AC 2012-5169: THE ROLE MODEL AFFECT AND ITS EFFECT ON UNDERREPRESENTED MINORITIES PURSUING DOCTORATES IN ENGINEERING EDUCATION

Dr. Rochelle Letrice Williams, ABET

Rochelle Williams recently joined the ABET headquarters staff as Educational Research and Assessment Manager in the Professional Services Department. In this role, Williams manages ABET's educational offerings on a global scale and leads technical education research projects. Prior to joining ABET, Williams held two positions at Baton Rouge Community College: Science Laboratory Manager and Adjunct Faculty in the Mathematics Department. In addition, Williams has worked closely with the National Science Foundation's Next Generation Composites Crest Center at Southern University. In this role, she supported the center's mission to increase the awareness of engineering education to underrepresented minority groups on both the secondary and post-secondary levels. Williams holds a Ph.D. in science and mathematics education and a master's of engineering in mechanical engineering from Southern University and A&M College in Baton Rouge, La., and a bachelor's of science in physics from Spelman College in Atlanta, Ga.

Dr. Eyassu Woldesenbet, Southern University and A&M College

Dr. Woldesenbet is professor of mechanical engineering at Southern University and Louisiana State University.

The Role Model Affect and Its Effect on Underrepresented Minorities Pursuing Doctorates in Engineering Education

1. Background

Regardless of race or ethnicity, engineering education began to see a decline in enrollment beginning in the early 1990's. To address this concern, among others, ABET adopted the Engineering Criteria 2000 (EC2000), which introduced a new paradigm in engineering education.[1] The new paradigms in engineering education went beyond the need to keep students on the cutting edge of technology, but required students to have interpersonal skills, be inquisitive and innovative, and most importantly, possess inter-disciplinary knowledge. In order to combat the decline in engineering enrollment, teachers had to be willing to step out of their comfort zone and take an active role in students' learning to adequately prepare them for not only a multi-dimensional education, but a graduate level education, as well.

The relationship between student and engineering faculty has been reported as the key element that distinguishes between graduate-level and undergraduate-level education.[2,3,4,5] Seymour and Hewitt[5] reported the high attrition rate in science, math, and engineering are linked to the dullness of the lecture model, the inadequate faculty guidance, and intimidating nature of the classroom. Astin and Astin[3] reported that student interaction with faculty often has a positive effect on student development, retention, and involvement; however, the authors also found this not to be necessarily true for engineering students. They believed interaction with engineering faculty may not have the same positive affect on engineering students because those relationships may not appear to be positive to begin with. This is a contradiction to faculty roles, in that student-faculty interaction inside and outside the classroom should positively influence student learning.[6]

Furthermore, reports on faculty interaction with African American students at majority serving institutions vary. Some studies find that African American students often feel awkward about relationships with white faculty members, as faculty tend avoid interactions with them. In a study researching African American engineering and science doctoral students, Adams[7] found that these students encountered barriers that tend to be associated with the limited contact that

graduate faculty have with minority students. Participants reported that non-minority faculty members were typically uncomfortable with personal, one-on-one relationships with minority engineering students. Adams[7] reported that faculty discomfort was largely due to (a) the culturally restricted and misunderstood informational needs of African American doctoral students, (b) the perceived risk of mentoring an African American student based upon limited respect for academic abilities, and (c) a history of strained relationships between African Americans students and the various academic units. In addition, Adams reported that these strained relationships among faculty members and African American students may result in students' feelings of isolation and, in some cases, perceptions that faculty are uninterested in their learning. Kador and Lewis[8] examined the relationship and the importance of connecting African American doctoral students with advisors in the mentor roles. More specifically, this study brought to the forefront the importance, as well as the impact of mentors/advisors and their roles in facilitating academic success for African American doctoral students at predominantly white institutions (PWIs).

1.1 The Conceptual Framework: Social Cognitive Theory

Bandura's triadic model[9] of the environment's effect on self and behavior was used as the theoretical basis for this study. Bandura's model classifies three self-referent constructs: environment, self, and behavior. Each factor influences, and in turn, is influenced by the others, where, each element of the process provides information that will either positively or negatively reinforce the other elements. This research questioned which variables were responsible for African American students' engineering confidence in engineering programs as measured by effort towards doctoral degree persistence and explored to what extent the findings might differ for students at HBCUs and PWIs.

2. Method

A path analysis was used to evaluate the affect of faculty interaction on engineering confidence and doctoral degree persistence by addressing the research questions in section 2.1. Path analysis was conceptualized as a means for studying the direct and indirect impacts of measured variables on other measured variables considered to be effects.[10, 11]

2.1 Research questions

1. When comparing African American students in engineering programs, how does the direct effect between faculty interaction and doctoral degree persistence compare at HBCUs and PWIs?
2. When comparing African American students in engineering programs, how does the direct effect between faculty interaction and engineering confidence compare at HBCUs and PWIs?

2.2 Research population

Subjects were solicited from HBCUs and PWIs with ABET accredited engineering programs and doctoral degree programs in engineering. All participants were African American and had a GPA of 2.75 or greater. Subjects were asked to identify their race and thoughts on pursuing a doctoral degree in engineering. Those who identified as being African American and were either currently enrolled in a doctoral program or were considering enrolling were directed to the survey. All others were rejected. Of the 103 students selected, 46 attended an HBCU and 57 attended a PWI.

2.3 Subscale measures

A 60-item survey was developed by the researcher containing a seven-point Likert scale that asked participants to utilize the following rating scale: (1) very untrue of me, (2) untrue of me, (3) somewhat true of me, (4) neutral, (5) somewhat true of me, (6) true of me, and (7) true of me. The rating scales were used to assess the students' response towards their *engineering confidence*, perceived *faculty interaction*, and *doctoral degree persistence (effort)*.

2.4 Design and Methodological Procedures

Results of the survey were analyzed using SmartPLS[13], a software application for graphical path modeling. SmartPLS determines relationships between independent and dependent latent variables as linear composites. As a structural equation modeling (SEM) tool, SmartPLS is capable of simultaneously determining both the indirect as well as the direct path influences among all of the latent variables in a model.

Figure 1 introduces the proposed path model for analysis. The researcher sought to determine the direct affect faculty interaction (FI) has on engineering confidence (EC) and doctoral degree persistence (DDP) (paths 1 and 2) and the direct affect of engineering confidence on doctoral degree persistence (path 3). Simultaneously, this model will analyze the direct affect of engineering confidence on critical thinking (CT), help seeking(HS), and peer learning(PL) (paths 4,5, and 6), and in turn, their paths to doctoral degree persistence (paths 7,8, and 9), however, special attention will be to paths 1, 2, and 3 for this study.

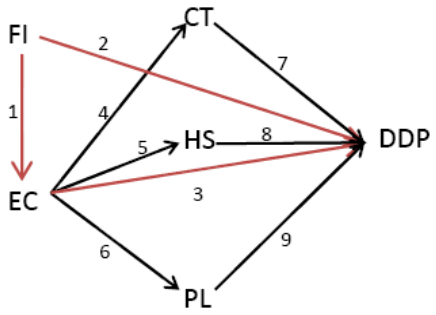

Figure 1. Proposed path model

3. Results

In SmartPLS, the evaluation of path models is two-fold. One must evaluate elements of the model structure with respect to the measurement model and structural model, separately. When assessing the measurement model, the quality of the validity and reliability measures are estimated and unidimensionality is confirmed by conducting an exploratory factor analysis. To evaluate the validity of the structural model, the coefficients of determination, R^2, and path coefficients are measured.

3.1 The HBCU Model

Assessment of the measurement model

Reliability and Validity

The reliability estimates for doctoral degree persistence, engineering confidence and faculty interaction were measured using two techniques: Cronbach's alpha and composite reliability. Degree persistence had a score of 0.93 and 0.95; engineering confidence had measures of 0.92 and 0.94; and faculty interaction had scores of 0.94 and 0.96 for alpha and CR, respectively.

Particular to path modeling, validity was measured using AVE or average variance explained. The proposed threshold value of AVE is greater than 0.500, where values for HBCU students were found to be from moderate to high values of AVE (0.684-0.872), thus, giving validity to the model. In addition to AVE values, cross loadings were obtained by correlating the component scores of each latent variable with all other items. If the loading of each indicator is higher for its designated construct than for any of the other constructs (i.e., E1, E2 and E3 will load higher on E than on FI or EC) and each of the constructs loads highest with its own items, it can be inferred that the models' constructs considerably differ with one another. This held true for the HBCU model.

Assessment of the structural model

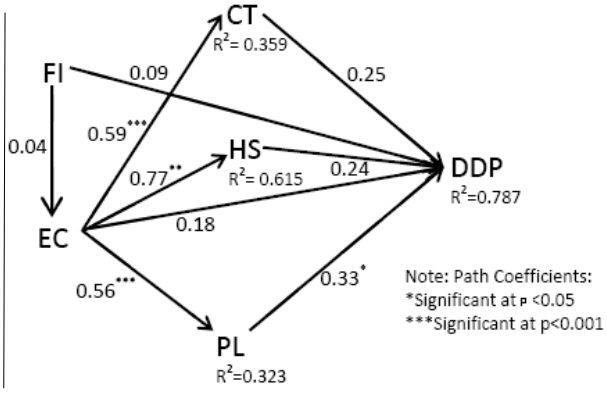

Figure 2a

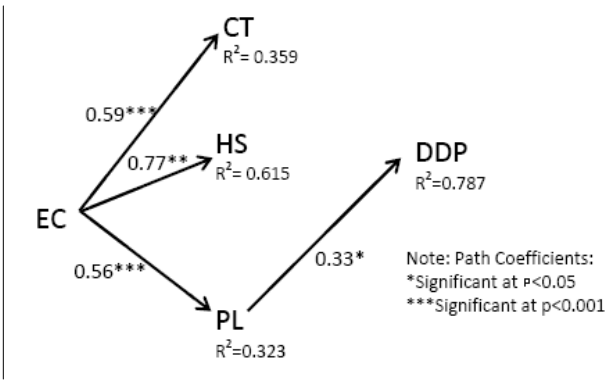

Figure 2b

Figures 2(a-b). Results of the HBCU structural model.(a)The original HBCU structural model. (b) The reduced HBCU structural model

The HBCU model was reduced to only show significant paths (Figure 2b) demonstrating there is no significant relationship between faculty interaction and doctoral degree persistence or faculty interaction and engineering confidence. An R^2 value of 0.787 was measured for doctoral degree persistence, indicating degree persistence accounted for more than a substantial amount of variance in the model.

3.2 The PWI Model
Assessment of the measurement model

Reliability and Validity

Cronbach's alpha and composite reliability (CR) were also evaluated in the PWI model yielding acceptable reliability measures. Degree persistence had a score of 0.84 and 0.90; engineering confidence had measures of 0.88 and 0.91; and faculty interaction had scores of 0.81 and 0.86 for alpha and CR, respectively.

Furthermore, observations of the cross loadings matrix showed that the models' constructs differ significantly with one another. Factor loadings for PWI data were found using an exploratory factor analysis. Items measuring doctoral degree persistence (E), engineering confidence (EC), and faculty interaction (FI) were observed to load heavily with their respective constructs. The proposed threshold value of AVE ranged from 0.51-0.75 for PWI students. Findings show acceptable values for doctoral degree persistence, engineering confidence, and faculty interaction, thus, giving validity to the model.

Assessment of the structural model

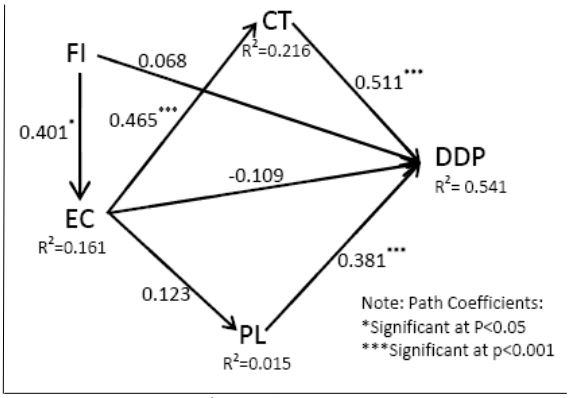

Figure 3a.

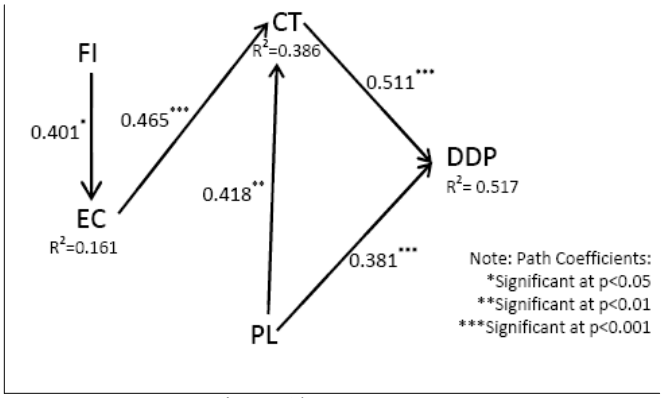

Figure 3b.

Figures 3(a-b). Results of the PWI structural model.(a)The original PWI structural model. (b) The reduced and revised PWI structural model

4. Discussion

This study was undertaken to determine if the proposed path model might shed light on students' academic progress in engineering programs by institution type (i.e. HBCU or PWI) as a result of faculty interaction. Particularly, this research questioned how students perceived faculty interaction and its influence on engineering confidence and doctoral degree persistence (effort).

Path models for both HBCUs and PWIs were proposed, evaluated, and revised and reduced in order to answer the research questions in this study.

The first research question sought to determine if faculty interaction had a significant positive correlation with doctoral degree persistence for students at HBCUs and PWIs, separately. Faculty interaction was unable to predict degree persistence in African American students at HBCUs. While the relationship between faculty interaction and degree persistence was positive, the path was not significant. This was not expected, as HBCUs are known for nurturing environments and minority role models in faculty positions. HBCU students reported that it was somewhat true of professors to be accessible (5.47) and willing to provide opportunities for students (5.28). Likewise, HBCU students reported that professors have somewhat strong advising skills (5.23), however, remained neutral when reporting having in interest in students' ideas and goals. This leads to question (1) the effectiveness of role models at HBCUs and (2) the advising styles of faculty members.

In addition, there was no significant direct effect between the relationship of faculty interaction and degree persistence at PWIs. Astin and Astin[3] reported that student interaction with faculty often has a positive effect on student development, retention, and involvement; however, the authors found this not to be necessarily true for engineering students. They suggested that interaction with faculty may not have the same positive effect on engineering students because those relationships may not be positive to begin with.

The role of faculty members as mentors/role models arises from the testing of paths 1 and 2 in both the HBCU and PWI model. Are engineering professors taking an active role in growing from a prescriptive advising style to one of a developmental advising style? Developmental advising stems away from the traditional, prescriptive technique of simply telling a student what courses are required each semester for their particular major and branches into one which Crookston[16] terms as, *"the belief that the relationship itself is one in which the academic advisor and student differentially engage in a series of developmental tasks, the successful completion of which results in varying degrees of learning by both parties."* Crookston[16] also

reported that developmental advising is intrusive, aggressive, and is not made to make students feel good.

Ultimately, this level of "reality-checking" is designed to help the student reach their full potential. It is the opinion of the researcher that while the underlying mission of many HBCUs is to provide a non-hostile atmosphere, students are not being equipped with the tools needed to develop an aggressive behavior towards degree completion. This is evident by the longer degree completion times and smaller graduation rates at HBCUs compared to that of PWIs.

The second research question addressed the affects of another direct path, faculty interaction and engineering confidence. Explicitly, when comparing African American students in engineering programs, how does the direct effect between faculty interaction and engineering confidence compare at HBCUs and PWIs?

While this research has already determined that faculty interaction alone does not influence African American students to persist through doctoral studies, it was assumed that faculty would, to some degree, play a positive role in a student's engineering confidence. Results from the structural models illustrated that the relationship from faculty interaction to engineering confidence was found to be significant in the PWI model, however, not in the HBCU model. In the PWI model, the path from faculty interaction had a positive significant effect on faculty interaction with a path coefficient of 0.401 with significance at the $p<0.05$ level. This indicates that while faculty interaction did not affect degree persistence, it does contribute to a student's sense of engineering confidence.

5. Conclusions and Implications

Factors that impede or enhance effort towards doctoral degree persistence is vital in increasing the number of African Americans receiving PhDs in the discipline. Researchers have identified faculty interaction, academic environments, self-efficacy, and academic confidence as likely predictors of degree completion in engineering.[5, 17,18] Moreover, researchers have found that faculty serving as role models/mentors[8, 19,20] can either enhance or diminish a student's degree

persistence, where African American students with poor faculty relationships are more likely to quit in the face of isolation.

This study highlights the importance of the role faculty have on engineering confidence in African American students at PWIs. In the HBCU model, this study strongly suggests the need to develop faculty interaction with students. While these environments are known to be more nurturing than predominantly white institutions, maybe they have become too relaxed in aggressively guiding students towards degree completion. Until there is a shift in the HBCU environment (faculty interaction) on the undergraduate level, there will continue to be a lack of graduate level degrees offered and earned at these institutions compared to PWIs.

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