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Documenting Engineering Identity: Electrical and Computer Engineering Departmental Documents and Student Identity

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Abstract: As concerns about the preparation of engineers grow, so has interest in the dimensions of engineering identity. This departmental document analysis deepens understanding of undergraduate electrical, computer, and software engineering identities. The electrical, computer, and software engineering department in question privileges the role of performance/competence in engineering identity at the expense of cultivating recognition or interest in the field. Additionally, these documents show an understanding of engineering identity that does not take social identities, such as race or gender, into account. Taken together, these documents construct the department's image of an 'ideal engineer.'

Undergraduate students' engineering identities have emerged as a prominent research topic among engineering educators. Identity—both in terms of social identities (i.e., race/ethnicity, gender, etc.) and as engineers (i.e., viewing oneself as an engineering person)—has been found to play a role in undergraduate persistence [1], [2], retention [3], [4], [5], and even teamwork [6], [7]. Recent research extends beyond assessing impact to understanding the concept itself—for example, recent work has identified recognition and interest as key players in whether or not a student will develop an engineering identity [8], [9], [10]. Understanding more about how undergraduate engineering students develop identities as engineers will help engineering educators better prepare students for engineering careers and support those students during their postsecondary experiences.

Much of the current research on engineering identity takes engineering as a monolithic discipline. In other words, it is taken as a given that different engineering disciplines function in the same way with respect to engineering identity development. However, previous research has shown that the culture of engineering disciplines do, in fact, differ from each other—for example, some disciplines, such as biomedical engineering, civil engineering, and chemical engineering, are more inclusive of gender diversity than others [11], [12]. Similarly, it is possible that there is some variation in engineering identity development between the separate disciplines.

Engineering in general, and electrical and computer engineering in specific, has a diversity issue: women and students of color are simply not persisting at similar rates as their male and white peers. For example, the AAUW reported only slightly more than 2000 women receiving electrical engineering degrees, compared to over 16,000 men [13]. Similarly, in 2013, 62% of all undergraduates enrolled in engineering programs were white [14]. Some of this attrition and disparity may be attributed to the climate within individual departments. It is possible to understand parts of departmental climate through what a department chooses to show about itself to prospective and current students, faculty and staff, and external stakeholders. By understanding the ways in which engineering departments look at engineering identity development, we can understand how these departments support students and their development.

Therefore, this paper explores undergraduate student engineering development using document analysis [15]. Our investigation focused on departmental documents from a single electrical & computing department in a large, public, Midwestern land-grant university. These documents, which range from public-facing websites to internal reports to informational texts, provide a window through which researchers can begin to view departmental priorities with respect to developing undergraduate engineering identities. Using qualitative and document analysis techniques, we asked the following research questions:

- How is an electrical, computer, and software engineering identity or identities characterized in departmental documents?
- How is an electrical and computer engineering department's commitment to undergraduate engineering identity development expressed in departmental documents?

Literature Review

What engineering identity exactly *is* makes up a large portion of the current research on the topic. While definitions of engineering identity are remarkably multifaceted, most research defines it first and foremost as a profession [16]. Rather than being primarily seen as something that someone *is* (as is the case for most social identities), this definition sees engineering as something that someone *does* [16], [17]. Thus, many studies show that undergraduate engineering students associate engineering with specific cognitive, affective, and performance variables [16]. For example, research has found that professional identity was closely connected to competence in technology adoption, scientific thinking, and professional knowledge, and that students see engineering as a way of thinking about and using math, science, communication, and problem-solving [18], [19]. In this conception of engineering identity, competence stands out as a significant factor—it acts as a bridging factor in the identity development process [20]. This process involves the evaluation of professional competence and comparison against perceptions of the profession [20]. Similarly, other research has found that students use self-assessments and external markers of approval to measure their own competence as future engineers [21]. Undergraduate engineering students also over-inflate their own sense of professional development and emphasize skills and competences that are not aligned with industry or society needs.

While still viewing engineering as a profession, previous research has also defined engineering identity in its relation to specific contexts, characteristics, or perceptions [16]. One study found that undergraduate engineering identity development encompassed two dimensions, the technical and the social [22]. These dimensions interact as students progress from connecting engineering to social experiences to identifying it with the application of math and science courses and their network of engineering peers [22]. Previous research also shows the ways that both students and faculty conceive of engineers as people who do specific actions in specific contexts, such as applying science and math, solving problems, and making things [18], [23]. Other studies have found that engineering identity is constructed through a series of characteristics—for example, engineers are perceived as honest, conscientious, confident, technically competent, conservative, good at decision-making, and team members as well as leaders [18], [21], [24].

While there are many factors that contribute to engineering identity development, current research has identified some specific factors that play constructive, directional, or detractive roles [16]. Constructive factors help students create their engineering identities, while directional factors move those identities along a trajectory. For example, cross-disciplinary experiences and portfolio construction activities help students engage in iterative definitional cycles in which they articulate who they are as engineers [25], [26]. Similarly, service-learning projects have been found to help students make connections between their identities as engineers and society [27]. That being said, engineering contexts can interact with social identities—especially race and gender—in ways that can detract from engineering identity development. Underrepresentation of women and students of color is well-established by current research [28]. Navigating hostile or indifferent climates in engineering makes it more difficult for women and students of color to develop their engineering identities. For example, one study found that women entered postsecondary engineering with less-developed engineering identities and experienced slower identity development than their male peers—potentially because they had to mediate between identities as women and as engineers [29].

Researchers have not yet exhausted the subject of engineering identity, especially in terms of disciplinary differences. Much of the contemporary research literature takes engineering as a monolithic discipline and does not account for finer-grained differences between fields nor for the importance of academic departments as the locations wherein identity is developed and enacted. While this paper is not comparative, it fills several gaps in the literature: engineering identity broadly conceived; specific identities for electrical, computer, and software engineering students; and understanding the role of the department in these phenomena. Additionally, very few of the studies summarized above focus on other contributing factors for engineering identity. Most studies rely on qualitative accounts or quantitative measures from students themselves—there is very little attention paid to cultural factors that may play a role in identity development. This study uses departmental documents as cultural artifacts that convey the way that the department in question constructs engineering identity and the formalized avenues through which it communicates these ideas.

Conceptual Framework

As a framework for the present study, we drew from research that situates engineering identity within the interplay of recognition, performance/competence, and interest [8], [9], [10]. Drawn from previous literature on STEM identities [30], [31], [32], [33], these constructs encompass students' abilities to perform engineering work and the need to recognize them as engineers.

Recognition plays a key role in this framework as it is essentially the external validation of an internal identification. Gee [34] defined identity as "being recognized as a certain 'kind of person' in a given context" (p. 99). This recognition operates on several levels and involves parsing out whether the given identity is one that is assigned by larger institutional or societal structures or is assumed by the person themselves. Recognition depends on interpretive systems that support the identity in question [34]. For example, being recognized as an engineer involves the acquisition of particular types of knowledge, the performance of specific skills, and being in a context where "engineer" is an identity that would be recognized. This recognition depends on other people and systems of meaning outside of one's self. Thus, it is possible for an identity to be withheld from a person or group of people. As Gee [34] wrote, "one crucial question we can always ask about identities of any type is this: What institution or institutions, or which group or groups of people…work to ensure that a certain combination, at a given time and place, is recognized as coming from a certain kind of person?" (p. 111). Recognition can be used to confirm the identities of some people while disconfirming others'.

Recognition, however, rests on having, doing, or being something that can be recognized by others. Thus, engineering identity is entwined with the performance of engineering activities and the competence conveyed by those performances. For example, Godwin and associates [9] found that performance in prerequisite physics and math courses was significant in—though not constitutive of—the development of undergraduate student engineering identities, especially given lack of exposure most high school students have to engineering disciplines. In many ways, performance/competence and recognition serve as the internal and external validations for engineering identity. Academic performance in engineering, math, physics, and other science fields plays a role in whether students will consider themselves as a person who 'does' or could do engineering [8], [9], [10]. If they believe that they are a person who could do engineering and do it well, external recognition comes into play to confirm this belief.

The final component of this engineering identity framework is interest [8], [9], [10]. While interest seems obvious, it has historically been overlooked in models of engineering identity that privileged performance/competence. In the context of engineering, interest can also be an obstacle, given the fact that relatively few students are exposed to engineering before college. Without foreknowledge of the field, undergraduates may enter with unrealistic expectations for their courses and professional opportunities; if they are not sufficiently interested in engineering, as well as the math and science components of engineering, they may not persist in the field [8], [9], [10].

Design & Methodology

This study used performance/competence, recognition, and interest to understand the construction of engineering identity in departmental documents. We focused on an electrical and computer engineering department in order to gain a deeper understanding of electrical, computer, and software engineering identity development within the culture of that discipline. Furthermore, this study provides an example of this framework of engineering identity being used with qualitative research, responding specifically to calls for additional research and research methods in the literature [8], [9], [10].

Research Site

This study focused on the departmental documents of an electrical and computer engineering department in a large, public, land-grant university in the Midwest. This university has a large, top-ranking engineering college with over 9,000 undergraduate students enrolled and approximately 50 tenured or tenure-track faculty in the electrical and computer engineering department. The department offers Bachelor of Science degrees in electrical engineering or computer engineering and maintains a joint degree program in software engineering with the computer science department. More than 2,000 students are majoring in electrical, computer, or software engineering. This department is also the recipient of two recent National Science Foundation grants (RED/SSTEM) that focus on departmental change, including supporting its attempts to develop undergraduate electrical, computer, and software engineering identities. These grants are but a few among a number of federally funded, cross-institutional grants the institution has been granted that focus on broadening participation in STEM fields at all postsecondary levels. Therefore, this site is a dynamic place that is focused on changing STEM to be more inclusive.

Document Analysis

The present study is part of a larger qualitative case study [35] that is investigating engineering identity development in electrical and computer engineering undergraduate students by means of observations, interviews, and documents. For this sub-study, we employed document analysis [15] to answer the research questions above. While often used for triangulating other qualitative or survey data, document analysis can also be a stand-alone method where warranted by data sources and goals of the research [15]. Documents can provide rich context and background on a research site or question, while also uncovering data and findings that may have gone otherwise unnoticed [15]. Thus, although the document analysis is ongoing and falls within the activities of a larger study, we present specific findings and implications drawn from the only the documents themselves.

Document analysis involves careful decision-making about which documents to include in the study. Documents must be relevant to the research questions and the framework being used [15]. There are no hard and fast rules about how many documents should be analyzed; rather, that consideration should also flow logically from the research design [15]. Based on our interest in examining how this department constructs engineering identity in its documentary artifacts, we focused on two specific types of documents: internal documents and public-facing documents. Public-facing documents analyzed included outreach information on the university website about the department and the three majors, transfer plans from state community colleges, graduation/curricular requirements, and plans of study. Internal documents included ABET self-study reports for each of the three programs. Some documents we included blurred the lines between public and internal, such as the college and department strategic plans. Additionally, we limited our analysis to current documents produced within the last five years, ensuring that we are using the documents that are actively shaping and reflecting the current departmental life. We chose to analyze public and internal documents in conjunction with each other because they allow us to see the stories that the department tells the public and itself about itself through official documentary artifacts. In this way, we are able to explore the messages within these stories about engineering identity for undergraduate engineering students in electrical and computer engineering.

TABLE I
DOCUMENT TYPES

Document Type	Document Sub-Type	# of Documents Analyzed
Public-Facing		
	Strategic Plans	4
	Department Information	7
	Major Information/Outreach	11
	Community College Transfer Plans	15
	Department Newsletter	6
Internal		
	ABET Self-Study Reports	4
	Internal Updates	1
Total		48

Analysis Procedures

Document analysis is a flexible method that can be used in a variety of research studies. This flexibility means that there is no set way to analyze documents and should instead follow the research design and conceptual framework of the study [15]. Overall, the goal of analysis is to "establish the meaning of the document and its contribution to the issues being explored" [15, p. 33]. Our analysis combined elements of content analysis and thematic analysis, and included the following steps: organizing data into categories, superficial examination, thorough examination, and interpretation [15].

After an initial collection of all the documents related to the larger case study, we sorted those documents in larger categories based on their perceived use. For example, the ABET self-study reports were categorized as 'internal.' The final set of categories included: internal, public-facing, curriculum-related documents, and student feedback. After we decided to focus on internal and public-facing documents, the first author reviewed all the documents and performed initial, *a priori* coding [36]. These *a priori* codes included: performance/competence, interest, recognition, and professional formation. This author additionally coded for content related to specific social identities, such gender, race/ethnicity, and international status. After discussing the initial coding results, all three researchers undertook a second round of focused coding [36]. During the focused coding stage, the researchers recoded each document with an eye to a) identifying the ways that each component of the engineering identity framework is constructed and deployed in the departmental documents and b) identifying emergent themes in the data.

Trustworthiness

We cultivated trustworthiness in our analysis in the following three ways. We ensured that we could access the broadest number of documents possible by pursuing multiple avenues of data collection: in addition to seeking documents from electrical and computer engineering faculty and administrators, we did a comprehensive internet search to gather documents that may have been overlooked or unavailable to department sources. The research team met regularly to discuss findings and resolve differences in interpretation. The team also memoed and kept a research log and code book that serves as an audit trail for the data collection and analysis process. Additionally, this study is a small part of a larger qualitative case study centered on engineering identity development in an electrical and computer engineering department. Therefore, we were able to compare our findings against other data collected in the larger study and judge whether our conclusions were consonant. Finally, we debriefed initial findings with other educational researchers as well as electrical and computer engineers.

Findings

The analysis of the departmental documents clearly demonstrated that engineering identity development was primarily focused on creating technical competency (performance/competence), rather than promoting sustained interest or recognition. Throughout the body of documents, performance was coded over 200 times whereas codes for interest and recognition were coded approximately 60 and 100 times, respectively. It should also be noted that recognition often overlapped performance or demonstrations of competence because recognition often took the form of an award.

The Prominence of Performance

Performance, in the context of this paper, is entwined with competence—it describes an individual's ability to perform the functions of electrical and computer engineering. In other words, performance touches on how competent a student is at doing the math, science, and engineering tasks involved. At the time a student applies to be an engineering major, either as a high school senior or community college transfer, they demonstrate their knowledge and skills through their academic performance, including their GPA, final grades in specific courses (e.g., mathematics), and ACT scores (*Electrical Engineering Self-Study Report*). The admissions requirements say nothing about students' extracurricular activities (even if they were engineering-related) or any non-academic indicators that are taken into account when admissions decisions are made. On the transfer plans from various community colleges throughout the state, part of the College of Engineering's Basic Program includes Calculus I and Calculus II with a grade of "C" or better, and the transfer plans note that progression into these classes may first require additional mathematics courses (e.g., *Community College Transfer Plans 2016-2017*). Once a student is accepted to the engineering major, their access to advanced content courses within the major is determined by their GPA (*Electrical Engineering Self-Study Report*). It is important to note that students need only be admitted to the university in order to start an electrical, computer, or software engineering major; in other words, students do not have to apply and be admitted to both the university and the college of engineering.

Throughout the electrical engineering major, the focus on specific professional competencies are at the heart of the seminar and capstone courses. These competencies include: "communication, teamwork, project management, initiative, continuous learning, and ethics" (*Electrical Engineering Self-Study Report*, p. 23). "Softer" skills, such as networking and career preparation, are developed outside the major's curriculum in extracurricular workshops, advising, or in ENGR 101, a freshman-level course called Introduction to Engineering (*Electrical Engineering Self-Study Report*, p. 23). This focused is echoed in the computer engineering and software engineering majors (*Computer Engineering Self-Study Report; Software Engineering Self-Study Report*).

The documents across the software, computer, and electrical engineering majors discuss the need to produce engineers who are well-rounded; that is, students who will have "an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability" (*Software Engineering Self-Study Report*, p. 34). As such, this demands that the program provide "the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context" as well as "a knowledge of contemporary issues" (*Software Engineering Self-Study Report*, p.34). However, neither of the majors provide students the space within their majors for coursework in elective areas that might better support knowledge in these outside areas beyond the 15 hours of general education requirements. The approved technical electives include advanced coursework within these majors (*Computer Engineering Technical & Elective Class List; Bachelor's Degree Requirements*).

The Precursor of Performance for Recognition

Recognition from others as an engineer is a key part of developing an engineering identity. A self-study report for Software Engineering lists peer-recognized expertise as the first attribute that the program expects from graduates (*Software Engineering Self-Study Report*). In a questionnaire for software engineering alumni, the program assesses the attainment of a productive career through students' ability to name examples of recognition such as professional awards or recognitions, leadership positions in the creation of a successful product, or a lead role in peer-reviewed publications or grants (*Software Engineering Self-Study Report*, p. 43). Each issue of the department's magazine for internal and external readers (e.g., alumni, donors, business partners, faculty, and students) highlights of students and faculty who received grants, awards, or professional achievements. The magazine also names alumni who were hired at high-profile companies such as Apple or founded their own companies (*Spring 2014 Department Newsletter*).

This publicity in the department's magazine provides a wide audience to celebrate the accolades of faculty and students. It also builds up the prestige of the department and provides external stakeholders, especially employers, with an expectation of the performance they can expect from future graduates of the program they may hire. However, this form of recognition minimizes other activities that serve specific functions for the department. Activities such as teaching, service, or community engagement are given markedly less space in the magazine, though other documents outline faculty and student engagement with K-12 schools, participation in engineering-based extracurricular activities, and mentoring. Notably, engagement with K-12 schools is noted as an important way to spark interest in students who will eventually apply for college and may consider applying for this specific program (*Electrical and Computer Engineering Department External Review*, pp. 53-54).

Engineering Identity Not Merged with Personal Identities

The departmental documents display a lack of identity in two areas: developing students' interest in engineering as a major and future career and connecting students' personal identities to that of an engineer, especially students from underrepresented groups. Overall, these documents assume that students are already interested and that this interest does not need to be maintained throughout the curriculum. Rather than focusing on why students might want to major in engineering, the body of documents instead focusing on the development of career options for students, thereby assuming they have already decided to become engineers. The program offers outreach activities with current engineering students who visit K-12 classrooms to encourage and excite younger students about studying engineering, yet it is unclear how the department develops interest in students who may be undecided about their major or think they want to study in another field. This assumption of interest in engineering is juxtaposed with the lack of preliminary recognition—although students are automatically assumed to be interested in electrical, computer, or software engineering and to maintain that interest, they are not recognized as engineers until they have acted on that interest in some laudatory way.

It is also unclear to what extent the department acknowledges the personal identities of its students and merges those with engineering identity, especially along gender and racial/ethnic lines. The value for diversity and inclusion is evident throughout the documents, yet how this value is put into action in promoting underrepresented students' participation in the field and helping them to be successful engineers is not. As part of its competencies, the Computer Engineering program states that its students should exhibit "cultural adaptability," or "Being open to making changes to accommodate the differences found in other cultures in order to interact effectively with individuals and groups from a different cultural background" (*Computer Engineering Self-Study Report*, p. 46). Rather than talking about students' own personal backgrounds and identities, diversity and inclusion are often depersonalized and framed as a technical competency for the workplace.

The department acknowledges the lack of diversity among its faculty members as well. The *Electrical and Computer Engineering Department External Review* notes that of the "50.5 FTE faculty in the department…six (4.6 FTE) are women. One faculty member is from an under-represented minority." This same document details the multi-year hiring plan that will hopefully increase the number of women and under-represented faculty members, but offers this caveat: "At the time a major problem from a faculty hiring perspective is that suitably qualified individuals in these demographic groups are difficult to find." The department notes that this could have a negative impact on the recruitment and retention of students: "Failure to improve demographics of our faculty and undergraduate body could lead to problems of perception and low interest in ECpE among women and underrepresented minority high school student" (*Electrical and Computer Engineering Department External Review*, p. 21). This point ties racial/ethnic and gender representation to interest in pursuing an engineering degree within this specific department.

More recently, the department received a multimillion dollar grant to support low-income students in the department and to promote increased participation of these students in the profession; many of the students currently being supported are women. Among the achievements of the grant are the creation of a leadership course for these students as well as financial support in the form of scholarships. As one of the principal investigators of the grant argued, "There should be nothing about science, technology, engineering, and mathematics that is gender specific," (*Summer 2017 Department Newsletter*, p. 3) meaning that gender should not define a female engineer in the profession. There are other broader efforts to create communities of students who share similar backgrounds such as programs for female students across STEM fields and learning communities for first-year students. Yet these efforts focus solely on the gendered aspect of students' identities and excludes race, ethnicity, and other intersecting identities.

Discussion

Based on previous research on engineering identity, this study understands it to be supported through performance/competence, recognition from others, and interest [8], [9], [10]. Performance, expressed as the exhibition of the different attributes outlined above like technical proficiency, is the key focus of the department's training of future computer and electrical engineers. In turn, recognition is granted when a student or engineer receives an award or other accolade from their peers, supervisors, or faculty members after displaying some or all of these attributes. Previous research has paid less attention to interest than other parts of engineering identity, and this study finds that this program, in turn, has not focused on this aspect as well.

Our first research question concerned how this department constructed engineering identity or identities. These documents, across the board, support previous research which understands engineering as something one does, rather than being integrated into part of who one is [16], [23]. Analysis of the documents, especially the self-study reports required by ABET for reaccreditation, shows the construction of the “ideal engineer” that emerges. First and foremost, the “ideal engineer” is a person of the future—specifically, an employee who is technically proficient; who works and communicates well with others on a team; who is a leader; a lifelong learner who exhibits knowledge and understanding about the world around them; and an excellent problem solver. Furthermore, the “ideal engineer” is recognized by peers for these characteristics in tangible ways—if not by awards or money, then by titles, accolades, publications, or other products. How this image becomes reality for an individual student who is assuming a new identity as an engineer in addition to their other personal identities (is much less clear.

The department’s depiction of the ideal electrical, software, or computer engineer contributes to the ways that undergraduate students understand engineers and engineering work. Previous research has shown that students usually emphasize scientific and technical competence and problem-solving when they think about who engineers are and what they do [18], [19]. Indeed, competence often stands out as the most important part of engineering identity to students [20]. This characterization is clearly reflected in—and mostly likely shaped by—the departmental documents analyzed here. As discussed above, this emphasis on performance/competence comes at the expense of recognition and interest and does not create the opportunity to merge personal or social identities with engineering identities. Ignoring these components of engineering identity may mean that the department will struggle to improve its recruitment and retention of under-represented racial/ethnic and gender minorities as well as its climate for diverse students [28], [29].

Our second research question asked how the department’s commitment to undergraduate engineering identity development was expressed in these documents. Our analysis shows that the department’s commitment is decidedly uneven. While there is considerable commitment to cultivating students’ technical competence, the department falls short in terms of recognition—except for exemplary accomplishments that are not accessible, attainable, or even necessary for all students—and the cultivation of interest. Additionally, this study shows that the depiction of the “ideal engineer” echoes previous research and excels at communication, teamwork, and leadership [18], [21], [24]. However, this study shows that those skills are not prioritized as highly in the major curricula as technical content. Thus, while the department desires to produce highly skilled, well-rounded researchers, their priorities show that their commitment lies with performance and competence. Ultimately, this document analysis indicates that engineering identity is considered by this electrical and computing department as something that is already formed, rather than under development during students’ college years. To a certain extent, the department takes a “just add technical proficiency” approach to producing future engineers. While that approach does not take into account the various components of engineering identity nor social or personal identities, it does indicate a belief that one can learn the skills to be an engineer.

Limitations

As this study focused solely on the analysis of departmental documents, this study has several limitations. First, the inclusion of documents was limited by what documents were publicly available online and what internal documents members of the department in question were willing and able to provide to us for analysis. Second, this study does not include ongoing efforts that may be in development or under review (e.g., new programs or outreach efforts) related to developing students' identities. Additionally, due to the focus on documentary evidence, we offer a relatively one-sided view of the departmental activities surrounding identity development—future research is that includes additional viewpoints is warranted. Finally, this research is limited in its generalizability. That being said, several of the documents included in this analysis are types that are fairly typical of departmental documents writ large. Many departments across the country publish strategic plans, major information, or have newsletters. Additionally, ABET self-study reports—required for accreditation—are required to have specific types of information included. Therefore, while the data itself is specific to this department, it is possible that analysis of other documents from other departments may show similar themes.

Conclusion & Implications

While departmental documents do not give a full picture of the activities programs engage in to foster undergraduate engineering identities, this study sheds light on how one engineering department constructs the 'ideal engineer.' It also shows the ways that this department facilitates the process of training its students to embody that ideal. Overall, this department focuses attention on the acquisition of technical proficiency, bestows recognition when the proficiency is proved in a prominent way, and assumes that students are already interested in engineering and that the curriculum adequately supports that interest.

This study is part of a larger research project focused on engineering identity development and helps to identify areas for future inquiry. First, there should be focus on students' extracurricular activities and participation in engineering-related activities outside the classroom that develop their interests in the profession. While the main focus of the curriculum may fall under performance, there may be other ways by which students are recognized by others as engineers and foster their interest. Second, there needs to be more research done on the disciplinary level. While this study starts to fill in the disciplinary picture for electrical and computer engineering, it represents only a small drop in the bucket. Specifically, comparative work is warranted to see if the findings that emerged with respect to this department will emerge in other disciplinary contexts (i.e., mechanical, civil, or chemical engineering). Also needed is research that looks closely at the process of disciplinary engineering identity development—how identity is developed or impacted by courses, labs, and other curricular and extracurricular activities.

This analysis does also offer implications for practice. Programs may consider redirecting some of the publicity they give to formal awards to engagement activities that still serve the profession such as outreach with K-12 schools or service-learning projects. Programs should also consider how they collectively think about student interest and motivation in engineering. They may want to gather data about what draws students to the major and what piques their interest. Additionally, programs should strive to incorporate real-world contexts into their curricula to help students make meaningful, relevant connections to their educations. Likewise, programs should assess and improve their climates for diverse students and consider ways to make more connections between engineering identities and social identities. Doing so will promote student retention, especially of women and underrepresented racial/ethnic minorities. Programs should consider the alignment of their curricula with their technical and professional priorities to ensure that both arenas are well and meaningfully represented in undergraduate education. Finally, electrical, computer, and software engineering departments should undertake systematic review of the messaging that they communicate in their documentation to ensure that the documents convey messages that will assist in student engineering identity development.

References

[1] N. W. Brickhouse, P. Lowery, & K. Shultz. “What kind of a girl does science? The construction of school science identities,” *Journal of Research in Science Teaching,* vol. 37, no. 5, pp. 441-458, 2000.

[2] O. Pierrakos, T. K. Beam, J. Constantz, A. Johri, & R. Anderson. “On the development of a professional identity: Engineering persisters vs engineering switchers,” Frontiers in Education Conference, 2009, pp. 1-6.

[3] M. Meyer & S. Marx. “Engineering dropouts: A qualitative examination of why undergraduates leave engineering,” *Journal of Engineering Education,* vol. 103, no. 5, pp. 525-548, 2014.

[4] C. E. Foor, S. E. Walden, & D. A. Trytten. “ ‘I wish that I belonged more in this whole engineering group’: Achieving institutional diversity,” *Journal of Engineering Education,* vol. 96, no. 2, pp. 103-115, 2007.

[5] S. E. Walden & C. E. Foor. “ ‘What’s to keep you from dropping out?’: Student immigration into and within engineering,” *Journal of Engineering Education,* vol. 97, no. 2, pp. 191-215, 2008.

[6] K. L. Tonso. “Student engineers and engineer identity: Campus engineer identities as figured worlds,” *Cultural Studies of Science Education,* vol. 1, no. 2, pp. 273-307, 2006.

[7] K. L. Tonso. “Teams that work: Campus culture, engineer identity, and social interactions,” *Journal of Engineering Education,* vol. 95, no. 1, pp. 25-37, 2006.

[8] A. Godwin, “The development of a measure of engineering identity,” ASEE 123rd Conference & Exposition, New Orleans, LA, June 26-29, 2016.

[9] A. Godwin, G. Potvin, Z. Hazari and R. Lock, "Understanding engineering identity through structural equation modeling," *2013 IEEE Frontiers in Education Conference (FIE),* Oklahoma City, OK, 2013, pp. 50-56.

[10] A. Godwin, G. Potvin, Z. Hazari and R. Lock, “Identity, critical agency, and engineering: An affective model for predicting engineering as a career choice,” *Journal of Engineering Education,* vol. 105, no. 2, pp. 312-240, 2016.

[11] S. M. Lord, R. A. Layton, & M. A. Ohland. “Trajectories of electrical engineering and computer engineering students by race and gender,” *IEEE Transactions on Education,* vol. 54, no. 4, pp. 610-618, 2011.

[12] M. Jenkins and R. G. Keim, "Gender trends in engineering retention," *34th Annual Frontiers in Education, 2004. FIE 2004,* 2004, pp. S2H-13-18, Vol. 3.

[13] C. Hill, C. Corbett, & A. St. Rose. “Why so few? Women in science, technology, engineering, and mathematics. American Association of University Women, 2010.

[14] Engineering Workforce Commission. “Engineering & Technology Enrollments, 2013,” Engineering Workforce Commission, 2013.

[15] G. A. Bowen. “Document analysis as a qualitative research method,” *Qualitative Research Journal,* vol. 9, no. 2, pp.27-40, 2009

[16] J. R. Morelock. “A systematic literature review of engineering identity: Definitions, factors, and interventions affectiving development, and means of measurement,” *European Journal of Engineering Education,* vol. 42, no. 6, 2017.

[17] L. L. Pozzer & P. A. Jackson, “Conceptualizing identity in science education research: Theoretical and methodological issues,” in *Sociocultural studies and implications for*

science education: The experiential and the virtual, C. Milne, K. Tobin, & D. DeGennaro, Eds. New York: Springer, 2015, pp. 213-230.
[18] E. Godfrey & L. Parker. "Mapping the cultural landscape in engineering education," *Journal of Engineering Education,* vol. 99, no. 1, pp. 5-22, 2010.
[19] K. Keltikangas and M. Martinsuo. "Professional socialization of electrical engineers in university education," *European Journal of Engineering Education*, vol. 34, no. 1, pp. 87-95, 2009.
[20] G. Tomer and S. K. Mishra. "Professional identity construction among software engineering students: A study in India," *Information Technology & People*, vol. 29, no. 1, pp. 146-172, 2016.
[21] M. Loui. "Ethics and the development of professional identities of engineering students," *Journal of Engineering Education*, vol. 94, no. 4, pp. 383-390, 2005.
[22] Huff, J., & Jesiek, B. K., & Zoltowski, C. B., & Ramane, K. D., & Oakes, W. C. (2016, June), *Social and Technical Dimensions of Engineering Identity* Paper presented at 2016 ASEE Annual Conference & Exposition, New Orleans, Louisiana.
[23] A. L. Pawley. "Universalized narratives: Patterns in how faculty members define 'engineering'," *Journal of Engineering Education,* 98(4), pp. 309-319, 2009.
[24] K. L. Meyers, M. W. Ohland, A. L. Pawley, S. E. Silliman, & K. A. Smith. "Factors relating to engineering identity," *Global Journal of Engineering Education,* vol. 14, no. 1, pp. 119-131, 2012.
[25] M. Eliot. "Constructing professional portfolios: Sense-making and professional identity development for engineering undergraduates," *Journal of Engineering Education,* vol. 100, no, 4, pp. 630-654, 2011.
[26] Forin, T. R., & Adams, R., & Hatten, K. (2012, June), *Crystallized Identity: A Look at Identity Development through Cross-disciplinary Experiences in Engineering* Paper presented at 2012 ASEE Annual Conference & Exposition, San Antonio, Texas.
[27] N. Dukhan, M. R. Schmauk, & J. J. Daniels. "Implementation of service-learning in engineering and its impact on students' attitudes and identity," *European Journal of Engineering Education*, vol. 33, no. 2, pp. 21-31, 2008
[28] B. K. Jesiek, Borrego, M., Beddoes, K., Hurtado, M., Rajendran, P., and Sangam, D., "Mapping Global Trends in Engineering Education Research," *International Journal of Engineering Education*, vol. 27, pp. 77–90, 2005
[29] X-Y. Du, "Gendered practices of constructing an engineering identity in a problem-based learning environment," *European Journal of Engineering Education,* vol. 31, no. 1, pp. 35-42, 2006.
[30] H. B. Carlone & A. Johnson, "Understanding the science experiences of successful women of color: Science identity as an analytic lens," *Journal of Research in Science Teaching,* vol. 44, no. 8, pp. 1187-1218, 2007.
[31] Z. Hazari, G. Sonnert, P. M. Sadler, & M-C. C. Shanahan, "Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: A gender study," *Journal of Research in Science Teaching,* vol. 47, no. 8, pp. 978-1003, 2011.
[32] G. Potvin, C. Beattie, & K. Paige, "Towards the measurement of undergraduate students' physics identity," Paper presented at the American Association of Physics Teachers Summer Conference, 2011.

[33] G. Potvin, K. Paige, & C. Beattie, “Building a valid and reliable assessment of physics identity. Paper presented at the National Association for Research in Science teaching Annual International Conference, 2012.
[34] J. P. Gee, “Identity as an analytic lens for research in education,” *Review of Research in Education*, vol. 25, pp. 99-125, 2001.
[35] S. B. Merriam, *Case study research in education: A qualitative approach*. San Francisco, CA: Jossey-Bass, 1988.
[36] J. Saldaña, *The Coding Manual for Qualitative Researchers, 3rd Ed.* Los Angeles, CA: Sage, 2016.