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Undergraduate Research Engagement Among STEM Majors

Susan Carol Losh* and Brandon J. O. Nzekwe
Florida State University | Tallahassee FL 32306
*(*E-mail: slosh@fsu.edu)*

Abstract: We examine facets of a researcher identity and attitudes towards a research career among several hundred physical and life science, engineering and mathematics (STEM) undergraduates at a large public Southeastern university We address how a researcher identity and researcher career attitudes relate to student awareness of university research opportunities, interest and research involvement. Special attention is paid to first generation college students and major undergraduate field, and to the effects of gender and ethnicity. Gender, ethnicity, college major, and first generation college student status influence facets of a researcher role-identity. The results may help explain undergraduate attitudes toward and identification with prospective STEM occupations as well as student awareness, interest, and involvement in research.

Key Words: STEM.

INTRODUCTION

Undegraduate research experiences, i.e., activities enabling students to perform intellectual investigations that contribute to disciplinary knowledge, are high-impact education practices. Through senior theses, research assistantships, internships, or independent projects, "apprentices" may review literature, assist in data collection or data analysis [1] in an interactive process with professionals [2].

Research engagement is one form of student involvement in college academic and social aspects that predicts persistence in college, baccalaureate completion or advanced degree aspirations [2-8], partly as a result of engagement and interaction with faculty. Research experiences can promote career marketability and career identification. Some pundits even assert that *all* undergraduates should have research opportunities [9,10], yet overall by senior year only about 20% have participated [11].

We address *researcher identity salience and career attitudes* among science, math and engineering (STEM) undergraduates, which may help explain how potential professionals pursue and sustain career goals. We study how student knowledge about research opportunities, interest, and their experiences relate to identifying as a researcher and career attitudes. We consider or control the effects of gender, ethnicity, college class level, and first generation college status, comparing physical science, life science, engineering, and computational science majors.

BACKGROUND

Many scholars believe that undergraduate research participation provides educational and career advantages [2,5,12,13], but few examine *why* students participate or *who* participates [3,10,14]. Fewer still have studied whether students identify with a future research career [15,16]. Most such studies focus on STEM majors, as we do here.

Undergraduate research involvement. In seeking to invigorate undergraduate studies, the Boyer Commission [17] proposed that student research involvement assume a central role (see also, American Council of Learned Societies, 2007; National Survey of Student Engagement, 2007) [18,19]. Federal initiatives now encourage such experiences, e.g., the National Science Foundation (NSF) sponsors Research Experiences for Undergraduates in diverse areas.

Such activities let students more closely identify with research-intensive careers [2,13]. Theoretically, we define the extent of this identification as *researcher role-identity salience*, i.e., whether someone aspires to a researcher role and is motivated to perform role anticipatory behaviors [20,21,22].

Research participation can foster *situated learning* [1] and shape a researcher role-identity by refining and/or modifying attitudes and stabilizing student identities as prospective occupational incumbents [2]. Research experience enables undergraduates to learn first-hand *in context* [23,24], not only teaching them *how* to do research, but also providing a practice forum through authentic apprenticeships [12,13].

Why don't more undergraduates participate? Many say that they lack time or interest, underestimate the importance of research, are unaware of opportunities, or see few incentives [10,14]. Students who do engage in research tend to be more motivated, knowledgeable about opportunities, or initially more interested [25,26], suggesting self-selection effects, and a reciprocal relationship between research interest and behavior.

Science and technology students. Undergraduate STEM majors form one-third of baccalaureates [27]. Concurrently, the STEM workforce has expanded: its 2004 to 2007 growth (3.2%) doubled that of the U.S. labor force, partly due to new areas (e.g., forensic anthropology), greater supply, immigration, and relatively low scientist and engineer retirements [27]. Thus, STEM undergraduates face a competitive labor market in which research experience can confer a competitive edge.

Undergraduate research interns report that these experiences clarify career interests [12,13], increase research understanding, and foster ethical behavior *in situ* [2,3]. They also express how peer, mentor, and faculty interaction create a perceived acceptance within a science community. These gains often translate into positive attitudes toward working as a researcher. Given a strong science research tradition, frequent science undergraduate participation is unsurprising [9,10,28,29].

Conceptual foundations: Researcher role-identity. A legitimate peripheral participant's transition to full membership within a community of practice entails a process of *role-identity development* [24] through situated learning [23,30]. For example, undergraduate interns enact the role-behaviors of a research scientist [2]. *Role-identity* describes role ownership through such conduct and self-identification [22,31]. When individuals use social roles as behavioral blueprints and self-defining mechanisms, roles become identities [20].

Role-identity salience describes hierarchically positioning discrete role-identities within the self-concept. Intrinsic and extrinsic gratifications achieved through performing valued role-behaviors can influence role-identity salience [31]. By enacting behaviors consistent with the social expectations of a role-identity, an individual expresses how they want others to regard them [32]. Students incline toward activities aligned with self-perceptions, making the self-concept germane to career decisions [21], e.g., joining science clubs or assisting with a professor's research, all in the expectation of becoming scientists.

Situated role-identities activate when behavior is oriented toward a particular social role [32,33]. Empirical research suggests that role-identity salience relates to: role importance, self-perceived others' expectations about one's role enactment; commitment to a role through contingent social relationships, and involvement to role-related activities [30]. Callero's (1985) study about blood donors presents quantifiable measures of role-identity salience, which we draw upon for our present study [20].

Individual actions provide a platform that others use to judge when appropriate role-behaviors are performed [34]. Thus, the evaluations of important others may support individuals in these behaviors. If an individual vacates a particular role, they may incur social losses because many of their important relationships were predicated on role occupation [20,22,35,36]. Hurtado et al. [16] argue that undergraduate research experiences foster mentor and peer support networks for students seeking further research involvement. Commitment also exists in research efforts, especially the allocation of discretionary time [20,30,37,38].

Career Attitudes. Gender, ethnicity, and first generation college status influence role identities. Some indirect evidence comes from research on undergraduate career attitudes, which has one focus on increasing female and minority representation in the sciences [16,39-41]. For example, Carlone and Johnson [15] found that being recognized as a "science person" by others helped strengthen women's science identities.

Sex stereotypes about "appropriate" gender occupations begin at least by elementary school [7,42,43], continuing into middle school [44,45,46]. Other evidence suggests that African-American, Hispanic American, or working class students, who are more often first generation undergraduates, become more easily discouraged in college science courses (e.g., see Harackiewicz, Canning, Tibbetts, Giffen, Blair, Rouse, & Hyde, 2013)[47].

RESEARCH QUESTIONS

1. How do researcher identity salience and research career attitudes relate to awareness, interest, and involvement in research activities among undergraduate STEM majors?
2. How do awareness, interest, involvement, researcher identity salience, and research career attitudes compare among physical or life sciences, engineering and mathematics majors?
3. How do gender, ethnicity, first generation college student status, and college year relate to researcher identity and career attitudes?

We anticipate that STEM majors *interested* in research will *know more* about undergraduate research opportunities; *interest* and *awareness* should positively correlate with *involvement*, which in turn should positively correlate with a r*esearcher identity*. Such an *identity* should correlate with *positive research career attitudes*.

METHODS

Under the auspices of a public southeast university Office of Undergraduate Research, all undergraduates (N = 30,744) in Spring, 2013 received an email invitation to complete an online survey on "undergraduate experiences". Items tapped demographics, attitudes toward research and a research career, and research experience. We collected data over four weeks with several email reminders sent by the university; 7,469 undergraduates (24%) completed virtually all the questionnaire.[1] Through the university office, which not only fielded the survey but also provided basic information on major, gender, ethnicity, and other variables, we can identify areas of survey over and under response to compare with self-reports.

We categorized majors according to the university's schools and colleges, augmented with information from the NSF's *Science and Engineering Indicators* (2014)[27]. Because there would be too few cases for multivariate analyses, we did not use finer divisions. **Physical science** majors included: biochemistry, chemistry, geology, meteorology and physics; biological sciences constituted the **life science** majors. **Engineering** included chemical, civil, computer, electrical, environmental, industrial, and mechanical engineering, and **computational sciences** included actuarial science, biomathematics, computer science, mathematics, and statistics.

Participants. Here, we concentrate on 1539 physical science, life science, engineering and mathematics undergraduates, who completed most of the online questionnaire. Table 1 presents basic data for these participants. With the exception of an overrepresentation of Asian-American students (who more often choose STEM majors in the university) and a slight underrepresentation of White American students, gender and ethnic distributions reflect the larger university. Perhaps indicating their desire to learn more about research opportunities, freshmen aspiring STEM majors are overrepresented, while upper classmen are underrepresented. In proportion to their numbers among university STEM majors, life sciences students are overrepresented while engineering and math majors are underrepresented. Nearly half (44%) were first generation college students.

Measures. We operationalized *researcher role-identity* through: *CENTRALITY* (role-identity importance); *CONSTRAINED* (self-perceived expectations of significant others); *CONNECTED* (interpersonal connections through research activities); and *COMMITED* (time and involvement in research activities). These measures were derived from Burke and Reitzes, Callero, Stryker and Serpe, and Thoits [20,30,37, 48].

To tap attitudes toward a research career, we slightly revised items that we had previously used listing "scientist" instead of "researcher" [49]. We could not find an "attitudes toward a research career" scale—indeed it is difficult even to find a measure of attitudes toward a *science* career [50].[2] Thus, we adapted items from Fraser's (1981) Test of Science Related Attitudes (TOSRA)[51], and added single items on awareness, interest, and overall participation in undergraduate research activities, and the likelihood of choosing a research career. Table 2 displays these items. Independent variables include: gender; ethnicity; and first generation college student status. We code college major as physical sciences, life sciences, computational sciences, and engineering.

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[1] We lose about one-sixth of this group on several research items, probably reflecting low familiarity, especially among younger students.

[2] Many instruments measure student attitudes toward science (e.g., Aikenhead & Ryan, 1992), but do not address assuming a science career.

Table 1: Demographic comparison of all university undergraduates with study STEM participants

Categories		All univ. undergraduates		Study participants	
		N = 30,744	%	n = 7,469	%
Gender	Women	**16,952**	**55.1%**	**824**	**53.5%**
	Men	**13,792**	**44.9**	**715**	**46.5**
Race/ Ethnicity	Asian/Pacific Islander	1,138	3.7%	103	6.7%
	Black/African American	3,074	10.0	136	8.8
	Hispanic/Latino	4,946	16.1	260	16.9
	Native American	341	1.1	15	1.0
	White/Caucasian	20,818	67.7	1005	65.3
	Other/Unspecified	427	1.4	20	1.3
Academic Classification	Freshman	3,216	10.5%	556	22.0%
	Sophomore	6,293	20.5	1,382	18.6
	Junior	8,960	29.1	2,069	24.2
	Senior	12,260	39.9	3,460	35.2
Academic Field	Physical sciences	956	17.0%	262	16.9%
	Life sciences	1,948	34.7	517	42.8
	Engineering	1,704	30.3	376	24.3
	Computational sciences	1,011	18.0	246	16.0

DATA ANALYSIS

We created salience and career attitudes indices from Confirmatory Factor Analysis (CFA) model loadings,[3] shown with the items in Table 2. Cognizance, Interest, Experience, Identity, and (career) Choice are single items (Table 2).

Thirty-five percent of these STEM students had research participation, slightly (but not significantly) more prevalent among men (36%) than women (33%). Asian American students most often participated in research (44%), followed by White (36%), Latino/a (31%) and Black American (26%) students ($X^2_{(3)} = 9.72$, p = .02; Cramer's V = 0.08). Continuing generation students more often engaged in research than first generation collegiates (37 vs. 31%, p < .01; Cramer's V = 0.07). Forty-four percent of physical science majors participated in research, compared with 36% of life science students, 34% of engineering majors and only 20% of computation science majors ($X^2_{(3)} = 36.23$, p < 0.001; Cramer's V = 0.15). Participation increased steadily from freshmen (18%) through fifth year seniors (50%; $X^2_{(4)} = 103.57$, p < 0.001; Cramer's V = 0.26). ***Bivariate correlations among cognitive items*** are shown in Table 3. All correlations are positive; some are exceptionally strong. Generally, correlations for felt expectations from others to enter research more strongly correlate with identity salience and the likelihood of a research career (but *not* with positive career attitudes) than those with one's social networks through research. These students indeed may feel constrained by expectations, perhaps from family, to become research scientists even if their feelings about that career are lukewarm. Correlations among the Centrality, Constrained and Committed indices are high, and exceed those for research Connections, suggesting that for undergraduate STEM majors, current social relations (e.g., faculty) play a lesser part in keeping students on a path to a research career than supposed.

[3]The model for this study had a $X^2_{(66)} = 482.89$, p < 0.001, a CFI and a TLI both greater than 0.95, a RMSEA index under 0.05, and an SRMR under 0.1. Because the Likelihood ratio Chi-square, like all probability distributions, is sensitive to sample size, we first identified this model using a hypothetical sample size of 500, which produced $X^2_{(66)} = 55.88$, p = 0.808, which, if anything, was "over fitted".

Table 2: Questionnaire items used in this study Factor loadings from Confirmatory Factor Analyses (CFA) are shown in the far left-hand column

Loadings	CENTRALITY of researcher identity	
1.000	SCITHNK	Doing research is something I rarely even think about.
1.480	FEELLOS	I would feel a loss if I were forced to give up doing research.
0.690	NOCLR	I really don't have any clear feelings about doing research.
1.764	IMPTPRT	Doing research is an important part of who I am.

Loadings	CONSTRAINED by perceived expectations of others	
1.000	INTRMS	Many people think of me in terms of being a researcher
1.116	IMPTME	Other people think that doing research is important to me
0.957	FRDSREL	It is important to my friends and relatives that I continue as a researcher
0.703	EXPECT	Many of the people that I know expect me to continue as a researcher
0.606	DISAPPT	Many people would probably be disappointed in me if I just decided to stop doing research.

Loadings	CONNECTED through research activities	
1.000	APRXKNW	Approximately how many people do you know through doing research in your field of study
0.415	IMPTYOU	Of all the people you know through doing research, how many are important to you?
0.394	OTHRACT	Of the people you know through doing research, how many participate in other activities with you?

Loadings	COMMITED through time and research involvement	
0.903	TMSPNT	I spend much of my time doing research.
1.000	HVRSCH	I am heavily involved in research-related activities.

Loadings	CAREER Interest/Attitudes	
0.805	DULBOR	A career in research would be dull and boring.
0.707	INTRSJB	A job as a researcher would be interesting.
0.624	DSLKCAR	I would dislike having a career in research.

Single items	
IDENTITY	Being a researcher is an important part of my identity
Career CHOICE	I am likely to choose a career in research.
COGNIZANCE	How much do you feel you know about undergraduate research activities/programs?
INTERESTED	How interested are you in participating/continuing your participation in research activities?
EXPERIENCE	Have you ever worked with a mentor/faculty supervisor on research-related activities?

Table 3: Correlations among research indices and items

	COGNIZANT	INTEREST	EXPERIENCE	CENTRAL	CONSTRAINT	CONNECTED	COMMITTED	IDENTITY	CAREER	CHOICE
COGNIZANT	1.00***									
INTEREST	0.17***	1.00***								
EXPERIENCE	0.45***	0.13***	1.00***							
CENTRAL	0.32***	0.58***	0.34***	1.00***						
CONSTRAINT	0.28***	0.33***	0.31***	0.60***	1.00***					
CONNECTED	0.29***	0.10***	0.35***	0.28***	0.24***	1.00***				
COMMITTED	0.37***	0.23***	0.42***	0.60***	0.67***	0.35***	1.00***			
IDENTITY	0.23***	0.35***	0.26***	0.62***	0.80***	0.20***	0.60***	1.00***		
CAREER	0.11***	0.48***	0.15***	0.56***	0.35***	0.14***	0.22***	0.40***	1.00***	
CHOICE	0.20***	0.37***	0.22***	0.60***	0.60***	0.20***	0.55***	0.61***	0.58***	1.00***

Minimum n = 1166 *p <.05 **p< .01 ***p< .001

The largest correlations with a research identification and career likelihood are with the felt centrality of doing research, others' expectations, and research involvement. The latter, of course, may be anticipatory socialization to prepare for graduate school or the occupational marketplace. Surprisingly, correlations with career likelihood are lower for knowledge about research opportunities, interest in research engagement—or even research experience.

Bivariate synopses. *Gender and ethnicity.* The effects of gender, ethnicity, college generational status, and major on Cognizance, interest, and participation are shown in Tables 4, 5 and 6. Women STEM majors were as cognizant, interested, and as likely to have had at least some research experience as men. First generation students felt they knew less about research opportunities and (as noted earlier) perhaps as a consequence, participated less often.

Table 4: Mean Score Cognizant Research Opportunities (high = 4)

Correlated Variable	$\bar{y}$	Statistical Results	*n*
Female	2.54	$t_{(1475)} = 0.08$ ns	798
Male	2.54	$\eta = 0.00$	679
White	2.52	$F_{(3,1473)} = 4.62$ $p = .003$	993
African American	2.39	$\eta = 0.10$	134
Hispanic American	2.61		253
Asian American	2.77		97
First generation college	2.43	$t_{(1475)} = 4.10$ $p < .001$	645
Continuing generation	2.62	$\eta = 0.11$	832
Physical science major	2.67	$F_{(3,1473)} = 13.87$ $p < .001$	255
Life science major	2.65	$\eta = 0.17$	629
Engineering major	2.39		359
Computational science major	2.34		234

Table 5: Mean Score Interest in Research Opportunities (high = 4)

Correlated Variable	$\bar{y}$	Statistical Results	*n*
Female	2.86	$t_{(1399)} = 0.15$ ns	759
Male	2.85	$\eta = 0.00$	642
White	2.77	$F_{(3,1397)} = 11.84$ $p < .001$	940
African American	2.75	$\eta = 0.16$	128
Hispanic American	3.17		242
Asian American	3.11		91
First generation college	2.90	$t_{(1399)} = 1.35$ ns	616
Continuing generation	2.82	$\eta = 0.04$	785
Physical science major	3.02	$F_{(3,1397)} = 17.17$ $p < .001$	239
Life science major	3.00	$\eta = 0.19$	596
Engineering major	2.77		340
Computational science major	2.46		226

Table 6: Did Student Participate in Research?

Correlated Variable	% Yes	Statistical Results	*n*
Female	33	$t_{(1516)} = 1.02$ ns	817
Male	36	$\eta = 0.03$	701
White	36	$F_{(3,1479)} = 3.25$ $p = .02$	995
African American	26	$\eta = 0.08$	134
Hispanic American	31		253
Asian American	44		101
First generation college	31	$t_{(1516)} = 2.67$ $p = .008$	666
Continuing generation	37	$\eta = 0.07$	852
Physical science major	44	$F_{(3,1514)} = 12.34$ $p < .001$	269
Life science major	36	$\eta = 0.15$	650
Engineering major	34		368
Computational science major	20		241

Asian American STEM majors felt the most knowledgeable about research opportunities, and nearly half had had a research experience. On the other hand, fewer African American and Latino/a STEM majors had research experience, although Hispanic American students had expressed the greatest interest in research engagement.

Physical and life science majors felt equally knowledgeable and interested in research opportunities than engineering majors, although physical science majors more often had actual research experience. On the other hand, computational science majors were the least interested in research opportunities and were least likely to participate—with less than half the participation rate of physical science majors.

Multivariate analyses. We examine how gender, ethnicity, first generation, student status and major influence facets of a researcher role identity and research career attitudes in a series of n-way analyses of variance. We also control for year in college, since seniors, unsurprisingly, have had more research experience than freshmen.

To illustrate net effects of these variables, we use a presentation program often linked to ANOVA: Multiple Classification Analysis (MCA). MCA adjusts for other correlated factors and covariates in an ANOVA equation, to produce "net effects". MCA is recommended here because several of these predictors are intercorrelated. For example, women were over twice as likely as men to major in a biological science (58 vs. 26%), while men were almost three times more likely to major in engineering (36 vs. 14%) and nearly twice as likely to major in a computational science (21 vs. 11%, $X^2_{(3)} = 192.40$, $p < 0.001$; Cramer's V = 0.35).

Although Asian Americans most often majored in a physical science (24%), while White (24%), Black (29%), and Hispanic (24%) American students more often majored in engineering, these were essentially chance fluctuations ($X^2_{(9)} = 10.61$, $p = 0.30$). However, first generation students more often than continuing generation students majored in engineering (28 vs. 21%) or computational science (20 vs. 13%) but less often majored in life sciences (37 vs. 47%, $X^2_{(3)} = 27.92$, $p < 0.001$; Cramer's V = 0.13). Males were more often first generation students than females (47 vs. 42%, $X^2_{(1)} = 4.24$, $p = 0.04$), and half or more of Black (64%), Hispanic (54%) and Asian (50%) Americans were first generation STEM majors compared with White Americans (38%, $X^2_{(3)} = 46.90$, $p < 0.001$; Cramer's V = 0.18).

Table 7: Basic ANOVA Models on Research Career Cognitions+

Predictor ⇓	Centrality $\bar{\bar{y}}$	Adjusted MCA $\bar{\bar{y}}$	Constraint $\bar{\bar{y}}$	Adjusted MCA $\bar{\bar{y}}$
Female*	14.68	14.50	11.59*	11.98
Male	15.18	15.38	12.20	12.33
White***	14.64	14.66	11.73***	11.74
African American	14.21	14.25	11.31	11.32
Hispanic	15.73	15.68	12.04	12.02
Asian	16.49	16.37	13.70	13.57
First Generation++	14.95	15.02	11.97	12.02
Later Generation	14.88	14.82	11.79	11.75
Physical science***	15.77	15.74	12.52***	12.47
Life science	15.33	15.53	12.10	12.34
Engineering	14.52	14.30	11.46	11.22
Computational science	13.47	13.33	11.17	10.96
η = 0.23	n = 1280		η = 0.21	n = 1262

Predictor ⇓	Connected $\bar{\bar{y}}$	Adjusted MCA $\bar{\bar{y}}$	Committed $\bar{\bar{y}}$	Adjusted MCA $\bar{\bar{y}}$
Female	5.73	5.81	4.47***	4.44
Male	6.50	6.41	4.90	4.94
White	6.42	6.32	4.58***	4.59
African American	5.62	5.57	4.42	4.41
Hispanic	4.43	5.01	4.85	4.86
Asian	7.50	7.15	5.42	5.36
First Generation*	5.06	5.24	4.69	4.70
Later Generation	6.89	6.75	4.66	4.64
Physical science***	7.85	7.71	4.89***	4.86
Life science	6.33	6.84	4.78	4.92
Engineering	5.97	5.66	4.64	4.49
Computational science	3.68	2.96	4.20	4.08
η = 0.28	n = 1147		η = 0.23	n =1276

Predictor ⇓	Identity $\bar{y}$	Adjusted MCA $\bar{y}$	Career Attitudes $\bar{y}$	Adjusted MCA $\bar{y}$
Female**	2.67	2.66	2.36	2.36
Male	2.87	2.88	2.40	2.40
White***	2.71	2.71	2.35***	2.35
African American	2.67	2.68	2.33	2.33
Hispanic	2.84	2.84	2.45	2.45
Asian	3.21	3.18	2.59	2.57
First Generation	2.73	2.73	2.40	2.39
Later Generation	2.80	2.80	2.37	2.37
Physical science**	2.95	2.94	2.52***	2.51
Life science	2.76	2.82	2.36	2.37
Engineering	2.70	2.64	2.33	2.32
Computational science	2.64	2.60	2.37	2.36
η = 0.19	n = 1268		η = 0.14	n = 1279

+Except for "Identity", variables are composites (see Table 2); college class level is a control covariate.
++ Please see text for first generation interaction effects.
*p < .05 **p < .01 ***p <.001

Table 8: Expressed Likelihood of Actually Having a Research Career+

Predictor ⇓	Likelihood Research Career $\bar{y}$	Adjusted MCA $\bar{y}$
Female*	2.82	2.82
Male	2.99	2.99
White	2.87	2.87
African American	2.81	2.82
Hispanic	2.96	2.97
Asian	3.12	3.08
First Generation++	2.90	2.90
Later Generation	2.90	2.90
Physical science***	3.21	3.20
Life science	2.85	2.89
Engineering	2.85	2.81
Computational science	2.78	2.75
η = 0.17		
n = 1279		

+Single item indicator, high likelihood = 5.
++ Please see text for first generation interaction effects.

Male STEM students were more likely than female to see a research identity as central to their identity and more likely to feel high expectations from significant others. Male students also more heavily invested their time and effort in research activities, and were slightly more likely to agree that they would have a research career.

Asian American STEM students rated research as more central to their identity, felt more constrained by others' expectations, were more heavily invested in research activities, viewed a research identity as an "important part" of them, and held more positive attitudes toward a research career. Hispanic American students, currently seen as an under represented group in STEM majors and occupations, were close behind Asian American undergraduates, although they reported knowing the lowest number of individuals through research activities.

Physical science students were clearly the most motivated toward research: research was the most central to them, they felt the greatest level of expectations from others, were the most "connected" through research activities, expended the most time and effort in research activities, had the most positive research career attitudes, and were the most likely to assume a research career. Computational science students were consistently at the other end of the spectrum: feeling the least constrained by others' expectations, the least committed in terms of research time and effort, knew the fewest individuals through research activities, and rated research as the least central to their identity. However, their attitudes about a research career were comparable to life sciences or engineering majors. All the results reported in this section are net of other predictors and college class level.

Generational student status interacted with three other variables. First generation Black, Hispanic, and Asian American STEM majors exerted more time and effort in research activities than continuing generation STEM majors, while first generation White students exerted less ($F_{3,1244}$ = 3.70, p = .011). First generation physical and computation science majors held more positive attitudes about a research career than their continuing generation equivalents ($F_{3,1248}$ = 4.02, p = .007). Male first generation STEM majors rated research careers as more likely than continuing generation males, while female continuing generation STEM majors rated the likelihood of a research career higher than female first generation majors ($F_{1,1247}$ = 3.59, p = .058).

DISCUSSION

We examined attitudes about and experience with undergraduate research, dimensions of researcher role-identity salience, and attitudes toward a research career among science and technology undergraduates. Background factors play some part in research affinity. Despite roughly equal knowledge of opportunities, interest and experience, male students were more involved and had higher researcher role-identity importance than females. It is possible that women, who among our participants were more often life science majors, may be aiming for advanced training in medicine—approximately 50% of medical students and 70% of veterinary students are female—and thus may be planning a clinical, rather than research, career. Future research should ascertain more clearly the career plans of women STEM undergraduates.

Asian American STEM students were consistently the most knowledgeable about and research opportunities, were most likely to have had undergraduate research experience, were the most interested in and behaviorally committed to research activities, and had the most positive research career attitudes. They also reported the greatest expectations from significant others to engage in research. Asian Americans are not generally defined as "under represented" in STEM fields, but Hispanic Americans are. Yet Hispanic students were the most interested in research opportunities, also pursued such experiences, and held positive attitudes about a research identity and career. The "leaky pipeline" for Hispanic American STEM majors may be due in part to their first generation college student status.

Most of our Hispanic and Black American STEM majors were the first generation in their families to attend college. We know from the interaction effects that these minority students are committed and ambitious. However, first generation students overall felt less informed about undergraduate research activities and less often participated.

They more often majored in engineering or computational sciences where undergraduate research opportunities may be less plentiful, and they have smaller social networks resulting from research activities.

First generation students take longer to complete a degree, perhaps because many must work their way through school; time and financial pressures may prevent them from learning more about research opportunities that could interest them—even at exactly the same university as continuing generation students. Because their parents were not college-educated, they may lack prior knowledge about opportunities that could provide not only more career clarification but also a more marketable competitive edge. This fusion of ethnicity and first generation status combine as a barrier that can hinder students from entering careers where they have an intellectual interest and could impede their career progress if they do enter research.

Undergraduate research offices, advisors and other personnel should make special efforts to bring research opportunities to the attention of first generation college students. By doing so, they will also encourage at least some African American and Latino/a students to take fuller advantage of college opportunities and help increase the number of STEM graduates. Coupled with other research evidence about campus engagement, these actions may increase first generation student integration into the college campus and thus support them in their educational persistence to achieve a degree.

We also found significant differences by type of STEM major. In particular, physical and life science majors felt the most knowledgeable and interested in undergraduate research opportunities. A research identity was the most central to them and they more often committed time and energy to research activities. Physical science majors had the largest research-related social networks, and the most positive research career attitudes and plans. Conversely, computational science majors were the least interested, least often participated in undergraduate research, had the lowest centrality of a research identity, and had the smallest research social networks. Certainly there are areas in computational science where undergraduates could engage in research. For example, computer simulations and *Monte Carlo* methods in several computational fields could interest these majors, as could research on critical thinking in mathematics and statistics. Perhaps faculty in these areas do not think of undergraduates as possible junior colleagues, or their efforts are not well-enough publicized to attract students.

LIMITATIONS

This is, of course, one relatively self-selected group of college undergraduates from a southeastern public university. Without further research, we don't know how much our results will generalize.

The undergraduate experience is a prime time to construct an occupational identity and to test activities consistent with that identity that can simultaneously provide marketable knowledge and skills. We initially anticipated that in the early twenty-first century, we would see considerable diversity among students in exploring and engaging in research opportunities and constructing identities that, at least for some, would encourage a research career. However, what we found instead were areas of first generation student "neglect", which may depress Black or Hispanic American entrants into STEM fields as researchers. It is our hope that colleges and universities will provide more outreach and support to increase awareness and participation in the wealth of research opportunities available for undergraduates.

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