Influence of Research Experience on Recognition and Identity Development in the Engineering Graduate Student Population

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***Abstract*— This research category Work in Progress study explores the relationship between research experience and engineering identity development in the engineering graduate student population. Preliminary data from a national survey of engineering graduate students is used to explore correlations between research experience and domains of graduate student identity related to being an engineer, scientist, and researcher. Our analysis shows that the recognition subconstruct of researcher and scientist identity domains are significantly positively correlated with research experience. The recognition subconstruct of the engineer identity domain is not significantly correlated with research experience. The future analysis plans beyond correlation are discussed, and implications for the engineering education community are proposed.**

Keywords—Engineering Identity, Graduate Students, Quantitative Survey

I. INTRODUCTION

This research category Work in Progress study explores the relationship between research experience and engineering identity (EI) development in the engineering graduate student (EGS) population. Nationally, the US is not producing the number of engineering graduates necessary to meet national innovation and engineering requirements [1]. Defining EI in EGS and the educational elements which can most directly influence EGS' persistence and motivation will assist engineering graduate programs to meet the needs of the engineering workforce [2]. EI has been described in undergraduates as a combination of performance/competence, interest, and recognition in math, physics, and science identity domains and influential on the choice of engineering as a career path for undergraduate students [3], [4], [5], [6], [7], [8]. Godwin and colleagues [4], [5] found that physics and math recognition were positive predictors of choosing engineering as a career path while performance/competence alone was a negative predictor. Further, recognition had the largest direct effects on physics and math identities [4]. The negative effect of performance/competence was mediated by recognition by others and interest in engineering [5]. Godwin's model is based on undergraduate students entering engineering from high school. EGS discuss their EI differently from undergraduate students by focusing on identity domains of scientist, researcher, and engineer [9]. Each domain contributes to the full EI of EGS. The unique aspects of graduate study which emphasize research and science within engineering explain the importance of these domains to EGS EI. The engineer domain should not be confused with EI, rather it is a distinct domain within EI which specifically represents EGS' existing self-concept as an engineer. The subconstructs of performance/competence, interest, and recognition are still present in EGS for each of these identity domains. Each domain and subconstruct is necessary to explore the full EI for EGS.

As we begin to explore the unique identity domains and subconstructs in EGS, the importance of recognition in undergraduate students leads us to investigate the importance of recognition in EGS' identity domains first. Because of the importance of recognition in the undergraduate EI framework, we sought to answer a research question related to recognition in the graduate student population. Specifically, this analysis is to address the research question: **Is research experience correlated with the recognition component of engineering identity?** We posit that research experiences provide opportunities for students to be recognized as scientists,

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researchers, and engineers by fellow students, staff, and faculty, both within lab settings and in research dissemination activities, thereby influencing their EI development. Our hypothesis is that research experience is correlated with the recognition subconstruct of engineer, scientist and researcher identity domains.

The relationship between research experience and recognition in EGS is an appropriate starting point for several reasons. First, both can be influenced by programmatic and advisor action. For instance, programs emphasizing research experience as vital to EGS success or advisors making an effort to comment (recognize) on students' efforts in research can be accomplished without additional funding or major programmatic effort. Second, the relationship has been shown to be important in qualitative work [9] and should be explored quantitatively.

A. Research Experience

Research experience is widely accepted as an integral part of graduate engineering education, and particularly important for Ph.D. students [10], [11]. However, research on graduate engineering education and engineering research experience is lacking [10], [12]), and it is an important avenue of work because research experiences can serve as an opportunity for students to develop and restructure identities [13]. Undergraduate research experience has been proposed as an important opportunity for students' connections of research to classroom knowledge [14]. Empirical research has shown the importance of undergraduate research experience in graduate STEM students, particularly in performance of research skills and the duration of research experience [15]. Interactions within research experiences provide opportunities for students to connect with peers and faculty outside of the classroom. For instance, ethnographic research in chemical engineering showed how learning in research groups was facilitated by interactions with faculty, lab staff, and other students [16]. Through interaction with others, students are recognized for their engineering knowledge and experience, and they gain competence in both presenting and defending their research practices. Experience with research groups has been connected to important learning processes such as communication and interaction, problem solving, and peer mentoring skills [2]. Research experiences may facilitate the development of scientist and researcher aspects of students' EI.

To intentionally promote and strengthen EI, the engineering education community needs to better understand how aspects of and specific activities in graduate engineering education positively impact EI. This study builds upon the EI literature by expanding the concept to EGS through the exploration of how research experience may contribute to the recognition construct of EI. Other research has explored how EGS experience and identity are distinct from undergraduate EI [17], [18], [19], [20]. Research group composition has been shown to influence recognition in EGS [21]. Here we explore the ways in which past and current research experiences influence the recognition subconstruct of EI through the domains of engineering, scientist, and researcher in EGSs. This work explores a relationship related to, but distinct from the existing literature, which explores the relationship of research group size and composition.

II. METHOD

This analysis is part of a larger research project that investigates EGS identities, identity-based motivations, future-time perspectives, and graduate school experiences [17]. Qualitative interviews and focus groups were used to explore graduate engineering identity and to develop a 15 minute quantitative survey covering these topics [9], [17], [18], [19], [20]. Data is currently being collected from a nationally representative sample of engineering graduate programs. Using a master list of engineering graduate research programs [22] a random sample of programs was selected to be nationally representative based on geography, program type, and program size. Geography was defined by state in which the program resides, program type was derived from the master list of engineering graduate programs [22], and program size was estimated by the number of doctoral degrees granted by each program in 2014 [23]. Selected programs were emailed a request to participate in the survey, which could be done by submitting a list of graduate engineering student emails or forwarding an email survey link to their students with participation and confidentiality information. Participants completed the survey on-line through the Qualtrics platform. Institutional Review Board (IRB) approval was received from the home institutions of the primary investigators.

Here, we analyze preliminary data (current n = 826, 33% of sample target). Our sample matches current reports of student demographics [24], with the majority of participants identifying as White (50%) or Asian (32%), male (63%), domestic (62%), and heterosexual (89%). We asked participants about the identity domains of researcher, scientist, and engineer on Likert-type scales. Participants rated themselves (5 -Strongly Agree to 1-Strongly Disagree) on statements about their identity such as I see myself as an ENGINEER; I see myself as a SCIENTIST; and I see myself as a RESEARCHER. Participants also rated statements about how others view them: My advisor(s) sees me as an ENGINEER; My advisor(s) sees me as a SCIENTIST; and My advisor(s) sees me as a RESEARCHER. Within each identity domain (i.e., engineer, scientist, researcher), six items were related to the recognition subconstruct (i.e., how others see the student). These items were combined for an average recognition score for each identity domain (engineer, scientist, researcher). The domain-specific recognition identity scores were then correlated with reports of their research experiences (Table 1).

III. RESULTS

Table 2 shows the correlation matrix for the recognition subconstruct scores by identity domain as correlated with the research experiences. A significant positive association with researcher recognition was observed for students who reported having their own research or dissertation project, having a paid research assistantship, having previous research experience, and belonging to a lab group. Scientist recognition was positively correlated and significant for the same research experience variables. No significant correlation was observed

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on the engineer recognition subconstruct for these research experiences. Scientist and researcher recognition scores were positively and significantly correlated. However, engineer recognition was significantly and positively correlated with science recognition and researcher recognition indicating some relationship does exist.

Table 1. Survey Question and Corresponding Variable Name

Survey Question (Yes or No)	**Variable Name**
Do you have a dissertation/thesis project?	Dissertation/Thesis
Do you have a research assistantship? (i.e., you are paid to work on a professor's project)	Research Assist.
Did you have research experience before starting your graduate program?	Past Research
Are you a member of a lab or research group with other graduate students?	Lab Group

their graduate programs and lacked the necessary skills in statistics and written research communication to participate effectively in research experiences [10]. Lack of these research skills hinders the opportunity for EGS to be recognized as researchers and scientists (*e.g.,* published peer-reviewed papers). While research experiences may already be encouraged, understanding the long-term impact on EI may help students more fully appreciate the importance of research experience. Second, graduate engineering educators can make use of this finding in program design and engagement of EGSs by reducing the time from matriculation to research experience in graduate engineering programs. Some participants indicated months or years had passed between their matriculation as EGS and beginning a research project. The significant relationship between current research (dissertation/thesis, research assistantship, or belonging to a lab group) and higher recognition as a scientist and researcher in EI

B. Limitations

The lack of effect on engineering identity was not expected, however a ceiling effect may be occurring for the engineer domain. A ceiling effect is when many participants score at the upper limit measured by a variable and causes data analysis to be difficult due to the lack of variation in scores [25]. Variation in scores is required for correlation analysis to perform correctly. In studying graduate students, we can expect that those with high EI are also those students joining graduate engineering programs. The correlation with researcher and scientist domains are significant and show the importance of the research experience in developing EGSs' identities beyond that of an engineer, specifically the importance of scientist and researcher identities.

Table 2. Correlation Matrix

	1.	**2.**	**3.**	**Dissertation/ Thesis**	**Research Assist.**	**Past Research**	**Lab Group**
1.Science Domain Recognition Score	--	.116*	.560**	.169**	.192**	.230**	.261**
2.Engineer Domain Recognition Score		--	.187**	.058	-.057	-.059	-.013
3.Researcher Domain Recognition Score			--	.294**	.334**	.233**	.388**

Notes: * indicates p = .001; ** indicates p < .001; n = 826 for all measures except: Past Research n = 825

IV. DISCUSSION

A. Applications

Our current results indicate that research experience can positively influence recognition subconstructs of students' researcher and scientist domain identities. The relationship demonstrates the importance of research experience to EGS EI development. Particularly, the relationship to research before beginning graduate school suggests a continued need for emphasis on research experience for undergraduate students and indicates a need to expand opportunities for undergraduate researchers to be recognized for their contributions (*e.g.,* posters, presentations, *etc*.). The carryover effect on EGS' EI from undergraduate experience indicates the significant importance of engaging students in research and science before they begin graduate studies. In a qualitative program review, Rogers & Gotkas found EGS felt unprepared for research in

C. Future Analyses

When data collection is complete, we will begin to more fully analyze our data. The full data set (n≈2200) will provide a more robust data set to firmly explore the relationships between research experience and EGS EI. Future analyses of our final data set will be necessary to position research experience within other influences on recognition and to fully conceptualize the function of recognition as a mediator of EGS

graduate identity domains. We will use a moderated mediation analysis to test how research experience influences the relationship of identity domains, subconstructs, and EI. Further, we will use a structural equation model analysis to determine the relationships between EGS identity domains (engineer, scientist, researcher) and subconstructs (recognition, performance/competence, interest).

D. Conclusion

The relationship between research experience and EI development in the EGS population is a new avenue of research, which has the potential to contribute to improving persistence and motivation in EGS. The preliminary data presented here explore correlations between research experience and domains of EGS EI. This preliminary analysis demonstrates the importance of the recognition subconstruct of the researcher and scientist domains to a strong EI. The significant positive correlations between research experience and these identity domains indicates an opportunity for engineering educators and researchers to influence EGS EI through increased research experience and opportunity for students to be recognized for their contributions to engineering research. The analysis of the final data set will provide opportunities to explore more relationships between EI domains and subconstructs.

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