Engineering Identity Development: A Review of the Higher Education Literature

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To cite this article:

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Article Info	Abstract
	The purpose of this systematic literature review was to appraise and synthesize the current scholarship pertaining to engineering identity development within the higher education context and create recommendations for future scholarship within engineering education. A review of the literature concluded that research on engineering identity development has increased over the past ten years, has been conducted primarily with qualitative methods, and has been primarily limited to academic communities focused on mathematics, science, and engineering education. In addition, current scholarship reflected that most of the work in this area has focused on the learning contexts and experiences of women and underrepresented racial/ethnic minorities with less focus on men, international, or graduate students. Future scholarship in this area should focus on expanding forms of engineering identity frameworks and focus to facilitate greater understanding of engineering identity development.

Introduction

Engineering advancements have been central to human progress since the beginning of time. Major historical events, from building the first canal to the invention of social media, were made possible because of engineers who designed, innovated, and solved problems throughout the world. The key to the future is no exception. In the United States, for example, the job outlook of all engineering professions in the U.S. is expected to grow in the next decade, with Biomedical Engineers leading the way at a 26% market increase (U.S. Bureau of Labor Statistics, 2016). Without a commitment to educating and sustaining the global pipeline of engineers, the world will not continue to progress and reach its full potential.

Despite the increasing demand for professional engineers and increasing college enrollments overall, stakeholders have expressed a shortage in identifying qualified, career-ready individuals (McCave, Gilmore, & Burg, 2014; United Nations Educational, Scientific and Cultural Organization [UNESCO], 2010). This shortage of engineers results from a lack of college engineering graduates available to meet the growing need for these roles. Furthermore, the engineering context is influenced by a need to manage global competition and address an aging and non-diverse workforce (UNESCO, 2010; World Economic Forum, 2015).

One aspect of engineering education that is still relatively underdeveloped (Patrick & Borrego, 2016) is the use and discussion of engineering identity. Gee (1999, 2000) defined identity as "the 'kind of person' one is seeking to be and enact in the here and now" (1999, p. 13). In addition, Gee also acknowledged that identity cannot be claimed in isolation and requires the participation of others to recognize that identity. Identity development examines how people progress in stages as they grow and develop throughout time (Chickering & Reisser, 1993; Erikson, 1964; Phinney, 1993). Engineering identity development is a rapidly growing area of international scholarship, drawing on research from the engineering, educational, psychological, and sociological fields. Prior research (e.g., McCave, Gilmore, & Burg, 2014; Owen & Rolfes, 2015; Tonso, 2014; Trytten, Pan, Shehab, & Walden, 2015) has shown that students who do not identify with the field or are not recognized by engineering faculty are more likely to leave the field altogether. To be successful, students must see themselves as future engineers and be recognized by others as such. However, some of today's best potential engineers, specifically women and underrepresented minorities, are not studying engineering or have chosen to leave the academic pipeline due to lack of identification with engineering (Nosek, Bnaji, & Greenwald, 2002; Ong, Wright, Espinosa, & Orfield, 2011; Patrick & Borrego, 2016; Pierrakos, Beam, Constantz, Johri, & Anderson, 2011; Ross & Godwin, 2016). If engineering departments across colleges and

universities can help cultivate stronger engineering identities, more women and minorities can be retained and ultimately contribute to the domestic shortage of creative and technical talent. As this area of research grows, it is imperative that scholars examine the current scholarship concerning engineering identity development. Such an examination has the capacity to make connections between various areas of interdisciplinary research on the topic to enhance college student engineering identity development.

The purpose of this systematic literature review is to appraise and synthesize the current scholarship pertaining to engineering identity development specifically within higher education, and create recommendations for future scholarship within engineering education. The following section addresses the way in which the authors scanned and analyzed the available literature within this area to present relevant findings about engineering identity development. The final section contains recommendations for future scholarship and is intended to challenge scholars to enhance their understanding of engineering identity development to produce greater, more nuanced understandings of this development process.

Methods

This study was a systematic review of the literature on engineering identity development in higher education, which provides a synthesis of the available literature and a holistic approach to understanding this topic (Baumeister, 2013; Baumeister & Leary, 2007). Due to the comprehensive nature of the topic, systematic literature review was selected as the appropriate methodology; this type of review utilizes a set of clear methods to identify, evaluate, and synthesize studies addressing a focused topic (Baumeister & Leary, 2007; Grant & Booth, 2009; Hutchinson, 1993; Slavin, 1995). This type of review seeks to provide a comprehensive and replicable search to minimize bias (Grant & Booth, 2009). A systematic review enables researchers to establish the parameters of existing research, identify relationships within the literature, and then provide directions for addressing gaps in knowledge and forming future research (Baumeister & Leary, 2007).

Data Sources

The researchers performed an initial search of the literature to refine the topic of engineering identity development in higher education and to organize an overview of what was to be written (Polgar & Thomas, 1995). Initial searches of the literature enabled the researchers to understand published work within this area in order to refine the topic and aims of this review (DePoy & Gitlin, 1993; Lang & Heiss, 1998). Abstracts were assessed according to the agreed-upon inclusion criteria and articles were retrieved and critically assessed by the researchers. Inclusion and exclusion boundaries were set to ensure that the researchers retrieved all relevant studies but were still defined in a manner that would produce a nuanced understanding of the topic area (DePoy & Gitlin, 1993; Oxman & Guyatt, 1988). Selection criteria were outlined to ensure that scholarship was included due to relevance to the topical area rather than simply relying on the researchers' familiarity or agreement with the available scholarship (Gehlbach, 2006; Hutchinson, 1993; Oxman, 1994; Oxman & Guyatt, 1988; Slavin, 1995). Exclusion criteria were identified to outline how researchers eliminated studies from consideration and defined the purpose of the study (DePoy & Gitlin, 1993). For this study, inclusion and exclusion criteria included:

1. The study was published between 2000 and 2017.
2. The study was considered a peer-reviewed article or published conference proceeding.
3. The study was available in full-text and written in English.
4. The study made use of some form of engineering identity either

   a. Exclusively or
   b. In conjunction with other concepts

5. The study addressed the nature of engineering identity development in higher education.

These criteria were selected to keep the focus of the literature review clear, defined, and feasible (DePoy & Gitlin, 1993). Researchers selected this 17-year time frame to reflect the recent literature that has been published since the turn of the new millennium. Published peer-review articles and engineering education conference proceedings were reviewed to include only updated, relevant, and rigorous articles. The decision to include only full-text English studies was a reflection of the language skills of the researchers.

Engineering identity development as a topical area was selected due to its emerging popularity within multiple disciplines and areas of scholarship. As a result, a review of the literature has the opportunity to influence a greater number of scholars and educational stakeholders across disciplinary boundaries. The topical area is both comprehensive as well as feasible due to its focus on engineering, rather than multiple fields of study or an aggregation of fields as is often seen with scholarship on science, technology, engineering, and mathematics (STEM). Furthermore, this work is narrow in its scope due to its focus on engineering identity development as a construct at the higher education level. Rather than attempt to review the literature from all sectors of education, this synthesis focuses on identity development transitioning into and through higher education.

Multiple library databases/digital libraries (Education Full Text, Education Resource Information Center [ERIC], IEEE Xplore, JSTOR, Project Muse PsycINFO,) and published searchable conference proceedings (American Society for Engineering Education [ASEE], Frontiers in Education [FIE]) were searched to provide the most comprehensive understanding of engineering identity development scholarship. ASEE and FIE conference proceedings were retrieved via the organizational websites (ASEE Conference Proceedings Search, 2017; IEEE Xplore Digital Library, 2017). These library databases/digital libraries and conference proceedings were selected due to their influence on the topic (Portney & Watkins, 2000). Particular attention was paid to selected key journals such as (alphabetically): *IEEE Transactions on Education, International Journal of Education in Mathematics, Science and Technology, Journal of College Student Development, and Journal of Engineering Education.*

Data Analysis

The researchers defined the scope of the review, gathering literature from peer-reviewed journal articles and published conference proceedings to achieve a comprehensive understanding of engineering identity development in higher education. The search terms used were: "engineering identity," "development," "higher education," "college," and "professional identity."

Abstracts were assessed according to agreed inclusion criteria. Selected articles and conference proceedings were critically analyzed by members of the project team independently. The initial literature search identified 398 possible sources. On examination of the abstracts, 154 full-text articles and proceedings were retrieved. Our final selection included only items that met the aforementioned inclusion criteria. The analysis reported here included 88 articles focused on engineering identity development in higher education.

The researchers used a qualitative, interpretive approach to data analysis in which they read, reflected, and created notes for each of the sources (Strauss & Corbin, 1990). Studies were critically appraised based on their appropriateness to the research question. To determine appropriateness for this review, the authors evaluated articles based on the content of their sections and used unprompted judgment based on their expert opinions. To organize the scholarship under review, a spreadsheet was created to log the following information from each article or conference proceeding: author(s), title, year, journal theoretical framework, methodology, key findings, and calls for future research. When reviewing content for this study, authors sometimes coded articles and conference proceedings under multiple categories to address their relevancy. Authors used frequency counts and thematic analysis to evaluate and categorize studies. Once an entry was made for each article or conference proceeding, thematic categories, relationships, and emergent themes were compared across the sources (Miles & Huberman, 1994; Ventres, Kooienga, & Marlin, 2006). A conceptual map was created to connect the most salient concepts across the literature. Throughout the literature review process, the researchers participated in peer-debriefing activities in which they exchanged ideas on project design, analysis, and interpretation activities. Collaborators held discussions to refine interpretations, organize emergent themes, and draw conclusions on the available scholarship.

Trustworthiness & Researcher Positionalities

To conduct a trustworthy literature review, mechanisms were woven in at each stage (Creswell, 2013; Lincoln & Guba, 1985). To establish trustworthiness, the three authors, who have different backgrounds, scrutinized the data independently and explored their positionalities. To understand and reduce the influence of biases, values, and experiences that the researchers were bringing with them to the project, the researchers explored their "position" in relationship to project through the act of memoing, or short writing exercises (Creswell, 2013, p. 216). All three researchers hold graduate degrees within higher education and either currently or have worked within the higher education field. The first author works as a faculty member within a higher education program

conducting research focused on STEM identity development. The second author directs academic support at a research-intensive university and has a background as secondary science teacher. The third author, whose interests center upon equity in education, has previous work experience in both engineering admissions and programming at a research-intensive, highly competitive school of engineering. While all three authors have done work in STEM education, none of the authors received a higher education degree in a science, math, or engineering discipline. This should be considered with the analytical process because the authors may theoretically understand or even be able to empathize with science identity development in the articles they reviewed, but none of them have first-hand knowledge of the experiences students face in the STEM disciplines.

Limitations and Delimitations

Like any empirical study, delimitations existed for this research. The first delimitation, which was constructed by the authors, was requiring "full-text" articles, which may infuse bias into the search. The "full-text" definition may have different meaning for different databases, but the authors felt that having access to full-text documents was important to read and code the articles accurately for data analysis. Another delimitation the authors created was to read articles that were written in English. This was primarily done due to the authors' language abilities and comfort levels, but also to avoid any misinterpretation that may occur as a result of linguistic translations.

Results and Discussion

The results of this systematic literature review demonstrate that engineering identity development is a topic that has received increasing attention within the past three years, and is primarily limited to discussion in academic communities focused on math, science, and engineering education. Due to challenges they encounter that ultimately led to low retention rates in the engineering field, the majority of work on engineering identity has explored the dynamic in women and underrepresented students, with a focus on African-American and Latina/o students. In addition, engineering identity literature has mainly been grounded in the context of learning and the experience of students in the classroom. However, most of the works have examined engineering identity as a unilateral framework and only few have explored the intersections of engineering identity with other elements of identity. This results section follows the following outline: (1) the characteristics of included studies on engineering identity development; (2) the focus of engineering identity research; and (3) the theoretical approaches to engineering identity research.

Trends on Reviews Journals and Conference Proceedings

The studies, both peer-reviewed articles and published conference proceedings, included in our analysis were published between 2000 and 2017. Our analysis included 53 peer-reviewed articles and 35 published conference proceedings. The number of published peer-review articles and conference proceedings addressing engineering identity has increased steadily over time. Around 2011, the scholarship on identity development began to increase, and 2016 marked the greatest number of works (17/88) published on the topic. Of the included studies, 19% (17/88) were published in 2016; most were published in engineering education, general education, and sociological/psychological journals (40/88). Studies were also found in math or science education journals (8/88). Fewer works have been published in journals focused on career development (2/88), scholarship of teaching and research (2/88), or research methods (1/88) (see Figure 1).

Most of the peer-reviewed articles on engineering identity development have been published in the *Journal of Engineering Education* (18/88). Studies were also found in *Cultural Studies of Science Education, Educational Studies in Mathematics, Harvard Education Review, International Journal of College Student Development, Journal of Educational Research, New Directions for Institutional Research,* and *NWSA Journal,* among others. The majority of engineering identity peer-reviewed articles were qualitative in nature (e.g., Bergerson, Hotchkins, & Furse, 2014; Foor & Walden, 2009; Foor, Walden, & Trytten, 2007; Godwin, Potvin, & Lock, 2016). Fewer peer-reviewed articles were quantitative (e.g., Bix, 2004; Burack & Franks, 2004) or considered mixed methods (e.g., Litchfield & Javernick-Will, 2015). A growing area of work on engineering identity is starting to be seen in published conference proceedings (e.g., Cross & Paretti, 2012; Godwin, Potvin, Hazari, & Lock 2013), with the majority of those conference proceedings being quantitative in nature. Fewer published conference proceedings center upon theory (e.g., Cross & Paretti, 2012) or mixed methods (e.g., Chachra, Kilgore, Loshbaugh, McCain, & Chen, 2008).
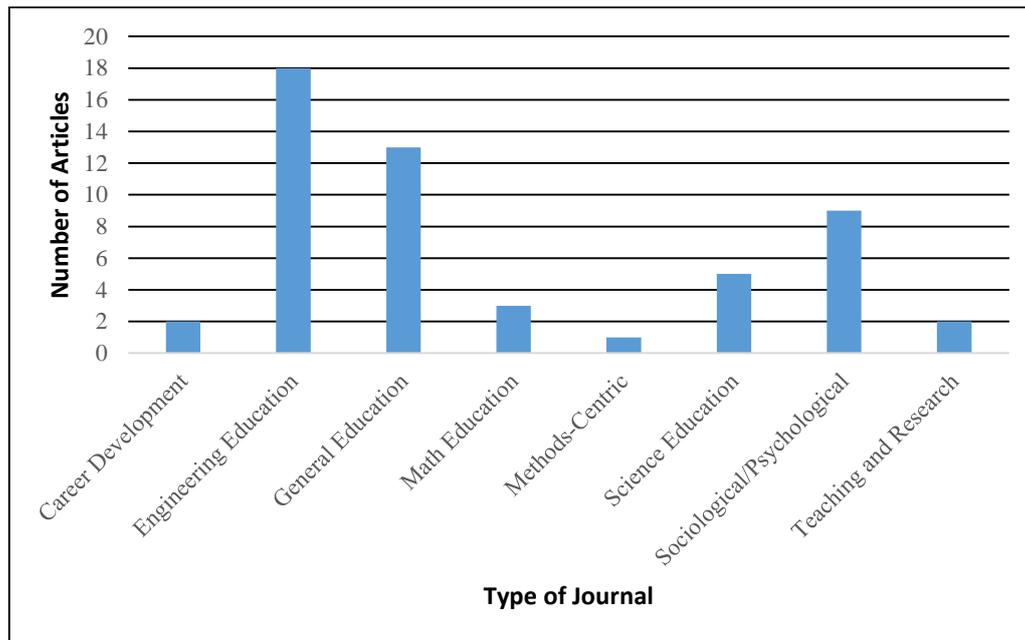
Figure 1. Number of articles by type of journal

Areas of Focus for Engineering Identity Development

Of the included studies addressing engineering identity, many have focused on the experiences of underrepresented populations within the engineering disciplines. Overall, 25% (22) of studies addressed underrepresented racial/ethnic minority students in engineering. There was a strong concentration of engineering identity studies focused on the experiences of women students (e.g., Hug, Jurow, & Chi, 2011) or underrepresented racial/ethnic minority students (e.g., Fleming, Smith, Williams, & Bliss, 2013). In addition, scholars have addressed the unique experiences of women of color (see Black & Williams, 2013; Ross & Godwin, 2016; Martin, Simmons, & Yu, 2013) and international students (Dutta, 2015), as well as the experiences of other students with underrepresented or non-normative identities (see Hughes, 2017; Kirn, Godwin, Benson, Potvin, & Verdin, 2016). Of the 88 studies reviewed, three directly addressed men of color (Lu, 2015), gay men (Hughes, 2017), or engineering identity related to individual customs and religion (Black & Williams, 2013). Studies specifically addressing engineering identity for Native American/American Indian, Native Hawaiian/Pacific Islander, multi-racial, or White students were not found (See Figure 2).
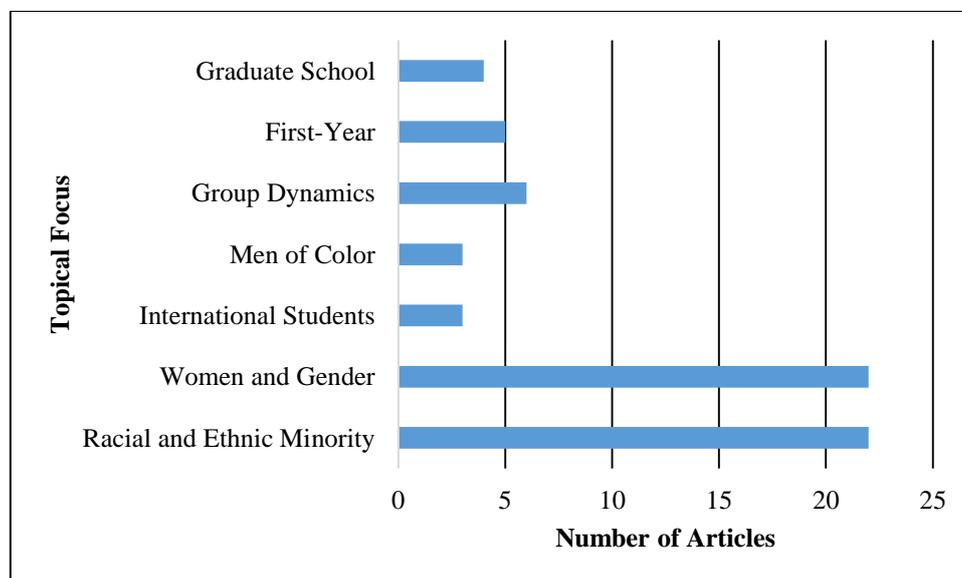

Figure 2. Number of articles by topical focus

Of the available scholarship, 25% (22) of studies focused on women and gender in engineering identity development (Du, 2006; Johnson, 2011; Settles, O'Connor, & Yap, 2016). Studies also addressed issues of persistence or retention (8/88) (Cech, Rubineau, Silbey, & Seron, 2011; Ross & Godwin, 2016) as well as group or team dynamics component (6/88) (Tonso, 2006; Trytten, Pan, Foor, Shehab, & Walden, 2015). Fewer studies (5/88) were found on first-year (see Atadero, Paguyo, Rambo-Hernandez, & Henderson, 2016; Green, Mohammadi-Aragh, & Warnock, 2015; Author, 2015) and graduate engineering identity experiences (4/88) (see Louis Kajfez & McNair, 2014).

Much of the available scholarship on engineering identity development is focused on the context of learning (12/88) (e.g., Walther, Kellam, Sochacka, & Radcliffe, 2011; Tatar, Van Beek, & Lillienkamp, 2016), including a focus on competence, curriculum, and learning strategies applied to both in-classroom and online learning environments. In addition, several studies address the major choice, career goals, and trajectories of students in relationship to their engineering identities (9/88) (see Lent, Sheu, Singley, Schmidt, Schmidt, & Gloster, 2008; Thomas, 2014). Similarly, other studies have been written about behavior, aspirations, confidence, expectations, balance, personality, social capital, engineering research, and self-concept (9/88) (e.g., Cech, Rubineau, Sibley, & Seron, 2011; Martin, Simmons, & Yu, 2013; McCave, Gilmore, & Burg, 2014).

Fewer studies were written regarding the measurements and relevant factors associated with engineering identity development (see Godwin, 2016). In particular, few studies addressed the relationships between agency, motivation, and engagement and engineering identity development or disciplinary differences that might create unique identity development experiences for students (e.g., Groen, Simmons, & McNair, 2016; Matusovich, Streveler, & Miller, 2010). The majority of the reviewed studies represented cross-sectional or single-institution scholarship rather than longitudinal or multi-institution scholarship (Prybutok, Patrick, Borrego, Seepersad, & Kirisits, 2016; Matusovich, Streveler, & Miller, 2010; Stoup & Pierrakos, 2016).

While research on engineering identity development has continued to grow, much of the scholarship portrays engineering identity development to include only one type of engineering identity rather than many types or manifestations. Of the studies included, only three made reference to differing types of engineering identities, including "leading" and "creative" identities (Black, Williams, Hernandez-Martinez, Davis, Pampaka, & Wake, 2010; Brookstein & Sadeghipour, 2016; Matusovich, Barry, Meyers, & Louis, 2011). In addition, very few studies addressed or placed their studies at Minority Serving Institutions (MSIs) or Hispanic Serving Institutions (HSIs) (see Fleming, Smith, Williams, & Bliss, 2013). As a result, much of the available engineering identity literature does not address development within these institutional contexts.

Theoretical Approaches to Engineering Identity Research

Of the 88 peer-reviewed articles and published conference proceedings that were analyzed, many discussed engineering identity in terms of other, more established, theories. Few articles, however, established new theoretical frameworks focused directly on engineering identity development. Furthermore, identity development theory was often built through foundations from other theories, such as motivation (e.g. desire, influences to achieve a goal), choice (e.g. selection of college, decision-making), critical (e.g. critique of society and culture), socialization (e.g. process of learning/participating in a culture), sociocultural (e.g. importance of society to individual development), asset-based (e.g. anti-deficit concepts, utilizing strengths of individual or community), developmental (e.g. way in which people grow or change), stage (e.g. distinct patterns of stages over time, successive order), and persistence (e.g. retention in college or major) theories. Identity or role theories (e.g., Matusovich, 2010; McClain, 2014; Meyers, 2012) were most often used to frame understandings of engineering identity development (25/88). Identity or role theory considers how an individual performs as a result of their desire to fill a socially defined role or category which comes with its own expectations and norms. Studies approaching engineering identity through this lens often included discussions around crystallized identity, normativity and non-normative identities, and navigation of identity (Carlone & Johnson, 2007; Louis Kajfez & McNair, 2014; Forin, Adams, & Hatten, 2012). Role theory was also discussed in terms of discipline-specific identification, group affiliations, and collective identities (Llewellyn, Pyke, Paterson, Landrum, Scarritt, Cullers, & Warner, 2016; Foor, Walden, & Trytten, 2007). In this approach, engineering students are thought of as navigating their identities or roles, and negotiating the various intersecting identities or dynamic experiences that emerge.
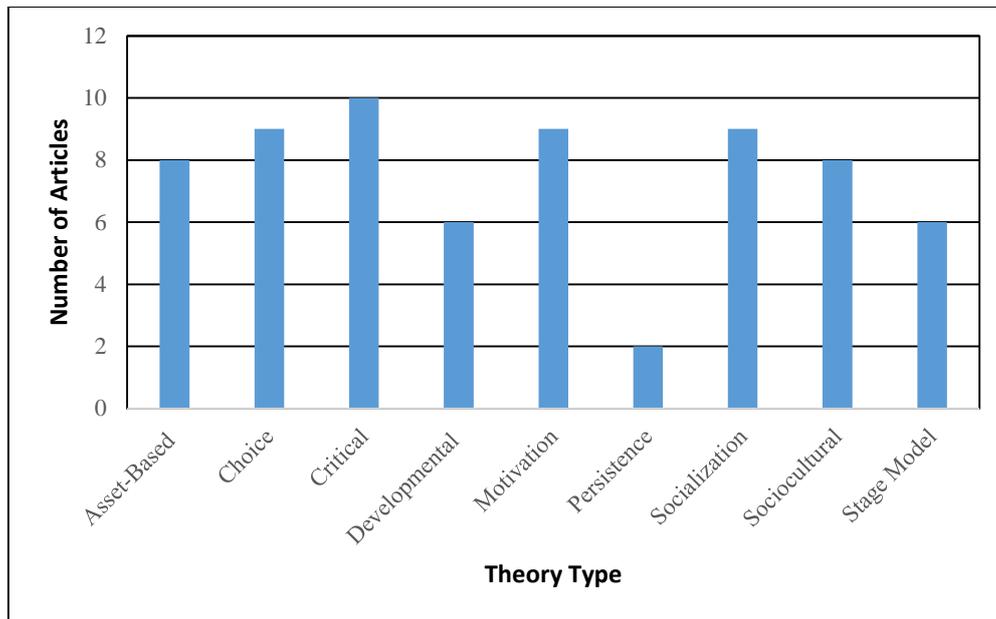
Figure 3. Number of articles by theory type

Critical theories were also utilized (10/88) to focus on engagement with gender, race, and the influence of intersectional identities present within the engineering disciplines (e.g., Godwin & Potvin, 2016; Godwin, Potvin, & Hazari, 2013; Trytten, Wong Lowe, & Walden, 2012). These critical frameworks focused on culture, discourse, agency, and engagement as key aspects to the identity development process. In these approaches, engineering students are considered to possess agency and self-efficacy within their educational journeys, yet scholars also have recognized that context and myriad identities influence the engineering experience and subsequent identity development process.

Similarly, socialization theories were also prevalent (9/88), particularly those focused on situated learning, group theory, and communities of practice (Hernandez-Martinez, 2016; Hug, Jurow, & Chi, 2011; Owen & Rolfes, 2015). Scholars discussed identity in the context of social practices and stages of socialization (or alienation) of students. In this way, studies sought to understand the ways in which students are socialized into or marginalized from engineering as a result of their interactions and identity development processes. Several studies also utilized sociocultural and asset-based models (8/88) which emphasized the backgrounds and knowledge that students were bringing with them (Llewellyn et al., 2016; Martin, Simmons, & Yu, 2013). Cultural community wealth, social capital, sociocultural perspectives, and contextualized understandings on learning were important ways that scholars approached engineering identity development. Learning theories approached identity development from different epistemological stances as well as examined it in terms of post-structural thinking, developmental asynchronous learning, and best practice orientation.

Within the broader literature, there is a debate as to how identity might be differentiated from other interrelated concepts. As a result, persistence (2/88) and a host of other developmental or stage model theories (6/88) were associated with engineering identity development, including concepts of sustainability, sexual-orientation development, language, and psychological well-being. Motivation, choice, and expectations models were also used as theoretical framings for these studies (9/88), particularly those utilizing or focusing on social cognitive career theory, self-efficacy, self-determination theory, or talent development theory (e.g., Jones, Tendhar & Paretti, 2016; Lent, et al, 2008; Perez, Cromley, & Kaplan, 2014).

Conclusion

As the demand for engineers grows in our global economy, engineering education stakeholders have increased efforts to recruit and retain engineering students. Scholarship on engineering identity will enable these efforts to be successful, but given the unique nature the engineering disciplines more nuanced research is needed to understand engineering identity development more accurately. Through its review of the available literature on engineering identity development, this article articulates the landscape of the available literature and explores ways in which engineering identity development research might be expanded in the future.

Recommendations

Several gaps exist in our understanding of the engineering identity development process. Although scholars have amassed a robust understanding of multiple aspects of the engineering experience as well as engineering identity development, there are still areas in which future research should seek to fill gaps in our knowledge. In particular, scholars may need to shift the design and focus of engineering identity studies to provide a wider range of understanding of the engineering student experience. In the future, more research should be conducted focusesd on the aforementioned areas to enhance our understanding of engineering identity development and to inform local, regional, national, and global engineering policies.

Expanding Forms of Engineering Identity Studies

Future research should focus on longitudinal models of understanding engineering identity development, specifically looking across the educational pipeline to understand how the concept of engineering identity might change over time. Longitudinal work could help improve understanding how students, particularly underrepresented racial/ethnic minorities and women, navigate their identities and how these students may be asked to negotiate those identities within the engineering environment.

Scholarship needs to focus on defining the concepts and measures related to engineering identity development with a wide variety of methods. More work is needed on the development and study of constructs and instruments designed to interpret engineering identity (e.g. Godwin, 2016; Godwin, Potvin, Hazari, & Lock, 2013). Quantitative work should look into experimental designs and studies that incorporate larger samples across time. In addition, scholarship using mixed-method approaches are greatly needed in the field. Merging datasets has the capacity to produce more robust understandings, coupled alongside qualitative work that has the capacity to focus on the lived experiences and voices of engineering students, particularly those who are marginalized within this context.

Replication and updating is needed to understand if change has occurred since the original studies were done, particularly thinking about the shift in politics, rhetoric, and colleges becoming more liberal places of thought with supported diversity efforts. This is coupled with the reality that women and URMs remain underrepresented within engineering. Future studies need to include a wider variety of student characteristics (e.g., generational status, literacy, social support) as well as greater attention to a wider range of institutional contexts (e.g., type, size, focus, geographic). Students across multiple disciplines who possess differing characteristics could broaden our understanding of the multitude of experiences that students in engineering have. In addition, examining disciplinary, institutional, and national contexts could help contextualize findings and enhance transferability as well as explain why/how identity development occurs within certain contexts.

Shifting the Focus of Engineering Identity Studies

Greater attention is needed to focus on understanding identity from a student development standpoint, understanding that identity development is not static and can change with environment and context, engagement and interest, and socialization and alienation experiences. Understanding how students understand their roles within engineering and beyond as well as how they navigate those roles may help our understanding of how engineering identity develops. Scholarship should focus on what it means to be an engineer and how identity development may be value-laden and heavily dependent on the held identities and contexts in which students find themselves.

Future scholarship should focus on the need for looking within subdisciplines to understand how students develop within these contexts. For instance, developing a civil engineering identity may be different from developing a mechanical or electrical engineering identity. Few research studies examine subdisciplines of engineering identity development and no empirical studies to date have looked at similarities or differences across various subdisciplines. Furthermore, given the move towards interdisciplinary work, future identity work should focus on how interdisciplinary engineering identities might form, particularly within group contexts.
Scholarship should focus on the organizational and engagement experiences of engineering students, particularly of students involved in identity-based engineering groups and the ability of engineering students, given heavy course loads, to engage in extra-curricular and often engineering identity-growing activities. Careful look should be given to various engagement experiences, both within and outside of the curriculum, that seek to promote professional identity development among students.

Future studies should seek to understand the expectation and realities of engineering students to understand identity development. It is important to think about the expectations and previously-held understandings of students as they come into the engineering programs, for these may help explain how and why some students develop a strong engineering identity and others do not. More work is needed in understanding the role that alienation and motivation play in developing an engineering identity and who becomes marginalized as a result. Further research is needed to understand more fully the roles that URM status and gender play in the identity development process as well as the cultural norms that remain in place that deter these students from being successful. Attention to the culture and climate present at both the departmental and institutional levels is needed to understand how professional identity development is systematically weaved into the college experience and ways in which institutions can do more to support students.

Future work on engineering identity development may choose to focus on the roles that attitude and major selection decisions have on the development of an engineering identity. Studies may include exploring how intersectional identities play into the way that students view their disciplinary confidence, competence, and self-efficacy, and how those issues relate to their identity development. Further scholarship may hone in on specific teaching strategies that seek to support engineering identity development, which may increase the participation, retention, and eventual persistence of engineering students at multiple levels of the engineering pipeline.

Table1. Summary of findings & implications for future research

Findings from Current Engineering Identity Research	Implications for Future Research
- Engineering identity research concentrated in engineering education, general education, and sociological/psychological journals - Research currently focused on identity experiences of women and racial ethnic minority students in engineering - Role theory most often used to frame understandings of engineering identity development	- Shifting the Design of Engineering Identity Studies - Longitudinal studies - Defining measures - Replication and updating - Differing student characteristics and institutional contexts - Shifting the Focus of Engineering Identity Studies - Student development centered - Exploring subdisciplines - Organizational and engagement experiences - Expectations and marginalization - Attitudes, culture, climate, intersectionality

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