A Review of the Literature on Transfer Student Pathways to Engineering Degrees

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Abstract

In 2012, the President's Council of Advisors on Science Technology (PCAST) documented the need to prepare more than 1 million additional STEM professionals in the U.S. workforce over the next decade, primarily through efforts focused on increasing retention rates and diversifying pathways.[1] One way to accomplish this is by creating and enhancing pathways into engineering for the community college sector.

Responding to a call for action from President Obama and his Council of Advisors on Science Technology, the author explores the current state of literature on engineering transfer students. In this paper, the author identifies gaps in the literature and provides implications for future research on diversifying pathways to engineering degrees for transfer students.

Introduction

Engineering is essential to our health, happiness, and safety.[2] As a result, quality of life in the United States is largely dependent on the fruitful efforts of a skilled science, technology, engineering, and mathematics (STEM) workforce which includes engineers that design, build, and create innovative products that affect us daily and help shape the future.[3] President Obama, in his State of the Union speech for three consecutive years, directly addressed the importance of STEM education to our country and its relationship to the health of the U.S. economy. The current administration has emphasized the need to increase STEM talent in the U.S. workforce and demonstrated a strong commitment to improve STEM education with a $3.1 billion investment in 2013.

Despite past national efforts, to expand the domestic STEM workforce, enrollment and degrees awarded in engineering have stayed relatively constant in the United States for more than two decades. According to the National Science Board, student enrollment in higher education increased by 30 percent between 1997 and 2007 while enrollment in engineering degree programs remained flat.[4] During the same time span, China increased production of STEM graduates by more than 200 percent while the U.S. reaped a mere 20 percent gain.[5]

In the face of stagnating numbers for engineering enrollment and degree production, the United States has experienced a decline in the percent of engineering bachelor degrees awarded to males and white (non-Hispanic) students, approximately 15 percent and 20 percent respectively.[6] This trend may not be a surprise given the recent increase in nationwide outreach programs designed to introduce women and racial/ethnic minorities to opportunities in STEM fields. However, the distribution of engineering degrees awarded across racial/ethnic groups is not reflective of the current demographic shift in the United States. According to the U.S. Census Bureau, 14 out of 50 states in our country have already shifted to majority minority populations with New Mexico, California, and Texas at the top of the list.[7] Since 2005, Hispanics have exceeded more than 20 percent of students enrolled in the K-12 education system,[8] yet they earned only 10 percent of the engineering degrees awarded in 2007.[9] Racial/ethnic minorities continue to be an untapped pool of prospective STEM talent in United States.

To build a STEM capable workforce, we must broaden participation in STEM for the entire domestic talent pool, including underrepresented minorities. Given that more ethnic/racial minorities begin their pursuit of higher education at schools other than four-year public/private colleges, it is critical that we create pathways into engineering from two-year public colleges. According to data collected by the National Center for Education Statistics, 42 percent of Hispanic students and 41 percent of African American students in undergraduate education during the 2007-2008 academic year were enrolled in two-year public colleges.[10]

In 2012, the President's Council of Advisors on Science Technology (PCAST) documented the need to prepare more than 1 million additional STEM professionals in the U.S. workforce over the next decade, primarily through efforts focused on increasing retention rates and diversifying pathways.[11] Creating and enhancing pathways into engineering for the community college sector is one opportunity for our nation to accomplish this.

Purpose

Responding to a call for action from President Obama and his Council of Advisors on Science Technology, this paper explores the current state of literature on engineering transfer students and provides implications for future research on diversifying pathways to engineering degrees for transfer students. Specifically, this literature review seeks to answer the following research questions:

1. What is known about the experiences and educational outcomes of engineering transfer students?
2. What opportunities exist for further scholarship to increase understanding of transfer student pathways to engineering degrees?

Scope/Method

To find peer reviewed articles on engineering transfer students, a search was performed using Engineering Village, an interface designed to simultaneously search three engineering databases: Compendex, Inspec, and National Technical Information Service (NTIS). Combined, the databases index: 1.) more than 5,000 engineering journals; 2.) journal articles, conference papers, books, dissertations, and technical reports in engineering and physical sciences; 3.) and reports from federal agencies such as NASA, the Department of Defense, and the Department of Energy. Search terms included: engineering, transfer student(s), and pathways.

The search yielded more than 180 articles relevant to the research topic. In addition, reference sections from journal articles on engineering transfer students were also reviewed to identify additional articles. To narrow the scope, articles in this literature review met the following criteria: 1.) peer reviewed article; 2.) published between 2000 and 2014; 3.) addressed experiences and/or educational outcomes of engineering transfer students.

Findings

Although there is limited research on pathways and outcomes for transfer students in engineering, there is a large body of literature on the experiences of community college students.[12] As a result, findings from this review are presented in three sections. The first section seeks to explain why there is limited research on pathways and outcomes for transfer students in engineering. Section two explores community college literature and its application to

transfer students in STEM. And section three focuses on literature specific to engineering transfer students. For sections two and three, the literature is organized according to the objectives of each study as defined in Table 1 (i.e. characterize, exploratory, and explanatory). After a discussion of the findings from this literature review, the paper concludes with implications for future research.

Table 1. Organizing literature based on the objectives of the study.

Objective	Description
Characterize	Study characterizes transfer student profiles, pathways, and/or outcomes.
Exploratory	Study explores transfer student experiences.
Explanatory	Study seeks to identify explanatory factors for some observed behavior.

Gaps in the Literature on Transfer Students in Engineering & Potential Explanations

For more than a decade, the National Research Council (NRC) and the National Academy of Engineering (NAE) have emphasized the important role that community colleges play in broadening participation and expanding pathways to engineering degrees.[13,14] In 2004, the NRC and NAE hosted a meeting with leaders in higher education to explore opportunities and strategies to enhance transfer pathways to four-year engineering programs for community college students. Meeting participants acknowledged that the transfer student pathway to engineering was not operating at full potential due to: 1.) "less than effective articulation agreements" to foster student transfer; and 2.) "a lack of cooperation and coordination" between institutions of education and state higher education agencies.[15] As a call to action for the education research community, meeting participants identified a number of areas for future research on transfer pathways to engineering degrees which included the following:

- "documenting performance outcomes in terms of recruitment, transfer, retention, and persistence to degrees in undergraduate engineering education."[16]
- "collection of comparative data to identify factors associated with the retention and persistence to the B.S. degree of women, minority, and non-minority male community college and transfer students."[17]
- document "perspectives of four-year educational institutions" related to articulations agreements and transfer processes[18]
- "in depth examination using both qualitative and quantitative data-collection methods of the experiences of a cohort of students entering and progressing through the community college pathway to engineering careers."[19]

Nearly a decade later, the body of literature on engineering transfer students is still very limited. Most of what we know is based on community college literature, which is limited in its application to STEM transfer students and even more so for engineering transfer students. So, why is it that we still know very little about engineering transfer students?

Some research suggests that transfer students are an afterthought at many institutions and that they "remain in the shadow of more prominent student populations" such as high-achieving first-time full-time students.[20] This may not be the case in totality, there are a number of four-year institutions with transfer receptive cultures that treat transfer students "with a devotion similar to that of first year students".[21]

The more significant issue hindering scholarship on engineering transfer students is insufficient data and "inconsistent definitions of who students are".[22] The challenge of identifying transfer students also impacts and limits the use of longitudinal databases to track transfer student progression between institutions. According to the Western Interstate Commission for Higher Education, there is little evidence to document what works when it comes to statewide articulation and transfers systems.[23] In order to improve pathways for engineering transfer students, we must be able to identify them first.

Community College Literature and its Application to Transfer Students in STEM

The body of literature on community college students is deep as it is broad.[24] Since the 1920s, community college literature has evolved from Hills' early work with junior college students and transfer shock[25] to improving understanding of transfer student experiences[26,27,28] and the affects that institutional policy can have on facilitating transfer student success.[29.30,31] Research tells us that students begin their pursuit of higher education in community college for many reasons (i.e. economics, location, flexibility, smaller classes, and emphasis on teaching).[32,33] However, many community college students face significant challenges on the path to successful transitions at 4-year institutions (i.e. lack of academic preparation, inaccurate transfer advising, unfamiliar with academic rigor and expectations at 4-year institutions, and weak transfer/articulation policies).[34,35]

Community colleges play an important role in educating science and engineering graduates, but there is limited research on pathways and outcomes for transfer students in engineering. According to the American Association of Community Colleges (AACU), nearly 50% of students in higher education are enrolled in community colleges.[36] In fact, 49% of female science and engineering graduates in 2008 enrolled in community college at some point in their academic careers. The percentage for Hispanic and African American science and engineering graduates was even higher, 53% and 51% respectively.[37] Despite the fact that nearly half of recent science and engineering graduates attended community college, most of what we know about engineering transfer students is generalized from a vast body of literature on the experiences of community college students.[38] For the purpose of this review, I will focus on community college studies pertinent to STEM transfer students. In particular, recent studies that identify differences for STEM transfer students and those that explore transfer student capital are worthy of deeper exploration.

Understanding Characteristics and Experiences of STEM Transfer Students

The Laanan Transfer Student Questionnaire (L-TSQ) is used to characterize and explore the experiences of transfer students at four-year institutions. Laanan developed the 304 item questionnaire to increase understanding of the adjustment process for transfer students (i.e. emotional and psychological development) and to identify factors that explain why transfer students experience transfer shock.[39] Transfer shock is defined as the temporary dip in GPA that a transfer student experiences during the first and second semester after transfer.[40] The L-TSQ, which requires 20-25 minutes to complete, captures information on student social demographics, community college experiences, and four-year institution experiences.

Laanan used Astin's Theory of Student Involvement and Pace's concept of "Quality Effort" as theoretical frameworks to develop the L-TSQ.[41] The instrument has been tested for

reliability and validity. Laanan argues that L-TSQ is an improvement over other student surveys (i.e. Pace's College Student Engagement Questionnaire and Community College Student Engagement Questionnaire) because it "measures transfer students' non-cognitive traits" and their psychological, academic, and social adjustment.[42] In the last decade, the L-TSQ has been applied to understand the characteristics and experiences of both STEM transfer students and engineering transfer students. Laanan surveyed two small groups of engineering students, primarily white males, using the L-TSQ.[43,44] Findings from the study presented more evidence to confirm the significance of student experiences with faculty.

New evidence exists to support the argument that STEM transfer students are different than STEM native students, where native students are defined as individuals who enroll in institutions as first time in college freshmen directly from high school.[45] Using responses from more than 3,000 seniors who completed the National Survey of Student Engagement (NSSE) between 2005 and 2009, Laanan and Zhang compared STEM transfer students to STEM native students at a 4-year institution in the Midwest.[46] The authors found that the STEM transfer student cohorts: 1.) were slightly older; 2.) included more women; 3.) were less likely to be enrolled as a full-time student; 4.) included more White (non-Hispanic) students; 5.) were less likely to reside on campus, and 6.) reported more B/C's than A's in their courses than STEM native students. While STEM transfer students were more likely to interact with faculty than STEM native students, they were less satisfied with the university. Based on findings from the study, the authors posit that student satisfaction (especially for transfer students) can be enhanced by creating an academic culture where faculty are more accessible to students.[47]

Surveys like the L-TSQ and the NSSE are powerful instruments that can be used to increase our understanding of the engineering transfer student experience. This research strategy aligns well with NRC and NAE's call for "in depth examination using both qualitative and quantitative data-collection methods of the experiences of a cohort of students entering and progressing through the community college pathway to engineering careers".[48] Research findings from surveys like L-TSQ can be used to design unique programming at community colleges and four-year institutions to facilitate the success of engineering transfer students.[49]

Transfer Student Capital and Application to STEM Transfer Students

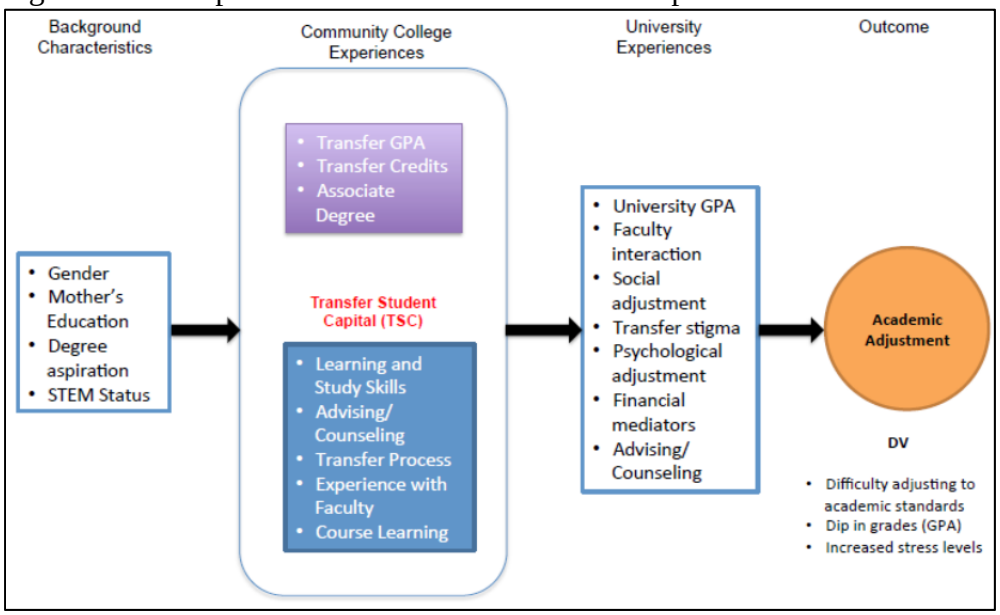
Laanan has also stressed the need and importance of accurately accounting for "factors that explain how and why transfer student are successful, not successful".[50] Building on prior research and development of the L-TSQ, Laanan coined the term transfer student capital and used it to explain differences between student outcomes.[51] His intent was to extend the literature and move beyond using GPA and transfer shock to characterize transfer students and their experiences.

According to Laanan, transfer student capital is the accumulation of knowledge about higher education that develops in a student as he/she interacts with faculty, receives academic advising/counseling, studies for coursework, navigates through university transfer policies to fulfill academic requirements, and proceeds through the transfer process from a two year college to a four-year institution.[52] His theory is that the students who possess larger accumulations of transfer student capital are more apt to transfer from a community college to a four-year institution.[53]

In 2010, Laanan, Starobin, & Eggleston hypothesized that transfer student capital was also correlated to the academic and social adjustment of transfer students at the receiving four-year institution. To explore the relevance of transfer student capital in student retention, the researchers proposed two hypothetical predictive models for academic transfer adjustment and social transfer adjustment.[54] The theoretical framework used to build the models was based on: 1.) Pascarella's model of student learning and cognitive development; 2.) Becker's human capital theory; and 3.) Hagedorn's notion of transfer as student retention.[55] To test the hypothetical predictive models, the researchers used a shortened version of the L-TSQ to collect survey responses from 900 students that transferred from public 2 year colleges to a land-grant university in the Midwest, between 2004 and 2007. Results from the study indicate that "learning and study skills at community college" positively influenced a students' academic transfer adjustment and "experiences with faculty at the land-grant university" positively influenced their social transfer adjustment".[56] In both models, "learning and study skills at community college" was conceptualized as a form of transfer student capital. Factors found to have a negative influence on students' academic adjustment included "student motivation for transfer" and "academic counseling experiences". "Course learning at community college" was the only factor found to have negatively influenced a students' social adjustment.

In a similar study, Laanan & Hernández presented an alternative hypothetical predictive model to investigate the role of transfer student capital in the academic adjustment of STEM transfer students and non-STEM transfer students at the same land-grant university in the Midwest.[57] The modified hypothetical predictive model for academic adjustment used in this study is presented in Figure 1.

Figure 1. Conceptual Model of Transfer Student Capital.[58]



Source: Transfer Student Capital: Examining the role of Transfer Student Capital in the academic adjustment of transfer students in STEM majors at Iowa State University.

Again, the researchers used a shortened version of the L-TSQ to collect survey responses from 858 students that transferred from community colleges to the Midwest land-grant university between 2006 and 2009. Forty-six percent of the survey responses were from STEM transfer students, and the cohort was predominantly from a white (non-Hispanic) ethnic/racial background (85%). Findings from the study indicated that: 1.) only 42 percent of STEM transfer students completed the associate's degree in the transfer process; 2.) non-STEM transfer students completed more of the associate's degrees in the transfer process; and 3.) transfer student capital factors proved to be statistically significant in predicting academic adjustment for all transfer students.[59] Based on these findings, Laanan and Hernández argue that "transfer student capital can be a significant contributor" to a student's academic adjustment.[60] In addition, institutions "should help student recognize and activate their unique forms of transfer student capital".[61] The researchers identified multiple opportunities to extend the literature on STEM transfers students. Two of the strategies highlighted involved: 1.) linking L-TSQ survey responses to longitudinal academic records for transfer students; and 2.) conducting qualitative studies to understand the experiences of STEM transfer students.

Transfer Students in Engineering

Nearly one decade after the release of NAE's report on *Enhancing the Community College Pathway to Engineering Careers*, the body of literature on engineering transfer students is still limited for reasons previously discussed (i.e. insufficient data, inconsistent definitions of transfer students, outright institutional neglect).[62] However, the tide is beginning to turn. Recently, substantial studies specific to engineering transfer students have been published using large scale data sets such as: 1.) the California Partnership for Achieving Student Success (Cal-PASS) database; 2.) the California Postsecondary Education Commission (CPEC) database; 3.) and MIDFILED, a multi-institutional database with 11 universities from the southeastern portion of the United States [63,64,65] Much needed and long overdue, these studies have just scratched the surface when it comes to understanding engineering transfer students and their experiences.

A handful of studies have started to: 1.) characterize engineering transfer student profiles, pathways, and outcomes[66,66,68,69,70]; 2.) as well as explore engineering transfer student experiences.[71,72,73,74] Table 2 provides an inventory of recent literature specific to engineering transfer students. The section that follows is dedicated to exploring this literature.

Table 2. Literature on engineering transfer students.

Objective	Description	Literature Specific to Engineering Transfer Students
Characterize	Study characterizes transfer student profiles, pathways, and/or outcomes.	<u>Mulit-institution (large scale studies)</u> • Blash et al., 2012 • Shealy, Brawner, Mobley, & Layton, 2013 • Sullivan et al., 2012 <u>Single-institution (small scale studies)</u> • Laanan et al., 2010 • Laanan, Jackson, et al., 2011
Exploratory	Study explores transfer student experiences.	<u>Mulit-institution (large scale studies)</u> • Blash et al., 2012 • Mobley & Brawner, 2013 • Mobley, Shealy, & Brawner, 2012

		• Mobley, Shealy, & Brawner, 2013
Explanatory	Study seeks to identify explanatory factors for some observed behavior.	

Sullivan et al.[75] analyzed longitudinal academic records in the MIDFIELD database for 90,000 engineering students, including 21,542 transfer students; they found that not as many women were making use of engineering transfer pathway and that native engineering students academically outperformed their transfer student counterparts. The researchers also identified evidence to suggest that the transfer pathway may be a good avenue for African American students since GPAs for native students and transfer students from this particular ethnic/racial group were similar.[76] Additional findings from MIDFIELD data indicates the lateral transfers into engineering (i.e. from one 4-year institution to another) are significant in size and may be worthy of deeper investigation.[77]

Based on an evaluation of academic records for more than 4,200 students in California, Blash et al.[78] found that transfer students who completed a degree in engineering were predominantly male (83 percent), Asian (40 percent), and Caucasian (31 percent). On average, the time to engineering degree completion was 6.5 years for students in their sample. In addition, students transferring to 4-year institutions with 70 credits or more "were no more likely…to complete their engineering degree in less than two years" than students who transferred in with fewer units.[79] Similar to findings from other research studies,[80] California transfer students who completed the degree in engineering were less likely to earn an associate's degree in the transfer process (less than 75 percent earned an associate's degree). On the path to an engineering degree, transfer students cited multiple challenges, including: 1.) financial issues (i.e. costs, financial aid, managing work and school); 2.) limited or inefficient offerings of lower-division coursework at community colleges; 3.) and fulfilling transfer requirements that varied by 4-year institutions in the state.[81]

There is still significant room to extend the literature on engineering transfer experiences. Mobley et al.[82] are in the midst of conducting 80-100 semi-structured interviews, with transfer students at the 11 MIDFIELD institutions, to increase understanding and improve the recruitment/retention of engineering transfer students. While interviews are still underway, the research team has released two reports to disseminate preliminary findings on first generation engineering transfer student experiences[83] and engineering transfer student perspectives on orientation academic advising.[84]

We also have a critical need to identify factors that explain why engineering transfer students are successful or not.[85] While quantitative studies using the MIDFIELD database have to potential to fill this need, they are also somewhat limited in providing explanations that can be generalized to small ethnic/racial groups[86] because educational outcomes for Hispanics, Native Americans, and Asian students are limited to a very small portion of the MIDFIELD sample due to location of participating institutions.[87] As a result, there is much left to learn about transfer students and their pathway to degrees in engineering, especially for those from underrepresented racial/ethnic groups.

Conclusion and Future Research

While there is a large body of literature on the experiences of community college students, little research has been conducted on pathways and outcomes for engineering transfer students. Most of what we know is based on community college literature, but it is limited in its application to STEM transfer students and even more so for engineering transfers students. This paper explores: 1.) explanations for why there is limited research on pathways and outcomes for transfer students in engineering; 2.) community college literature and its application to transfer students in STEM; 3.) and literature specific to engineering transfer students. Based on the findings from this literature review, one could argue that there is much left to learn about engineering transfer student profiles, pathways, and outcomes. Opportunities for further scholarship exist to increase understanding of transfer students and their pathway to degrees in engineering. Areas worthy of exploration include (but are not limited to) the following:

1. What are common characteristics of students who successfully transfer into four year engineering degree programs?
    a. Demographics
    b. Internal factors (cognitive & affective)
    c. External factors (community & college – sending & receiving institutions)?
2. What transfer pathways (i.e. vertical, lateral, swirl) are most commonly used by students who successfully transfer into four year engineering degree programs?
    a. Do these pathways vary by student race, gender, prospective engineering major at receiving institution, and existence or lack of formal institutional partnerships (i.e. Articulation Agreements, Transfer Admission Guarantees, Dual Admission Programs, Transfer Centers, etc.)?
3. Are transfers students succeeding in four year engineering degree programs? How does student achievement and educational outcomes vary by student race, gender, prospective engineering major at receiving institution, enrollment status, and transfer pathways (i.e. vertical, lateral, swirl)?
4. How do institutions improve/hinder transfer pathways into four year engineering degree programs?
5. How do institutions improve/hinder transfer student success and transition into four year engineering degree programs?

Future research in these areas will close a gap in the literature on engineering transfer students as well as develop a clearer understanding of transfer student pathways as a means to increase engineering degree production and broaden participation in engineering careers. In addition, findings from this research will inform decisions on how to allocate limited resources (i.e. financial and human) to diversify pathways and increase the number of students who transfer into and succeed in engineering at four-year institutions.

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