Understanding how First-Generation College Students' Out-of-School Experiences, Physics and STEM Identities Relate to Engineering Possible Selves and Certainty of Career Path

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***Abstract*— This full, research category study examines how out-of-school experiences in Grades 9-12 predict first-generation college students' engineering possible selves and certainty of career path. The data for this study came from a large-scale survey on outreach programs which was distributed in first-semester English courses to capture an array of responses from students interested in STEM and non-STEM careers. We used structural equation modeling to examine a set of hypotheses: 1) out-of-school experiences would be mediated by interest and recognition in physics and STEM and no direct effect will be found for out-of-school experiences on physics and STEM identities, 2) these identities subsequently predict engineering possible selves, and 3) engineering possible selves will predict certainty of career path. The results of our structural equation modeling analysis supported our hypotheses, out-of-school experiences alone are not enough to develop an identity as a physics person or STEM person, rather they need to be mediated through recognition by others and an underlying interest. A physics identity and a broad STEM identity were found to significantly predict students engineering possible selves. Engineering possible selves were a significant predictor of first-generation college students' certainty of career path. Future possible selves for first-generation college students have important implications for academic development, integration into their community of practice, retention, and the formation of a future professional identity.**

Keywords—first-generation college students; engineering possible selves, STEM identity; physics identity, structural equation modeling

I. Introduction

Students who come from historically marginalized groups (e.g., racial/ethnic minorities, low income, first-generation college students) are thought to have scarce economic and social resources, which results in different lived experiences compared with privileged students [1]. Students who come from low socioeconomic communities face various structural challenges: they are more likely to attend schools with lower levels of funding and limited science educational learning material [2]. However, out-of-school experiences offer a way to reduce the achievement gap between students from low-income and high-income households, as well as contribute to interest in and understanding of STEM [3]. The experiences students have outside of the classroom can make a difference in what students learn inside the classroom [3].

The Committee on Learning Science in Informal Environments [4] noted that out-of-school learning experiences "include a broad array of settings, such as family discussions at home, visits to museums, nature centers, or other designed settings, and everyday activities like gardening, as well as recreational activities like hiking and fishing, and participation in clubs" [p. 1]. The Committee posited that everyday experiences can be sites for learning science. Participation in out-of-school science environments supports students' interest and motivation to learn about the natural and physical world, engages students with scientific language and tools, and allows students to see themselves as science learners and "develop an identity as someone who knows about, uses, and sometimes contributes to science" [4, p. 4]. Thus, out-of-school experiences appear well-suited to foster first-generation college students' STEM identities.

The development of an identity supports students' future commitments to the engineering field, where students who were further along in their engineering degrees demonstrate stronger engineering identities [5]. Not only does commitment to a discipline result from identifying with the discipline, the process of learning to participate in a community also fosters an identity development in the discipline. Learning is an ongoing process of participating in a community of practice, and becoming a member involves taking on roles, behaviors, and attitudes that are defined and shared within such community [6]–[8]. STEM identities (specifically, physics and mathematics role identities) have been found to predict students' choice of an engineering major [8]. Additionally, students' development of a STEM identity has important

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implications for academic development, integration into their community of practice, retention, and the formation of a future professional identity. Students' identities are influenced in their past and the imagined possibilities of who they can become in the future [9].

However, prior to post-secondary education, most students have little to no direct engineering experience or meaningful exposure to engineering practice [10]. Often high school students who intend to major in a variety of STEM fields take the same mathematics and science courses in their pre-college education, regardless of future intended major. A lack of direct engineering experience makes the development of an engineering identity prior to college more difficult than for other science and mathematics disciplines, such as biology or chemistry, which offer at least some direct, explicit experiences for students in high school [11]–[13].

II. THEORETICAL FRAMING

A. Multiple Identities

Identities are "traits and characteristics, social relations, roles, and social group memberships that define who one is" [14, p. 69]. At any given time, an individual has multiple intersecting and contextually defined identities. These multiple identities interact with each other and, depending on the context or situation, one or a few may become more salient [15]. For example, being "the only one" can often make particular underrepresented identities more salient in an engineering context. First-generation college students live in intersecting multiple social identities e.g., gender and racial/ethnic groups to name a few, and often these identities are marginalized and stigmatized in society and in engineering. Multiple identities are important because all forms of identities (e.g., social, personal, and role identities, discussed below) never operate as mutually exclusive; rather, they interact with each other, depending on the context and the salience of particular identities within that context [15]. It is important to use the multiple identities lens to understand the first-generation college student population because these students have multiple identities as the result of unique lived experiences. These experiences are tied to who students are as individuals and how they position themselves and are positioned by others in the world. The dynamics of students' gender, race/ethnicity, and socioeconomic status cannot be separated and thus should be explored together.

Social identity involves intergroup relations, an individual's connection or categorization with a certain group, i.e., first-generation college student, racial/ethnic minority, and/or woman [8].

Personal identity are a "set of meanings that define the person as a unique individual" [15, p. 124], it helps define who one is. Personal identity can be distinct from social and role identity in that the unique set of meanings can go beyond or are linked one's group member and role identity [14].

Role identity, as described by Stets and Burke [8] involves "acting to fulfill the expectations of a role, coordinating and negotiating interaction with role partners, and manipulating the environment" to meet the needs of the role being acted out [p. 226]. An individual who takes on a role identity (i.e., being a physics person or STEM person) adopts the meanings and expectations that accompany the specific role [8]. Developing a role identity has been defined as "being recognized as a certain 'kind of person,' in a given context" [16, p. 99]. An individual cannot be recognized as a certain kind of person unless she/he makes visible (performs) their competence in particular domains (e.g., physics or broadly STEM; [17]–[20]). However, we know that the accumulation of scientific facts and concepts is not enough to develop an identity as a physics or STEM person; this requires motivation and interest to learn more [21]. Identity in this definition has been measured by three interrelated constructs: *interest* in the subject, feelings of *recognition* by others, and perceptions of *performance/competence* [17]–[19], [22].

B. Possible Selves

Possible selves is a future-oriented outgrowth of an individual's self-concept [15, p. 124] (i.e., individuals' perceptions of their behaviors, attitudes, abilities, or evaluative judgements). The lens of possible selves "provide[s] a goal post for current action[s] and an interpretive lens for making sense of experiences[s]" [23, p. 117]. This identity-based motivation framework states that individuals, for example students, are motivated to act upon the world in ways that are congruent to who they wish to become and wish to avoid becoming [23], [24]. Possible selves can include a personal and/or social identity [24]. For example, when engineering students ask themselves if they can be a college graduate, they are not only asking a personal identity question, but also a social identity question (i.e., Can people like me graduate from college with an engineering degree?).

Students construct future possible selves by analyzing and synthesizing what they know about their own abilities, characteristics, and what they know about the skills needed to attain their future selves (e.g., their goal of becoming an engineer) [11]–[13]. Research has shown that possible selves can motivate students' involvement and persistence in school. Similarly, the possible selves lens has been used to understand how "low-income students of color are able to successfully overcome the well-documented aspirations-achievement gap" [25, p. 58].

C. Career Certainty

To understand career certainty, we borrow the definition of career certainty from Hartung [26], who refers to it as the "degree to which individuals feel confident, or decided, about their occupational plans" [p. 1]. A study of STEM and non-STEM interested students by Cass and colleagues [27], looking at engineering career decisions, found that the largest increase in students' interest in engineering careers occurred during the high school years, with 81% of interested students indicating desire to choose engineering careers by the end of high school. Another study examining how background characteristics of engineering students relate to career certainty and uncertainty found no differences in uncertainty by gender or family goals of working in engineering (career goals) [28]. However, in our prior work, we found a positive interaction effect for having a physics identity and being a first-generation college student in predicting engineering choice of major [29].

III. Research Questions

Based on these theoretical frameworks and the need for research on first-generation college students at the intersections of multiple identities, we explore the following research questions:

1. *Do first-generation college students' out-of-school experiences foster physics and STEM identities?*
2. *What effect do out-of-school experiences have on first-generation college students' future possible selves and choice of an engineering major?*
3. *What gender differences exists for first-generation college students' physics identity, STEM identity, engineering possible selves, and certainty of career path?*

We examined these research questions through a set of incremental hypotheses: 1) out-of-school experiences would be mediated by interest and recognition in physics and STEM, 2) no direct effect will be found for out-of-school experiences on physics and STEM identities, 3) seeing oneself as a physics person and STEM person subsequently predicts engineering possible selves, and 4) engineering possible selves will predict certainty of career path.

IV. Method

In the fall of 2013, a large-scale survey was administered at twenty-three 4-year institutions and four 2-year colleges in students first-semester English courses. Administering the survey in English courses allowed for an array of students interested in STEM and non-STEM careers. The purpose of the survey was to capture how students' out-of-school experiences shaped their career plans. Among the survey measures were out-of-school experiences, STEM-related interest, and STEM identity constructs, and items pertaining to future career satisfaction. A total of 15,847 students completed the paper-pencil survey.

In this analysis, we focused specifically on first-generation college students. A total of 5,754 (36%) of students indicated their parents' level of education as either "less than a high school" diploma," "high school diploma/GED," or "some college or associate/trade degree." We classified these students as first-generation college students. Our classification of first-generation college students is consistent with various reports, i.e., U.S. Department of Education [30] and Higher Education Research Institute [31]. Whereas 8,122 (51%) students indicated both parents level of education was either a "bachelor's degree" or "master's degree or higher" and 1,971 (12%) who did not report parents level of education. Our analysis omitted students who were continuing-generation college students and students who did not report parents level of education.

Students were asked to mark their interest in various STEM and non-STEM careers during middle school, beginning of high school, end of high school, and beginning of college, values were coded as 1—"checked this career" and 0— "did not check this career." Only students' self-reported career interest at the beginning of college were used in this analysis. Of the 5,754 first-generation college students sample, 873 were interested in various engineering careers at the beginning of college (i.e., mechanical engineering, electrical engineering, civil engineering, biomedical engineering, environmental engineering, industrial engineering, general engineering, engineering technologist, computer science). Our analysis focused on first-generation college students interested in the various engineering fields at the beginning of college. From this population, 210 identified as female, 637 identified as male, and 26 did not indicate a gender.

The survey items used in this study included students' responses to the question, "Which of the following interests and experiences did you have while growing up?" Students were asked to mark the grade level (grades 9, 10, 11, and/or 12) in which they had the STEM-related out-of-school experience as shown in Table I. Individual scores (i.e., 1 = marked and 0 = not marked) for each grade level were used to create a composite score comprised of all grade levels to obtain a range from 0 = did not have the experience to 4 = had the experience in all grade levels. This scale allowed us to examine not only the effect of each experience, but also the frequency of the experience on students' career pathways.

Additionally, students were asked to rate "To what extent do you disagree or agree with the following statement" about their various STEM-related identities and possible selves. Single items were used to capture students' overall physics identity: *I see myself as a physics person*, STEM identity: *I see myself as a STEM person,* engineering possible selves: *I see myself as an engineer in the future*, and certainty of career path: *I am certain of my chosen career path.*

TABLE I. STEM-Related Out-of-School Experiences

Tinkered with mechanical devices (e.g., rifle, bow and arrow, car jack, pulleys, wheelbarrow, sewing machine)
Tinkered with electrical devices (e.g., cars, batteries and bulbs, radio, TV)
Mixed chemical/materials. Engaged with chemistry sets, kitchen chemistry
Took care of or trained an animal
Planted seeds, watched plants grow, watched animal behavior, collected things in nature (e.g., butterflies, rocks)
Observed or studied stars and other astronomical objects
Participated in science groups/clubs/camps
Participated in science/math competition(s)
Read/Watched non-fiction science
Read/Watched science fiction
Played computer/video games
Wrote computer programs or designed web pages
Talked with friends or family about science

Three items were used to separately capture students' physics interest, physic recognition, STEM interest, and STEM recognition. A description of the interest and recognition items can be found in Table I. These items were assessed using a 6-point anchored numeric scale of 0—No, not at all to 5—Yes, very much.

A. *Analysis*

First, we examined data for univariate and multivariate normality using skewness, kurtosis, and Mardia's Test. Violations of skewness would indicate a variable has an absolute value of 2.0 or greater and violations of kurtosis would indicate that a variable has an absolute value of 7.0 or greater [32]. These absolute value ranges are based on data with large sample sizes $n > 300$ [33]. Mardia's Test for multivariate normality assess skewness coefficients, kurtosis coefficients, and their corresponding statistical significance [34]. Cronbach's alpha was used to measure construct reliability, alpha values between 0.70 to 0.95 indicate that as a set, the items are closely related [35]. Robust corrections were employed in the case that these tests revealed non-normality in the data.

Structural equation modeling (SEM) was used to test the overall research question about the effects that out-of-school experiences have on physics and STEM identities, and how these identities effect first-generation college students' future possible selves and choice of an engineering major. To conduct an SEM analysis, the measurement model of each latent variable (i.e., physics interest, physics recognition, STEM interest, and STEM recognition) needed to be tested using confirmatory factor analysis. Model fit for the confirmatory factor analysis was assessed using the following indexes: chi-square goodness of fit, comparative fit index (CFI; acceptable values above 0.9), Tucker Lewis index (TLI; acceptable values above 0.9), root mean square error of approximation (RMSEA; values less than 0.05 indicate excellent fit, less than 0.08 indicate moderate fit), and standardized root mean square residual (SRMR; acceptable value is less than 1, where 0.0 would indicate perfect fit) [36]–[38]. Following the verification of model fit, structural model fit was assessed, using the same fit indexes, to test all hypothesis.

Lastly, we examined the relationship between gender (female and male) on the latent variables, physics identity and STEM identity, and the observed indicators, engineering possible selves and certainty of career path, using multiple-indicators multiple-cases (MIMIC) modeling. MIMIC modeling allows for the comparison of latent means and is fitted similar to an SEM [39]. All analysis was conducted using the R programming statistical software version 3.4.3 [40]. The lavaan package was used to conduct the confirmatory factor analysis, structural equation modeling and MIMIC modeling [41].

V. RESULTS

Upon examining the normality of our data, we found acceptable ranges of univariate normality, skewness was within absolute values of 2.0 or less and kurtosis was within absolute values of 7.0 or less. Mardia's test for multivariate normality returned estimates of multivariate skewness $\gamma_{1,p} = 116.727$, $p < .001$ and multivariate kurtosis $\gamma_{2,p} = 1110.895$, $p < .001$. These results indicate that the data are not multivariate normal; hence, a robust maximum likelihood (MLM) estimator was used in the analysis to correct for non-normality. The χ^2 statistic produced by MLM is a Satorra-Bentler scale (χ^2_{SB}). MLM requires a listwise deletion method [42]; therefore, cases with missing data on any variable were removed from the analysis [41].

A. *Measurement Model*

Confirmatory factor analysis was conducted for the latent constructs of physics and STEM to determine how well the survey items measured the intended constructs (Table II). In models with large sample sizes, the chi-square goodness of fit test is biased; however, other measures like RMSEA are less prone to these issues and reflect good fit of the model [38]. The Satorra-Bentler adjusted chi-square test for goodness of fit for the physics and STEM identity constructs was $\chi^2_{SB} = 131.937$, $df = 48$, $p < .001$. The fit indexes were CFI of 0.988, TLI of 0.983, RMSEA of 0.061 with confidence interval of 0.049 to 0.074, and an SRMR of 0.019. Overall, the fit

TABLE II. CONFIRMATORY FACTOR ANALYSIS FOR PHYSICS AND STEM IDENTITY

Latent Variable	Indicator	Standardized Factor Loading	Standard Error	Item Reliability	Construct Reliability	Average Variance Extracted
Physics Interest	Interested in learning more about STEM	0.920	0.040	0.846	0.941	0.845
	STEM excites curiosity	0.947	0.038	0.897		
	Enjoy STEM learning	0.963	0.034	0.927		
Physics Recognition	Teachers see me as STEM person	0.941	0.034	0.885	0.933	0.827
	Others ask for STEM help	0.911	0.035	0.823		
	Friends see me as STEM person	0.935	0.034	0.874		
STEM Interest	Interested in learning more about physics	0.860	0.050	0.740	0.958	0.890
	Physics excites curiosity	0.940	0.046	0.884		
	Enjoy physics learning	0.956	0.043	0.914		
STEM Recognition	Teachers see me as physics person	0.889	0.043	0.790	0.951	0.861
	Others ask for physics help	0.892	0.038	0.796		
	Friends see me as physics person	0.947	0.037	0.897		

Note. acceptable values of item reliability > .50, construct reliability > .70, and average variance extracted > .50

indexes suggest we have good measurement model fit.

Table II presents the standardized factor loadings, standard error, item reliability, construct reliability, and average variance extracted. All standardized factor loadings were above the acceptable minimum of 0.45 [37], [43]. Item reliabilities were evaluated using the multiple squared correlation (R^2) of the item with the factor, all items were above 0.50 acceptable value indicating each item measured above 50% of the variance. Construct reliability was examined using Cronbach α; all constructs were above 0.70, indicating good reliability [35]. Lastly, the average variance extracted for each latent variable was above 0.50 acceptable value, indicating the amount of variance captured by each construct is greater in relation to the amount of variance due to measurement error [44].

B. Structural Model

After establishing acceptable model fit for the physics and STEM latent constructs, the hypothesized structural model was examined (i.e., the structural model). All out-of-school experiences (listed in Table I) were examined, but may not be shown, because we removed non-significant paths from the final model to obtain the most parsimonious model. The resulting model is shown in Figure 1. The out-of-school experiences significant for physics identity were participating in science competitions, tinkering with mechanical devices, and talking about science. Moreover, the out-of-school experiences significant for STEM identity were writing computer programs or designing web pages, tinkering with electrical devices, and talking about science. Prior work has established that, in predicting students' mathematics identity, [18], [22], physics identity [22], and engineering identity [45], their perceptions of performing and understanding STEM content are mediated by their interest and recognition in these STEM fields. We also know from literature that engineering and broadly STEM education in elementary and secondary schools is "still very much a work in progress" [10, p. 2]. Consequently, high school students have little to no exposure to engineering and STEM-related concepts, and there is still a relatively small percentage of students taking physics in high school [46]. Inquiring about their capabilities to perform well or understand engineering content may not be the best approach. Therefore, rather than directly measuring students' perceptions of their ability to understand STEM and physics concepts, we assessed how their out-of-school experiences in these areas fostered interest, recognition, and, ultimately, identity.

The Satorra-Bentler adjusted chi-square test for goodness of fit was $\chi^2_{SB} = 622.92$, $df = 176$, $p < .001$. The fit indexes were CFI of 0.96, TLI of 0.95 and RMSEA of 0.07 with a confidence interval of 0.06 to 0.08. Model fit indexes suggest good structural model fit.

VI. DISCUSSION

In this study, we used students reported exposure to out-of-school STEM experiences to understand their relationship

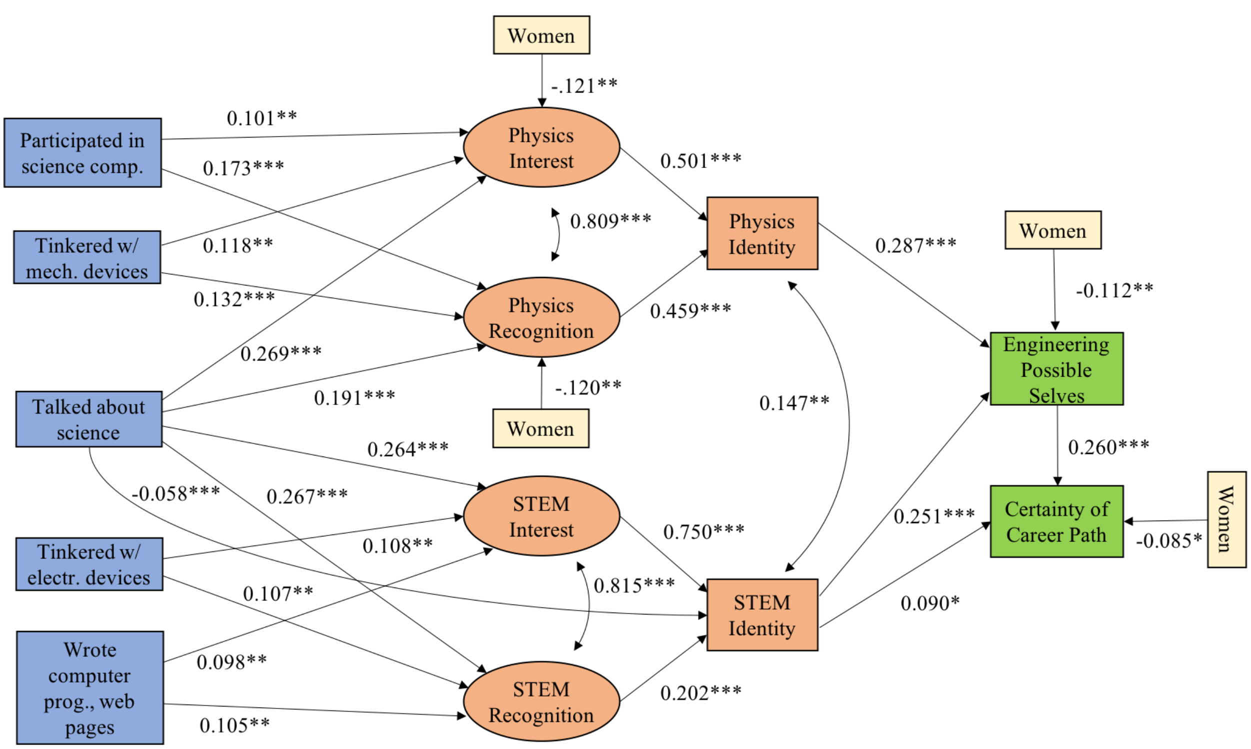

Fig. 1. Structural Equation Model of First-Generation College Students' Out-of-School Experiences

with physics and STEM interest, recognition, and identity. Prior research has found that out-of-school learning environments play an important role in promoting and building interest and over time supporting STEM identities [4], [47]–[49]. Additionally, another study found that students who persisted in engineering had meaningful experiences (i.e., summer camps, competitions, etc.) [50]. While we did not measure persistence in this study, we are indirectly understanding the relationship between experiences, identity formation, possible selves, and certainty of career path.

Our results indicate that developing a physics identity is not simply shaped by the out-of-school experiences first-generation college students receive throughout their high school trajectory. There was no direct effect on physics identity by participation in science competition, tinkering with mechanical devices, and talking about science. We can conclude that these out-of-school experiences are not related to forming a physics identity for these students, rather they require the mediation of interest and recognition in physics, ($\beta = 0.501$, $p < .001$) and ($\beta = 0.459$, $p < .001$), respectively. Only three out-of-school experiences (i.e., participation in science competition, tinkering with mechanical devices, and talking about science), from the list of thirteen possible options, were significant in predicting students' physics identity. From these results, we conclude that only a few STEM experiences will have an impact in first-generation college students' physics identity development. Specifically, our analysis reveals that talking about science has the strongest impact in first-generation college students' interest in physics ($\beta = 0.269$, $p < .001$) and recognition as a physics person ($\beta = 0.191$, $p < .001$), followed by tinkering with mechanical devices ($\beta = 0.118$, $p < .01$; $\beta = 0.132$, $p < .001$) and participating in science competition ($\beta = 0.101$, $p < .01$; $\beta = 0.173$, $p < .05$).

In examining first-generation college students' STEM identity, three out-of-school experiences were significant: talking about science, tinkering with electrical devices, and writing computer program/web pages. There was a small negative direct effect between talking about science ($\beta = -0.058$, $p < .001$) and first-generation college students' beliefs of seeing oneself as a STEM person. This negative direct effect did not exist for physics identity. Similar to physics identity, no other out-of-school experience directly supported first-generation college students' beliefs of seeing oneself as a STEM person. Instead, interest and recognition in STEM mediated the relationship between out-of-school experiences and seeing oneself as a STEM person, ($\beta = 0.750$, $p < .001$) and ($\beta = 0.202$, $p < .001$) respectively. Interest in STEM had nearly three times the impact on first-generation college students' self-reported measures of *I see myself as a STEM person,* with an estimated value of $\beta = 0.750$, compared with being recognized as someone that can do STEM, $\beta = 0.202$. Talking about science had the highest effect on first-generation college students' interest in STEM ($\beta = 0.264$, $p < .001$) and recognition in STEM ($\beta = 0.267$, $p < .001$), compared to the other out-of-school experiences.

Consistent with prior work that found strong correlations between interest and recognition [18], [22], there was a large and significant relationship between students' interest and recognition in STEM (correlation = 0.809, $p < .001$) and physics (correlation = 0.815, $p < .001$). When correlating the individual identity measures, there was a smaller relationship between first-generation college students' self-reported measures of *I see myself as a STEM person* and *I see myself as a physics person* (correlation = 0.147, $p < .01$). These results emphasize the need to measure first-generation college students' specific disciplinary identities (e.g., physics, mathematics, and engineering) in order to obtain more a nuanced understanding of how students begin to form identities as engineers and how those identities influence students' confidence that they will stay in engineering. Nonetheless, both a STEM identity and physics identity contributed to first-generation college students' long-term identity goal of seeing themselves as engineers, ($\beta = 0.287$, $p < .001$) and ($\beta = 0.251$, $p < .001$) respectively. Direct paths from physics and STEM interest and recognition onto engineering possible selves were not tested. The variance explained for engineering possible selves is 19%, $R^2 = 0.19$. When examining the relationship between a physics and STEM identity and certainty of career path, only STEM identity was significant ($\beta = 0.090$, $p < .05$). Prior work has found that a physics identity was a significant predictor of choice of engineering major for all students [22], however our study found that physics identity, for first-generation college students does not predict certainty of career path. However, the presence of an engineering possible self had a significant positive relationship on certainty of career path ($\beta = 0.260$, $p < .001$) indicating that first-generation college students' images of themselves as future engineers contribute to their certainty in their respective engineering career path. The total variance explained for certainty of career path is 11%, $R^2 = 0.11$.

In our analysis we used a MIMIC model to examine the relationship between gender and the latent variables of interest and recognition in both physics and STEM. Additionally, gender was regressed onto engineering possible selves and certainty of career path to determine the effect of identifying as a woman on our outcomes. When examining the role of gender in first-generation college students' physics and STEM identities, our study revealed that, compared with men, women have less interest in physics ($\beta = -0.121$, $p < .01$) and feel less recognized as someone that can do physics ($\beta = -0.120$, $p < .01$). By contrast, we found no significant gender difference for STEM interest and recognition. To further understand the gender differences in physics, we used a Welch's t-test to determine if on average males were more likely to take Physics 1 in high school than females. Result from the Welch's t-test revealed that females were not less likely to take Physics 1 in high school compared to males $t(197.3) = 0.88$, p = n.s. Perhaps, the female students in this sample were interested in physics in the beginning of the semester but slowly lost interest as the semester progressed. Similarly, we hypothesize that interest in physics for female first-generation college students may not be maturing due to a lack of recognition as a capable physics learner by peers, instructors, or family members. Our analysis indicates a strong positive correlation (above .80) between interest in physics and recognition as a physics person. Thus, interest in physics can be developed through an individuals' environment, peers, educators or parents [51]. However, causality cannot be determined between physics interest and physics recognition, due to the cross-sectional nature of the study. We hypothesize that the lack of recognition as the type of person that can do physics, for women, may be due in part to the gender gap in physics conceptual inventories [52]. Studies have postulated that the gender gap in conceptual inventories may be due to students background, preparation, discrimination, and stereotype threat [52]–[54]. How a student is perceived by and positioned, through recognition, by significant others in their lives as the kind of people that can do physics has an important relationship with their interest in the subject. How a student internalizes these beliefs in shaping who they are and how they position themselves in the world has predictive value for identity development, possible selves, and certainty of career path [22], [55]. Thus, the absence of being recognized by others as a physics student or learner, may result in diminished interest in physics.

Prior work has shown that the individual measure of physics identity is the strongest predictors of choosing an engineering major in general [22], [27] and specifically for male students [22]. In the same study by Godwin et al [22], males were also significantly more likely to have higher measures of mathematics identity (I see myself as a math person), compared to females. However, in this study of first-generation college students, the individual measures of physics identity (I see myself as a physics person) and STEM identity (I see myself as a STEM person), had no significant direct gender difference.

In examining the effect of a female identity onto engineering possible selves, we found that female first-generation college students were less likely to have a future perception of themselves as engineers (β = -0.112, $p < .01$) and were subsequently less certain of an engineering career path (β = -0.085, $p < .05$). We know from literature that having a positive perception of oneself can serve to motivate behavior [9]. However, students develop perceptions of who they can become in the future by social comparisons. Markus and Nurius [23] posit that an individual's thoughts, feelings, characteristics, and behaviors are compared and contrasted with "those of salient others" [p. 954]. That is, the people and environment students have around them matters. The environment female first-generation college students experience are not inert backdrops, their identities are created through the "transactions between people and their everyday socio-physical environments" [56, p. 698]. Research has shown that the students' siblings and family members have been influential in their choice of an engineering major [57]. Our sample of female first-generation college students may not see themselves represented in the field of engineering due to a lack of representation in their own environments and thus find it difficult to imagine someone like them as engineers. Equally likely is a lack of recognition by their physics instructors or STEM related instructors as the type of students that can do engineering.

VII. Conclusion

Our study examined the relationship between thirteen out-of-school experiences on first-generation college students' physics and STEM identities. We found that only the following out-of-school experiences indirectly fostered a physics and STEM identity development: talking about science, tinkering with mechanical devices, and participating in science competitions, tinkering with electrical devices, and writing computer programs/webpages. Similar to previous work that found that beliefs about ones' performance/competence in physics, alone, are not enough to develop a physics identity, out-of-school experiences did not directly affect a physics or STEM identity. However, there were indirect effects, mediated through interest and recognition. Our study also found that having a physics and STEM identity was positively related to engineering possible selves, and, ultimately, to the certainty of an engineering career path.

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