The Challenges and Affordances of Engineering Identity as an Analytic Lens

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Abstract

In this theory paper, we seek to review recent scholarship on the construct of engineering identity to help identify the challenges and affordances of its use in engineering education research. The growing interest in expanding the body of professional engineers has sparked new interest in engineering identity. We begin with a survey of early and contemporary identity studies before focusing on studies of identity in science and, finally, engineering. We posit that engineering offers a unique lens for viewing identity, as it is a context that comes with a distinctive set of historical norms, values, and beliefs. A body of research has grown in attempts to understand what professional identity means for engineering students, how it forms, and to develop measures for studying the construct in this particular context. Engineers are trained to be empirical and solution-focused. Aligned with this orientation, scholars in engineering identity tend to ground their work in well-defined frameworks that include a collection of traits developed within the context. Although this perspective provides easily definable lenses for analyzing identity, more research is needed into the factors that influence students' identity development – particularly those that are within the control of engineering educators. This paper will provide a review of an engineering identity study, explore the challenges and affordances inherent in this work, and discuss the practical implications for engineering educators and scholars.

Introduction

In the early 17th century, the philosopher John Locke developed a theory of mind that advanced the idea that individuals are born as *tabula rasa*, or blank slate: the mind arrives in the world as an empty vessel, waiting to be filled with knowledge. These ideas influenced subsequent early scholars in education. Locke's work suggests that the responsibility of teachers is to input knowledge into students, and that students demonstrate that they have learned by outputting that same knowledge, providing the foundation for what is widely recognized as the "traditionalist" form of education today. While later philosophers and educational scholars pushed back against the idea that students are little more than passive, empty vessels and that the simple input-output model is representative of learning [1], Locke's philosophy persists in many disciplines, particularly those that historically involve traditionally rigid ways of thinking and doing. Recent research in these disciplines has suggested that these educational norms influence many aspects of students' experiences, feelings, and outcomes, including the identities that students form as students and as pre-professionals.

The influence of Locke and the traditionalist view of education is evident in STEM fields, and engineering departments in particular: STEM subjects are known for support of meritocracy and for grading practices based primarily on high-stakes assessments [2-4]. Foundational courses -- the start of an unforgiving undergraduate workload -- serve to "weed out" students at an early stage, and typically result in large numbers of D, F and W grades, which often leads students to drop the major [2-3; 5]. The curriculum in these lower-level courses typically focuses on solving abstract problems that meld mathematics and physics, but may not stretch into an area that students recognize as "engineering" [6]. Research shows that these factors influence student persistence and attitudes about the field [2]. This context also makes a sense of belonging challenging for students who do not fit in with the dominant norms and values [7] or whose ways of thinking may differ.

Meanwhile, students in engineering majors have an attrition rate near 50 percent, with minority students dropping out of the engineering degree at higher rates than white students [8-9], and engineering remains a STEM field still unable to achieve gender [10-11]. Although high academic standards are often cited as the reason for this "leaky pipeline" of students away from the engineering major, the culture and tradition found within engineering classrooms may be a significant factor [3-4]. Recent research in engineering education has suggested the importance of examining constructs, such as students' sense of identity, self-efficacy, and classroom community, in order to better understand how the context of engineering education influences student outcomes. The literature suggests that the formation of a professional identity in engineering has a significant impact on students' persistence within the engineering context [3; 12-13]. Because of the implications for retention, more research is needed into the factors that influence students' identity development – particularly those that are within the control of engineering educators.

To fully understand the current context of engineering education, we must first begin by examining identity in a broader context. Therefore, we will first examine early understandings about generalized identity to provide a foundation for the field, and then we will discuss the current understandings from the perspectives of psychology and sociology. Using these insights, we will discuss identity as it is situated in the disciplinary-specific areas of the sciences and engineering. Throughout these discussions, we will explore the challenges and affordances of identity as an analytic lens, and discuss the practical implications for engineering educators and scholars.

Identity Studies: Early Understandings

Identity study developed primarily since the Industrial Revolution, with principal contributions from theorists in the fields of sociology, psychology, anthropology, and education. In 1902, sociologist Charles Horton Cooley introduced the idea of the "looking glass self," in which individuals' self-concept is developed through an interpretation of interactions with others: "in imagination we perceive in another's mind some thought of our appearance, manners, aims, deeds, character, friends, and so on, and are variously affected by it" [14]. Our ideas about how we appear to others, and our interpersonal reactions, form our identity. Cooley discussed three main components to the looking-glass self: our conceptualization of our appearance to another; our conceptualization of that person's judgment of our appearance; and a self-feeling, such as shame, based on that conceptualization. Cooley [14] talked about the resulting ideas as forming the intellectual content of the self, which are infinitely variable and dependent on personality and context. His work suggests that everyone that a person meets throughout their lifetime influences the formation of the self through the function of the looking-glass. Cooley's ideas stem from an interactionist perspective of sociology, which holds that understandings about why people behave as they do can be developed by observing everyday social interactions and understanding the meanings that individuals attach to situations. Cooley's observation that industrialization had made people more individualized, and less connected, drove much of his work in this area.

George Herbert Mead, one of the founders of social psychology in the early 20th century, extended Cooley's work, positing that the self is a product of social interaction and emphasizing

the role of communication in the social process. Mead suggested that identity is formed through the looking-glass, but he restricted that function to particular life stages and interactions between an individual and a closer group of more formative figures [15]. Mead posited that children go through several stages of limited self, in which they are unaffected by others' perceptions of them, and it is not until a more advanced state of development – the "game stage" – when children are able to begin comprehending the attitudes and beliefs of the "generalized other," or society overall. In this stage, individuals begin to understand societal expectations, which influence the perception of the self. Mead also developed the distinction between the "I" and the "me," where the "me" is the social self, or how we believe the generalized other sees us, and the "I" is the response to the "me," or the reaction to society's perceptions [15]. Mead's work also emphasized the use of language in acting and reacting to social interactions, suggesting that there is no thought or action without language.

The work of Cooley and Mead served as a springboard for later research into identity, a field that diverged into several directions over the rest of the 20th century, as outlined in Figure 1. Kuhn and McPartland [16], in their research using the Twenty Statements Test on assumptions and self-attitudes, argued that identity is relatively fixed and stable; Freud's [17] work framed identity as individualized self-image, an autonomous construct directed by the individual. Goffman [18] argued that each individual has multiple "selves," and each behaves according to the situation; Erikson [19] and Vygotsky [20] framed identity as dynamic and situated. The views of these scholars demonstrate one divergence within the study of identity: stable and consistent vs. situated and dynamic. The differences in these viewpoints relates to a divergence between the inward and outward nature of identity. The perspective that identity is stable and consistent suggests that identity exists primarily within the self; the perspective that identity is situated and dynamic suggests that identity fluctuates according to the role or situation. In the following section, we will discuss the contemporary understandings of identity that have evolved from these early perspectives.

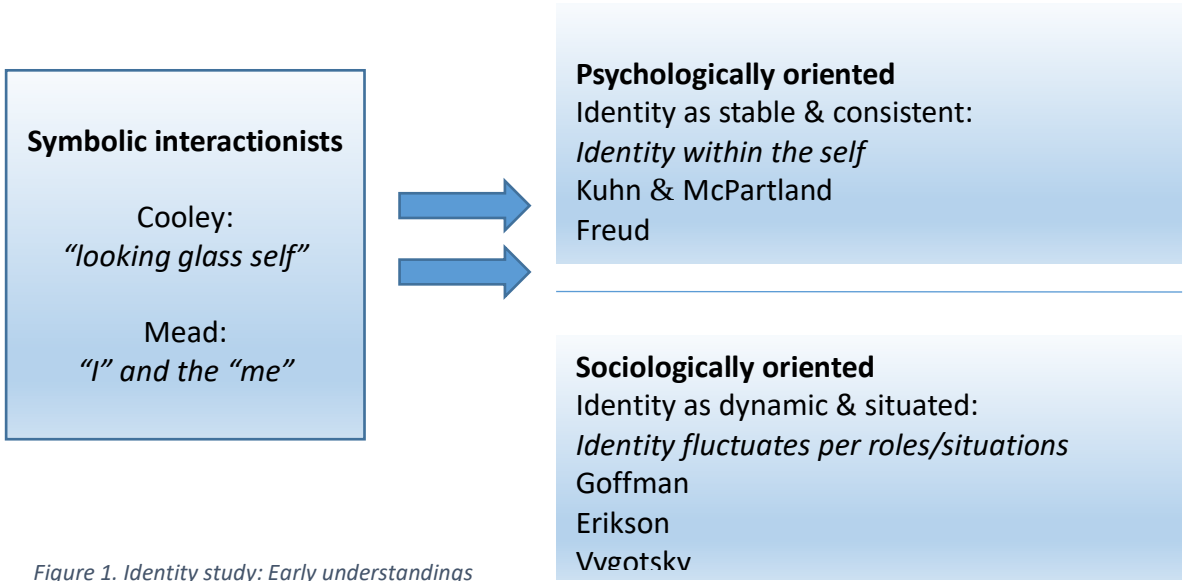

Figure 1. Identity study: Early understandings

Identity Studies: Contemporary Understandings

These earlier perspectives on identity formed the foundation for more recent viewpoints, although a firm working definition within the realm of the social sciences remains elusive and evolving. Tajfel [21] refers to identity as a sense of belonging to a social category, and involves the wide social strata that a person may associate with, such as race, class, gender, religion, sexual preference, language, physical ability, among many others. MacLure [22] viewed identity as a resource that individuals can use to understand themselves in relation to other people. Later contemporary research on identity has led to the conclusion that individuals possess many identities [23-27]: an individual undergraduate may identify as a student, a football coach, a son, a father, and a partner. The literature in this area suggests that these roles are understood as separate identities, and that the accumulation of multiple identities is an inevitable condition of life in a complex society [25]. These ranges of social identities come with norms, assumptions, and expectations about behavior and beliefs, and provide information about the characteristics of the social group. Each identity also drives the individual in a particular direction for the attainment of goals, and may inhibit individuals from pursuing goals in areas that feel at odds with a given identity.

In Lave and Wenger's seminal work [28], the researchers theorize that the process of learning leads to the formation of new identity: learning involves the "historical production, transformation, and change of persons." This perspective speaks to the view of identity as an ever-changing experience that continues developing throughout a person's life, as new experiences may lead to learning (formally or informally) and the development of new perspectives and ideas. Wenger's ideas around communities of practice [27] which integrate social learning theory and social constructivism, stem from this viewpoint. Wenger describes communities of practice as a group of individuals, with a shared domain or area of interest, who engage in collective learning to achieve a common goal [29]. This practice occurs within historical and social contexts, and learning occurs within the community through social constructivism [27]. The Zone of Proximal Development, the distance between what a learner can accomplish independently and what s/he can accomplish with help from peers [30], is utilized to push community members forward in their understanding of how to achieve the common goal through the use of resources and the knowledge base [27]. The developing practitioner develops identity through the learning that occurs through engagement in meaningful activities within a community of practice [27]. This is one affordance of identity as an analytic lens: Learning involves becoming a member of a learning community and forming an identity within that community.

Some research on identity has developed under the moniker of Identity Theory, and this work has moved in two related directions: "the first concentrates on examining how social structures impact the structure of self and the impact of the latter on social behavior, while the second concentrates on the internal dynamics of self-processes as these impact social behavior" [25]. The sociologically oriented perspective of identity role theory suggests that group identity is the observable traits common across the individuals immersed in a role (25; 31]. In order to identify with a role, such as someone in a particular profession, the individual must integrate the meanings and beliefs associated with that role into the individual's self-concept. Individuals can have a multitude of different roles and be members of different groups, but the roles that have the most influence on identity are those which influence behavior. In contrast, social identity theory,

which stems from a psychological perspective, involves an internal process of self-categorization that is not observable [26].

Some researchers have explored the ways in which identity can be used as an analytic tool, particularly in educational research. Gee [24] begins an explanation of his model of identity by framing the concept as a "kind of person," which implies stasis at first blush. However, he goes on to suggest the changeable nature of this conceptualization by explaining: "The 'kind of person' one is recognized as 'being,' at a given time and place, can change from moment to moment in the interaction, can change from context to context, and, of course, can be ambiguous or unstable" [24]. Gee explains that there are four ways to view how an individual can be a "kind of person," and emphasizes that these four perspectives are not divorced from one another, but connected in complicated ways. According to Gee, the Nature-identity is a state of being that is recognized as meaningful; the Institutional-identity is an authorized position; the Discursive-identity is a complex mix of an individual characteristic and context that derives its source of power from recognition through interaction; and Affinity-identity is found in distinct affiliations of an individual to a group that engages in sustaining social practices. The latter type of identity is rooted in Lave and Wenger's work [28] on identities-in-practice and communities of practice. Figure 2 provides an outline of the origins of this aspect of Gee's work, and tracks some of the research on identity that stemmed from this framework.

Two common themes emerge from Gee's work: the necessity of recognition by others for the identity to take place and have meaning, and its dependence on context. Gee explains that recognition depends on an interpretative system, and all of the four types of identities are related

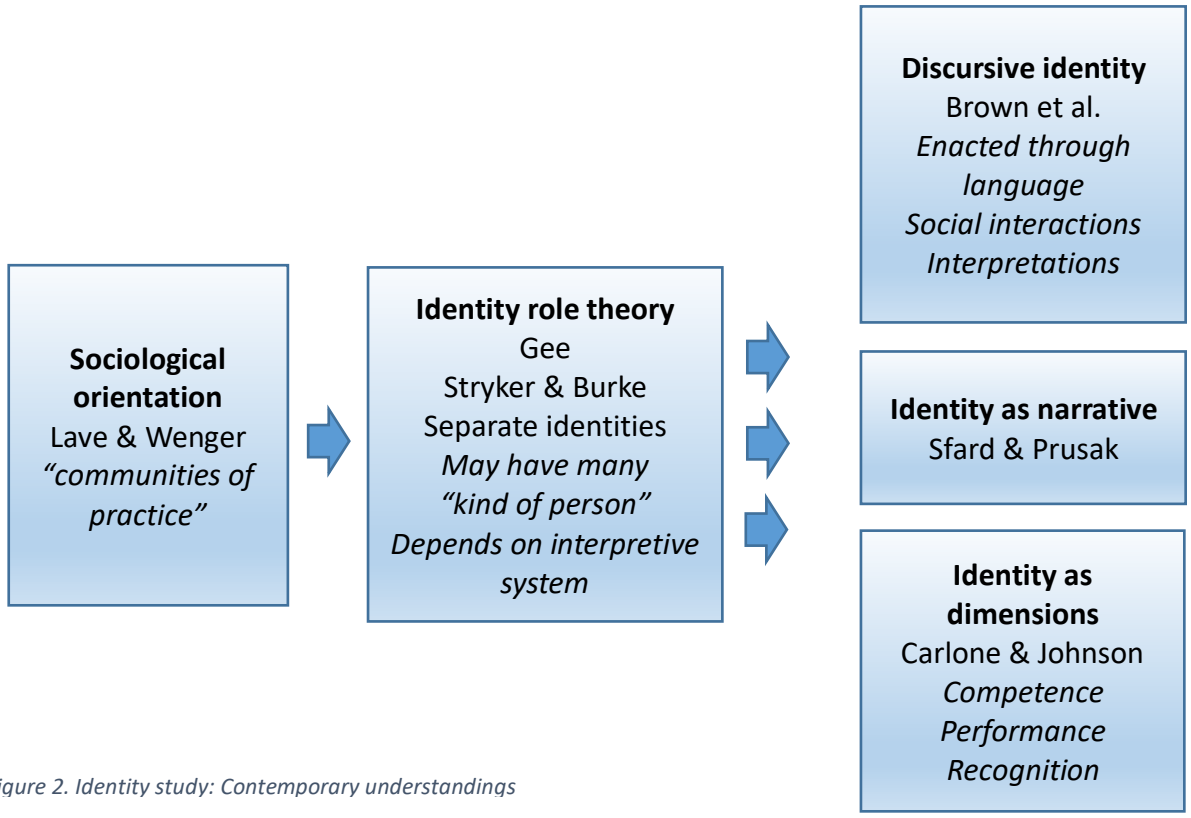

Figure 2. Identity study: Contemporary understandings

to an interpretive system; as a result, any one identity may be understood differently once it is

subject to another interpretive system. In this sense, Gee's conception of identity is externally oriented. Identity is relative.

Gee applies these ideas to a variety of contexts within education, and considers the "new capitalism" [24] as a significant consideration within the societal context where Nature, Institutional, Discursive, and Affinity identity elements work. Gee discusses new capitalism as a change in socioeconomic conditions, and suggests that scientific, technological, and demographic shifts have influenced relationships between individuals and resulted in an emphasis on identity through affinity groups. In addition, because the new capitalism tends to value flexibility and multidimensionality rather than traditional stability and inflexibility [24], some traditional categories of individuals that influence identity could transform into something viewed in a more positive or negative light. Examples of such shifts may be pulled from history and contemporary trends. For example, bilingual or trilingual students have traditionally been viewed through the lens of a deficit model that laments the academic challenges that schools assume these children will face, whereas today, the trend – in some areas of the country -- is towards appreciating the diverse linguistic abilities of these students. The identities of teachers and students, and the positive or negative values society places on those identities, influences patterns of behavior and expectations, both within the schools and along their professional trajectories. As society shifts towards increasingly postmodern values, our view of different identities will likewise be altered [24].

Drawing upon Gee's identity framework in which "discourses are ways of being certain kinds of people" [24], Brown et al. [32] outline the construct of discursive identity to investigate the ways in which individuals' identities are developed through discourse. This perspective discusses identity as enacted through language, social interactions, and interpretive processes: discursive identity "reflects an understanding that speakers select genres of discourse with the knowledge (tacit or implicit) that others will … interpret their discourse as a signal of their cultural membership" [32]. Discursive identity aligns with the sociocultural view of identity development, in which an individual's presentation of oneself to a community, and the community's recognition of the individual as a kind of person, is central to an identity. This perspective also recognizes the agency of the individual in communicating an identity role to a community. Brown et al. present the framework of discursive identity as an analytic lens to explore how students participate in scientific communities of learning within the classroom, and suggests that educators can influence how students' identities are constructed and co-constructed. These perspectives have led to a number of additional frameworks for viewing identity, including intersectionality, which considers the connection between an individual's social and educational circumstances. Intersectionality has been one model for examining students of color in higher education, as it provides a lens for considering that the impacts of multiple identities are not simply added one to another, but that these identities interrelate to have a much more profound effect [33]. This framework lends itself to a comprehensive approach to studying identity.

Sfard and Prusak [34] offer a related but divergent perspective on identity, concurring with Gee on the crucial nature of context and recognition in determining identity, and on the framing of identity as an analytic tool. However, they reject the simplistic definition of identity as a "kind of person," suggesting that this definition implies "there is a thing beyond one's own actions that

stays the same…there is a thing beyond discourse that remains unchanged" [34]. This interpretation suggests the existence of a core identity [24] that may not be malleable: Sfard and Prusak suggest that Gee's interpretation serves as an agent of stagnation and, potentially, a self-fulfilling prophecy. While Sfard and Prusak agree that identity is socially constructed, they also seek to make the concept operational so that it is useful in a practical sense. They define identity as stories about people: "those narratives about individuals that are reifying, endorsable, and significant" [34], emphasizing the dynamic and discursive nature of identity and the human agency that is involved. The stories may be told by the individual, or by others, and the act of telling the story, and the story being received by another person, impacts the narrative and therefore the identity. This work extends on previous narrative research into identity that linked storytelling to teachers' professional identity and described the complex interplay between knowledge, context and identity [34].

Sfard and Prusak distinguish between actual and designated identities in their exploration of the significant narratives that influence self-concept. Actual identity refers to stories about the current state of an individual, while designated identity refers to narratives that relay an expected state at some point in the future. Designated identities are significant in that they drive an individual's actions and feelings about what is possible. The downside is that they may be limiting: "More often than not…designated identities are not a matter of deliberate rational choice" [34]. Sfard and Prusak point out that divisions between a person's actual and designated identities often lead to unhappiness, and that learning is necessary to close these gaps. For example, in their study of high school mathematics students in Israel, the researchers uncovered differences in the narratives of immigrant and resident students, and in the narratives told about them by their elders, that appear related to the efficacy of the students in mathematics. For the immigrant students whose designated identities were prescriptive and well-formed, knowledge of mathematics was viewed as essential to the type of person they wanted to be in the future. Consequently, these students performed more effectively in math. Identity provides an important lens for viewing individuals' learning and behaviors within the realm of education.

These contemporary perspectives of identity provide a framework for a theoretical understanding of the construct as it applies to science and engineering identity. As identity has been studied extensively in the sciences in recent decades, particularly in relationship to attracting and retaining women and minorities in these fields, a review of science identity will provide foundational understandings about a disciplinary-specific perspective which has informed inquiry into engineering identity. The following section will explore prominent perspectives on identity in the sciences, a field of student which has influenced viewpoints on identity in engineering.

Science Identity

Beyond these general conceptions of identity, scholars in science education have conceptualized identity with a disciplinary focus. While the literature on science identity is vast, a number of scholars have made important advances upon which those working in engineering identity have drawn.

The realm of science as a profession offers a useful lens for viewing identity, as it is a context that comes with a distinctive set of historical norms, values, and beliefs. The culture of science

includes an emphasis on meritocracy [2-3], and science departments at the university level, which serve to train pre-professionals in the science content, reflect this culture. University science classrooms are known for a traditional lecture style featuring passive learning, along with high enrollment, particularly at the lower levels, where grades based largely on a handful of exams are the norm [2]. Seymour & Hewitt [3] describe the competitive nature of this context: students are expected to sink or swim while navigating courses designed to weed them out, and to work with professors who may have less interest in teaching and more interest in conducting research. Carlone & Johnson [35] point out that the existing literature offers little explanation for how students experience and succeed in the context of scientific disciplines, and they propose identity as an analytic lens for exploring these issues.

Carlone and Johnson [36] draw on previous literature around identity role theory [25; 31] to create a model for exploring identity development in the sciences, while noting the elusive quality of an operationalized conception of identity in the literature. The researchers discuss the need for a "methodological and analytic direction" [36], in line with the traditional nature of much scientific thinking. Their framework is comprised of three dimensions – competence, performance, and recognition – that interconnect to form a professional identity. Figure 3 provides a visual model of how these dimensions interconnect. Competence involves the individual's knowledge and understanding of science content and the ability to apply this knowledge to scientific contexts. Performance is the way that an individual makes visible their knowledge of scientific practices; a social context that includes an audience is necessary for performance. Recognition involves the acknowledgement from the self, and others, that an individual is a "science person" [36]; this often occurs through the performance of knowledge and skills in a social context. These dimensions, together, influence a person's professional identity.

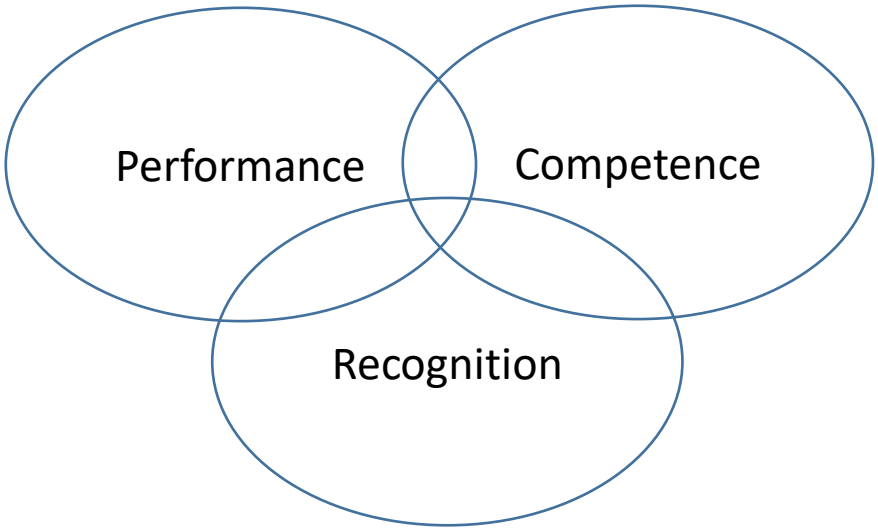

Figure 3. Carlone & Johnson (2007) identity model

The dimensions of this model overlap in significant ways, emphasizing the interconnected nature of identity, and all three are required for high levels of science identity. For example, aligning with the body of literature that describes identity as socially constructed, competence and performance without recognition are unlikely to foster a strong science identity; such situations are documented in the literature that explores the challenges faced by women in the sciences, and as possible reasons for the lack of gender parity in some science disciplines [4]. Carlone and

Johnson [36] argue that social strata like gender, race, and ethnicity influence science identity, despite the inexplicit connection between these aspects of a person in the literature on science identity; they point out that the localized context, which may include the influence of social categories, is a factor in the limitations and opportunities that an individual perceives, and in the emergence of an identity. The Carlone and Johnson model offers an important analytic tool that accounts for the interconnected dimensions and contextual influences that comprise an identity.

These discipline-specific perspectives on identity formation in the sciences have influenced identity research in engineering. In the following section, we will discuss the research on identity as it relates to the engineering discipline.

Engineering Identity

Research on engineering identity draws directly on previous literature that frames the generalized concept of identity in various ways. Tonso [4] discusses the everyday identity language used by many budding engineers to describe the sense of belonging to a group of individuals who engage in engineering as a practice, suggesting a connection to Wenger's [27] work on communities of practice. Related literature founded in the theory of situated learning focuses on the interrelationship between identity and learning, in which learning creates changes in identity through participation [27-28]; in this view, a key aspect of learning is the process of identifying with a community of practice. The literature acknowledges the complex interconnectedness of the engineering discipline itself and the unique social context in which it resides. Tonso [4;13], a leading researcher in qualitative engineering identity, divides the current state of the discipline-based identity literature into three areas: identity as collective; identity as drawn from the perspectives of developmental psychology; and identity as drawn from the perspectives of sociocultural studies. We will examine each area below.

Identity as collective. Within the perspective of collective identity, the work emphasizes the role of engineering as a global profession, examining the similarities and differences between engineering identity in various areas of the world. Downey & Lucena [37] found significant differences between the values associated with engineering identity in a study of several Western countries, and suggest that these differences were created through sociocultural factors and national approaches to economics. MacKenzie [38] found that engineers are required to be diverse practitioners and develop an engineering identity that is heterogeneous in nature. The development of an engineer stems from the interaction of competencies and professional identity, with each shaping the other on the global scale, emphasizing the role of context and social expectations in the development of an engineering identity.

Identity as drawn from the perspectives of developmental psychology. From the perspective of developmental psychology, engineering students' identity is tied to the need to align with the profession in terms of a set of characteristics that are necessary for success [13]. These characteristics are considered malleable and teachable, rather than inherent. Researchers in this area tend to focus on engineering identity as a set of traits available to the individual while acting within the profession, rather than some of the more elusively-defined conceptions of identity. Loui [39] found four types of characteristics needed for identification with the profession: technical competence, interpersonal skills, work ethic, and moral standards such as integrity.

These characteristics are seen as inherent to being an engineer, and are required for identity to form.

Identity as drawn from the perspectives of sociocultural studies. Research in the sociocultural perspective highlights social expectations of behavior and competence. Anderson, Courter, McGlamery, Nathans-Kelly, & Nicometo [40] found that skill in communication is critical to engineering work, in addition to problem solving, teamwork, learning and personal contributions, suggesting that social skills may be central to strong engineering identity. Faulker [41] found that characteristics that are stereotypically considered masculine (problem-solver) or feminine (good communicator) are both necessary to engineering work, even though the discipline is traditionally considered masculine in nature. Faulker argued that gender stereotypes inhibit professional identity production for both male and female engineers, demonstrating the wide range of socially expected skill in the field.

Related to the sociocultural perspective and drawing on Carlone and Johnson's model of competence, performance, and recognition, Tonso [13] used the framework of figured worlds -- socially produced and culturally constructed territories -- in conducting research to uncover the identity meanings inherent within a U.S. engineering college by examining the terms used to describe different types of engineering students. The study then juxtaposed these general identity categories with the experiences and challenges of two students in presenting themselves as engineers within the school culture. Tonso found that the language used by students to discuss each other's engineering identity illuminated a ranking system that involved perceived competence in engineering, as well as the students' social prowess, and their interest in computers. Identifiers such as "loner," "geek," and "dormie" suggested lack of social skills or interest, while "betty," "jock," and "slacker" suggested an affinity for socializing and/or Greek life. Identifiers such as "computer whiz" or "technogeek" suggested a fascination with computers, while "brown-noser" and "curve-breaker" suggested high academic achievement (in a somewhat negative way). Tonso argued that these campus engineering identities framed interpretations of individuals' actions, and that campus engineering identities provided these students with a way to interpret and recognize performances of engineering selves. The study found that the process of recognition of a student as an engineer is very important in the formation of an engineering identity, and the terms used to describe different students provide a framework used to judge actions. As recognition confers a sense of belonging on the student, Tonso also discusses that the campus identities outlined in the study suggest the degree to which a student may belong in the unique figured world of the engineering department.

Another study of engineering identity based partly in Carlone and Johnson's model of competence, performance, and recognition involved a subject-related role identity framework. This framework posits that individuals attach meanings to social and cultural roles, and that "an individual has as many selves or identities as he or she has groups of people with which he or she interacts" [42]. Engineering students negotiate the various roles (identities) that they play within the different contexts of their lives; some of these roles may add or detract from their ability to identify as engineers. Godwin's initial study in this area focused on the development of an instrument to measure the engineering identity of introductory-level undergraduates. The background for the study included previous literature on a quantitative measure of physics identity used to understand STEM career choices, and on an expanded version to measure math

and science identities. These measures were used in several large-scale quantitative studies, and included three constructs: performance/competence belief (related to self-efficacy); interest in the subject; and feelings of recognition (i.e., feeling that others see them as the type of person that can do the work) [42]. Together, these three constructs are reliable in describing students' self-beliefs, which comprise a students' identity, and "are predictively valuable for understanding career choices" [42]. The theoretical framework for the instrument stemmed from social identity theory and symbolic interactionism, and Godwin focused on the internal dynamics and roles that impact behavior. Godwin concluded that the results provide strong validity evidence for the developed instrument to measure the identity constructs of performance/competence, interest, and recognition.

A follow-up study [43] investigating engineering students' identity development across the four (or more) years of undergraduate education found that the same subject-related role identity instrument can measure identity among students in different years of their undergraduate education, not just the introductory level. This study also revealed that recognition and performance/competence beliefs are higher in year four than in year one; interest in engineering did not show this significant difference. The authors discuss the idea that this phenomenon may be explained by persistence: those with little initial interest may be the students who later drop the major. In addition, all of the identity measures in this study show a decline in year two. They discuss this trend as possibly related to the "sophomore slump," when engineering students begin to encounter more demanding discipline-specific coursework that challenges their academic abilities [43]. The authors suggest that this period of challenge and uncertainty in the students' course progression may be an ideal time to focus on bolstering students' performance/competence and recognition beliefs, in order to sustain students' engineering identity and improve student retention in the major.

Scholars such as Godwin have worked to develop quantitative instruments for measuring students' engineering identity, but these studies have occurred over a period of years within the undergraduate time frame. These longitudinal results have some limitations, including their status as a "snapshot" [43] that does not represent the changeable nature of identity in the long-term, or pinpoint the factors most influencing those results. A challenge for current researchers is the absence of a quantitative instrument to capture short-term changes in identity. More exploration of quantitative instruments that would capture changes in students' identity over shorter time frames would be useful in providing instructors and institutions with tangible ways of nurturing students' development of engineering identity.

Practical Implications - Community as a Lens for Identity

Research on identity within the undergraduate engineering context has drawn upon a variety of theories and research ranging from generalized identity theory to identity development specific to the scientific disciplines, which have had historically similar problems to engineering when it comes to student recruitment and retention. Research in STEM fields has suggested that the culture of the discipline is connected with students' identity formation, which has practical implications as a factor in students' persistence in the major. Another practical relationship is the connection between identity and students' sense of community, which may be fostered through the actions and attitudes of the instructor. The following section discusses the rationale

for utilizing classroom community as a way to encourage the development of students' engineering identity

The psychologists McMillan and Chavis [44] define community as a feeling of belonging, as a sense of individual members' importance, and as a feeling of confidence that the needs of individuals will be met through membership within the group. Community members cannot just go through the motions, but must believe that their active participation will benefit them in some way. The community regulates members' behavior and norms and provides an identity for the group [45]. Within an educational context, "members of strong classroom communities have feelings of connectedness. They have duties and obligations to each other and to the school and they possess a shared faith that members' educational needs will be met through their commitment to shared learning goals" [46]. For students, a sense of community increases persistence, the availability of support and information, cooperation between individuals, and overall satisfaction [47-49]. The creation of communities within a classroom setting is critical for learning and participation [46].

Sfard [50] offers a framework for examining learning theories that provides a useful lens for discussing the relationship between the social aspects of learning that occur within the classroom community and students' identity development. Other theorists, such as Lave and Wenger [28], Brown, Collins, and Duguid [51], and Wortham [52], provide additional justification for examining students' identity within the context of a classroom community.

Sfard [50] proposes exploring learning theories through the use of metaphors. The acquisition metaphor proposes an understanding of learning as an accumulation of material goods, suggesting that learning has a beginning and an ending point. Sfard argues that the acquisition perspective provides the underpinnings for the vast majority of learning theories, from learning that is passively received to learning that is constructed by the student: in each case, theorists are interested in the acquisition of knowledge as a commodity to be gained. In contrast – but not in opposition – Sfard also presents the participation metaphor as an up-and-coming perspective on learning. In this alternate view, "learning a subject is now conceived of as a process of becoming a member of a certain community" [50], and participants in the learning process must be able to communicate using the discourse of the community, and to behave adhering to its norms. Educators may act to maintain the continuity of the community, while student novices will potentially reform the practice [50]: the participation metaphor encompasses the active involvement of teachers and students in learning, and the process implies no clearly defined beginning or end point. Sfard discusses this framework as related to identity development, and suggests that each metaphor has consequences for how students' identity evolves through the learning process:

> "While the (acquisition metaphor) stresses the individual mind and what goes 'into it,' the (participation metaphor) shifts the focus to the evolving bonds between the individual and others. … whereas the (acquisition metaphor) stresses the way in which possession determines the identity of the possessor, the (participation metaphor) implies that the identity of an individual, like an identity of a living organ, is a function of his or her being (or becoming) a part of a greater entity" [50].

The participation metaphor suggests that learning involves becoming a member of a learning community and developing an identity within that community. Brown et al. [32] and Lave and Wenger [28] explore "communities of practice" in which learning and identity formation takes place through participation in a group with a shared domain and common goal. The process of participation is essential to the success of a community of practice and identities-in-practice. Wortham [52] argues that critical elements of learning on the micro level within the classroom are a factor in promoting social identity. In discussing the link between community and identity within the undergraduate engineering context, Allie et al. [53] note: "The classroom community is clearly an important resource in providing a safe space where students can start to experiment with new identities. Sitting passively in a lecture hall gives limited opportunities for developing your identity."

While a single professor cannot alter the entire context of an engineering students' educational world, educators do influence the way student identities form [32]. Professors have some control over the community that arises within their classroom, as the instructor establishes and maintains the norms that influence behaviors and interactions. "Identity should be understood as a resource as well as an artifact of classroom interaction" [32]. This framework serves as an affordance of identity, as it can lead to more empowerment among professors of engineering to influence students' professional identity formation, and to impact student outcomes by altering classroom pedagogies to include fostering a sense of community.

Conclusion

The construct of identity is a complex concept that has evolved over the past century, with roots in psychology, sociology, and education. A number of tools and perspectives have been developed related to discipline-specific identity, as fields of study include a set of norms, values and beliefs, offering a useful lens for viewing identity. Research shows that students' identity within a discipline is connected with persistence in the field of study, which has implications for departments and universities seeking to improve student retention in a major.

This paper has reviewed relevant portions of early and contemporary identity studies as foundations for a discussion of identity within the disciplines of science and engineering. As engineering identity study has gained more attention as an important link to student persistence within the major, scholars have moved towards finding quantitative measures of the construct; while these measures have shed some light on the shifts in students' engineering identity throughout their undergraduate years, more research is needed in areas that will guide instructors and institutions towards practices that will nurture students' identities and cement their sense of belonging in the profession.

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