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Self-Efficacy of Engineering Transfer Students: Links to Faculty Interaction and Other Forms of Capital

Sandra L. Dika
University of North Carolina at Charlotte, 9201 University City Blvd, Charlotte, NC 28223, USA, sdika@uncc.edu

Brittany D. Hunt
University of North Carolina at Charlotte, 9201 University City Blvd, Charlotte, NC 28223, USA

Miguel A. Pando
University of North Carolina at Charlotte, 9201 University City Blvd, Charlotte, NC 28223, USA

Brett Q. Tempest
University of North Carolina at Charlotte, 9201 University City Blvd, Charlotte, NC 28223, USA

Monica E. Allen
North Carolina A&T State University, 1601 E. Market Street, Greensboro, NC, USA

Abstract: To address the enduring issues of underrepresentation in engineering education, a small but growing body of research has examined social and cultural explanations for engineering persistence among women, racial/ethnic minorities, and other underrepresented groups, however limited research has explored the unique experiences of engineering transfer students. In this exploratory study, we examine the extent to which relationships with engineering faculty and other forms of engineering-related capital (e.g., aspirational, navigational) are related to engineering self-efficacy among transfer engineering students. The findings of the study may have implications for future research and practice to increase access to engineering education and persistence of transfer students in engineering.

Keywords: Engineering education, Transfer students, Student-faculty interaction, Self-efficacy

Introduction

While the participation of women and minoritized groups in engineering has gradually increased in the past two decades, they remain underrepresented in degree attainment and the engineering workforce (NSF, 2017). To address the enduring issues of underrepresentation in engineering education, a small but growing body of research has attempted to move away from a deficit perspective and has examined social and cultural explanations for engineering persistence among women, racial and ethnic minorities, first-generation college students, and other underrepresented groups. Frameworks emphasizing social and cultural capital, as well as the unique forms of capital possessed by students from marginalized groups (e.g., cultural wealth), offer alternate perspectives to focus on how underrepresented students navigate and persist in engineering.

In the United States, attending a two-year college can serve as an affordable entry point to obtaining a four-year degree in a science, technology, engineering, and mathematics (STEM) field. While successful transfer of students from two-year to four-year colleges represents a unique opportunity to broaden STEM participation and contribute to critical workforce needs, data show that STEM transfer students are significantly less likely to complete their degrees than peers who begin at four-year colleges, and this effect is more pronounced for URM students (Chen, 2013; Dowd, 2011).

As part of a federally funded project on the role of student-faculty interaction for the persistence of underrepresented racial/ethnic minority (URM) students in engineering, we gathered qualitative and quantitative data from undergraduate engineering students at one four-year, doctoral granting university in the Southeastern United States. For the study reported herein, we focus specifically on an analysis of questionnaire data from junior and senior transfer engineering students to understand how perceived quality of relationships with faculty and other forms of capital are related to engineering self-efficacy.

Literature Review

Participation and Persistence for Underrepresented Engineering Students

Differing participation and persistence in engineering in the United States has been investigated using theoretical frameworks from higher education (Astin, 1993; Tinto, 1993), sociology (Bourdieu, 1986; Coleman, 1988; Lin, 2001), and psychology (Lent, Brown, & Hackett, 1994). The importance of interactions, resources, and supports is prominent across these theories as precursors to beliefs about one's abilities and identity that support academic effort, performance, and career persistence. Research and theory on interactions with faculty, other sources of capital (i.e., cultural wealth), and self-efficacy, particularly for underrepresented students in engineering, frames this study of transfer students, an underrepresented and understudied group in engineering education.

Interactions with Faculty

Predominant frameworks of participation and persistence in higher education emphasize the role of student interaction with faculty (Astin, 1993; Tinto, 1993). Social capital frameworks offer another way to understand how and why interaction with faculty is important for persistence of students in STEM, through defining ties to institutional agents (faculty, staff, administrators) as links to important information needed to navigate and succeed in the college environment. Student-faculty interactions (SFI) are vital to the success of all engineering students, including underrepresented racial/ethnic minority groups (URM). Research over the past 15 years has evidenced the relationship of SFI with academic performance, persistence, and academic and personal growth for URM students in STEM disciplines, including engineering.

Underrepresented students of color (i.e., Black or African American, Hispanic or Latino, Native American) in STEM disciplines benefit greatly from faculty-student interactions. Research has shown that frequent interactions with faculty and support from contact with faculty are linked with higher grades (Cole, 2008; Cole & Espinoza, 2008), and that URM students who conducted research with faculty members improved their academic performance (Barlow & Villarejo, 2004; Kim & Sax, 2009). Faculty-student interactions are generally beneficial to URM students especially when conducting research with faculty or receiving mentorship from faculty, however some literature suggests that receiving criticism from faculty or interacting with faculty to discuss course materials did not suggest that students would increase their GPAs. Overall, engineering students' interactions with faculty are vital for retention and persistence (Amelink & Meszaros, 2011; French, Immekus, & Oakes, 2005; Vogt, 2008) and are especially critical for Black and Latino students in ensuring their academic success (Cole & Espinoza, 2008; Cole & Griffin, 2013; Hurtado et al., 2011; Martin, Simmons, & Yu, 2013). Limited research has explored the importance of student-faculty interaction for engineering transfer students in particular. In a recent qualitative study of social and cultural capital among female STEM transfer students (Starobin, Smith, & Laanan, 2016), participant experiences evidenced how positive student-faculty interactions play a role in enhancing women's self-efficacy beliefs.

Cultural Wealth as Capital for Engineering

Traditional social and cultural capital theories (Bourdieu, 1986; Coleman, 1986) emphasize how the values and practices of dominant groups are rewarded in education. The notion of community cultural wealth (CCW; Yosso, 2005) was developed to show how communities of color and other non-dominant groups create wealth that is valuable for persisting in education. Six forms of CCW are proposed as part of this framework: aspirational, linguistic, familial, social, navigational, and resistant. The notion of CCW as an alternative framework to understand the success of URM students and other underrepresented groups in STEM and in engineering has not yet been extensively explored. A handful of published studies have employed the concept. Martin and Newton (2016) explored asset-based theories, including CCW, to understand how engineering students named unearned advantages and disadvantages. Peralta, Caspary, and Booth (2013) found that aspirational, linguistic, and familial capital sources were most evident in a study of Latino students persisting in STEM education. A study of upper-level Black and Latino engineering students by Dika, Pando, Tempest, and Allen (2018) found aspirational and familial capital to be the most salient in student attributions of success. The most comprehensive work to date, by Samuelson and Litzler (2016), utilized the CCW framework to examine the persistence of a multi-institution sample of African American and Latinx undergraduate engineering students, finding that the majority of interviewed students emphasized the importance of navigational (68%) and aspirational (61%) capital, with smaller proportions discussing familial and resistant capital (39%). Across these studies, findings suggest the centrality of aspirational capital as related to the other forms.

The aforementioned study by Starobin and colleagues (2016) is one of few to examine the social and cultural capital of transfer students in STEM, based in Laanan's (2004) notion of transfer student capital, which emphasizes negotiation of the transfer process. Women participants in the study expressed that adjustment to the university was facilitated by positive and helpful interactions with academic advisors and professors, while women engineering students mentioned being involved in research projects with faculty.

Engineering Self-Efficacy

Self-efficacy as a Concept

Self-efficacy is defined as a person's belief in their ability to perform well within a particular discipline (Bandura, 1997). The importance of self-efficacy is perhaps markedly more pronounced in engineering programs given the academic rigor and intensity of the coursework. A few engineering self-efficacy measures has been developed and validated in recent years (Concannon & Barrow, 2009; Mamaril, Usher, Li, Economy, & Kennedy, 2016; Marra & Bogue, 2006). A common focus of the instruments is the perceived capability to master engineering content and coursework. The instrument developed by Mamaril et al. (2016) includes a scale focused on engineering-specific skills, while Concannon and Barrow's (2009) measure includes a scale on engineering career outcome expectations.

Self-efficacy as a Predictor

Engineering self-efficacy has been studied to determine its relation to retention, persistence, and overall success among students in the field. Aleta (2016) reported that students who judged their own engineering backgrounds as strong and positive were more likely to perform well in engineering programs and on engineering exams, and their engineering self-efficacy was also shown to be correlated with academic achievement. Other research has been dedicated to the intersections of self-efficacy and gender. Marra, Rodgers, Shen, and Bogue (2009) found that among women in male-dominated academic domains, self-efficacy was particularly important in providing a means to persist. In addition, women's levels of self-efficacy often increase as they continue in their program, though their measures of inclusion often decline. Women's perception of sexism or prejudice also negatively impacted their feelings of self-efficacy related to engineering degree completion (Cadaret, Hartung, Subich, & Weigold, 2017).

Self-efficacy as a Mediator or Outcome

Micari and Pazos (2016) reported that self-efficacy acts as a mediating factor between both instructor connectedness and satisfaction and peer alignment and satisfaction with engineering. This means that as a result of increasing instructor connectedness, peer alignment or both, student levels of self-efficacy also increase which subsequently causes an increase in satisfaction with their program of study. In addition to these variables, students who have taken pre-engineering courses and who have engineering hobbies often have higher measures of self-efficacy than those who do not (Fantz, Siller, & Demiranda, 2011). Engagement in engineering sponsored programs, such as ambassador programs, has also been shown as a factor contributing to an increase in engineering self-efficacy (Anagnos, Lyman Holt, Marin-Artieda, & Momsen, 2014). Other factors such as obtaining good grades, exposure to positive role models, and receiving positive feedback from professors or mentors may also augment engineering students' self-efficacy (Usher, Mamaril, Li, Economy, & Kennedy, 2015).

Research on Transfer Students in STEM and Engineering

The pathway to a successful academic career in STEM is often a difficult one, with some students being unable to manage the academic rigor and intensity of their program. Transfer students often face additional barriers to which colleges and universities are sometimes not attuned. However, some protective factors do exist that aid in the success of this particular population. For instance, the higher the level of education completed by a transfer student's father, the more likely they are to be successful in STEM (Lopez & Jones, 2017). In addition, students are more likely to pursue an engineering degree if they perceive engineering degrees as prestigious and have an interest in problem solving and understanding how things work (Allen & Zhang, 2016).

To stoke this interest, some colleges and universities partner with community colleges to offer research opportunities to students interested in STEM fields, which is regarded as a best practice to ensure transfer success (Alting, Delale, & Barba, 2013). Hirst, Bolduc, Liotta and Packard (2014) argue that such pre-transfer programs and research experiences help develop pathways to four-year programs. In addition, such partnerships have been identified as being important in aiding the success of women and underrepresented minority (URMs) transfer students in STEM academic achievement (Jackson, Starobin, & Laanan, 2013). Once a female or URM student has successfully transferred into a four-year STEM program, Jackson et al. (2013) identifies support systems, collaborations with faculty, and career opportunities like workshops as being critical to ensure academic persistence and degree completion for these populations. For women specifically, positive faculty interaction is key (Starobin et al., 2016).

For transfer students as a whole, advising is critical during pre-transfer, pre-enrollment and first term (Brawner & Mobley, 2016). Concannon and Barrow (2009) found that transfer students scored lower on self-efficacy related to engineering curriculum than their non-transfer counterparts. An advisor committed to helping students achieve collegiate success can provide the motivation and support that a transfer student needs during this transitional time; however, unsatisfactory or inadequate advising has been reported as a barrier (Packard, Gagnon, & Senas, 2012). Transfer student specific courses, seminars and programs at the collegiate level are also identified as a best practice in easing transition (Alting et al., 2013; Jackson et al., 2013; Laugerman, Shelley, Mickelson, & Rover, 2015; Wang, Lee, & Prevost, 2017). Conversely, inability to enroll in necessary courses in a timely manner can result in unnecessary coursework that incurs extra time and costs for transfer students (Packard et al., 2012).

Connections and Gaps in the Extant Literature

Self-efficacy is vital for engineering success, particularly for transfer students. Thus, universities should task themselves with fostering and developing academic and engineering self-efficacy in their students to encourage success and persistence to graduation. In addition to self-efficacy, partnerships with community colleges, transfer specific programming, and faculty support have also been identified as best practices in ensuring transfer student success. Though previous studies have explored general self-efficacy measures among engineering students, scant literature exists on engineering self-efficacy specifically among transfer students. Even fewer studies explore these concepts in relation to faculty interaction and other forms of protective factors and characteristics.

Methodology

This exploratory correlational study examines the relationship of interactions with faculty and other forms of capital with engineering self-efficacy among transfer engineering students (junior and senior class level) using data obtained from an online questionnaire administered at an urban research institution in the Southeastern United States in Spring 2015. The study reported is part of a larger, mixed-methods project on the role of student-faculty interaction in the persistence of underrepresented students in engineering.

Instrumentation

The authors developed an online questionnaire as part of the larger project including support and interactions prior to enrolling in engineering (7 items), frequency of out-of-class interactions with faculty (4 items), assessment of quality of relationships with faculty, students, and staff (6 items), barriers experienced during studies (7 items), engineering self-efficacy (17 items), and cultural wealth (9 items). The focus in this study is on perceived quality of interactions with faculty, cultural wealth, and engineering self-efficacy.

1) Perceived quality of interactions with faculty: Students indicated extent of agreement with the statement "I have a positive and supportive relationship with College of Engineering faculty" on a 5-point scale from 1=strongly disagree to 5=strongly agree ($M= 4.24$, $SD=0.82$).

2) Engineering self-efficacy: Seventeen items related to engineering self-efficacy (Concannon & Barrow, 2009) were included on the questionnaire used for this study. Items were rated on a 7-point scale from 1=strongly disagree to 7=strongly agree, as in the original instrument. Three items on the original instrument related to course taking were not included on our questionnaire because they do not apply to students in the junior or senior year of studies. Exploratory factor analysis to identify factors among these 17 items supported a three-factor model – engineering self-efficacy (ESE, 5 items), engineering career outcome expectation (ECOE, 7 items), and coping self-efficacy (CSE, 5 items). While previous studies differentiated between two engineering self-efficacy subscales (four subscales total), the factor analysis did not support separation of these items given the exclusion of the three course taking items. The internal consistency estimates for ESE and ECOE were similar to those reported in previous studies, however Cronbach's alpha for CSE was significantly lower (0.55) and thus it was removed from further analysis in this study. Descriptive statistics and wording for the 12 items corresponding to ESE and ECOE are shown in Table 1.

3) Cultural wealth: While research to study the concept of cultural wealth has generally utilized qualitative methods, we developed nine items for our questionnaire to explore whether and how the different forms of capital could be assessed quantitatively. Social capital was divided into 4 items to assess different networks and resources (peers, faculty/staff, campus organizations, off-campus organizations). The wording of the statements was developed using the descriptions in Yosso (2005), and students indicated a level of agreement with each statement from 1=strongly disagree to 5=strongly agree. The wording of each item, along with descriptive statistics, is shown in the findings in Table 2. Participants expressed high agreement with ability to maintain hopes and dreams for the future (M=4.41, SD=0.73) and having the ability to switch communication styles or language (M=4.38, SD=0.83), and least agreement with drawing on connections with off-campus community organizations to be successful (M=3.37, SD=1.13).

Table 1. Scale and Item-level Statistics for Engineering Self-efficacy Measures (n=141)

Scale	Items	Mean (SD)
Engineering self-efficacy (ESE) M=5.70 SD=0.89 Cronbach's α = 0.80	I can succeed in an engineering curriculum.	6.35 (0.67)
	I can succeed in an engineering curriculum while not having to give up participation in outside interests.	4.62 (1.94)
	I can excel in an engineering major during the current academic year.	6.09 (0.91)
	I can complete any engineering degree at this institution.	5.65 (1.35)
	I can succeed (earn an A or B) in an advanced engineering course.	5.70 (1.28)
Engineering career outcome expectation (ECOE) M=6.22 SD=0.55 Cronbach's α = 0.81	Someone like me can succeed in an engineering career.	6.41 (0.83)
	A degree in engineering will allow me to obtain a well-paying job.	6.44 (0.66)
	I expect to be treated fairly on the job (same opportunities for pay raises and promotions).	6.31 (0.76)
	A degree in engineering will give me the kind of lifestyle I want.	6.02 (1.00)
	I expect to feel "part of the group" on my job if I enter engineering.	6.03 (0.94)
	A degree in engineering will allow me to obtain a job that I like.	6.22 (0.77)
	A degree in engineering will allow me to get a job where I can use my talents and creativity.	6.15 (0.83)

Participants

Of 275 total participants in the online questionnaire, 149 indicated they had transferred to the institution. A total of 141 engineering transfer students had complete data and were included in the final sample for the current study. The majority identified as White/Caucasian (79%), male (81%), and having parents who had earned a four-year degree (64%).

Analysis

For this exploratory study, we utilized bivariate correlation to investigate relationships between the variables of interest and develop questions for further research and study.

Findings

To examine the relationships between sources of capital for transfer students (quality of interactions with faculty, cultural wealth) with engineering self-efficacy, we calculated bivariate correlations (shown in Table 2). All of the sources of capital showed low to moderate positive correlations with engineering self-efficacy variables, while perceived quality of relationships with faculty had the weakest relationship. Engineering self-efficacy (ESE) was most strongly linked to aspirational, faculty connections, and familial capital. Correlations of forms of capital to engineering career outcome expectations (ECOE) were stronger overall, and showed a different pattern. Navigational and aspirational capital forms were the most strongly related to ECOE, followed by linguistic, faculty and peer connections, and familial capital.

Table 2. Correlations between Forms of Capital and Engineering Self-efficacy (n=141)

Forms of capital[1]	*Mean (SD)*	*Engineering self-efficacy (ESE, 5 items)*	*Engineering career outcome expectation (ECOE, 7 items)*
I have a positive and supportive relationship with College of Engineering faculty (quality of relationships with faculty)	4.07 (0.76)	0.07	0.17*
I can maintain my hopes and dreams for the future, even when confronted with barriers. (aspirational)	4.34 (0.65)	0.33***	0.38**
I have the ability to switch communication styles or languages based on environment (academic and non-academic). (linguistic)	4.12 (0.85)	0.19*	0.34**
I maintain a connection to my home community and culture. (familial)	4.11 (0.85)	0.27**	0.26**
I draw on connections with peers to be successful in college. (social-peer network)	4.30 (0.72)	0.22*	0.28**
I draw on connections with individual faculty and staff members to be successful in college. (social-faculty/staff)	3.81 (0.96)	0.30**	0.31**
I draw on connections with campus organizations or offices to be successful in college. (social-on-campus)	3.53 (1.14)	0.22**	0.09
I draw on connections with off-campus community organizations or agencies to be successful in college. (social-off-campus)	3.19 (1.09)	0.21*	0.22**
I have developed strategies to navigate difficult people and situations at the university. (navigational)	4.05 (0.70)	0.14	0.41**
I challenge university practices that seem inequitable. (resistant)	3.50 (0.94)	0.14	0.19*

$^{*}p<.005$, $^{**}p<0.01$, $^{***}p<0.001$

[1] All single item measures scored on 5 point scale, 1=strongly disagree to 5=strongly agree

Discussion and Implications

The descriptive results of this exploratory study suggest that beliefs about engineering ability and career outcome expectations are positively related to perceived sources of capital among transfer engineering students. While perceived positive and supportive relationships with faculty were weakly related to engineering self-efficacy, drawing on connections with faculty to be successful in college did have a moderate positive relationship with both self-efficacy variables. The separation of social capital into four variables (faculty/staff, peer, on-campus, off-campus) allowed for the examination of the relative importance of connections with faculty and staff (compared to peers and organizations) for transfer student success.

Our findings linking faculty support with engineering self-efficacy align with extant literature. Positive interactions with faculty have been linked to academic success for students from underrepresented and minoritized groups in STEM (Cole & Espinoza, 2008; Hurtado et al., 2011) and engineering specifically (Martin et al., 2013). Female transfer students in STEM identified assistance from faculty and advisors as helpful in adjustment to the university environment (Starobin et al., 2016), and engineering undergraduates reported that receiving positive feedback from professors promoted feelings of self-efficacy (Usher et al., 2015).

Two additional forms of cultural wealth stand out in our analysis, and may be particularly important for transfer students. Maintaining hopes and dreams for the future despite real and perceived barriers (aspirational) and remaining connected to home culture and community (familial) was positively related to beliefs about engineering ability and expectations about career outcomes among the transfer engineering persisters in our study. These findings support previous studies that also found aspirational and familial capital to be important factors in persistence in STEM among students of color (Dika et al., 2018; Peralta et al., 2013; Samuelson & Litzler, 2016).

Findings in this study offer an alternative to a deficit perspective on transfer students in engineering. Further, these findings suggest that beliefs about engineering ability and future career success are linked to the use of connections with faculty and staff to succeed in engineering. While the nature of the sample and design used in this study limit the generalizability of the findings, they suggest that our continued research should consider the role of cultural wealth in explaining engineering self-efficacy and persistence among transfer and other underrepresented student groups.

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