Using Predictive Variable Analysis to Investigate Non-Academic Factors that Contribute to the Persistence of Undergraduate Engineering Students

Shonda W. Bernadin, Wachell McKendrick and Charmaine Caldwell

Abstract

This work in progress describes the study of how dispositional variables such as gender and ethnicity affect the persistence of undergraduate Electrical and Computer Engineering (ECE) students at two different institutions. ECE students from an Historically Black College or University (HBCU), along with ECE students from a Predominately White Institution (PWI) who matriculate at the same engineering school and take the same engineering classes, are included as the targeted populations for this study. Previous research on the non-academic factors that contribute to the persistence of undergraduate electrical and computer engineering (ECE) students suggested that, of the ten variables studied, *academic integration* and *institutional commitment* were the two primary factors that moderately correlate with persistence in the ECE major. Bivariate correlations of predictor variables indicated that for academic integration (AI), financial stress and institutional commitment were the strongest indicators of AI. For institutional commitment (IC), financial strain had the strongest impact. The other predictive variables in this study included Degree Commitment, Social Integration, Scholastic Conscientiousness, Academic Efficacy, Academic Motivation, Collegiate Stress, and Academic Advising. Though correlation analyses revealed strong correlations among predictive variables, there may also be strong correlations among dispositional factors, such as gender and ethnicity, which were not investigated in the sample population in previous research. Also, incorporating cross-validation methods of reliability will provide deeper insight to the non-cognitive persistence factors impacting engineering student success. In this paper, the researchers describe an investigation study on dispositional variables that may influence the persistence of ECE students in similar academic environments. In addition, cross-validation studies will be presented which may provide meaningful reliability measures. The results of this study will contribute to the advanced knowledge of the impact of psychosocial factors on engineering student success. Results may also contribute to the design of effective prediction models for persistence of undergraduate engineering students.

Keywords

Persistence, Retention, non-academic variables of persistence, prediction models, Engineering

Introduction

Previous research[12] on the persistence of engineering students at the FAMU-FSU COE suggests that the completion of the pre-engineering program requirements is a strong indicator of students' persistence to graduation. The data from the study showed that of the 1,997 first-time-in-college (FTIC) engineering students who entered the pre-engineering program in fall 2004, 46% of the FSU students completed the program requirements and only 25% of the FAMU students completed the program requirements. These results are disturbing and suggest there are major underlying factors that are impacting the persistence of pre-engineering students in the major at both institutions. In an effort to further investigate these results and provide some justification for implementing effective student support programs, a persistence study was implemented and its results are described in this paper. For consistency sake, it becomes necessary to define how the terms *persistence* and *retention* are used in this research. In this work "student persistence" describes those students who are matriculating in their engineering program after having completed the pre-engineering program. The term "student retention" describes those students who are currently matriculating in the pre-engineering program. A research study was designed to explore students' perception of themselves and their learning environment using common factors that impact persistence and retention.

Background

Tinto's[13] seminal retention model will be used to identify psychosocial factors related to the COE engineering students' persistence. Tinto proposed that students who academically and socially integrate into the campus community increase their commitment to the institution and to their goals and thus are more likely to graduate[14]. The two concepts in this theory interact with and enhance each other. Karp, Hughes, and O'Gara[15] note that in this model, academic integration occurs when students become attached to the intellectual aspect of college and social integration occurs when students develop positive relationships and connections inside and outside of the classroom. The concept of integration is so prominent that the assumption is if colleges provide sufficient opportunities for students to engage in the institution, then students become integrated and persist in their studies. In an expansion of his model, Tinto[14] noted that cultural barriers must be removed for underrepresented students so that they can connect to the campus community. With the low level of persistence in the engineering major, it will be instructive to utilize this theoretical model to identify specific factors that could positively impact academic and social barriers and, ultimately, student-persistence rates in engineering.

The literature on retention and persistence rates in higher education is plentiful as outlined by Palmer, et.al[7] Davidson, Beck and Milligan[16] identified eight primary themes that impact student retention and persistence rates. In this paper those themes were categorized into ten factors based on analysis results from previous studies [17]. The ten primary persistence factors that are identified in this study include: *academic integration (AI), social integration (SI), degree commitment (DC), collegiate stress (CS), academic motivation (AM), academic advisement (AA), scholastic conscientiousness (SC), institutional commitment (IC), financial stress (FS),* and *academic efficacy (AE)*.

Academic integration is a student's perception of how well their engineering curriculum and instruction aid in their achievement of their personal goals. Some variables that may influence

academic integration include quality of instruction and feelings of intellectual growth [16]. Social integration is a student's perception of their sense of community, how similar they feel to their peers, their sense of belonging, etc. [16]. Degree commitment measures the value a student places on obtaining their engineering degree. Collegiate stress measures the degree to which academic stress influences a student's college life experiences. Academic motivation measures a student's desire to pursue excellence in academic tasks. Academic advisement refers to a student's perception of the quality and level of advisement they have received at their institution. Scholastic conscientiousness measures the value students place on their academic responsibilities, such as turning assignments in on time and arriving to class on time. Institutional commitment refers to how committed a student is to completing their degree at their current institution. Financial stress refers to a student's level of worry or difficulty in meeting their financial needs in college. Academic efficacy measures a student's belief in himself or herself to meet the academic performance goals.

Method

A persistence study was designed to analyze the impact of non-academic factors on persisting Electrical and Computer Engineering (ECE) students. The research was conducted in a junior-level Electrical and Computer Engineering Signals and Systems course. This is a required course for ECE students. Students in this course were at least one-year removed from having completed the pre-engineering program, thus, these results may be used to characterize successful models for pre-engineering program completion.

Lindheimer suggested that the newer version correlates better with identifying at-risk students. Responses for the following ten factors were recorded and analyzed: Institutional Commitment, Degree Commitment, Academic Integration, Social Integration, Scholastic Conscientiousness, Academic Efficacy, Academic Motivation, Collegiate Stress, Academic Advising and Financial Strain. Furthermore, the College Persistence Questionnaire demonstrated strong validity and reliability [16-17] with an average Cronbach alpha score of $\alpha = 0.70$ for all factors [18].

Questions were answered on a 5-point Likert scale with a sixth option denoting "not applicable". The item-response scale depended on the language of the question. For example, an item in the academic advisement category asked *"How satisfied are you with the academic advising you receive here?"* used an item-response scale ranging from (*very satisfied* to *very dissatisfied*). The data analysis phase converted these responses to a favorability scale which indicates a positive or negative feeling about the student's experience (+2 indicated *very favorable* to -2 indicating *very unfavorable*). All participants signed a consent form and approval to administer the questionnaire was obtained from the FAMU and FSU Institutional Review Board. Participants were assured that their answers would remain confidential. The CPQ-TV3 was administered in pencil-and-paper format during the twelfth week of the fall semester of class. Most of the participants completed the CPQ-TV3 in less than 20 minutes.

Data Analysis

The data was coded using favorability scores to code item responses (+2 very favorable; +1 somewhat favorable; 0 neutral; -1 somewhat unfavorable and -2 very unfavorable). Descriptive and inferential statistics were used to measure the mean and variance of the data as shown in

Table 2. All statistical tests were conducted using Minitab® Statistical Software. Figure 3 shows the histogram plot of each factor after conducting normality tests.

Based on the normality tests, it was concluded that the each of the persistence factors followed a normal distribution pattern and basic statistical analysis methods could be used in analyzing the data. It is also worth noting a few observations about the data: (1) The "6" value indicated a "not applicable" response from the student; (2) the *degree commitment (DC)* factor is skewed in the positive or favorable direction. This observation can be explained by using the fact that this sample population has already completed the pre-engineering program and are nearing the last phase of their undergraduate curriculum, so they may have more determination and perseverance to finish their degree than lower-level students; (3) *institutional commitment (IC)* is also skewed in the favorable direction which may suggest that students in this sample population are committed to their institution at this stage in their program matriculation; and finally, (4) *scholastic conscientiousness (SC)* is negatively skewed, which may suggest that students place minimal value on their academic responsibilities, such as turning in assignments in a timely manner or arriving to class on time.

Table 1- Mean and Standard deviation scores for sample set of Electrical and Computer Engineering Participants 2014-2015

	Mean		**Standard Deviation**	
	Fall 2014	**Fall 2015**	**Fall 2014**	**Fall 2015**
AI	0.4108	2.914	1.205	1.1748
SI	0.4887	2.4747	1.085	1.1397
DC	1.418	1.6012	1.032	0.9524
CS	0.5618	2.3935	1.187	1.2575
AM	0.4790	2.6385	1.146	1.1917
AA	-0.041	3.4675	1.249	1.3113
SC	-0.302	3.5208	1.787	1.4190
IC	0.5914	2.7571	1.787	1.4765
FS	0.7487	2.7792	1.757	1.4941
AE	0.3228	2.7686	1.215	1.1376

Correlational analysis was also performed on the data to determine relationships between primary factors. The results are presented in the next section along with a discussion of some observations.

Results and Discussion

Intercorrelational values were determined and a correlation matrix using the Pearson correlation coefficient method was constructed. The Pearson Method evaluates the strength to which two variables tend to change together in a linear fashion. It assumes normality among the data. Minitab® 17 was used to perform the analyses. Table 3 shows the results for Fall 2014.

Table 2-Intercorrelation among retention variables (p-values in parenthesis) – Fall 2014

	AI	SI	DC	CS	AM	AA	SC	IC	FS	AE
AI	1.00	0.126*	0.153*	0.163	0.135	0.047	-0.068	0.252*	0.198*	0.083
SI	--	1.00	0.152	0.047	0.06	-0.022	0.084	-0.059	0.108	0.021
DC	--	--	1.00	0.127	0.093	0.059	-0.013	0.087	0.110	0.065
CS	--	--	--	1.00	0.114	-0.004	-0.108	0.077	0.066	0.060
AM	--	--	--	--	1.00	0.085	0.144	0.108	0.113	-0.010
AA	--	--	--	--	--	1.00	0.028	0.178	0.042	0.084
SC	--	--	--	--	--	--	1.00	0.109	0.019	-0.001
IC	--	--	--	--	--	--	--	1.00	0.223*	0.079
FS	--	--	--	--	--	--	--	--	1.00	0.108
AE	--	--	--	--	--	--	--	--	--	1.00

N= 56, * $p < .001$

Table 4-Intercorrelation among retention variables (p-values in parenthesis) – Fall 2015

	UNIV	CLASS	MAJOR	GENDER	RACE	AI	SI	DC	CS	AM	AA	SC	IC	FS	AE
UNIV	1.00	--	--	--	--	--	--	--	--	--	--	--	--	--	--
CLASS	0.191	1.00	--	--	--	--	--	--	--	--	--	--	--	--	--
MAJOR	-0.147	-0.043	1.00	--	--	--	--	--	--	--	--	--	--	--	--
GENDER	-0.075	0.386	0.015	1.00	--	--	--	--	--	--	--	--	--	--	--
RACE	-0.174	0.095	0.020	0.095	1.00		--	--	--	--	--	--	--	--	--
AI	0.083	-0.107	-0.112	-0.167	-0.166	1.00	--	--	--	--	--	--	--	--	--
SI	-0.054	-0.101	-0.002	0.074	-0.072	0.100	1.00	--	--	--	--	--	--	--	--
DC	0.009	-0.200	-0.199	-0.036	-0.110	0.038	0.136	1.00	--	--	--	--	--	--	--
CS	-0.003	-0.097	0.114	-0.096	-0.130	0.072	0.004	0.243	1.00	--	--	--	--	--	--
AM	0.120	-0.078	-0.150	-0.063	-0.098	0.049	-0.048	0.149	0.083	1.00	--	--	--	--	--
AA	0.185	-0.078	-0.138	-0.143	-0.125	0.288	0.093	0.099	-0.060	0.184	1.00	--	--	--	--
SC	0.072	-0.092	0.210	0.095	0.129	-0.197	0.036	-0.124	-0.273	-0.015	0.060	1.00	--	--	--
IC	0.140	0.124	-0.233	-0.112	0.021	0.015	-0.172	0.058	0.002	0.012	-0.133	0.190	1.00	--	--
FS	0.118	0.227	0.184	-0.006	0.014	0.026	-0.035	-0.053	0.191	0.005	0.035	-0.116	-0.083	1.00	--
AE	-0.045	0.086	0.695	0.123	-0.109	0.060	0.027	0.068	0.132	-0.088	0.048	-0.077	0.016	-0.047	1.00

N= 58, *p < .001

Using a p-value less than 0.05 (5% significance level) and only considering correlation relationships with $r > 0.2$ (i.e. factors at least having a moderate association), then we can make the following observations:

- Dispositional variables of gender, ethnicity, class and university attended added in this present study were not significantly correlated with the items of the CPQ – TV3. In this sense the variables may not be related to persistence in the major.

- Previous correlations noted in the prior study were not significantly correlated in the present study. That is, those items in the CPQ – TV3 which were moderately correlated in the previous study are not at all significantly correlated in the present study.

- Class may have been a determining factor in this present study, as the population was primarily juniors and seniors in their matriculation and did not identify as being as affected by non-academic factors presented in the instrument. This may be particularly so as students are approaching the completion of their studies and have in fact persisted to this point in the major.

Scatterplots help to determine linear relationships between variables. If there is a pattern or clustering, then regression analysis can be used to gain more insight to the type of relationship between variables. Based on the correlation matrix, graphical descriptions of correlated factors were plotted and no linear relationship could be observed from the data.

Limitations of the study

The results of this study are limited. The first limitation is that the data represents a small subset of the ECE population though the sample is diverse and is thought to be an accurate representation of the demographics of the entire ECE population. Another limitation of this study is that since it was completely anonymous the item-responses cannot be disaggregated to observe results by demographic groups. This limits the understanding of how non-academic factors may impact the persistence of underrepresented groups. Additionally, this study uses of the Pearson Method for calculating intercorrelations between bivariate data. This method is commonly used for normal data and assumes a linear relationship between two variables. However, for highly-skewed data it may be ineffective in revealing patterns for other underlying relationships that may exist in the data[23]. More investigations should be performed to determine the validity of using the Pearson Method for this type of data set. Furthermore, this study relies on self-reported survey data. Despite some challenges to internal validity, self-reports are widely used in educational research and are generally considered valid if the information requested is known by the respondent, if the questions are phrased clearly, and if students deem the question worthy of a response[19].

Future Work

The current research describes a preliminary study of primary factors and dispositional variables of race and ethnicity impacting the persistence of engineering program students with a diverse population as noted in previous work [17] as a limitation. Previous data can characterize a model

of student success in the Electrical and Computer Engineering program. In previous work [17] the CPQ-TV3 permits institutional administrators to determine which variables have the greatest impact on persistence at their school. While the present correlations do not take the interrelations among predictor and dispositional variables into account, persistence in major and retention may be affected by a collection of variables. These variables will need to be delineated in future work with a sample of underrepresented students at the present institution. Doing so will assist in gaining a broader perspective on persistence as administrators determine which variables need focus in any intervention programs.

Conclusions

In this paper, a research study that identifies primary non-academic factors and hypothesized dispositional variables of race and ethnicity impacting student persistence in an Electrical and Computer Engineering program is presented. Quantitative data collection methods were used and analyses were conducted using descriptive and inferential statistics. Based on the results, there was no significant correlation between persistence factors and dispositional variables of race and ethnicity. This result suggests that these dispositional factors may not be significantly related to student's persistence in the engineering major. While the variables studied have been shown to be related they are not significantly related, nor predictive in this present study. These variables will need to be delineated in future work with a sample of underrepresented, incoming students at the present institution. Clearly, these results warrant further investigation to gain deeper insight into persistence factors of engineering students.

References

1. United States Census Bureau Statistics, 2008 http://www.census.gov/acs/www/data_documentation/2008_release/
2. Chen, X. (2013). *STEM Attrition: College Students' Paths Into and Out of Education STEM Fields*_ (NCES 2014-001). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, D.C.
3. Center for Institutional Data Exchange and Analysis (2001). *1999–2000 SMET Retention Report.* Norman: University of Oklahoma.
4. American Society for Engineering Education, *"Going the Distance-Best Practices and Strategies for Retaining Engineering, Engineering Technology and Computing Students", Retention Project Publication, August 27, 2012, http://www.asee.org/retention-project*
5. Strayhorn, T. L., Long, L. L., Kitchen, J. A. Williams, M.A., & Stentz, M. (2013). Academic and social barriers to black and Latino male collegians' success in engineering and relates STEM fields. *American Society for Engineering Education120th Conference and Exposition.*
6. Harvey, W.B. (2008). The weakest link: A commentary on the connections between K-12 and higher education. *American Behavioral Scientist, 51,* 972-983.
7. Palmer, R., Davis, R. J., Moore, J. L., & Hilton, A. A. (2010). A nation at risk: Increasing college participation and persistence among African American males to stimulate U. S. global competitiveness. *Journal of African American Males in Education, 1,* 105-124.
8. Downing, R. A., Crosby, F. J., & Blake-Beard, S. (2005). The perceived importance of developmental relationships on women undergraduates' pursuit of science. *Psychology of Women Quarterly,* 29, 419-426.
9. Strayhorn, T. L. (2008). The role of supportive relationships in facilitating African American males' success in college. *NASPA Journal, 45,* 26-48.
10. Murphy ,T. E., Gaughan, M., Hume, R. & Moore, S. G. (2010). College graduation rates for minority students in a selective technical university: Will participation in a summer bridge program contribute to success? *Educational Evaluation and Policy Analysis, 32,* 70-83.

11. Tsui, L. (2007). Effective strategies to increase diversity in STEM fields: A review of the research literature. *The Journal of Negro Education, 76*, 555-581.
    Elliot, A. J., & Murayama, K. (2008). On the measurement of achievement goals: Critique, illustration, and application. *Journal of Educational Psychology, 100* (3), 613-628.
12. Perry, Reginald J. An analysis of a pre-engineering program model used to predict a student's persistence to graduation. *Frontiers in Education Conference, 2013 IEEE*. IEEE, 2013.
13. Tinto, V. (1975). Dropout from higher education: A theoretical synthesis of recent research. *Review of Educational Research, 45*(1), 89-125.
14. Tinto, V. (2012). *Completing college: Rethinking institutional action*. Chicago: University of Chicago Press.
15. Karp, M. M., Hughes, K. L., & O'Gara, L. (2010). An exploration of Tinto's integration framework for community college students. *Journal of College Student Retention: Research, Theory and Practice*, *12*(1), 69-86.
16. Davidson, W. B., Beck, H. P., & Milligan, M. (2009). The college persistence questionnaire: Development and validation of an instrument that predicts student attrition. *Journal of College Student Development*, *50*(4), 373-390.
17. Lindheimer III, J. B. (2011). *The College Persistence Questionnaire: Developing Scales to Assess Student Retention and Institutional Effectiveness* (Doctoral dissertation, Appalachian State University).
18. Mentzer, Bruce Duane. *THE CORRELATION OF SOCIAL, FINANCIAL, AND ACADEMIC SUPPORTS TO MILITARY BENEFIT RECIPIENTS'PERSISTENCE IN COLLEGE*. Diss. Liberty University, 2014.
    Pace, C. R. (1985). The Credibility of Student Self-Reports.
19. Good, J., Halpin, G., & Halpin, G. (2000). A promising prospect for minority retention: Students becoming peer mentors. *Journal of Negro Education, 69*, 375-383.
20. Holdren, J.P., & Lander, E. (2010). STEM Education Report to the President. *STEM Report.* Washington, DC.
21. May, G. S., & Chubin, D. E. (2003). A retrospective on undergraduate engineering success for underrepresented minority students. *Journal of Engineering Education, 92*, 27-39.
22. Townsend, R. D. Improving black student retention through social involvement and first-year programs. *The Bulletin* 75.6 (2007).
23. Hauke, Jan, and Tomasz Kossowski. Comparison of values of Pearson's and Spearman's correlation coefficients on the same sets of data. *Quaestiones geographicae* 30.2 (2011): 87-93.