The Impact of Self-efficacy, through Experiential Education, on the Retention of Engineering Students

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Abstract

Northeastern University, a member of the Northeast Louis Stokes Alliance for Minority Participation (NELSAMP) including The University of Connecticut, The University of Massachusetts Amherst, The University of Rhode Island, and Worcester Polytechnic Institute , is leading an NSF-funded LSAMP engineering educational study to investigate the hypothesis that participation in practice-oriented experiential education (POEE) programs, such as formal cooperative education, internships and research experiences for undergraduates, leads to enhanced self-efficacy, augmented learning, and an increased likelihood of retention, particularly among minority students who are historically under-represented in engineering. Self-efficacy, defined as the confidence built on one's prior experiences, has been shown to contribute to students' success in undergraduate engineering programs. The current study proceeds to further explore the self-efficacy of three racial/ethnic groups of students, (Caucasian, Asian, and Black/Hispanic) in terms of three domains, (1) the work environment, (2) career development, and (3) academic success. Multiple discriminant analysis was used to study the separation of the three groups and the distances between them using a survey instrument developed to assess vocational and career self-efficacy at Northeastern University.

Introduction

Two themes addressed in the literature on higher education are (1) the need for a larger pool of professionals going into careers in science, technology, engineering and mathematics (STEM) as society becomes increasingly more scientifically advanced and technological in the future; and (2) consideration of the need to increase the diversity of the pipeline of candidates entering these professions as a way to meet the growing national requirements for STEM professionals.[1,2] Federal agencies and universities have created programs to increase the participation of under-represented groups in science and technology training programs in recent years.[3,4] There is some evidence that these programs are increasing the diversity of these fields.[5]

However, the literature suggests that many of the students entering an undergraduate engineering program do not complete it.[6] As is highly reflected in the low national retention rates of Black and Hispanic American students pursuing undergraduate engineering degrees. The present study was designed to address an issue of retention in an engineering program, one's sense of self-efficacy, or operationalized confidence, or to perform in work, career and academic contexts in the first year of engineering education. The concept of self-efficacy was proposed by Albert Bandura in his much broader theory of cognitive behavior, and has been expanded to apply specifically to career development in engineering.[7,8] Self-efficacy has been suggested as a key component of successful achievement. Self-efficacy can be conceptualized as a person's own sense of their ability to perform.

An individual's self-efficacy is largely formed by that individual's past experience of success and failure over time. It can be a major reason for explaining student performance in an undergraduate engineering program (Raelin, et. al, 2011)[8]. Further, under-represented potential students may experience negative social-cultural messages when they experience learning in science or math, or when they find themselves in science, engineering or mathematics academic environments (Zeldin, Britner, & Pajares, 2008)[9]. Therefore, the question addressed in this study

was: Does the level of one's perception of his or her self-efficacy to perform in an undergraduate engineering environment assume them to be a member of an under-represented ethnic or racial group?

Participants

A total of 653 undergraduate engineering students were asked to complete the self-efficacy survey in the semester prior to their going on their first cooperative learning experience. This represented more than 80% of the population of students at this large urban university. Of the 643 students who gave information about their ethnic or racial backgrounds, 73 were Asian American, 457 were Caucasian, and 113 were represented as other. This other group specifically consisted of 14 African Americans, 36 who identified themselves as Hispanic/Latino, 2 identified as Native Americans, and the remaining 61 either identified as just "other" or multiracial. Males (n=509) out-numbered females (n=138) at approximately 5:1, and six neglected to indicate their sex. The sample also included 179 students who attended private school, while 447 reported attending public school prior to their enrolling in their college programs. Most of the students participating in the study had just completed, or were close to completing their freshman year. More than 2/3 of the students in the sample came from public schools. Most characterized their schools as suburban (58%), while about 15% came from urban backgrounds, and 11% characterized their school districts as rural. Almost 2/3 said there schools were rather homogenous in in terms of race/ethnicity and socio-economic status.

Measurement Instrument

As part of a larger study, students were asked to complete the "Survey on Workplace Learning."[10] Three scales of this instrument were used in the present study, Work Self Efficacy (WSE), Career Self Efficacy (CSE), and Academic Self Efficacy (ASE). The items (or questions) contain statements to which the respondents indicate their level of agreement on a scale of 1 (not at all) to 5 (Completely). The WSE scale has 31 items. CSE is made up of 25 items, and the ASE has eight. Each of these scales has high reported reliability and validity.[10] The scale was administered in students' classes or online.

Multiple discriminant analysis was used as the main analysis for addressing the question. Discriminant analysis is a technique for identifying group membership from a set of independent variables such as survey items.[11] In the present study the independent variables were the survey items, and the dependent variables were the *a priori* membership in the ethnic group classifications.

Results

Data were analyzed with the Statistical Program Social Sciences (SPSS), an IBM product. Initially, the White group was compared to all the diversity groups combined to determine whether or not diversity in general was an issue in group identification. To explore the effectiveness of the questions in the survey for separating the groups, a subsequent analysis was done by removing the Asian American group from the combined diversity and analyzing a three group comparison. This was possible because the Asian group was the only one large enough in

the sample for meaningful analysis, and second, it was recommended by findings in the literature which suggested that Asian American scored more like Caucasian Americans (Hackett, Betz et al, 1992). The first analysis compared the Caucasian students to all others as a combined diversity group. The separation between the Caucasian students on WSE was significant (*Wilks' λ* = .865, $\chi^{2(31df)}$ = 82.85, *p*<.001). <mark>In other words, the items associated with perceived self-efficacy in the work context, the two groups were different.</mark> Part of the output from the data analysis program is a classification table which revealed that using the items in the WSE set, 94% of the Caucasian students could be identified correctly from their ratings while only 27.7% of the diverse (other) group could be identified.

The Career Self Concept respondents were similarly analyzed. The separation between the Caucasian students and the diverse group on CSE was statistically significant (*Wilks' λ* = .899, $\chi^{2(25df)}$ = 62.46, *p*<.001). However, the Career items were slightly less effective in identifying the separation between the White students and the others. Specifically, the items were effective in identifying 94.6% of the white students by their CSE ratings, and only 17.7% of the others.

Finally, the Academic Self Concept scales responses were analyzed. The separation between the Diversity and the Caucasian students on CSE was not significant (*Wilks' λ* = .978, $\chi^{2(8df)}$ = 14.20, *p*=.08). In other words, the vector of ratings on the ASC scale was not effective in separating the two groups.

Three groups analysis on WSE scale
As stated earlier, to further explore these results, the Asian American group was removed from the combined diversity group and established as a separate group, resulting in analysis of separation across three groups. The 73 students in the Asian American seemed to constitute a sufficient number for analysis as a separate group. Further, research has suggested little difference between Asian and White engineering students in performance and academic ability.[12] Thus, subsequent analyses were based on three groups, Caucasian, Asian American, and Other (primarily composed of Latino and Black students).

The first analysis in this series was done on the three groups of students' ratings of the WSE items. Means, standard deviations, and the significance of the differences across the groups for each survey question were identified. (The analysis reflects the analysis for the students who provided complete data (n=593).

The multivariate analysis suggested separation between all three groups (Functions 1 and 2: *Wilks' λ* = .779, $\chi^{2(62df)}$ = 143.64, *p* < .001; Function2: *Wilks' λ* = .905, $\chi^{2(30df)}$ = 14.20, *p*=.002). The items on the WSE scale were effective in identifying 95.7% of the white students by their WSE ratings, 24.3% of all other students, but only 16.2% of the Asian American group. Eleven of the 31 WSE survey questions contributed to the separation between the groups. There was considerable variability in terms of the patterns of ratings of items across groups. That is, Caucasian students gave higher ratings, reflecting more self-confidence around work issues on some items(e.g., "Master an organization's slang and jargon" and "Solve most problems eventhough initially no solution is present"), while Asian Americans and the Others groups each rated their ability higher on different items. In the analysis of comparison of means across items,

the criterion for the F-tests was alpha=.05 for rejection of the null hypothesis of no difference between groups.

Three groups analysis on CSE scale

Analysis of the Career Self-Efficacy scale yielded mixed results on the discriminating functions (Functions 1 and 2: *Wilks' λ* = .848, $\chi^{2(50\ df)}$ = 97.954, *p* < .001; Function2: *Wilks' λ* = .946, $\chi^{2(24df)}$ = 14.20, *p*=.103). Thus, the distinction between two of the groups was supported. The third group could not be distinguished from at least one of the other two. We explored this finding in two ways. First we considered the accuracy of the separation into groups based on the scale ratings. Using responses on the items, the discriminant analysis procedure that was used was effective in identifying 97.9% of the white students by their CSE ratings, 11.7% of the other students, and only 4.3% of the Asian American group. The lack of accuracy in classification found for Function 2 probably was reflected in the closeness of the two groups. The second way we considered the finding was to look at the means of the ratings and the one-way ANOVAs of the differences between the means across groups. Five of the 25 items listed statistically significant F-ratios beyond the .05 level of alpha. However the means of the significant items were very similar in both pattern and magnitude. Generally the highest self ratings on the statistically significant career self-efficacy items were in the Caucasian group, except for the item concerning making plans for the next five years (item 34). For this item, the Other group rated itself the highest, followed by the Asian group of students.

Three groups analysis on the ASE scale

Finally, the multiple discriminant analysis of the ratings on the eight items of the ASE scale suggested that the students in the three groups did not report an overall statistically significant difference (beyond the .05 level of alpha) in their confidence that they could do the work required in their engineering curriculum, and no single items were statistically different across the groups (Functions 1 and 2: Wilks' λ = .962, $\chi2^{(16\ df)}$ = 24.41, p < .081); Function2: Wilks' λ = .984, $\chi2^{(7\ df)}$ = 10.20, p=.117). All groups rated their perception of their academic ability to perform as relatively high (in the 3.54 to 4.57 on the five-point rating scale). The highest rated item was on item 63 ("Achieve an engineering degree at this institution") as the highest rated scale for all groups. Again, we looked at the questions in the survey to help provide meaning to the results.

Discussion and Conclusions

The results suggest that the groups can be identified by their self-efficacy ratings to some extent. In both two group and three group comparisons, the academic self-efficacy scale was not useful in separating the groups. The items on the WSE scale were most effective in identifying the white students from the other two groups. The Caucasian students could also be identified from the Asians and Combined Diversity groups based on ASE ratings. This finding supports the assumption in the literature that self-efficacy is an important variable to consider in designing engineering education experiences. However, the kind of self-efficacy being considered is important. For example, while WSE was effective, the Career Self Efficacy measure that we used was less so, and the academic measure was not useful in separating the groups. While the Whites students tended to rate themselves as more confident than the other groups, this was not the case often enough to generalize the finding. Further, the "Other" group, mostly Black and

Hispanic, was not always lower than the White and Asian groups, and was higher on many items in the survey.

Generalizing the results of this study to a widely distributed population of engineering undergraduates should be done with caution. The school providing the data is known as a highly selective institution and most students accepted to study engineering are probably relatively confident of their ability to be successful in the program. Thus, the findings could be attributable to the university sample used in the study as well as a number of other issues. As mentioned earlier, this study is part of a larger one in which the impact of coop experience on self-efficacy will be assessed. It is expected that difference between the groups will be reduced by successful cooperative experiences.

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