disabilities in science and engineering. Special Report NSF 21-321.* https://ncses.nsf.gov/pubs/nsf21321/report

National Center for Science and Engineering Statistics (NCSES) (2023). *Diversity and STEM: Women, minorities, and persons with disabilities 2023. Special Report NSF 23-315.* https://ncses.nsf.gov/wmpd.

Odera, E., Lamm, A. J., Odera, L. C., Duryea, M., & Davis, J. (2015). Understanding how research experiences foster undergraduate research skill development and influence STEM career choice. *North American Colleges and Teachers of Agriculture, 59*(3), 180–188.

Ong, M., Smith, J. M., & Ko, L. T. (2018). Counterspaces for women of color in STEM higher education: Marginal and central spaces for persistence and success. *Journal of Research in Science Teaching, 55*(2), 206–245.

Oyserman, D. (2015). Pathways to success through identity-based motivation. Oxford University Press.

Robinson, K. A., Perez, T., Nuttall, A. K., Roseth, C. J., & Linnenbrink-Garcia, L. (2018). From science student to scientist: Predictors and outcomes of heterogeneous science identity trajectories in college. *Developmental Psychology, 54*(10), 1977–1992. https://doi.org/10.1037/dev0000567

Saetermoe, C. L., Chavira, G., Khachikian, C. S., Boyns, D., & Cabello, B. (2017). Critical race theory as a bridge in science training: The California State University, Northridge BUILD PODER program. *BMC Proceedings, 11*(S12), 21–21. https://doi.org/10.1186/s12919-017-0089-2

Stets, J. E., Brenner, P. S., Burke, P. J., & Serpe, R. T. (2017). The Science Identity and entering a science occupation. *Social Science Research, 64,* 1–14. https://doi.org/10.1016/j.ssresearch.2016.10.016

Syed, M., Zurbriggen, E. L., Chemers, M. M., Goza, B. K., Bearman, S., Crosby, F. J., Shaw, J. M., Hunter, L., & Morgan, E. M. (2019). The role of self-efficacy and identity in mediating the effects of STEM support experiences. *Analyses of Social Issues and Public Policy, 19*(1), 7–49.

Taing, A., Nguyen-Rodriguez, S., Rayyes, N., Marayong, P., & Buonora, P. (2022). Student perceptions of undergraduate research-infused courses. *Understanding Interventions, 13(1),* 1-21.

Trott, C. D., Sample McMeeking, L. B., Bowker, C. L., & Boyd, K. J. (2020). Exploring the long-term academic and career impacts of undergraduate research in geoscience: A case study. *Journal of Geoscience Education, 68*(1), 65–79. https://doi.org/10.1080/10899995.2019.1591146

Vu, K.-P., Mendoza, R., Chun, C.-A., Dillon, J., & Kingsford, L. (2023). The CSULB BUILD Scholars Program: A research-intensive upper-division program to broaden and diversify the behavioral and biomedical research workforce. *Understanding Interventions, 14*(1), 1-37.

Webb, R. M., Lubinski, D., & Benbow, C. P. (2002). Mathematically facile adolescents with math-science aspirations: New perspectives on their educational and vocational development. *Journal of Educational Psychology, 94*(4), 785–794. https://doi.org/10.1037/0022-0663.94.4.785

Author Information

Hiromi Masunaga (Corresponding Author)
https://orcid.org/0000-0001-8801-8114
California State University Long Beach
1250 Bellflower Blvd., Long Beach, CA
U.S.A.
Contact e-mail: *Hiromi.Masunaga@csulb.edu*

Chi-Ah Chun
https://orcid.org/0000-0002-1902-450X
California State University Long Beach
1250 Bellflower Blvd., Long Beach, CA
U.S.A.

Kim-Phuong L. Vu
https://orcid.org/0000-0003-1823-1555
California State University Long Beach
1250 Bellflower Blvd., Long Beach, CA
U.S.A.