2006-2229: THE CRUCIAL ROLE OF ENGINEERING FACULTY ON STUDENT PERFORMANCE

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The Crucial Role of Faculty in Student Performance: Academic Integration versus Faculty Distance

Abstract

Large numbers of students' depart from engineering programs before graduation.[1] Several reasons have been posited such as attrition resulting from inadequate academic support, or from lowered student confidence due to estrangement from faculty members.[3,4] For example, in fields such as engineering and computer science, students have commented on the inaccessible or unapproachable nature of faculty. To evaluate this previous body of research, this study gathered data across four research universities. Using structural equation modeling, it measured environmental effects, i.e., academic integration or faculty distance on a) self-efficacy, b) academic confidence and c) self-regulated learning behaviors, and d) GPA. Results showed that faculty distance lowered self-efficacy, academic confidence and GPA, where academic integration had positive effects, especially for females. In past studies, GPA has been a statistically significant predictor of "stayers" and "leavers" in science and engineering programs.[2] Consequently, ongoing educational reform efforts must encourage engineering faculty to understand the significance of their student/professor relationships because its potential for student retention, especially for females, is significant. In concluding, recommendations are offered for faculty to help improve student retention with emphasis on interventions to retain females in engineering programs where they remain drastically underrepresented.

Background of the Problem

Overall, approximately 40% of those who begin college with the intention of undertaking engineering do not complete their programs of undergraduate studies indicating that in the case of engineering studies, a central problem is one of persistence.[1] When attending engineering courses, students may be stunned at the level of difficulty in their coursework.[2, 3,4] In these classrooms and lecture halls, faculty may, or may not, realize the critical role they play in a student's decision to persist. Undoubtedly, classroom dynamics may exert tremendous influence on students' academic persistence or willingness to sustain effort in their subjects.[3,4,5] While many faculty members may disagree that they are discouraging some students, very subtle and often undetectable behaviors may have a negative effect on students.[4,5,6]

Astin[6] was among the first to document that schools of higher education treat students differently and students are actually aware of these subtleties. Further, Serex[7] identified males and females in education and nursing programs (i.e., feminine professions) who regardless of gender unanimously felt the classes had a "warm" atmosphere. Conversely, both males and females in accounting and engineering rated their classes as "cooler." More recently, in Seymour and Hewitt's[4] book, the high attrition rates for science, math and engineering students is linked to the intimidating nature of the classroom, the dullness of the lecture model and inadequate faculty guidance. While this is true for both genders, it is more so for females.[4]

"Chilly" environments may have an efficient but not necessarily supportive function.[5] If we consider the alternative to traditional college lecture halls, collaborative learning research has highlighted the distance between faculty and students in institutions of higher education: the

fragmentation of curriculum, the detached and impersonal lecture style and routinized tests.[8] These foster a system that reinforces students who are passive learners, yet simultaneously ambitious and competitive toward their classmates. It is this competitive classroom atmosphere which has often left women feeling more alienated.[2,3,4] Unfortunately, these dynamics constitute the features found in a typical research institution[8] where the number of female enrollments in engineering has been declining.[9]

Designing a collaborative learning environment would require a complete revamping not only of courses, but also institutional frameworks. However, the lecture model is reinforced blatantly by institutional reward systems that favor limited engagement in teaching and bestow more recognition on research.[8] In these institutions, not only are achievements for faculty members seen as a scarce honor, but also students are handpicked for prestigious honors, and research and teaching assistantships. In essence, these behaviors serve to produce a pecking order, i.e., a hierarchical system where common practices such as grading on a curve further delineate achievement. In Smith and MacGregor,[8] one faculty member was quoted as saying that many of her colleagues felt that her collaborative teaching methods were a "lazy" way to teach. This resistance to change may send an implicit message that there is no reason to "fix" a system that is not in need of repair in spite of the fact that it has been documented that this very system provides the exodus for a large number of students, particularly females, into other majors.[2,3,4]

Incentive for this paper originated when conducting gender research in engineering. In the pre-and-post-survey interviews, both young men and women spoke out and indicated their majors were, at times, academically overwhelming. Astin[6] documented that frequent student interaction with faculty has positive effects on student development, involvement, and retention; however it was also found that this conventional wisdom was not true for engineering students. It was further noted that "greater interaction with faculty may not have the same positive effect on engineering students simply because these interactions are less likely to be perceived as favorable."[6]

While an earlier paper analyzed the sample by gender, these had small to moderate effect sizes.[5] Quite unexpectedly, academic integration did not favor either gender. However, while the females felt slightly more discrimination from both faculty and male peers, discrimination had stronger negative effects on males' effort.[5] Therefore, the former research study[5] was modified to highlight the importance of faculty approachability not only for females but for *all* students in engineering programs. Finally, suggestions will be given to engineering faculty to address potential shortcomings in their delivery of content and interactions with students, particularly females.

Literature Review

Conceptual Framework -- A Social Cognitive Model

To frame this study in a grounded body of research, Bandura's Social Cognitive Model[11] provided the theoretical basis. Encompassing a holistic perspective, it includes the objective features of a setting, the behaviors of the participants, the subjective experience of the learner and the interpretation of his or her interaction with the environment.[12] Bandura's Model[11]

classifies these three self-referent constructs: environment, self and behaviors as self-reinforcing, symbiotic, and dynamically changing.

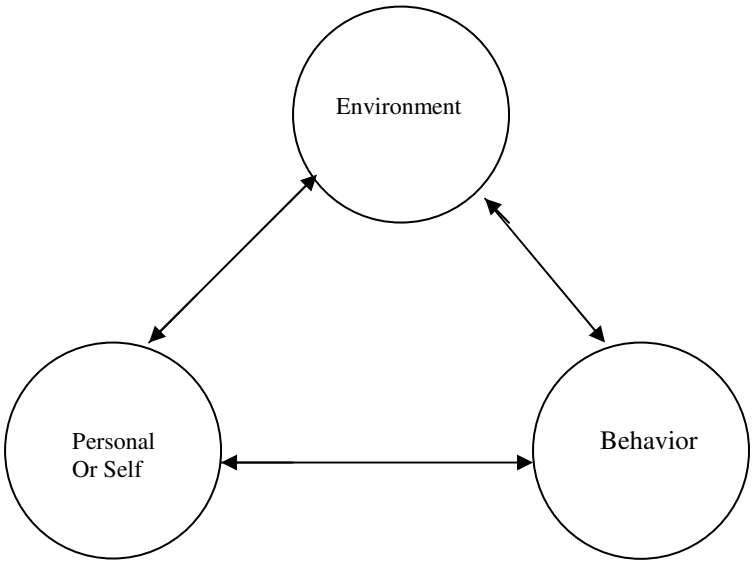

Figure 1. Bandura's Social Cognitive Model [11]

From Bandura's Model,[11] personal (i.e., self) factors influence, and in turn, are influenced by both behavior and environment. Each element of the process: personal or self, behavioral, and environmental provides information that either negatively or positively reinforces the other elements, culminating in strategic interpersonal adaptation of thought, emotion, action, and context in an ongoing process toward goal attainment or abandonment.

Zimmerman[12] expanded upon Bandura's[11] work claiming that one's outcomes can be altered through self-reflection and assessment culminating in personal efforts to self-regulate (self), by undertaking tasks to enhance achievement (behavior). This was later known as self-regulated learning. Zimmerman[12] found that of the three constructs, environment was the most important because it will either enhance or discourage student engagement and persistence. Consequently, using the premise of Zimmerman,[12] contrasting the environmental variables (i.e., academic integration or faculty distance) with the relevant self (self-efficacy and academic confidence) and behavior (effort, critical thinking and help-seeking/peer-learning) constructs forms the basis of this research model. The outcome variable, GPA, often measures motivation: the major determinant of academic goal attainment or abandonment.[2]

Environment Constructs

Academic integration. Who enters the academic engineering pipeline is important, but those who do not persist waste precious resources in engineering programs. Some of the earliest work on persistence as a function of academic environment was done by Tinto[13] who noted that an educational environment affects an individual's ongoing commitment to his or her studies. Tinto's Student Integration Model[13] showed a relationship between an individual's persistence and the institution's academic characteristics. Conversely, Bean[14] argued that a student's grades

will reflect their levels of social and academic integration, thus his or her persistence[15]. Although from slightly differing viewpoints, both agree that students' academic integration and support will have an effect on performance, persistence and ultimately completion of an academic degree program.[16] More recently, it was confirmed that academic integration was a crucial determinant of those women who stayed in engineering and those who did not.[2]

Distance. Undoubtedly, students' interpersonal experiences with professors and peers remain essential to develop a sense of belonging. However, teachers' perceptions of their helpfulness often do not match their students' perceptions[17]. In a lecture style room, it may be an implicit assumption that questions are not welcome and teachers are not approachable even though the teachers themselves may have an opposite view of themselves.[17]

However, lack of awareness on the part of professors may have negative consequences, especially for the academically under-confident or socially excluded, i.e., often females in engineering programs.[4] If students feel more threatened by distant faculty or "chilly" classrooms, they may be the ones who become less self-assured and apply less effort and fewer active learning strategies. This could lead to greater academic stress and perhaps failure.[18].These students might constitute the "dropouts" or the "switchers". Key studies found that faculty played a crucial role in a woman's willingness to persist in their studies.[2,3,4]

Self Constructs

Self –efficacy and Academic Confidence. A key element of motivation is an individual learner's perceptions of self-efficacy.[11,19,20,21] A defining aspect of self-efficacy, and that which distinguishes it from the more general notion of academic self-confidence, is its domain specific nature.[20,21,22,23] Therefore, an individual's perception of self-efficacy will differ from domain to domain, and within a domain, from context to context. For success within a specific domain, self-efficacy is the most crucial variable for goal attainment in motivational frameworks and is hypothesized to have the strongest effects on GPA.[11,19,20,21]

Much research has been conducted over the last few decades on self-beliefs and their effects upon one's subjective assessments of his or her competence. Studies have emphatically shown that people with positive self-views can overcome even the greatest obstacles and strive to succeed.[24] This assessment of the individual's self confidence is derived from general feelings based upon memories of past experiences or upon people's judgments of their capabilities to organize and execute courses of action to attain specific goals.[11] The contrast between self-efficacy and academic confidence may explain why engineering switchers often enter other related scientific fields, e.g., math or physical sciences. For example, while the "engineering switchers" may feel an overall academic confidence in mathematics or sciences, they may feel less academically confident (or self-efficacious) in their engineering majors. It is important to measure both academic confidence and self-efficacy separately because both have been linked to success, i.e., GPA.[25]

Academic self-confidence and self-efficacy are not mutually distinct. Both would lead to favorable progress in an engineering degree program.[26,27] When examining the SAT scores of women that enter engineering, they rank amongst the most academically talented. In the large-scale study by Nauta, Epperson, and Waggoner[26] conducted at a well-established Midwestern

university, the math test scores of females in both engineering and biological sciences were examined. Also, to determine if confidence differed by major, confidence scales were administered to the same females entering both programs. In essence, the females majoring in engineering had both higher math entrance scores and stronger measures of self-confidence than their female counterparts in biological sciences.

However, when comparing women to men, several studies have found that women self-report their academic confidence and engineering self-efficacy as lower than men's.[2,4,5,28,29] Accordingly, self-efficacy may be enhanced or diminished due to feedback from external factors such as society, support systems, climate of the classroom, and available resources.[12,22] If professors give negative or intimidating messages while offering little support, how well women weather the storm may depend on their resilience. Accordingly, if women started losing academic self-confidence, they were highly likely to leave engineering.[2]

Behavior Constructs

Effort. While goal commitment is important, mental effort plays a crucial role in successful goal completion. Clark[25] indicated that time spent on goal completion is meaningless without expending the necessary mental effort. However, effort is a fragile and mutable variable because it is subject to the strategies the individual employs in the face of challenges and obstacles. It is related to the underlying factors that contribute to the expectancy beliefs an individual maintains about him or herself as reality sets in and unexpected situations arise. In fact, belief in effort prevails as the most consequential attributional pattern students can acquire to reinforce achievement goals.[30] Because students would probably not be motivated to expend the necessary effort unless they believe they can succeed in engineering, self-efficacy and effort should be strongly related. Given that these students are academically similar in terms of their entrance scores and requirements, relative ability does not present an issue. However, it is here that women may be at a disadvantage; their increased effort may diminish their self-efficacy because they might attribute their hard work to lack of ability to solve engineering problems as effectively as do men.[2]

Critical thinking. Wolters[31] found that one of the most frequently used self-regulated learning strategies employed in college work was critical thinking, which would obviously be a crucial component for success in engineering programs. The critical thinking scale employed in this research most closely measured the self-regulated learning strategy known as elaboration, which is crucial for both knowledge acquisition and retention.[30] In the form of questioning, elaboration requires the learner to draw upon previous knowledge that would effectively scaffold and integrate new material. Therefore, the amount of critical thinking one applies when undertaking difficult tasks that require a great deal of problem solving ability may directly affect whether students are able to solve, retain and recall coursework material. Unquestionably, critical thinking would be vital for academic success in any higher education program and even so for graduate work. Because critical thinking or venturing outside class materials is somewhat risky, it should rely strongly upon self-efficacy. In the landmark Goodman Research Group[2] study, women reported less ability to understand concepts and solve problems than males, thus lowering their self-efficacy. Clearly, applying fewer critical thinking skills could limit women's engineering academic performance.

Help-seeking and Peer learning. Newman's Vulnerability Hypothesis[32] states that students who are socially and cognitively unsure might not seek help. According to Ryan and Pintrich,[33] there are several reasons why students may not seek help. One major barrier arises when females fear being labeled as incompetent or lacking ability.[3,4] However, several studies have shown women in the sciences to have stronger preferences than men for group learning and help-seeking with peers.[2,3,4]

Not only is academic support essential from professors, but Ryan and Pintrich[33] differentiated between the consequences of negative reactions from teachers and those of peers. In their study, when students' perceptions were positive toward peers, they were more likely to seek help; but when they were going to incur perceived threats to their competence, they were less likely to ask fellow students for help. In other words, when the cost of asking for help becomes greater than the advantages for receiving it, a student may not ask for help even though it could alleviate a great deal of distress.[34] In engineering programs where students feel intimidated asking questions, help-seeking would be linked to academic integration where a professor creates a classroom environment wherein students feel safe asking questions or at least not intimidated to approach professors and/or peers for further clarification of course materials.

Conclusion

In summary, the climate of the classroom, the student perceptions of the teacher, peer acceptance and the teachers' approachability will all combine to determine whether a student will successfully employ the necessary effort, critical thinking, and help-seeking behaviors needed to succeed. Moreover, effective use of these strategies should raise GPA, the outcome variable in this model. Finally, the major premise of this research states that the environment will either serve to enhance or diminish a student's sense of self-efficacy and academic confidence which either negatively or positively affects active learning strategies such as help-seeking, effort and critical thinking.

Method

Research Questions

What are the most obvious gender differences when answering the following questions?

1 Does academic integration increase a sense of academic competence-as measured by self-efficacy and academic confidence?

2. Does distance decrease positive self-assessments as measured by self-efficacy and academic confidence?

3. Does academic integration lead to an increase self-regulated learning: effort, critical thinking and help-seeking/peer learning?

4. Does distance decrease self-regulated learning: effort, critical thinking and help-seeking/ peer learning?

5. How do the self-variables and behavior variables interrelate?

6. Which variables most affect GPA?

7. What are the indirect path values to GPA under both academic integration and distance?

Reliability
A crosscheck of the results from each institution was performed to determine data consistency in for each institution. For subscale reliability, Cronbach's alpha was computed. An inter-item analysis was performed and items, which did not add to the reliability, were deleted. An exploratory factor analysis was utilized to further delete subscale items that did not load onto their corresponding factors. Afterward, confirmatory factor analysis (CFA) determined factor consistency and correlation. Afterward, Bandura's Model[11] was confirmed using structural equation modeling (SEM). For both the CFA and SEM good to adequate fit indices were calculated to ensure model reliability.

Validity
External validity was addressed by gathering a moderately sized sample gathered across four similarly ranked research universities. Administering all surveys under similar conditions during the same quarter or semester of the academic school year insured internal validity. The author personally administered all surveys in similar classroom settings and workshops. The study maintained concurrent validity through observations in classrooms, workshops and discussion groups. Finally, informal discussions were held with student advisors and faculty at each institution for further feedback regarding their interpretations of students' performance and faculty approachability. By utilizing both qualitative and quantitative methods, a stronger case was made for data accuracy.

Research Population
The men and women surveyed were engineering students from several branches of engineering. Approximately 30% of the sample was drawn from engineering campus organizations, such as the Institute of Electronic and Electrical Engineers (IEEE) and Society of Women Engineers (SWE). These groups have open membership, and one can join regardless of academic standing, race, ethnicity or sexual preferences indicating that this portion of the sample, although self-selecting, would not have any external barriers to admittance. These clubs were visited in order to purposefully over-sample women so that adequate numbers could be captured for data analysis.

All students were enrolled in similar academic institutions in that they are all highly ranked West Coast research universities with similar admissions requirements. Additional surveys were gathered from large undergraduate core statistics courses required for all engineering students. These classes were identified by department administrators because the professors were willing to include the survey administration as part of their lecture.

Sample Overview
The sample was comprised of students across four large, first-tier, West Coast research universities (N = 713, males = 409; females = 304). There were 89 seniors (mean GPA: 2.97), 116 juniors (mean GPA: 2.82), 165 sophomores (mean GPA: 2.88), 281 freshmen (mean GPA:

2.83) and 62 unreported. The unreported GPA students' surveys were not deleted as they did not alter the sample's statistical profile in any significant manner. The majority of students self-reported as White (i.e., of European descent) N = 260, and the second major group consisted of Chinese (i.e., of American descent) N= 204. These two groups comprise approximately 65% of the sample. Other ethnic/racial groups were varied and were much smaller in number with the next largest group, Korean having only 45 members. Ethnicity/race was not part of this research design, but it does raise the question of what makes up a "typical student" in today's university setting.

Missing Data

Missing data for the subscales were interpolated by using a subscale's item mean as calculated by gender.

Table 1
Students' Self-reported Ethnicity/Race

Ethnicity	No.	Ethnicity	No.	Ethnicity	No.	Ethnicity	No.
Caucasian	263	Japanese	24	South & Central American	18	Arab	10
Chinese	204	Mexican	20	South Asian	14	African American	9
Korean	45	Mex. American	20	Pacific Islander	13	Native American	1
Vietnamese	26	Filipino	19	Thai	10	Others	18

Results

To test the relationship of gender or class (i.e., freshmen, sophomore etc.) with GPA, a factorial ANOVA analysis was run. The results indicated insignificant relationships between gender or/and class with GPA. The ethnic makeup of the students was varied but is assumed to be representative of this regional academically high-performing population. Ethnicity or race was not analyzed because of the small numbers in most groups.

Table 2
Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Faculty Distance	673	5.00	35.00	15.62	5.96
Academic Integration	672	8.00	56.00	36.82	7.13
Self-Efficacy	641	7.00	28.00	21.64	4.49
Academic Confidence	700	6.00	30.00	15.32	2.65
Help Seeking/Peer Learning	673	6.00	42.00	27.09	7.13
Effort	709	7.00	28.00	20.46	4.12
Critical Thinking	690	5.00	35.00	21.78	5.25

By examining the skew in the data, in general, Table 2 indicates that students reported high levels of self-efficacy and application of effort. Students also reported greater levels of academic integration than faculty distance.

Table 3
Cronbach's Reliability Estimates and Factor Variance for Subscales

Subscale	Reliability	Variance %	Item No. Deleted
Academic Integration[27]	.85	56.13	3
Distance[5]	.74	36.83	9
Self-Efficacy[35]	.91	64.35	N/A
Academic Confidence[36]	.83	55.40	N/A
Effort[35]	.85	54.01	N/A
Help Seeking[35]	.60	42.51	2
Peer Learning[35]	.72	64.64	N/A
Combined Help seeking And Peer Learning[35]	.79	50.0	N/A
Critical Thinking[35]	.79	54.91	N/A

From Table 3, all subscales returned better than adequate (> .06) to excellent (> .90) reliability estimates.

Table 4

Means and Effect Sizes by Gender

Variable	Gender	N	Mean	SD	T	Sig.	Effect Size
Academic Integration	M	372	.02	1.04	.047	.64	.04
	F	268	-.02	.95			
Distance	M	368	-.01	.98	-2.80	.005	.20
	F	281	.13	1.10			
Self-efficacy	M	405	.11	.96	3.25	.000	.26
	F	302	-.15	1.03			
Academic Confidence	M	389	.09	1.04	2.71	.007	.21
	F	299	-.12	.93			
Effort	M	397	-.15	1.00	-4.56	.000	.34
	F	301	.19	.98			
Help Seeking	M	382	-.09	.99	-2.70	.007	.21
	F	289	.12	1.01			
Critical Thinking	M	387	.12	1.04	3.68	.000	.28
	F	286	-.16	.93			

Note. Differences in N-values account for students who did not complete the entire survey.

From Table 4, females reported greater levels of faculty distance and effort. Females also reported lower self-efficacy and critical thinking.

Confirmatory Factor Analysis (CFA)

A confirmatory factor analysis was performed using EQS version 6.1. The hypothesized factor loadings were allowed to vary freely and all constructs were allowed to inter-correlate. In Table 5, all subscale items were randomly bundled into 3 items per construct in order to minimize the

data. F1 = bundled items for academic integration; F2 = bundled items for faculty distance; F3 = bundled items for self-efficacy; F4 = bundled items for academic confidence; F5 = bundled items for help seeking; F6 = bundled items for effort; and F7 = bundled items for critical thinking.

Table 5
Factor Correlations from Confirmatory Factor Analysis (N = 391 Males; 293 Females)

	GPA	F1	F2	F3	F4	F5	F6	F7
GPA	1.0	.10	-.12	.44**	.41**	.15*	.30**	.11
F1 (AcadInt)	.06	1.0 ---	-.49**	.27**	.12	.30**	.30**	.36**
F2 (Dist)	-.07	-.44**	1.0	-.25**	-.22**	-.12	-.17	.01
F3 (SelfEff)	.44**	.28**	-.32**	1.0	.60**	.31**	.47**	.50**
F4 (AcadCon)	.41**	.13*	-.28**	.58**	1.0	.19**	.20**	.33**
F5 (HelpSeek)	.14**	.39**	-.07	.17**	.03	1.0	.36**	.36**
F6 (Effort)	.25**	.20**	-.02**	.54**	.22**	.37**	1.0	.26**
F7 (CritThnk)	.11*	.40**	-.03	.40**	.33**	.44**	.44**	1.0

Note. All values have a probability * = p < .05; ** = p < .01; *** = p < .001. Males are in the lower left under the diagonal and females are in the shaded upper right above the diagonal.

From Table 5, the academic integration and faculty distance correlations are in the expected direction (i.e., negative). As expected, self-efficacy and academic confidence are highly positively correlated. Moreover, the two self and three behavior variables are all correlated in the expected positive direction.

Structural Equation Model (SEM)
Using EQS Version 6.1, a fully-saturated structural equation model was computed. The Wald Test was utilized to delete non-statistical paths to improve fit to a minimum of .90. The LaGrange Multiplier Test was utilized to optimize the model by identifying independent variables which could co-vary to further improve model fit.

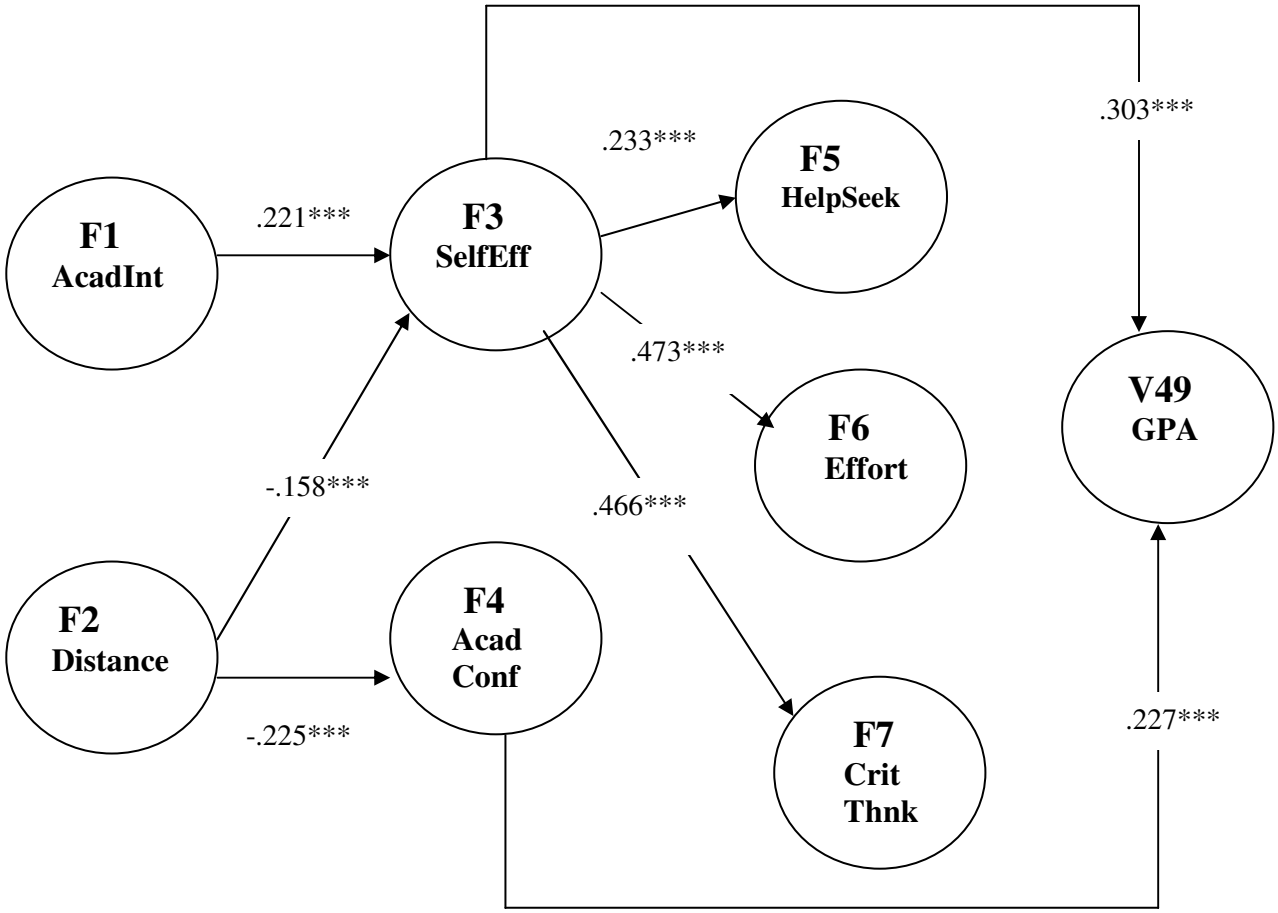

Figure 2. General Structural Equation Model (N = 684)

Note: All path values have a probability * = p<.05;** = p < .01; *** = p <. 001. Paths which were insignificant or colinear were deleted.

Table 6
Reliability and Fit Indices from CFA and SEM

Confirmatory Factor Analysis	
Comparative Fit (CFI)	.95
Non-Normed Fit (NNFI)	.96
Cronbach's Alpha	.78
Structural Equation Model	
Comparative Fit (CFI)	.93
Non-Normed Fit (NNFI)	.91
Cronbach's Alpha	.78
Root Mean Square Error Analysis (RMSEA)	.07

Note: The data were a good fit for the CFA and the data adequately fit the SEM.[37]

Discussion

In summary, the research statistics confirmed the effects of environment on students' self-assessments, learning behaviors and corresponding academic performance. In answering the first and third research questions, academic integration had positive effects on self-efficacy. Academic integration had moderate effects on the behavior variables indicating that students will have greater engagement in the course material if they feel positive toward faculty and their classrooms environments. For males, academic integration had the strongest relationship to help-seeking, but for females, it had a stronger relationship with self-efficacy. This further confirms the greater importance of academic integration for females because self-efficacy is the greatest predictor of GPA, which is strongly linked to persistence in engineering programs.[2]

In answering the second research question from Table 4, faculty distance had the greatest relationship (i.e., negative) with the self-variables. Where academic integration only affected self-efficacy, distance had negative effects on both academic confidence as well as self-efficacy – underscoring that faculty can strongly affect student outcomes. Again, this emphasizes the importance of faculty to make themselves available to students as this will enhance their sense of self. From Table 5, it also appears that women reported greater faculty distance than men which could further deteriorate both their self-efficacy and academic confidence, and consequently, their academic performance. For Question 4, as noted in Figure 2, self-efficacy had very strong effects on critical thinking and effort where academic confidence had insignificant effects.

In Table 4, gender differences were reported for effort where females reported working harder. This may not serve to enhance their self-efficacy or performance as this could be construed as a lack of engineering ability. This statistic is derived from the entire sample of females: those who reported faculty distance and academic integration. However, gender differences were diminished when females encounter faculty which are approachable (i.e., academic integration).[5] From Table 5, females' academic integration was positively correlated with their critical thinking (.27) and self-efficacy (.36) making it on par with males (.28 and .40 respectively). This is a new

finding in the literature.[5] Previous studies have shown females to be less willing to deviate from what is taught in class (i.e., critical thinking) because critical thinking is linked with self-efficacy, which has been lower for females in engineering courses.[3,4]

In answering Question 6, as predicted, from Table 5 and Figure 2, self-efficacy has the largest effect on GPA with academic confidence following closely. From Table 5, there is a high positive correlation between academic confidence and self-efficacy indicating that students who have one tend to have the other.

Measuring the direct and indirect path values to GPA with either self-efficacy or academic confidence as the mediating variables, the summative path values indicate a moderate difference from those in Figure 2. For example, the cumulative direct and indirect path values of academic integration to self-efficacy to GPA raise the path value to approximately .37. The direct and indirect path values from distance to self-efficacy and academic integration lower the path value to GPA to approximately .20. This is a key finding as it measures faculty's importance in raising or lowering student GPA.

In concluding, Bandura's Model[11] was confirmed – the environment created by faculty has the ability to strongly affect student performance, thus his or her persistence. When learners are engaged, active, and self-regulating using strategies such as help seeking, effort and critical thinking, they probably have higher levels of academic self-confidence and self-efficacy, which will raise their GPA – a central goal for any academic engineering institution.

Limitations

In this research, generalizability might present a concern. First, the sample was conveniently taken and although no obvious problems arose from this convenient sample, this type of sample may have limitations. Second, although the author captured data from similar institutions, there are obvious institutional differences; however, the institutional statistical profiles were similar when measuring all constructs. On the other hand, these elite institutions' students may not be characteristic of the entire population of engineering students. Nonetheless, one could argue that although these were West Coast research institutions, there would be generalizable features to large research institutions elsewhere in the US. Finally, models are never exact representations of the real world, but this research provides insights into the effect of faculty behavior on student performance.

Implications

Implications for teachers and professors based upon this research:

1. Make yourself more accessible to students in ways that generate positive and welcoming interactions. Avoid condescending interactions, however slight and subtle. Encourage student-student and student-professor interactions through in-class discussions and questions.

2. Become aware of gender biases in teaching and advising practices. Take some workshops or training in this area to understand how to change the classroom to make them more "female friendly".
3. Understand the importance of student/faculty interactions. Treat all students with respect and avoid labeling some students as better than others; they may simply be more confident and efficacious, not brighter.

4. Enhance the curriculum by promoting group-based projects and study teams. Encourage collaboration, not competition.

5. Explain that effort is the most important component of success and that all students will have to work hard to succeed. Use examples from history such as the hundreds of attempts by Edison to create the light bulb. Explain most research takes years to perfect no matter how bright an individual may be.

6. Inform students about the value in working together in study groups. Advise them to join social and academic campus clubs and networks with other students in their major.

7. Encourage students to take a "how to learn" course which teaches critical thinking.

Conclusion

Higher education systems that are competitive and hierarchical have been criticized as having a negative impact on most students. In universities where the lecture format is the norm, students may not doubt the effectiveness of the delivery methods to which they are exposed. Moreover, they may fail to realize that the education they are receiving has little to do with their future careers. Wulf,[38] President the National Academy of Engineering commented on the lack of applicable skills when students enter the job market. This could be extended to technical skills such as team decision making, collaboration and real-world problem solving skills.

While it has been noted that cooperative, constructivist learning may be more effective for retention of engineering students, Wulf[38] remarked that the watershed changes in engineering programs have not been forthcoming and that the "lecture format is far from optimal." He further stated that "An approach called 'asynchronous learning networks' has shown that better or comparable results can be obtained among students and faculty who communicate only over computer networks. I interpret these results mostly as a condemnation of the lecture format, which is somehow failing to exploit the benefits of personal interaction."[38]

As a final note, despite the well-documented limitations of lecture style classrooms, during the one-year course of this research throughout 2002, most of this data was gathered from students in sizable lecture-style auditoriums. This data was also gathered post-Internet bubble, a period throughout the 1990's when the qualified technical labor could not meet the industry's demand for skilled technical labor. Given this, one has to wonder when the cost of attrition and exclusion will become an incentive for institutional revamping of science higher educational systems.

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