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What Underrepresented Minority Engineering Majors Learn from Co-Ops & Internships

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INTRODUCTION

Higher education in the United States (U.S.) is an expansive enterprise, comprised of more than 4,300 colleges and universities and approximately 21 million college students enrolled part-time or full-time for study. Countries vary in the size and scope of postsecondary education systems (Altbach, Berdahl, & Gumport, 1999), making the U.S. system the largest in the world. Women represent the numerical majority on most U.S. college campuses and nearly 40% of U.S. college students identify as underrepresented ethnic minorities (URMs) including Blacks/African Americans, Hispanics, Asian Pacific Islanders, Native Americans, and bi/multiracial (non-White) students. Despite their growing presence in higher education, URMs still represent a small proportion of students majoring in high-demand fields such as engineering. The National Science Foundation (NSF) reports that 39% of URMs "plan to major" in science and engineering fields as freshman, but less than half of these earn an undergraduate engineering degree; rates are startlingly lower for Blacks and Hispanics.

One way to increase retention and graduation rates in engineering for all students is to enhance their overall skills and readiness for engineering-related work by way of cooperative education (i.e., co-op) and internships[1] that offer students "real-life, hands on" experience in their major subject. The Center for Postsecondary Research at Indiana University identifies such experiences as a "high-impact practice" that likely produces significant learning gains for students, although research is sparse on learning that accrues from internships and co-ops in engineering (Linn, Howard, & Miller, 2004). Still, it is estimated that thousands of students participate in either co-op or internships annually, 67% of recent college graduates completed at least one internship while in school, and 56% of employers expect to hire more interns in the future. Despite their widespread use and popularity, we know relatively little about the influence of co-ops and internships on URM students' learning in engineering. This is the gap addressed by this study.

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[1] There is consistent evidence that *all countries* are concerned about work preparation and provide “hands on experience” during training through internships, practicum, or apprenticeships.

Using a blend of survey and interview data, we will investigate the role that co-ops and internships play on enhancing URM students' learning in engineering in two primary areas (i.e., professional competencies, problem solving) as well as their professional identity. Survey data were collected using an online, web-based survey administered to URM engineering majors at predominantly White institutions in the southeast and Midwest regions of the country. Interview data were collected using a semi-structured protocol that asked questions about the nature of the co-op or internship, elicited stories about students' experiences, and what the student believed they gained from the opportunity. Implications for policy, practice, and teaching will be highlighted for the US and similarly-situated countries or related fields/disciplines.

REVIEW OF LITERATURE

To conduct a study on learning that accrues from co-ops and internships to URM students majoring in engineering, it was necessary to review the existing literature in a few areas. First, a long line of inquiry supports the role that experiential learning plays in the cultivation of talent. Experiential learning holds that experience (i.e., practice) is the source of learning and development (Kolb, 2014). Of course, experiential learning represents a number of opportunities ranging from service-learning to co-ops and internships (Stanton, 1992).

Prior research on service-learning internships provides ample support for the power of co-ops and internships to produce learning in professional fields such as engineering. For instance, Rehling (2000) focused on students in business and communications and found that their skills and understanding were enhanced through such internships, as well as their sensitivity to the needs of others. Industry-sponsored internships were deemed valuable as part of career preparation.

Many industries or fields use hands-on experiences such as co-ops and internships to prepare trainees for high-quality performance in a particular field or job. For instance, internships are highly effective in principal preparation programs. Thus, educators strive to expose principals-in-training to competent models—practicing administrators—from whom they can learn (Cottrill, 1994). And internships are a core component of ABET-approved engineering programs (ABET., 2010).

Just as engineering education programs are major- or discipline-specific (e.g., environmental, computer), so too are co-ops and internships in such fields. Although only 10% of construction education programs include field internships nationally, there is a long-standing belief that knowledge, skills, and abilities are enhanced through authentic involvement in co-ops and internships in construction engineering and internships produce learning that cannot be attained any other way. Tener (2004) studied the Purdue Construction Engineering Management Internship program and found that students learn time management strategies from weekly site meetings, effective communication skills working on a team, and the challenges of leadership as they observe interactions between the superintendent and subcontractors, for example.

There is other evidence supporting the notion that industry-based internships constitute significant learning experiences for students in engineering or technical fields. For instance, Biasca and Hill (2011) evaluated the Paper Science and Engineering program (PSEN) at the University of Wisconsin-Stevens Point that typically offers sophomore students employment at a paper mill for eight months. They found that students gained a sense of accomplishment from helping the mill meet its "bottom line" goals, time management skills as they worked to prioritize daily tasks, and communication strategies from reflective journaling and speaking "on the job." There was less evidence that students learned much about the organization itself, industry issues, corporate values, or aspects of their own professional identity. Not only have researchers shown that internships produce learning but Fogg and Putnam (2004) provided data indicating that internships often lead to higher earnings once in a professional job.

Despite this evidence base, there are important limits to what we know about internships in engineering and the role they play in student success. Scholars who have focused on internships and co-ops tend to discuss them generally using learning theory as a frame (e.g., Linn et al., 2004; Stanton, 1992), while those who focus on industry-based internships in engineering education programs rarely focus on URMs or the role that race/ethnicity might play in creating differential learning opportunities (e.g., \Tener, 2004 #6662}. This study was designed to address this gap in knowledge specifically and we strongly believe that the analysis and conclusions in this study may well be applicable to experiential learning in other disciplines, fields, for different student populations and countries beyond the United States that are concerned about workforce preparation.

METHODS

This study is part of a larger federally-funded research study designed by the lead author (Strayhorn) as part of a five-year CAREER grant from the U.S. National Science Foundation (NSF). The objectives of the larger study were to understand students' pathways to and through science, technology, engineering and math (STEM) fields with a principal focus on ethnic minority males. Although the larger study is comprised of national data, surveys, interviews, and observations, this work-in-progress paper is based on survey and interview data only.

Sample

The survey sample was comprised of 1,150 students majoring in engineering or a related subfield at a NSSE-participating institution. Sixty-four (64%) percent of the sample were women and over 57% were Black/African-American or Latino. Consistent with the nature of engineering and ABET-approved programs, 29% of respondents had "done" or completed a co-op or internship, 51% "plan[ned] to do" one, and interestingly approximately 20% "did not plan" to do so or hadn't decided at the time of survey. A fuller description of the analytic sample will be included in the final paper.

Interview participants (n = 10) were mostly minority males, given the lead authors' interest in this subpopulation, and over 50% were sophomores or juniors majoring in engineering or a subfield. All interview participants were bachelor degree-seeking and had the ability to participate actively (and without assistance) in a one-on-one interview with a member of our team. First-year, first-semester students and those living with severe disabilities were excluded from the study as the former are not likely to have internship experiences yet (or to have declared a major necessarily) and the latter may not be able to work in an internship without audio, visual, or other assistance. Table 1 presents a summary of the interview participants.

[Table 1 about here]

Data Collection

Part One: Survey. Survey data were collected in a national administration of the National Survey of Student Engagement (NSSE) sponsored by the Center for Postsecondary Research at Indiana University. The NSSE is a survey instrument designed to measure the quality and quantity of students' engagement in educationally purposeful college activities. Items relate to participation in various co-curricular (e.g., clubs and organizations) and curricular (e.g., internships) programs and activities. Additionally, the NSSE questionnaire includes a set of items that elicit information about students' perceived learning gains, making it suitable for the present study. For instance, one item asked: "To what extent has your experience at this institution contributed to your knowledge, skills, and personal development in analyzing quantitative problems?" Response options ranged from 1 (*very little*) to 4 (*very much*); other items asked about communication skills, working on a team, and ethics, to name a few. To date, more than 600 colleges and universities have participated in the national survey.

A web-based approach was employed since response rates are frequently low to mailed, hardcopy surveys (Crawford, Couper, & Lamia, 2001). Specifically, students attending NSSE-participating institutions were invited in the Spring semester to participate in the study via email. Electronic invitations included a hyperlink to the URL of the website on which the NSSE questionnaire was located. University registrars forwarded the invitation to potential participants using a randomly selected list of eligible students. No strategies were used across-the-board to encourage student participation, although evidence, to date, suggests that NSSE response rates range from 20 to 45%, which is considered good for web-based surveys (Crawford et al., 2001).

Part Two: Interviews. Interview data were collected from Fall 2008 through Spring 2015 by the authors or members of a formal research team led by the principal investigator. Qualitative data were collected via in-depth, one-on-one interviews, which is a widely-accepted technique for eliciting such information (Kvale, 1996). The purpose of interviewing is to "find out what is in and on someone else's mind" (Patton, 1990, p. 278). Interviews were conducted in such a way to elicit stories from each participant about his academic experiences generally but also what he derived from co-ops and internships specifically. Interviews averaged approximately 45 minutes, ranging from 23 to 85 minutes.

In short, a semi-structured interview protocol was developed, tested, and used in this study that included questions about each participant's demographic background, prior schooling experiences, aspirations for college, as well as the quality and nature of his engineering field experiences. Questions were designed to elicit recollections of challenges, people, and circumstances related to what was learned from co-ops and internships. Where necessary, probes were used to prompt remembrance of pivotal moments or to clarify meaning (e.g., "Can you tell me about a time when…" or "Can you say that differently…"). Use of probes and follow-up prompts are highly recommended in qualitative studies (Patton, 2002). All interviews were digitally recorded and professional transcribed verbatim for later analysis. Transcripts were stored electronically in a data information system.

Data Analysis

Given the study's objectives, data analysis consisted of three major tasks. First, survey data analysis proceeded in three stages. Descriptive statistics were calculated to observe any patterns among data points. Then, exploratory correlation analyses were conducted to test the magnitude and direction of relationships among variables; these are not included in the paper due to page limits but will be presented in the conference session. Third, hierarchical linear regression techniques with a nested design were used to estimate the influence of internship/co-op experiences and background variables on URM engineering majors' perceived learning gains, controlling for a battery of potentially confounding factors. Hierarchical regression analysis is "a method of regression analysis in which independent variables are entered into the regression equation in a sequence specified by the researcher in advance" (Vogt, 1999, p. 129). This approach yields more conservative estimates of statistical relationships, thereby reducing the chances of making Type 1 errors—that is, in this case, claiming a relationship between internships/co-ops and learning when there is none.

Interview data were analyzed using a three-stage constant comparison method described by Strauss and colleagues (Strauss, 1995; Strauss & Corbin, 1998). First, transcripts were read and re-read to generate initial categories of information or codes that represented "an initial plot of the terrain” (Miles & Huberman, 1994, p. 69); this is known as open coding (Strauss & Corbin). Next, codes were collapsed by grouping categories that seemed to be related to each other while leaving intact those that stood separate from all others. This smaller list of categories was used to generate “supercodes” or categories (Strayhorn, 2011). Discrete codes were then sorted and organized into a smaller list of 10 categories. Lastly, categories were compared and contrasted to understand the degree to which they were similar; closely related categories were combined into themes and renamed, where needed, so that the whole named reflected the sum of its parts.

FINDINGS

Hierarchical linear regression (HLR) tests were used to evaluate the relationship between URM engineering majors’ participation in internships/co-ops and perceived learning gains as measured by the NSSE. Results were statistically significant (F[4,923] = 7.46, $p < 0.01$, $R = 0.18$, $R^2 = 0.03$, Adj. $R^2 = 0.027$), indicating that URM engineering majors who participate in internships/co-ops report greater learning gains than their same-race peers who do not work in internships/co-ops. Other significant predictors of URM engineering majors’ perceived learning generally and problem-solving learning specifically were age (b = - 0.002) and transfer status (b = -0.139). Collinearity statistics suggest that multicollinearity was not a problem for this investigation and both part- and partial correlations reinforce interpretations from the HLR analysis.

Consistent with the NSSE analysis, interview participants spoke at length about the ways in which their internship or co-op experiences constituted significant learning as they were authentically involved in the “actual work of the field,” as one participant put it. Generally, URM engineering majors were satisfied with their internship/co-ops experiences and found them rewarding. Consider the following:

> From co-op to co-op, ever since my first experience it was great. It was like my first real job—it was with Honda. It was kind of everything I imagined it would be. I was in the test department and I was testing brand new cars and the people I worked with were great, my mentor was great, my boss was great so I had a great experience for six months. (Derrick)

> Actually my best learning experience wasn't in the classroom, it was from my internship. I finally got a chance to learn and apply stuff from class to real-life problems. Once I had a good experience, I wanted to stay. (Homer)

Not only did participants speak, at length, about their satisfaction with internships and co-ops but they provided insights about what they derived from their experiential field experience in terms of learning, professional development, and understanding of their professional identity. Consider the following:

> You learn a lot—not just real-life engineering issues, like what you'll do as an engineer but other stuff like working with people. At [my internship] I worked with pretty young like 30's people and then people on the top like my boss. I had to work with American managers and Japanese managers and clients all over [the world]. (Miguel)

> On my resume I have knowledge of AutoCAD and, yes, I learned that from my engineering degree [program] but I *really* (emphasis added) learned it from my summer internship when I worked with my mentor doing some CAD projects with AutoCAD mechanical. When you're doing an AutoCAD design a lot of shapes are already built into the program so you're creating the design for the electrical person to follow. It's cool because I learned how to build the basic components myself. (Alexis)

While participants shared countless examples of what they learned from internships and co-ops in terms of communication, interpersonal, and technical skills such as CAD use, relatively few offered clear examples of what they learned about the profession, the organization where they interned, engineering issues, ethics, or their own professional identity. Some students shared that they felt like mentors and co-op supervisors gave them "stuff to do" but didn't always take the time to explain why they're doing it, how it fits within the larger scope of work, or prepares them for the workplace.

Interestingly, the vast majority of participants—both men and women—spoke candidly about the ways in which race/ethnicity seemed to shape their internship experience. For example, one participant explained feeling looked over, ignored, or invisible at his internship site as a Black male. Some women shared how mentors seemed to expect less of them (and, consequently, assign them menial tasks) based on the mere fact that they were undergraduate women. Findings suggest critically important implications for research, teaching, and practice.

CONCLUSION

Recall that the purpose of this study was to investigate the role that co-ops and internships play on enhancing URM engineering majors' learning engineering in two primary areas (i.e., professional competencies, problem solving) as well as their professional identity. Result from analysis of NSSE data provide persuasive evidence supporting the conclusion that engineering majors engagement in internships and co-ops produce significant learning gains in terms of problem-solving, communication, and learning more about work.

Insights from one-on-one interviews support these conclusions using stories shared by students themselves. Clearly, engaging URM engineering majors in internships and co-ops is one way to facilitate learning in core areas (e.g., problem-solving), soft skills (e.g., working on a team), and career learning. From internships students learn how to communicate professionally, skills for managing time and prioritizing tasks, and technical skills such as CAD design, computer programming, and management/leadership.

Much more needs to be done to educate students about engineering as a profession, the infrastructure and goals of engineering industries and organizations, as well as students' professional ethics and values. For instance, engineering faculty might incorporate these topics specifically in undergraduate engineering courses or professional seminars. Internship coordinators might follow the example of Biasca and Hill (2011) to develop a rubric that requires students to complete reflective essays and web-based surveys after each "work day" at an internship site that asks about ethical decisionmaking, professional values, and what they've learned about the organization.

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