VARIABLES RELATED TO ACADEMIC SUCCESS IN PRE-ENGINEERING FOR STUDENTS AT RISK

Except where reference is made to the work of others, the work described in this dissertation is my own or was done in the collaboration with my advisory committee. This dissertation does not include proprietary or classified information.

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VARIABLES RELATED TO ACADEMIC SUCCESS IN PRE-ENGINEERING FOR STUDENTS AT RISK

Robert Karcher

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VARIABLES RELATED TO ACADEMIC SUCCESS IN PRE-ENGINEERING FOR STUDENTS AT RISK

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Robert Karcher, son of Robert J. Karcher and Lee Ann Hudson, was born May 15, 1953, in Bethesda, Maryland. He graduated from Old Dominion University with a Bachelor of Arts in 1975 and The Southern Baptist Theological Seminary with a Master of Divinity in 1978. He worked in pastoral ministry throughout East Alabama for 15 years. He received the Master of Education in Counseling from Auburn University in 1993. The following year he began his work at Auburn University as the Assistant Director of Admissions. In 1996 he was appointed Acting Director of Admissions for the university and served in that position for 2 years, until moving to the College of Engineering as Director of Student Services. For the past 9 years his responsibilities as director included assessing student needs within the college, supervising academic advising for the pre-engineering program, coordinating course content for the freshman Engineering Orientation class, organizing tutoring services for core curriculum classes, managing recruitment efforts for the college, and evaluating enrollment and retention trends among engineering students. In addition to his work in the College of Engineering, he has taught undergraduate classes in Student Success for the university and Adolescent Development, Learning, and Motivation for the College of Education. Presentations to professional organizations include the Mid-South Educational Research Association and the National Academic Advising Association. Robert has two children, Denise and Russell, and is married to the former Debbie Miller of Opelika, Alabama.

VARIABLES RELATED TO ACADEMIC SUCCESS IN PRE-ENGINEERING FOR STUDENTS AT RISK

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Undergraduate engineering enrollment has shown signs of stagnation. The American Society for Engineering Education reported that, from 2001 through 2004, national enrollment remained virtually unchanged: 96,426 in 2001 and 96,978 in 2004. There are numerous explanations for this trend. They include a lack of information about engineering careers for prospective students, academically under prepared high school graduates, and individual differences among students as related their ability to complete the curriculum, their study habits, their strategies for learning, and their ability to manage their time.

Student attrition at all collegiate levels has also been recognized as a major factor impacting engineering enrollment. During the past decade research focused on pre-engineering students, and most of it targeted predictive variables related to persistence and attrition. However, a gap existed in the literature. What was missing was a study of pre-engineering students who persisted into major, despite being predicted to drop out of engineering.

The purpose of this study was to examine the relationship between non-cognitive variables and persistence for at-risk pre-engineering students who persisted, or failed to persist, into upper level engineering studies. From pre-existent data collected on 2,276 freshman pre-engineering students for a 4-year period (2000-2003), 848 participants with an ACT mathematics score ≤ 24 were determine to be at-risk students. Those with missing data were excluded, which resulted in 491 complete cases for analyses.

Results from a discriminant analysis indicated that at-risk students who persisted differed significantly from those who did not on a weighted combination of non-cognitive variables. Bivariate analyses showed that six non-cognitive variables significantly correlated with group membership: academic self-concept, math, study habits, intrinsic motivation, academic success, and work ethic. These findings provide insight into at-risk students who succeed in engineering and can assist in the creation of specialized interventions for those who might not otherwise.

ACKNOWLEDGEMENTS

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I. INTRODUCTION

The launch of sputnik on October 24, 1957, created an unprecedented technological frenzy. Enrollments in engineering programs swelled as the general populace in the United States came to the sobering conclusion that other countries posing a threat to our way of life had surpassed us in the race to space. The perception was that we no longer held the title of technical superiority and, for many, relinquishing the position of being the undisputed leader was not an option. Almost overnight there was a renewed focus on teaching math and science at all levels of education, hoping to awaken the slumbering intellect of America's youth and stem the tide of Russia's momentum.

Since that era, and before, the United States has taken pride in its advanced technology. Politicians cite how it has improved the quality of life when they run for public office, religious leaders point to it as an indicator of how blessed the nation is, and educators use it to espouse the importance of establishing a sound math and science curriculum. The appearance is that all major sectors of American society have a vested interest in the advancement of technology.

Advancement in technology requires the expertise of certain individuals or groups, and engineers are specially trained professionals who can meet the challenge. The need for people who are equipped to deal with highly technical problems is growing; however, annual reports of the American Society for Engineering Education (ASEE) for the years 2001 – 2005 indicated relative stagnation in full-time undergraduate enrollment in the United States for the first half of the decade in the new millennium. During this period national enrollment changed relatively little, with 357,837 full-time engineering students in 2001 and 364,767 students in 2005. It is noteworthy that during the same time period freshman enrollment dropped from 96,962 to 95,961. Relative to the national trend, the Office of Institutional Research and Assessment reported that engineering enrollment in the institution under study dropped from 2,995 in 2001 to 2,698 in 2005, while freshman enrollment witnessed a gradual decline, with infrequent peaks. (See Figure 1.)

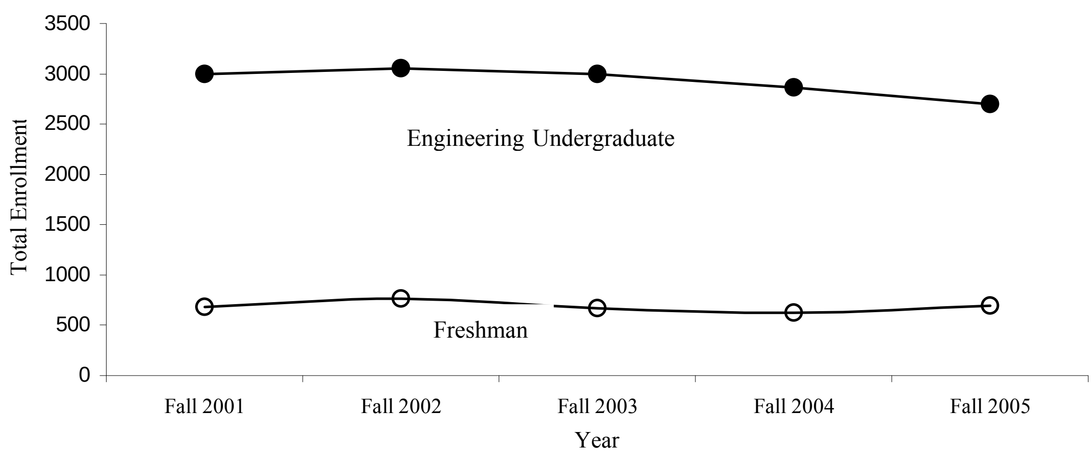

Figure 1. College of Engineering Enrollment from 2001 to 2005

Added to this disturbing enrollment phenomenon is a long-standing tradition of high rates of attrition among freshman pre-engineering students. In one recent freshman attitudinal study, Besterfield-Sacre, Atman, and Shuman (1997) reported that less than 50% of engineering freshmen persisted to earn an undergraduate engineering degree, with at least half this attrition occurring during the first year. One can easily understand the sense of uneasiness among some College of Engineering administrators. Retention of undergraduate engineering students is a nationwide problem and, with the number of engineering graduates remaining relatively stagnant while the demand for students equipped with technical problem solving skills increases, the problem of engineering student persistence is a growing concern.

For over 3 decades, college student persistence has received significant attention in the literature. Pioneers such as Vincent Tinto, John Bean, Ernest T. Pascarella, and Patrick T. Terenzini have advanced theories of student persistence. These early pioneers in college persistence were primarily concerned with the general student body. Much of the research focused on reasons students failed to persist. Academic background and selected cognitive variables, particularly as related to standardized test scores and mathematics preparation, received considerable attention. Some researchers conclude that academic background, regardless of other variables considered, significantly impacts college grades and subsequent persistence (French, Immekus, & Oakes, 2003; House 2000). Others viewed the problem as a complex interrelationship between student workload, study time, and the way they approach learning (Kember & Ng, 1996; Moller-Wong & Eide, 1997); while others (Goodyear & Halstead, 2001) stated that there were a number of other factors that deserve consideration, including one's attitude, self-confidence, interactions with instructors, and aptitude. It was not until the past 2 decades that a greater focus was applied to engineering persistence. During that period engineering programs came under the lens of quantitative investigation and many of the same cognitive variables that were used with the general student body were applied to engineering students.

To those responsible for maintaining high profile engineering programs of study, causes for stagnation and, in many cases, decreases in enrollment are myriad. Some writers such as Hirsch, Gibbons, Kimmel, Rockland, and Bloom (2003) suggest that it begins with a lack of information that students have about engineering careers, while others, such as Yurtseven (2002), point out that although engineering salaries rank among the top 5% of all professions, students are not attracted to them because they are unaware of the opportunities available to engineers. Harkening back to Vincent Tinto, a pioneer in college student retention, much research on engineering is devoted to how well the student fits with the institution; however, most is directed toward under-prepared high school graduates, with a smaller portion focused on individual differences as related to a challenging curriculum, personal study habits, learning strategies, time-management skills, and ability.

Although engineering programs were becoming a focus of research, the freshman year pre-engineering student was being virtually unattended. The small amount of research that did exist tended to examine students enrolled in mathematics and science courses, with no application to those interested in pursing studies in engineering.

As will be noted, the volume of literature on college student persistence is sizeable. Researchers undertook a monumental task when they studied academic preparation, institutional characteristics, and certain prescribed interventions. The evidence of past reports points toward a focus on the quantitative examination of cognitive variables, particularly as related to the abundance of information on the relationship of standardized test scores, grade point averages, and high school curriculum to matters of persistence in college. What is lacking in the literature is a quantitative examination of non-cognitive variables and college student persistence.

Essentially, there is a void in the literature that encompasses two vastly important issues related to engineering persistence. The first matter that is neglected is the lack of information on the impact of non-cognitive variables that all students bring to college. Everyone has a unique way of perceiving certain environments, and all have a different understanding of their ability to successfully navigate through the different demands of their surroundings. The second neglected topic is the first year pre-engineering student. The lack of information on this population demonstrates the reinforcement of the attitude that these students are not enrolled in engineering course work; therefore, they do not qualify as crucial participants in an examination of engineering persistence. However, this population is crucial to engineering enrollment and their impact on the discipline is highly significant.

The current body of knowledge lends itself to an understanding of students who fail to persist in engineering, models that predict failure, and remediation to help alleviate problems of attrition. Research tends to focus on cognitive variables. However, other non-cognitive variables have been considered: self-efficacy (Lent, Brown, & Larkin, 1984), student perspectives on attrition (MacGuire & Halpin, 1995), personality variables that work in concert with grade point averages and ACT scores (Benefield, Walker, Halpin, Halpin, & Trentham, 1996), student interest (Hirsch et al. 2003), student commitment (Beil, Reisen, Zea, & Caplan, 1999), student experiences (Christie, Munro,

& Fisher, 2004), and personality variables identified through the MBTI (Felder, Felder, & Dietz, 2002; Smyth Stewart, 2002; Thomas, Benne, Marr, Thomas, & Hume, 2000).

As noted, much of the research focuses on retention/attrition predictor variables that were cognitively oriented. We understand much about who should and should not succeed. In addition, numerous researchers study and describe a wide range of interventions for this at-risk population. What is lacking is research into non-cognitive variables that may help explain why some students, who are predicted to be at risk, succeed and advance into upper level engineering studies.

Purpose of the Study

The purpose of this study was to examine the relationship of non-cognitive variables among pre-engineering students that signify differences that exist among those who persist and fail to persist into upper level engineering studies, though they are identified as at risk for attrition. It is noteworthy that not all students who fail to persist into major depart from the program due to a grade point deficit or failure to complete the rigorous curriculum. A portion of the population chooses to leave the program for a wide range of personal reasons; however, only those students identified as at risk are considered in this study.

Research Question

The research question that will guide this study is: Do non-cognitive variables differentiate at-risk pre-engineering students who persist into upper level engineering studies from those who do not persist? The hypothesis is that non-cognitive variables make a significantly weighted contribution to students who persist into an engineering major, though they are considered to be at risk.

Definition of Terms

At Risk

For the purpose of this study, students who enroll in the College of Engineering as first time freshmen and present an ACT mathematics (ACTM) score ≤ 24 are considered to be at risk for attrition.

Attrition

Determined by the students' status at the time they depart from pre-engineering or advance into an upper level engineering discipline. Students who transfer to other programs of study within the institution, transfer to other institutions, or are dismissed from the program due to failure to meet the pre-engineering requirements are included in the determination of the rate of attrition.

Minimum Grade Point Average

The cumulative average of all grades earned in courses taken during the pre-engineering period. Students are required to maintain a minimum grade point average of 2.2 to be eligible to advance into upper level studies and declare a major within the College of Engineering. The cumulative grade point is subject to adjustment if the student elects to enact grade forgiveness. Academic grade forgiveness is permitted on courses in which the student earns a letter grade of D or F. Grades in courses for which grade forgiveness is enacted are dropped from the student's cumulative average, resulting in an adjusted grade point average. Students are permitted to advance into upper level engineering studies with an adjusted grade point average. Required courses must be repeated at the institution and grade forgiveness can be initiated on no more than three classes.

Non-cognitive Variables

These variables consist of self-reported personal characteristics that students possess. Broadly, they include that which students think about their potential for success in the college and an engineering environment, what they feel about their ability and how well they fit into the program, and how they reportedly behave as associated with academic studies and learning. The examination of non-cognitive characteristics is important to this study because it is hypothesized that self-reported characteristics can be identified that significantly contribute to differences in persistence.

Persistence

Represents a construct commonly referred to as retention. The timeframe includes the pre-engineering period of undergraduate study until such time that a student is eligible to enter upper level studies. Students are considered to persist when they complete all required courses, maintain the required minimum grade point average, and commence studies within upper level engineering studies.

Pre-engineering

This term refers to a prescribed curriculum and timeframe that commences with the beginning of freshman studies in the College of Engineering. This period has a twofold purpose: First, it provides what the college considers to be sufficient time and latitude in subject matter for students to explore all engineering disciplines prior to declaring an intended major and, second, classes taken during this period serve as necessary prerequisites to all courses required within the various engineering disciplines. Students are expected to complete 30 credit hours before they are permitted to advance into upper level engineering studies. The maximum tenure permitted in pre-engineering is

60 credit hours, after which a student is expected to be eligible to enter upper level studies. Failure to complete the pre-engineering requirements prior to achieving junior status results in dismissal from the engineering program.

Pre-engineering Curriculum

This curriculum consists of required courses that are prescribed in the pre-engineering program of study. For the institution under consideration those courses include two semesters of calculus, two semesters of laboratory science as required by each engineering major, one semester of engineering problem solving, one semester of engineering orientation, and one semester of study in a computing language.

Upper Level Studies

Students advance into this portion of the curriculum after all pre-engineering requirements are fulfilled, including successfully completing all prerequisite classes and maintaining the required minimum grade point average. This period begins during the sophomore year and includes coursework that is required within the various engineering disciplines.

Significance of the Study

A study on pre-engineering retention, defined as persistence into an upper level engineering major, is important for a number of reasons. First, enrollment of entering freshmen is declining and engineering administrators need to discover important issues related to the retention of students who are interested in the field. Second, the time of greatest attrition in engineering education is during the pre-engineering period. Research on pre-engineering students is negligible though this population constitutes a large number of students who directly impact enrollment in the College of Engineering. Next, research on variables related to early identification could assist engineering personnel who seek to admit candidates who are more likely to persist. Finally, although this study focuses on pre-existing characteristics, it can serve to aid in the establishment of interventions for students who are considered to be at risk.

This study, which proposes to investigate variables related to a known outcome, high rates of attrition among pre-engineering students, is important to engineering student recruiters, admissions officers, academic advisors, and student service program directors. A clearer understanding of certain non-cognitive characteristics related to what students think about their ability, how they feel about the engineering curriculum, and what motivates their behavior is valuable to those who seek to recruit and retain future engineers.

Further, this study can provide additional insight for an academic discipline that is equipping the leaders of emerging technologies, which is growing at a seemingly exponential rate. The exploration of non-cognitive variables among a portion of the engineering freshman population that is expected to fail, yet persist through the pre-engineering program and enter an upper level engineering degree track, can benefit at-risk students as well as those who work with them.

II. REVIEW OF LITERATURE

Research on college student attrition and retention is extensive, with the majority of it focused outside the engineering field. This review will move from a broad general background to more focused work in the context of engineering and, finally, to the issue of pre-engineering. Transitioning from the general to the specific, information is presented in the following sections: (a) College Persistence, (b) Engineering Persistence, (c) Student Attitudes and Perceptions of Engineering, (d) Freshman/Pre-Engineering Persistence, (e) Engineering Pedagogy and Student Learning Styles, (f) Retention Initiatives for Freshman Engineering Students, (f) Predicting Engineering Students At Risk, and (g) Summary.

College Persistence

Few would argue the importance of retention to higher education. However, there is a caveat. Not every student stays in one college, nor is 100% retention a realistic or desirable goal. It is impractical to suppose that a single institution can meet the needs of every student, or that everyone who enters college discovers that it is the ideal track for them to achieve their career goals.

Understanding that retention is a highly personal and complex issue, Rummel, Acton, Costello, and Pielow (1999) suggested that certain attrition within a university was actually positive. If the institutional goal is to meet the student's academic needs, then there must be an honest appraisal with the probable conclusion that some students do not fit into their environment. Though the explicit goal is student success, universities need to exercise caution with this worthy ambition and, as suggested by Rummel et al., not lose sight of the fact that they do not need to retain students who are not academically suited for their environment. As the authors further noted, many students with good grade point averages leave school because they do not receive what they need from a university such as class size and an academic environment compatible with their philosophy. An attempt to maintain such an unnatural relationship with good students could have a negative impact, leading to lower moral and self-esteem.

When one considers doing that which is in the student's best interest, retention becomes a matter of far more than keeping students at the institution. The initial task for a college leader is to assess as accurately as possible why students leave. Some students leave school for personal reasons, such as finances, family issues, or other unstated problems. Rummel et al. contend that in such cases the school's policy makers should attend to students' needs through stronger social support/counseling efforts. To retain students properly with an appropriate strategy, we need a better understanding of why they are leaving school. If the goal of retention is student success and doing that which is good for the student, then it must start early. Good retention begins with good assessment.

Nearly 30 years ago Vincent Tinto put forward a student integration model for persistence, which forms the backdrop to this review. A citation search of recent publications in ERIC and Googlescholar indicate that the influence of his pioneering work remains strong. Modeled after Durkheim's theory of social suicide, Tinto (1975) contended that, when college is viewed as a social system with its own values and social structures, dropout from that social system can be treated in a manner analogous to that of suicide in the wider society. The driving assumptions of the theory are basically twofold. First, the match between an individual's characteristics and those of the institution shape two underlying individual commitments: a commitment to completing college, termed goal commitment, and a commitment to his or her respective college, termed institutional commitment. The second assumption is built off of the first, in that the stronger the goal of college completion and/or the level of institutional commitment, the greater the possibility of persistence.

Academic and social domains frame much of the recent research and it is noteworthy that Tinto made a distinction between these domains in college. A student can achieve integration in one area without doing so in another and withdraw voluntarily (like suicide), as in the case of performing well in the academic domain but not the social domain. Students may also be forced to withdraw (dismissed) when excessive emphasis in one domain distracts from integration into the other domain, such as extensive time given to social activities at the expenses of academic studies.

Another pioneering theorist that significantly impacted studies on college student persistence was J. P. Bean. It was his work that filled in a gap in Tinto's model, namely, the role of external factors in shaping perceptions, commitments, and preferences. As noted by Cabrera, Castaneda, Nora, and Hengstler (1992), "This topic is particularly relevant from policy as well as institutional perspectives, given the different social and institutional programs aimed at stimulating enrollment and preventing attrition by addressing variables other than institutional ones" (p. 144).

In contrast to Tinto, who proposed that his is a descriptive model, Bean (1980) put forth a causal model of persistence and departure that was steeped in empiricism. Bean's orientation toward a more empirically based statistical approach was reflected in an article written in 1980, "Dropouts and Turnover: The Synthesis and Test of a Causal Model of Student Attrition," where he said: "The main problem with these previous models of student attrition (Tinto) lies in the fact that the definition of variables used in the analysis rendered the models unsuitable for path analysis" (p. 156). Admittedly, Bean is building his argument for using path analysis in a causal model; however, the statement signifies that the bedrock of the theory rests on statistical analysis, which is certainly appealing to those conducting quantitative research. As will be noted, Bean's so-called external factors receive notable attention in the literature.

Much energy has been devoted to single outcome (single risk) models in establishing that which constitutes an at-risk student. Research tends to depend on a single entity, chosen from a cornucopia of options. Recently, a model was set forth that involved survival analysis, sometimes referred to as an event history model. Though used infrequently, this model was designed to study longitudinal events and take into account the (possible) interdependence between competing choices confronting students.

Murtaugh, Burns, and Schuster (1999) proposed to illustrate the use and advantage of survival data with retention data and to increase retention for at-risk students. By examining the timing of events, they discovered that withdrawals occurred in pulses at the end of each school year, with a steep decline at the end of the student's first spring quarter. Their analysis consisted of pre-college characteristics, involvement in campus programs, and demographic characteristics. They found that in-state students had lower attrition rates than non-residents; African American students were more likely to graduate than were members of other ethnic groups, if they were equally prepared; and retention decreased with increasing age, which may be a function of the convenience of class schedules.

Institutional Characteristics

For many people it is paramount to preserve the custom of the institution, whichever form it may take. Institutional change can be painstakingly slow and massive institutional change can be non-existent. However, Tinto (1982) presented a daunting challenge to those concerned with student retention when he said, “It seems unlikely that we will be able to greatly reduce dropout without some very massive and far-reaching changes in the higher educational system” (p. 695). Tinto’s model of fit involves both student and institutional characteristics. Selecting a college to attend is not a matter of one size fits all. Schools come in all sizes and forms: public, private, large, and small. Some invest greatly in the student while others seem to neglect the needs of this vastly important population.

Few, if any, institutions boast excessive amounts of revenue. Budgets are tightly administered and every department is accountable for the allocation of funds. It seems, though, that schools would be most committed to its chief commodity, the student, yet spending varies among institutions. Toutkoushian and Smart (2001) conducted a study on self-reported gains experienced by students. They found that the level of spending could have a direct impact on student gains in interpersonal skills and learning. Further, in other matters related to the institution they made some interesting discoveries that run contrary to conventional wisdom. First, admissions selectivity may raise the quality of entering first-year students, but it does not appear to contribute to students' self-reported gains in learning. Second, as reported by the students, there is no evidence of gain on the dimensions of interpersonal skills and learning, due to lower student-faculty ratios.

Another commitment of resources that is popular in institutions is the learning community. In addressing institutional conditions that support student success, Tinto (1999) implored them to place retention at the core of their mission and he advocated "the use of learning communities and the collaborative pedagogy that underlies them as an important component of any institutional policy to enhance student success" (p. 6). It is his opinion that these supportive communities that promote student involvement are especially important during the first year of college.

Zhao and Kuh (2004) pointed out that there are basically four forms that most learning community models follow: curricular, classroom, residential, and student-type. The path that a school elects to follow requires a commitment of time, personnel, money, and space. Tinto (1998) held that all approaches hold two things in common: shared knowledge, or a coherent first year educational experience rather than an unconnected array of courses, and shared knowing, or the experience of actively trying to know or learn the material.

In an effort to determine if participation in a learning community is linked with success, Zhao and Kuh (2004) researched data on first-year and senior students in the National Survey of Student Engagement. They reported that "participation in learning communities is uniformly and positively linked with student academic performance, engagement in educationally fruitful activities, gains associated with college attendance, and overall satisfaction with college" (p. 115). However, this begs a question that researchers reference: Do learning communities directly affect student gains, or do they provide a fertile environment for student growth through engagement with other agents of socialization, such as peers and faculty members? Colleges may be devoting significant resources to an effort that has an indirect effect on student success. A critical task for those who administer programs that support student retention is to study and compare other activities that might yield similar results at a reduced cost.

Anderson-Rowland and Urban (2001) presented a paper during an Institute of Electrical and Electronics Engineers (IEEE) conference that failed to lend strong endorsement to Inclusive Learning Communities (ILC) for engineering students. Engineering freshmen that enrolled in the ILC lived on a designated floor of a residence hall and enrolled in a common group of classes, including introduction to engineering, mathematics, English, and chemistry. Discussion throughout the paper pointed out that elements of the project, such as academic and career mentoring, meet-the-dean events, and dinners with a professor program, were poorly communicated to the students. Results indicated that, "the one-year retention of the CEAS (College of Engineering and Applied Sciences) residence program is about the same as that of all CEAS freshmen. Engaging the students in activities still remains a challenge" (p. T4G-6). Although living communities may hold promise for the retention of entering freshmen, if the program is not properly promoted and students fail to engage actively in provided services, then the impact on retention may be negligible. Participation is such an activity is voluntary and enlisting students to join is problematic for many programs aimed at retention.

Another relatively popular form of institutional support is the provision of tutoring programs that assist students with courses that are deemed to be at high risk for failure. Large sums of money are devoted to these programs, hoping to improve student performance in the classroom. However, in a doctoral study conducted by Waldrop (2000) the number of hours that pre-engineering students engaged in peer tutoring had no significant effect on the grade point average of selected courses, specifically chemistry, physics, calculus, and statics. The author concluded that while “tutoring might have a positive residual effect with retention and integration, academic performance is often not affected by it” (p. 106).

It is also reasonable to conclude that a stand-alone tutorial may have relatively little impact when compared to more intensive forms of institutional intervention. In a study on minority engineering student performance, Weatherby (2001) found that freshman students engaged in one of two intervention strategies, cooperative learning with reciprocal peer tutoring (CL-RPT) or traditional didactic tutoring with computer-assisted elaborative instruction (DT-CAE), demonstrated a full letter grade increase in mean mathematics grade point average when compared with non-participants. It is noteworthy that these results should be tempered by the fact that participants were recruited to the programs and those who chose to accept the invitation could have been predisposed to a higher level of motivation. Students with a lower lever of motivation may have declined to participate.

Student Fit

A major tenet of Tinto's theory is the need for academic and social integration; however, Beil et al. (1999) hypothesized that this integration into the university community is related to persistence through the mediation of commitment. Their findings suggested that, while integration is a significant predictor of commitment and commitment is a significant predictor of retention, the significant relationship between integration and retention disappears when commitment is included in the model. It is the level of commitment, not the extent of one's academic and social integration, which has a direct impact on retention. Students who are well integrated into the academic and social communities early in their first year tend to be more committed to remaining enrolled.

Christie et al. (2004) conducted a study based on Tinto's construct of student-institution fit. Citing his theory, they determined "a need to consider the extent to which different university environments offer students different kinds of experiences, and the extent to which a good fit is achieved between student and institution" (p. 632). These researchers investigated factors in the decision to withdraw, based on a post-hoc analysis of students who left college and those who persisted. They determined that non-completion was a result of a complex range of factors that included poor choice of course(s), limited social support networks, and lack of fit between student and institution. It is interesting that some students demonstrated resilience and persisted despite a weak fit, suggesting the need for research on that which makes some pressures bearable for one student but not for another. The focus of such research may then be on any differences that exist between student commitment and tenacity.

In part, DesJardins, Ahlburg, and McCall (2002) employed Tinto's theory of student integration in an event history model. They proposed that a single outcome model fails to take into account the interdependence of competing outcomes that confront a student, such as stopout and graduation. Simply put, some students stop attending for a period of time, for a variety of personal reasons. In single outcome models stopouts, by definition, can easily be deemed as part of the institution's rate of attrition when, in fact, they may actually return to school when competing problems are resolved. By longitudinally examining stopouts and graduates, they found:

> Stopouts are more likely to be male, from underrepresented minority groups, from the metropolitan area, enrolled in General College, have lower first-term GPAs and higher loan amounts in year one, have lower ACT scores and high-school rank percentiles, and indicate a need for assistance on all of the "help" variables in the study. Graduates are more likely to be white, female, from out-state, enrolled in the (state's) Institute of Technology, have first term GPAs one-half of a grade higher than stopouts, receive less financial assistance than stopouts, and have higher high-school rank percentiles and ACT scores. (p. 564)

Engineering Persistence

As indicated in chapter I, reports on engineering enrollment suggest stagnation in the number of undergraduate students pursing engineering programs of study. However, when both freshman enrollment and persistence are considered, the matter becomes increasingly alarming. Besterfield-Sacre et al. (1997) reported that less than 50% of engineering freshmen persist to earn an undergraduate engineering degree, with at least half that attrition occurring during the first year.

Engineering program educators have long recognized the problem of attrition, and scholarly publications on the topic are relatively plentiful. However, taken in balance, an attitude exists among some educators that gives the appearance that the discipline is comfortable adopting an elitist attitude that says if a student is incapable, then he or she needs to transfer another program of study. While it is true that engineering is not for everyone, and many are not prepared to complete the rigorous curriculum, a better understanding of the problem is needed. This large population of students cannot be dismissed as academic misfits.

In an effort to understand student perspectives as related to engineering attrition and persistence, MacGuire and Halpin (1995) conducted one of the few qualitative studies on this topic. Based on factors that the students identified in the interview process, interviewees were asked to make recommendations for newly arriving engineering students. Their recommendations are reminiscent of behavioral and cognitive theorists as they stressed the need for dedication, hard work, strong study skills, and a solid background in math and science. For high school students considering engineering, the interviewees further suggested that it would be helpful for practicing engineers, as well as currently enrolled engineering students, to visit the schools and present information that describes the discipline and the demands of the curriculum. Finally, suggestions were offered for engineering programs of study: Those who teach university core curriculum classes need to be more approachable and there needs to be more opportunities for pre-engineering students to find out what engineering is really like.

Turning the focus of engineering retention onto engineering education, Richard Felder, then a faculty member in the Department of Chemical Engineering at North Carolina State University, examined the impact of engineering pedagogy on student persistence. Beginning with an introductory course in the fall semester of 1990, Felder taught a cohort of students in an experimental sequence of five chemical engineering courses. The outcome was a longitudinal study presented in five parts in the *Journal of Engineering Education* (1993-1998).

In the first published report, Felder, Forrest, Baker-Ward, Dietz, and Mohr (1993) collected data on 124 students enrolled in the first-level Introduction to Chemical Engineering (CHE 205) course. Information included family and educational background, student profiles on the Myers-Briggs Type Indicator (MBTI), the Learning and Study Strategies Inventory, and responses to a questionnaire regarding attitudes and expectations. This information was correlated with student performance in the introductory course and several significant predictors of success or failure emerged.

With a level of significance of $p < .01$, the authors' findings suggested that there were significant differences in passing frequencies among different student groupings. While differences in attitudes and expectations were evident, the probability of passing CHE 205 was greater for students who came from suburban or urban backgrounds than those from rural backgrounds ($p = .0003$), those who worked at an outside job 10 hours per week or less than those who worked 11 or more hours per week ($p = .094$), those who spent between 2 and 12 hours per week in extracurricular activities than those who spent more than 12 hours per week ($p = .071$), those who spent less than a typical amount of time on social activities than those who spent more than a typical amount of time ($p = .025$), those who scored greater as intuitors than as sensors on the MBTI ($p = .027$), those who were of Caucasian descent (69% of 102) than those who were of African-American descent (38% of 8), and finally, those who scored greater as extroverts (77% of 56) than those who scored greater as introverts (65% of 60) on the MBTI. Taken collectively, these results hold potential for academic advisors who seek to provide guidance for freshmen undertaking engineering studies.

In the second part of the longitudinal study on engineering student performance and retention, Felder, Mohr, Dietz, and Baker-Ward (1994) examined differences between rural and urban students. Using data collected for the original cohort, they found that students from urban backgrounds had greater numbers of parents who attended college and majored in science or technology, thus providing a role model for engineering studies; scored higher on all criteria used to make college admissions decisions, indicating greater academic preparation; and earned substantially more Advanced Placement credit for introductory courses, coming from school systems with budgets that supported advanced course work. Most striking were the differences observed in the letter-grade distribution of the two groups in CHE 205. When taking into account transfer students, minority students, parental education, SAT scores, and first-year grade point average, the rural/urban variable made a statistically significant contribution. Engineering programs cannot neglect students with rural backgrounds, but changes are required. It is not simply a matter of greater funding for public education, though the issue may begin there. It extends to matters of higher education. As the authors suggested, "to help these students, remedial and supportive measures in college teaching and advising programs will be required" (p. 216).

Student characteristics continued to be the focus in the third study as reported by Felder, Felder, Mauney, Hamrin, and Dietz (1995). Shifting from student background variables to student gender, the authors examined a concern that has preoccupied those who are involved with engineering recruitment and retention since its inception as a formal discipline of study:

> Why is it that women in the study, whose qualifications were arguably better than those of the men when they entered the chemical engineering curriculum, earn lower grades in chemical engineering courses and exhibit progressively lower confidence levels and expectations of themselves as they advanced through the curriculum? (p. 15)

Worded differently, women in engineering whose credentials are equal to or better than that of men fail to persist. Survey results indicated that women, in contrast to men, entered the engineering program with greater anxiety and lower confidence in their ability, chose to exit the program rather than repeat a failed course, attributed poor performance to a lack of outside help rather than a lack of hard work, and felt their contributions during group sessions (a cooperative learning style that is generally palatable to women) were diminished by their male counterparts. Interestingly, Takahira, Goodings, and Byrnes (1998) also observed a negative impact on female students who performed poorly in an engineering class in which they found “the gender gap in persistence widens slightly (favoring males) when students get lower grades” (p. 302). Resultant to the Felder study, the authors set forth a few pragmatic suggestions: develop peer mentoring, strengthen existing women’s organizations such as the student chapter of the Society of Women Engineers, use cooperative learning courses in a way that provide equal benefits to men and women, and educate faculty and advisors to the problems and needs of women students.

One strength of Felder’s (1995) work is that it stands in sharp contrast to many single trial studies that examine a new or different teaching technique employed in a single freshman-level introductory class. The active and cooperative instructional methodology under examination in this fourth study was used for a sequence of five chemical engineering courses spanning five semesters. The cohort of students that began in the fall of 1990 was exposed to virtually the same pedagogy in all five classes. The approach involved minimizing the instructor's role as the source of knowledge and placing more responsibility on the students through homework assignments and cooperative team activities, varying questions on assignments and exams to involve brainstorming, troubleshooting, problem formulation, and balancing concrete information and abstract information with presentations that flowed inductively from the concrete to the abstract. Of the students surveyed, 92% rated the experimental courses as more instructive than their other chemical engineering courses, 8% rated them as equally instructive, and none of the students rated them as less instructive. Perhaps more importantly, students performed better in the experimental courses, with the grade distribution skewed toward higher grades: 26 As, 40 Bs, 11 Ds, and 26 Fs.

Felder, Felder, and Dietz (1998) presented the fifth and final report on engineering student performance and retention, comparing outcomes for an experimental cohort and students taught in a traditional chemical engineering setting. With the exception of a greater number of students in the experimental group with parents trained in science, there were no significant differences between the two groups. In terms of outcomes, there were a few noteworthy observations. First, in the five engineering course sequence, grades among the experimental group were consistently higher in the second through fifth courses. When grades in two junior-level thermodynamics classes (outside the experimental sequence) were compared, the authors found:

> The average experimental group grade was a half a letter grade above the average comparison group grade, and relative to the comparison group, the experimental group earned almost twice the percentage of As and less than half the percentage of Ds and Fs. (p. 472)

Student ratings of engineering courses revealed that the experimental group consistently rated their classes to be more interesting and the 5-year graduation rate in chemical engineering was 85% for the experimental group as compared to 65% for the comparison group. Considering that the experimental group earned higher grades and that the comparison group was twice as likely to leave engineering prior to graduation, this study points out the need for engineering educators to evaluate the effectiveness of a traditional lecture-centered pedagogy.

Voices continue to be raised that point to attrition in engineering programs as an alarming issue. In a paper presented during an ASEE/IEEE conference, French et al. (2003) focused on cognitive and non-cognitive variables as predictors of achievement and persistence among engineering students. Not surprisingly, cognitive domains included high school rank, grade point average, and standardized test scores. Referencing Tinto's theory that students who are more socially integrated into the college environment are more likely to persist, the writers chose to use social integration and motivation as non-cognitive variables. They concluded that high school grade point average has the greatest effect on persistence and student integration has a lesser, but significant, effect. While this finding may not be startling to the engineering community, it goes beyond antidotal assumptions and provides a platform for further research on the topic.

Moller-Wong and Eide (1997) conducted an extensive longitudinal study on engineering students, which followed a cohort of 1,151 participants from 1990 through 1995. Using 100 independent variables for each student, an exceeding large number, the authors employed the use of logistic regression with backward elimination and developed a model for predicting engineering students who were high to low risk for attrition. Interestingly, while gender, ethnicity (with the exception of African American), and the number of semesters of high school math were not statistically significant, the math portion of the student's ACT was critical.

Student Attitudes and Perceptions of Engineering

The assumption on the part of many engineering educators is that students naively enter pre-engineering studies without an understanding of the curriculum and profession, which negatively impacts commitment and persistence. This notion is one that seems to have merit. Acker, Hughes, and Fendley (2002) observed that students undertake engineering studies for a number of reasons, only to find, "a more interesting major or a more desirable career path outside of the discipline. Also, numerous respondents indicated they chose engineering initially because of a family member, namely a parent" (p. 38). As Besterfield-Sacre et al. (1997) pointed out, students who departed from engineering in good standing have grades similar to those who persisted, but they possess poorer attitudes toward engineering.

Many entering freshmen have limited insight into two important factors: their motivation for selecting pre-engineering and the curriculum requirements. Since the institution under study requires that entering freshmen declare an intended major during the application process, it is not uncommon for students to report that they selected engineering simply because they had to make a choice and it seemed viable.

It is obvious from an early stage that many students are unclear about their reasons for entering pre-engineering. Beronja and Bee (1986) found that one's motivation for entering engineering varies between average students (2.00 to 2.49 grade point average) and good students (2.50 to 4.00 grade point average). Average students reported that the following external variables were extremely important factors in their decision: employment opportunities, job security, and high potential salary. Internal variables included good work habits, a strong motivation to succeed, an ability to get along with others, and lots of hard work and effort. External variables for good students were their aptitude for math and science and the prestige of engineering as a career, while internal variables consisted of an inquisitive nature, logical thought, and organizing and administrative ability. This post-hoc survey confirmed the motivational characteristics that successful engineering students tend to possess: an aptitude for math and science, logical thinking, and an ability to organize. Noteworthy is the fact that although the average students did not report math aptitude as an essential quality, they felt that being motivated to work hard would guarantee success. Perhaps it was this drive that accounted for meeting the minimum requirements and allowed them to stay in the program.

Problems with freshman-year persistence in pre-engineering programs likely begin well before students undertake college-level studies. Hirsch et al. (2003) found that, among high school students in New Jersey indicating an interest in pursing engineering studies, nearly half did not know if the advantages of studying engineering outweighed the disadvantages. Further, only one quarter of those surveyed correctly named five different types of engineers, and this finding came from a group that supposedly had an interest in engineering. The authors concluded that despite having pre-requisite knowledge, interest, and self-confidence in math and science, many students possess little knowledge about engineering.

As previously noted, institutional fit is an important variable among retention theorists and, as purported by Besterfield-Sacre, Moreno, Shuman, and Atman (1999), engineering student attitudes likely differ across institutions: large versus small, private versus public, research versus teaching, and urban versus non-urban. The assumption is that student attitudes vary across institutions and the greater the attitude/institutional fit, the greater one is likely to persist in engineering. Their report was the result of a 3-year longitudinal study involving 20 U.S. engineering programs and nearly 70,000 students. Based on their findings, the authors reported:

> There appear to be consistent differences in how entering students assess their attitudes at private, teaching focused, small or urban institutions. Students who choose to attend private or teaching focused institutions tend to like engineering more and have a higher perception of the engineering profession than do students who attend public or research oriented schools. (p. 10)

It is apparent that the challenge for large public research institutions is to discover ways in which to engage their students and present a more favorable image of engineering to its students, both at a more personal level.

Freshman/Pre-Engineering Persistence

High rates of departure have a long-standing tradition among pre-engineering programs. In an early report on problems of retention among this population, Skoner and Jolongo (1988) put forward four pragmatic suggestions:

1. During the recruitment period, inform prospective students of the difficulty of the program and the benefit of an engineering education.

2. Provide academic support programs such as peer tutoring to assist marginal students. This approach should not be confused with remediation, which would result in an extended matriculation for under prepared students.

3. Ensure effective academic advising.

4. It may be useful to provide introductory engineering classes that focus on relevant projects and provide field trips that allow for observation of practicing engineers.

These four suggestions may appear to be an over simplification to a sizeable problem but, as will be seen, they capture the essence of most of the research on pre-engineering persistence.

Baillie and Fitzgerald (2000) surveyed students who dropped out of the Imperial College in London to determine some of the problem areas for students who were de-motivated and failed to continue their engineering studies. Their findings suggest that these students found that the level of math and theory was too high, they did not see the challenge in engineering and perceived it to be dull, they did not know how to make the most of lectures and tutorials, and they felt isolated and out of depth because they were no longer top of their class. These concerns plague many programs of engineering that must contend with presenting a pre-engineering curriculum to under prepared students who depart from the discipline because they report that they do not like engineering, when, in fact, they have been immersed in mathematics and science and not engaged in engineering course work.

In an effort to understand factors that influenced the academic performance of freshman year pre-engineering students, Amenkhienan and Kogan (2004) conducted a qualitative study, using nine focus groups to discuss student perceptions of variables that contributed to their success. Primarily, these variables focused on student behavior and resulted in 12 helpful activities that were eventually grouped into three major themes: personal effort and involvement, peer interaction, and faculty contact. The students, as related to the personal effort and involvement factors, made striking comments. Most were successful high school students, though it required relatively little effort on their part. What they quickly learned as pre-engineering freshmen was the need for good time management skills and completion of assigned and unassigned homework outside of class. Further, the successful students took advantage of university and college-level services that enriched their academic performance.

Amenkhienan and Kogan further noted the importance of peer and faculty interaction. Primarily, peer interaction provided a network with upper division students and study groups in which the students worked collaboratively. The impact of faculty was positively associated with teaching styles that included hands-on activities and group work. Also, meeting with faculty during posted office hours helped students to process information correctly and find more ease in asking questions during class, provided they attended.

Tinto's student integration model has spawned hundreds of empirical studies. Recently, Elkins, Braxton, and James (2000) established construct validity for the separation stage of Tinto's stages of incorporation into "the membership of communities of colleges and universities" (p. 265). Acknowledging that approximately three fourths of all dropouts leave sometime during the first year of college, the authors examined the impact of separation on first-time enrolled students. In their study, "separation constitutes the first stage of passage into the college career and may require some personal transformation and possibly rejection of the norms of past communities" (p. 253). If a student's past community, a social network composed of significant persons such as family and friends, question the value of college attendance and do not provide support, early departure is likely. In essence, if students fail to receive support for college attendance from family and friends, early departure from college is likely and, conversely, students willing to reject the values (attitudes toward college attendance) of their past communities are more likely to persist from the first to second semester of their first year in college.

Elkins et al. (2000) concluded that the greater a student's initial level of institutional commitment, the more likely the student is to perceive a need to reject attitudes and values of past communities. In contrast, the higher a student's high school academic achievement or the higher the parent income, the less likely is the perceived need to reject past attitudes and values. The factor of rejection of attitudes and values is important in the separation process and the decision to persist. "Students who receive substantial support for college attendance or who perceive a need to reject the attitudes and values of their past communities are less likely to depart from college early" (p. 261), the authors noted. They extended a pragmatic observation to educators: early demonstrations of absenteeism and low grades may be signs that a student is experiencing difficulty negotiating the separation stage and may be at risk.

Engineering Pedagogy and Student Learning Styles

There is a significant amount of research focused on pedagogy and student learning, as will be seen. When taking the teaching environment into consideration, the challenge for post-secondary educators, especially those involved in high profile research programs, is to balance publication demands, deal with time constraints associated with directing graduate students, prepare lectures, and assess students. It is no easy task to manage the requirements of one's job and create a learning environment that motivates students. In an article entitled "Fostering Creative Thinking in Student Engineers," Baillie and Walker (1998) explored the issue of engineering pedagogy and student learning. They found that which many students in pre-engineering programs express to be their greatest concern. Students need "to see the relevance and worth of in academic learning" (p. 6). In short, students tend to develop more creative and effective learning styles when that which is being taught is challenging and holds interest. This finding addresses one of the problems confronting a pre-engineering program where academically demanding courses are taught in large, impersonal lecture halls, frequently staffed by a graduate assistant with minimal classroom experience.

A central theme in educational psychology is the understanding of that which motivates students in the classroom. Lecture has been the preferred mode of delivery for many disciplines, including engineering. The issue for many faculty members is a concern that the amount of information shared with students needs to be optimal and this form of instruction provides the best platform to ensure that it happens. However, Van Dijk, Van Der Berg, and Van Keulen (2001) concluded that this concern may be somewhat inflated. They discovered that students in an experimental interactive engineering classroom learned as much as students in a traditional lecture and the experimental group reported being more motivated to learn.

An abundance of variables have been studied, including instructional methods and students' conceptual levels. Hancock, Bray, and Nason (2002) examined these variables in a computer technology course taught at a large university in the southeastern United States. Their research found the following:

> High conceptual level students in the student-centered instruction condition obtained a significantly higher mean score in motivation than did high-conceptual-level students in the teacher-centered instruction condition. In addition, low-conceptual students in the teacher-centered instruction condition obtained a significantly higher mean score in motivation than did high-conceptual-level students in the teacher-centered instruction condition. (p. 7)

It is also noteworthy that all students, regardless of conceptual level, were more motivated in student-centered instruction. While most institutions do not take the time to measure entering engineering students' conceptual levels, it seems that it would be in their best interest to examine their instructional culture.

Though not explicitly stated, the issue of institutional fit was the implicit topic of "An Analysis of the High Attrition Rates Among First Year College Science, Math, and Engineering Majors." In this study, Daempfle (2004) explored reasons students departed from highly technical majors at or before their initial matriculation in college. In part, early student departure may be attributed to the pedagogy of post-secondary educators. The higher level epistemological demands of science, math, and engineering (SME) professors often collide with the oversimplified belief in the certainty of knowledge that many recent high school graduates hold. The result of this conflict then results in students perceiving the SME classroom as impersonal and cold.

In response to the so-called chilly climate of SME classes, Daempfle boldly proposed a change in the structure of the post-secondary classroom. There needs to be a "shift from simple knowledge transmission to actively and cooperatively engaging students" (p. 48). Although he acknowledged that traditional lectures dominate introductory SME courses, he recommended that faculty increase their involvement, become more approachable, and present their material in a more multidisciplinary manner. Daempfle's recommendations are similar to those of Alpay (2001), a lecturer in chemical engineering who used tenets of educational psychology to suggest that engineering pedagogy should be student centered, given that leading theorists purport that learning is a complex process of student motivation, self-concept, locus of control, and cognitive styles.

Recognizing that relatively few studies focus on college instruction as a contributing factor in attrition among science, mathematics, and engineering students, Loftin (1993) employed the use of factor analysis of a student-rating instrument. The findings of this study suggest that among seven factors that account for 76.2% of the total variance that helps explain attrition, the presentation skills of the instructor, student perception of personal progress in the course, and student-teacher interaction account for the greatest variation. As the author discovered, "In effect, personal feelings of competence and learning that students gain from a course appears to have a more profound impact on student persistence in mathematics and science" (p. 19).

Engineering pedagogy has received considerable attention in recent literature, and Derlin and McShannon (2000) undertook the task of examining the compatibility of student learning and traditional approaches to teaching in engineering. While the focus was on differences in learning styles among different genders, ethnic groups, and the class standing of students, a few salient points were made that address the needs of pre-engineering freshmen. The data suggested that freshman engineering students reported learning with faculty in an informal environment, outside of class, contributed most to the their success. This information may be classified as striking, considering the fact that many engineering programs adhere to a traditional instructional strategy that supports students whose learning styles are more independent and self-directed. As with other similar studies, the authors proposed a shift in engineering pedagogy that is more inclusive, allows for more informal student/faculty interaction, and includes greater involvement in teamwork activities.

Effective pedagogy was the theme of a paper presented to the 2004 session of the American Society for Engineering Education. Conner et al. (2004) suggested a reformation for engineering curricula at the Virginia Polytechnic Institute and State University. Their suggestions followed an investigation of retention within the school's engineering program, a survey and analysis of time that faculty spent on nine topics, and web-based departmental feedback. In essence, the authors called for greater linkage between the general engineering curriculum and other engineering disciplines, a spiral curriculum that revisits basic general education ideas repeatedly, and the development of an engineering theme that is woven throughout the curricula to provide a contextual framework for learning. Although the effectiveness of this pedagogical shift remains to be seen, it holds promise for aspiring engineering students who, early in their curriculum, frequently fail to recognize how pre-engineering courses integrate with specific engineering majors. Perhaps this is one way to address the frequently repeated refrain, "I am leaving engineering because I do not like it." This statement is a peculiar retort for students who have not yet undertaken formal engineering studies.

Mathematics is an essential foundation for studies in engineering, and it impacts the majority of the course work in most pre-engineering curricula. However, as Croft and Ward (2001) noted, engineering students do not attend college to study mathematics; their interest is engineering. The result is an enrollment in freshman-level mathematics courses that have a wide range of understanding and skills in algebra, trigonometry, and calculus. To accommodate the class, most teachers resort to teaching to the middle range of the group, while leaving the bottom portion bewildered and the top portion bored. Is it any wonder that students lack motivation and become discouraged during their pre-engineering tenure?

To address the problem, Croft and Ward (2001) reported on a mathematics pedagogy employed at Loughborough University: an open learning environment. Their approach was an effort to allow students with various levels of experience and understanding to make progress through mathematics. The program consisted of two 50-minute lectures and one tutorial per week, a Mathematics Learning Support Centre for one-on-one assistance, and student-centered workbooks that were associated with computer-aided learning material. Through use of these materials, students could self-assess their understanding of the lessons and progress through the course. As with many reports on new approaches to pedagogy, this article lacked an assessment of observed learning outcomes.

In a study conducted on engineering and education students, Birenbaum (1997) offered a different approach to student learning strategies and suggested that preferences for different types of assessment affect one's motivation, effort, and self-efficacy. The author's proposal was, "a need for adapting the assessment to the examinee's affective as well as cognitive characteristics in order to enhance the validity of his/her test score interpretation" (p. 80). As a study on learning strategies and assessment, this report raises many important questions that can be submitted to scientific inquiry; however, its pragmatism is called into question. As the author pointed out, this approach to assessment could prove to be a complicated and impractical endeavor. In large classroom environments, where expediency is paramount, it is unlikely that assessment preferences can be taken into consideration.

Retention Initiatives for Freshman Engineering Students

As noted, there is significant concern about engineering retention, particularly among entering freshmen. Much has been reported about reasons for persisting or leaving engineering. However, the question remains: What can be done with that which the students are saying through surveys, aptitude tests, and interest inventories? One answer is to address freshman student concerns in an introductory engineering course, which is most effective if taken during the first semester, freshman year. As Anderson-Rowland (1997) suggested, when students are asked their opinions and questioned about reasons for choosing and persisting in engineering, the outcomes need to be discussed with other students during their first year of college. The class in which these opinions can be shared is the freshman introduction to engineering course. It is in such an environment, early in the student's undergraduate work, where issues uncovered by the author — salary, interests, work, and job opportunities — can be discussed and reinforced.

Many engineering programs employ the use of freshman introductory courses. Though defined differently among institutions, the purpose of such instruction has two fairly universal dimensions: inform the students about the engineering discipline and improve retention of freshman students in order that they may enter upper level engineering studies. It is the latter point that was the topic of research for Hoit and Ohland (1998). The authors employed the use of a 2x2 Chi-square test to compare expected and observed retention frequencies, which demonstrated that the retention of the general population and that of women who enrolled in a newly developed introduction to engineering course at the University of Florida was significantly increased. This course was a departure from the traditional 3-credit-hour lecture-based class, traditionally known as Sleep 101. The content consisted of interactive laboratory activities that were representative of the all the undergraduate engineering departments. Although it is difficult to defend a significant increase in retention on the basis of a single introductory class, the authors suggested that, “the primary advantages of the course as designed are the use of active learning and the early association of students with the engineering departments” (p. 84).

In an effort to increase retention for students in the School of Engineering at Indiana University-Purdue University Fort Wayne (IPFW), Pomalaza-Raez and Groff (2003) developed a freshman-year success course. Similar to a study by Inelmen (2001), this course was described as “a multidisciplinary, project-driven learning process that encourages students to develop problem solving and teamwork skills and fosters their creativity and logic” (p. 1). Students were required to participate in a robotics project that involved a wide range of disciplines that comprise many engineering programs of study: computer science, physics, mathematics, biology, psychology, engineering problem solving, and art. Although the student profile of the institution the authors studied consisted of a large number of non-traditional students, the content and purpose of the course was applicable to more traditional settings. Results indicated that a greater number of students enrolled in the experimental pilot course were retained, with a 17.14% increase in retention in the School of Engineering. Also noteworthy was the drop in the rate of attrition from IPFW: 3.33%. Their findings were similar to those of Inelmen (2001) who used a multi-disciplinary, highly interactive, real-life problem approach and found that student motivation and understanding were greatly enhanced.

Findings such as these reinforce the importance of an introductory engineering course during the freshman year, but they lack the rigor of statistical analysis typically applied to an experimental design. The question that remains is this: To what degree is the percentage increase in retention statistically significant? Without appropriate analysis one is left with the impression that, while there are multiple models of intervention, one may be as good as another.

Predicting Engineering Students At Risk

It seems that many colleges are interested in assisting college students who are deemed to be at risk. The challenge is to discover a reliable set of predictors in an early warning system that results in focusing limited resources on highly effective interventions. With diminishing state supported funding, public institutions can ill afford to aim blindly at poorly defined targets.

Academic Preparedness

Predicting those students who will persist into engineering studies can begin at an early stage in one's schooling. Mau (2003) conducted a longitudinal study that tracked 827 students who indicated interest in science and engineering (SE) careers from the eighth grade through the 2 years following secondary education. Results demonstrated that only 176 (22%) retained that interest as they entered college 6 years later. Not surprisingly, the report suggested that career aspirations and persistence were a function of race and sex, with men more likely than women to persist in SE career aspirations. Further, among the variables studied, Mau's findings were consistent with that of other studies on engineering persistence: "Math self-efficacy seems to be the most predictive variable for persistence in SE aspirations" (p. 238). The implication is that understanding student behavior and preparedness for SE majors needs to begin as early as the middle school years.

The focus of many studies that investigate variables that predict persistence in science and engineering majors are on characteristics of students entering the college pipeline. Early warning indicators were the subject of a study conducted by Beck and Davidson (2001). They sought to determine if the scores from the Survey of Academic Orientations (SAO) were reliable early warning indicators. If so, these scores might allow university officials to identify freshmen who are likely to be at risk and receive low grades. Consistent with earlier studies on academic background measures, the Academic Efficiency and Academic Apathy orientation scales were the best predictors of students' grade point average. Although they explained less variance, the Structure Dependence and Mistrust of Instructors scales held statistical significance. As the authors suggested, an important conclusion for those interested in identifying students at risk is "after taking SAT scores and high school rank into account, SAO scores significantly added to the prediction of grade point average. This will allow for a focus on students most likely to receive low grade point averages" (p. 717).

Systems modeling is a trademark of industrial engineering problem solving and, as a professor in that discipline, Owusu (2001) proposed such an approach for improving engineering education and retention. In a paper presented at the American Society for Engineering Education Annual Conference & Exposition in Albuquerque, New Mexico, the author outlined an expert system approach that matches student interest with academic discipline and identifies courses in which the student may need tutorial assistance. Problem areas are identified early in the process and assistance is provided early in the students' college experience. Owusu's model holds that identified controllable inputs such as student background, study skills, and support systems must be addressed by the institution early in the educational process as the student progresses through the system.

Mathematics Preparedness

Herzog (2005), in posing a challenge to Tinto's model of persistence, asserted that it was developed over 20 years ago and based on academically and socio-economically homogeneous, full-time cohorts. While these are dimensions worth examining, he stated, they do not capture the impact of under preparedness in core subject matter. Sounding a note that should ring true to those interested in engineering retention, he went on to conclude that math is an important at-risk indicator for the general college student population. "Enrollment in remedial math," Herzog noted, "raises the odds to both dropout and transfer out. Student performance in first-year math courses is the strongest retention predictor for new freshmen in their first semester" (p. 915). Finally, the study confirmed the need to more closely examine preparation and curricular requirements in math and their relationship to student retention. This finding on mathematics is also consistent with that which students who were experiencing difficulty in engineering studies said in interviews conducted by Forsey, Marshall, Cutler, and Pulko (2001). Students in this qualitative study cited mathematics "as the least enjoyable and most difficult aspect of their course" (p. 5).

Zhang, Anderson, Ohland, Carter, and Thorndyke (2002) further emphasized the impact of mathematics when they found that "not surprisingly, math SAT scores correlate positively with graduation. Specifically, a 100-point increase in math SAT score results in a 30 to 60 percent increase in likelihood of graduation" (p. 9). They further noted that one's high school grade point average, along with math SAT scores, correlated positively with graduation rates for all nine universities they studied.

First Term Grades

In a doctoral study on students who advance into, and graduate from, an engineering program of study, Fletcher (1998) explored the impact of high school grades and first-quarter college grade point average. The author concluded that "the strongest single predictor variable was first quarter grade point average. First quarter grade point average had an Eta of .639 for advancement to a major in (an) engineering program and .454 for graduation from the College of Engineering" (p. 80). This study is consistent with that of Shuman, Delaney, Wolfe, Scalise, and Besterfield-Sacre (1999), who stated that, "an average of 58% of those students placed on first term probation leave engineering during their freshman year. These students account for approximately half of the freshman engineering first-year attrition" (p. 4).

Although first-term college grades fail to predict persistence prior to enrollment, these findings are significant, as noted by Bundy, LeBold, and Bjedov (1998). The authors of a paper, "Assessment of the Impact of Freshman Engineering Courses," monitored engineering students for a 10-year period and found that which others noted: "Of the 43% who leave engineering, the majority (84%) do so before they enter a professional school" (p. 406). Noting this exceptionally high rate of attrition during the pre-professional period, when students are enrolled in first-year courses that are academically demanding, it was suggested that careful attention be paid to placing students in appropriate mathematics courses so that they can achieve acceptable grades. It was further suggested that students who were deemed to be at risk required supplemental assistance in core foundational courses, which would make it possible to persist in engineering.

First-term grades were also the topic of a paper presented by Scalise, Besterfield-Sacre, Shuman, and Wolfe (2000) that identified high-risk students in engineering programs. However, they reported on the impact of first-term probation. Not surprisingly, they noted that the percentage of students on academic probation after the first semester who transferred out of engineering studies (59%) was much higher than for those (24%) who were not on placed on probation. The task was to predict which students would be placed on academic probation, examining such variables as a summer impact program, engineering abilities, study habits, and problem-solving abilities. The authors employed the use of logistic regression to indicate the probable occurrence or non-occurrence of students being placed on probation at the end of their first term. While 54 of 63 true positives were correctly predicted to go on probation (86%), a large number of students (94) were false positive, or incorrectly predicted to go on probation. This large population of incorrectly identified students calls into question the predictive value of the model.

That engineering students are at greatest risk for attrition during the first year has been established. Required classes in mathematics and science constitute the pre-engineering core curriculum. Calculus, chemistry, and physics are the gateway to advanced studies and literature on these subjects is more extensive. House (2000) evaluated the joint contributions of academic background measures and self-beliefs in explaining students' cumulative grade performance in science, engineering, or mathematics fields of study. Consistent with the report of French et al. (2003), he concluded that academic background measures were the most significant predictors of grade performance, regardless of gender. The two measures that contributed the greatest were, in weighted order, high school class percentile and ACT composite score. Although not as significant, higher academic self-concepts led to higher first-year grades.

Individual Characteristics

While a large portion of recent research places emphasis on one's academic background, it has been recognized that other personality variables can contribute to identifying at-risk students. Since the introduction of the Myers-Briggs Type Indicator (MBTI), personality assessment has been popularized in virtually every sector: business, industry, military, churches, and schools. It is no understatement to say that the general population has become exposed to the personal preference measures of the test's four scales: introversion-extraversion, sensing-intuition, thinking-feeling, and judging-perceiving. Although most possess only a layman's understanding of the personality types, the power of the instrument is evident in its popularity and widespread use.

In an effort to explore the effects of personality types on engineering student performance and attitudes, Felder et al. (2002) employed the use of the MBTI. As a tool for studying engineering students, the authors acknowledged that this instrument was effective for characterizing the way students approached learning and responded to instruction; however, they "strongly caution against using it to discourage a student from pursuing engineering or any other curriculum or career" (p. 15). In other words, they discouraged using the MBTI as a predictive tool for engineering persistence and suggested that each of the different personality types can learn to function within engineering, or virtually any other setting. Beyond the element of prediction, the researchers concluded that the MBTI points out the importance of recognizing that all personality types exist within classrooms and varied pedagogical approaches need to be employed to address the diversity of the student population. Engineering classrooms are often characterized as traditional or lecture oriented, which may disadvantage students with an orientation toward feeling, extraversion, sensing, and perceiving. The challenge is to explore ways in which the classroom can emphasize more active and cooperative learning while maintaining the integrity of the traditional approach that appeals to many personality types.

Smyth Stewart (2002) drew similar conclusions on the use of the MBTI as a predictive tool for persistence into an upper level engineering major and subsequent graduation with an engineering degree. "Coupled with other factors, such as high school preparation, commitment to a college degree, and knowledge and understanding of the career of engineering, it becomes increasingly difficult to link precise type functions with specific success or failures," she said (p. 64). However, Chi-square tests of significance did result in one statistically significant relationship between the judging/perceiving function and successful performance of engineering students. Judging students were more likely to be admitted to an engineering major (55.5% as compared to 46.3%) and to graduate (46.8% as compared to 39.1%) with an engineering degree. This finding is not surprising when one considers the characteristics of a judging student profile. As the author noted:

> Students who more naturally manage their time and prefer to complete projects on a daily basis have an advantage in this curriculum For perceiving students, the

daily demands typically require that they function in ways that conflict with their natural inclinations to work in spurts of energy to specific deadlines. (p. 65)

In a study conducted on students at the Georgia Institute of Technology, Thomas et al. (2000) drew conclusions similar to that of Smyth Stewart concerning the MBTI. They suggested that engineering programs tend to attract students who are thinking and judging; however, "the results seem to indicate that using psychological type to predict performance at this level of analysis in engineering may not be successful" (p. 41). Taken as a whole, the conclusion of most studies is that the MBTI is not a valuable predictive tool for persistence in engineering. However, as shall be seen, prediction of persistence or success in engineering remains a strong topic of research.

In a paper presented to the American Association for Higher Education in Washington, D.C. on continuous quality improvement in an engineering program at a large southeastern university, Benefield et al. (1996) investigated variables that would likely predict students at risk of failure. Consistent with other studies, they found "a strong correlation between ACT scores and successful completion of the pre-engineering program" (p. 4). Nearly 71% of students who had a composite score of 27 or greater completed pre-engineering, while only 60% who enrolled with a score of 24 completed the program. Perhaps even more significant is the ACT math score, with a mean of 26.45 for those who successfully completed pre-engineering. Multiple regression analysis indicated a strong relationship (regression coefficient of .61) between first quarter grade point average and ACT math scores, self-reported high school grades, study habits, scores on the group Embedded Figures Test, father's highest educational level, and self-reported academic preparation. This study, like others, demonstrates the importance of math preparation, as indicated by the correlation of ACT math scores and success in pre-engineering. However, it also points out other personal variables that work in concert with math scores for those students who persist through the pre-engineering curriculum.

One such personal variable that receives significant attention in educational psychology literature is the concept of self-efficacy, a cognitive mechanism that impacts behavior. Briefly, the theory maintains that one's beliefs about his or her ability to perform certain tasks will determine the amount of effort put forward. Lent et al. (1984) examined the relationship of self-efficacy beliefs and persistence in science and engineering majors. They examined four aspects of student self-efficacy: level and strength as related to educational requirements and level and strength as related to science and engineering job duties. Their findings suggested that high self-efficacy groups generally achieved higher grades and persisted longer in technical majors than did low self-efficacy groups. At the heart of matter is the issue of that which determines one's level of self-efficacy. It would seem that those who are well prepared in mathematics and science would tend to have higher levels of self-efficacy since they have the necessary pre-requisite knowledge for highly technical studies.

In a longitudinal study on Israeli students, Lufi, Parish-Plass, and Cohen (2003) examined how academic persistence related to personality variables, along with academic and demographic information. Their conclusion, which is salient to the work of university administrators, maintains that academic persistence correlates positively with college grades and personality variables account for only a small proportion of variance. Based on their findings, it seems paramount for college educators to examine students' academic characteristics closely when designing programs that address the needs of those considered at risk.

Recognizing that education is "an aggregate of both cognitive (content knowledge and technical skills) and affective (attitudes) process" (p. 140), Besterfield-Sacre et al. (1997) studied freshmen entering an engineering program of study at the University of Pittsburgh. The models they developed helped them to identify students with the greatest potential to leave engineering, in good standing or in poor academic standing, before the students began their college studies. Not surprisingly, they found that students with high ability, as determined by high school rank, are most likely to leave engineering in good standing. Presumably, their exit is due to that which might be expected of high achieving students: They have a wide-range of interests, only one of which is engineering. Conversely, students who departed from the program in poor standing rated general impressions of engineering higher than the other groups, but they seemed to lack realistic expectations about themselves and the field of study. Their confidence level in succeeding was typically high when they began their studies, but they did not do well academically, possibly due to time management, study skills, or an extrinsic motivation focuses on financial reward.

Conventional wisdom has long held that a student's study habits can translate into success in college. In an effort to explore the effect of study habits on achievement in engineering, Blumner and Richards (1997) studied 69 first-year engineering students at the University of Virginia. Using the dimensions of distractibility, inquisitiveness, and compulsiveness to inventory the study habits of the participants, they found that high achieving students scored significantly lower on distractibility and higher on inquisitiveness, while compulsiveness failed to demonstrate any significant difference. These results suggest that surface-level studying (compulsive behavior such as rote memorization) has little positive consequence for engineering studies, while the ability to concentrate (lower level of distractibility) and make sense out of the material (higher level of inquisitiveness) result in higher achievement status.

At the Mercer University School of Engineering Lackey, Lackey, Grady, and Davis (2003) explored a non-technical variable, a dialectic notebook that freshman students maintained, to predict their academic success. They contended that the effort put into this assignment was a strong indicator of the student's degree of "engagement, attitude, initiative, time management skills, study habits and willingness to persevere" (p. 46). It was further hypothesized that a strong relationship existed between notebook scores and grade point average. Using stepwise regression to predict engineering student grade point averages, the researchers found, given the independent variables SAT-M, SAT-V, HS GPA, and notebook score, the notebook accounted for the greatest percentage of variation, 33%, in the GPA; however, gender differences were discovered. While notebook scores made the greatest contribution for male students, the HS GPA most strongly correlated with female GPA. Of interest is the relationship between male student scores on the SAT and the notebook: As test scores for entering freshmen increased, the predicted notebook scores decreased. The writers suggested that male students with high entering SAT scores may diminish the value of the notebook exercise and concluded that it carries little utility. Nonetheless, as an instrument that represents attitudes and willingness to learn, Lackey et al. concluded that the notebook score is "a reasonable predictor of freshman student success in the Mercer University School of Engineering curriculum" (p. 47).

Summary

That considerable gaps exist in scholarly research on persistence among pre-engineering students has been determined. The current body of knowledge lends itself to an understanding of student and institutional characteristics, part of which generalize to engineering students. Of particular interest and application is research by French et al. (2003) on engineering student success, House's (2000) study on predictors of grade performance in science, engineering, and mathematics, and Herzog's (2005) report that mathematics is the strongest retention predictor for new freshmen in their first semester.

Studies on non-cognitive variables are also negligible in the literature and constitute a significant gap. The orientation of many researchers is toward that which is more readily quantifiable, such as student grades, standardized test scores, and high school subjects.

It is apparent that all studies contribute to an understanding of college student persistence, a population of which engineering is a subset. While individual and institutional characteristics are applicable, the deafening silence of studies using non-cognitive variables, conducted on pre-engineering students, points out the need for future research on a population that is highly at risk.

III. METHODOLOGY

This is an ex post facto study, and as such it quantitatively explores the relationship between self-reported non-cognitive variables and persistence or non-persistence among pre-engineering students considered to be at risk for attrition. Information that is germane to the methodology is presented in the following sections of this chapter: (a) Review of the Problem, (b) Participants in the Study, (c) Procedures, (d) Variables, (e) Data Preparation and Analysis, (f) Statistical Treatment of the Data, and (g) Limitations.

Review of the Problem

A necessary first step of this study was to determine what constitutes an at-risk student. Based on relevant research, mathematics is most frequently treated as the single greatest predictor of persistence in an engineering program of study. The ACT, which was once known as The American College Testing Program Inc., is widely regarded as a reliable predictor, and it is the examination commonly used by the Admissions Office of the institution under study to determine a student's ability to complete college-level course work. It consists of a multiple-choice test format and is taken prior to making application to college. Four areas of academic skills are assessed: English, mathematics, reading, and science. For the purpose of this study, the mathematics component was used to identify at-risk pre-engineering students. As noted by Beronja and Bee (1986) in "Investigating the Motivations of the Pre-Engineering Major," "performance on the math component of the (ACT) test provides the greatest disparity between the average student and the good/excellent student" (p. 85).

In a study on engineering retention at the University of Alabama, Acker et al. (2002) discovered that a score of 25 on the mathematics portion of the ACT provided a good cut-off for the likelihood of students transferring out of the program. An examination of ACT scores among students enrolled at the institution under study indicated similar results. Among 848 students who scored ≤ 24 on the mathematics portion of the test, only 25% were admitted into upper level studies in engineering. Therefore, an ACT mathematics (ACTM) score of ≤ 24 constitutes the at-risk student population in this study.

The purpose of this study was to determine if there was a set of non-cognitive variables among at-risk pre-engineering students that signify differences that exist among those who persist and those who fail to persist into an upper level engineering major. This study is an exploration of non-cognitive variables that significantly contribute to persistence into upper level engineering studies among the at-risk pre-engineering population.

Participants in the Study

Participants in this study were selected from a population of 2,276 pre-engineering students who matriculated as first-time freshmen in pre-engineering at a large southeastern public university. All participants enrolled for classes during one of four fall semesters, 2000-2003, and completed upon entrance the College Freshman Survey (Halpin & Halpin, 1996), an assessment yielding results for advising and monitoring.

The population was filtered and those who took the ACT and completed the College Freshman Survey were retained for analysis. Students were divided into two groups: those who were considered to be at risk to depart from the engineering program prior to advancing into upper level studies and those who were expected to persist. The ACTM score was used to determine at-risk students.

The at-risk participants were further divided into two groups: those who advanced into upper level engineering studies and those who departed the pre-engineering program with a cumulate grade point average < 2.2. Participants who departed prior to the posting of first semester grades or in good standing, with a cumulative grade point average ≥ 2.2, were excluded from the study. The result is a severely restricted population; however, these limitations ensure that the group proposed for this study is analyzed.

To derive the number of complete and valid cases, the original population (2,276) was examined to determine the number that reported an ACTM score ≤ 24. This investigation resulted in a sample of 848 students that was further filtered, using two groupings: those admitted to upper division studies in engineering and those who departed from the program with a cumulative grade point average < 2.2. Of those cases, 224 students departed from engineering with a grade point average ≥ 2.2 and 42 remained in the pre-engineering program. This resulted in 582 cases that could be clearly categorized into one of the two status groupings under study.

Due to the focus of this study on at-risk students, those who departed with a grade point average ≥ 2.2 and those who remained classified as pre-engineering were not considered. It is noteworthy that a small number of students may remain in the pre-engineering program though they exceed the time normally allowed for that status.

Typically, such students have appealed to the College of Engineering for an extension of time in order to qualify for upper level studies or they are no longer at the university and they are, in effect, inactive in their studies.

Data further suggested that among the 582 resulting cases, 370 students (64%) departed from the program unsuccessful, with a grade point average <2.2, and 212 (36%) were admitted to upper level studies. In essence, nearly two thirds of this population departed the College of Engineering with a low grade point average. Students at this level of achievement are not only ineligible to continue their engineering studies but also they are in jeopardy of being ineligible to continue their studies at the university.

Among the 582 cases that met the criteria for inclusion, 90 students did not complete the College Freshman Survey. Thus, they were excluded from the study and considered as missing cases. In order to establish the number of valid and complete cases, an examination of all possible independent variables and the dependent variable (student status) was conducted. This investigation resulted in 491 cases that completed the survey instrument, reported information on the selected independent variables, and had a status of admitted to engineering or departed unsuccessful with a grade point average < 2.2. These 491 participants constituted valid cases and were used for further analysis.

Results for the 491 cases were similar to earlier findings on 582 cases: 304 (62%) departed the program unsuccessful and 187 (38%) were admitted to upper division studies. Once again, nearly two thirds of this population departed the program with a grade point average that did not meet the minimum requirement for advancement into upper level studies in the College of Engineering (see Table 1).

Table 1

Status of All Students Reporting ACTM ≤ 24 and Students With Complete Information

Students		Admitted to engineering		Left unsuccessful	
	N	*N*	*%*	*N*	*%*
All students with ACTM ≤ 24	582	212	36%	370	64%
Complete cases with ACTM ≤ 24	491	187	38%	304	62%

Procedures

Data were collected on pre-engineering students, on campus, prior to the first day of fall classes. As part of a long-term study, the College of Engineering requires all freshman students who enter during the fall semester to complete the College Freshman Survey; an instrument that measures cognitive and non-cognitive attributes. Letters were mailed to all pre-engineering freshmen, prior to their scheduled orientation session, advising them about the time and location for completing the survey. Students who failed to complete the survey were asked to attend a make up session on the day before fall classes began. Personnel within Engineering Student Services, faculty from the College of Education, and graduate assistants proctored the survey.

University staff members greeted students upon their arrival. They were then led to a large auditorium-style classroom in which the instrument was administered. After being seated, students were introduced to members of the university community by a member of Engineering Student Services and explanation was provided as to the purpose of the instrument they were preparing to take. Faculty from the Educational Foundations, Leadership, and Technology (EFLT) Department, who developed the instrument, provided further instruction on how to complete the survey. All participants were issued one survey booklet, one scantron for recording answers, and two pencils. Approximately 1 hour was required to complete all items. The survey followed a multiple-choice format and all responses were recorded on the scantron, which students presented to a reviewer upon completion. As students exited the testing area, trained university staff members reviewed their information to ensure proper completion and to check for missing data. Students who presented incomplete information were asked to supply necessary data.

Sources of Data

Pre-existent data from an on-going institutional project within the College of Engineering were used in this study. The instrument used for this project, as well as all resulting data, was developed and managed by faculty members in the EFLT Department. The university's Student Information System was used to determine student grade point averages and to establish who advanced into an upper level engineering major or failed to advance into an upper level engineering major. The database that was used was confidentially maintained on a computer file in the office of one of the principal developers of the survey instrument and was not available to the general public.

Variables

Non-cognitive variables were identified in the survey and constituted the independent variables. These variables consisted of self-reported measures that reflected the student's attitudes, opinions, or beliefs and were classified as self-reported personal characteristics.

The dependent variable was labeled engineering status and was determined by the student's advancement into upper level engineering studies or departure from the program with a low grade point average (< 2.2). This was the single dependent variable used in this study.

Data Preparation and Analysis

All student data were reviewed to identify missing information. All cases with missing data were eliminated from the study for analysis. Independent and dependent variables were analyzed using the software package SPSS version 16.0 for Windows.

Statistical Treatment of the Data

The first step involved using ACTM scores and dividing the population into two groups: those who were at risk of failure and unlikely to enter upper level engineering studies and those who were likely to persist into upper level studies.

The next step was to employ a bivariate correlation on all independent variables with the dependent variable to determine the strength of the relationship and reliability. A predetermined level of reliability was set at .50 and those self-reported independent variables that met the established cutoff were retained for further investigation.

Finally, since the purpose of this study was to quantitatively examine differences that may exist between at-risk students who advance into upper level studies and those who depart with a low grade point average, discriminant analysis was employed. This statistic is a useful tool when multiple independent variables are used to examine a dependent variable and predict group membership.

Limitations

Limitations exist with this methodology. First, the population was restricted to first time entering freshmen during the fall semester. It did not include on-campus or off-campus transfer students or those who entered the program during other semesters. Second, the institution under study was located in a state that primarily used the ACT. This test was used to determine at-risk students. Students who presented SAT scores alone were excluded from the study, which constituted a minority number of students. Although ACT/SAT conversion tables were available, they are not highly reliable and therefore were not used. Third, for various reasons some students did not take the entering freshman survey. This portion of the population constituted missing data and they were excluded from the study. Fourth, only students who departed the program with a low grade point average were considered for this study. Students with above average grade points also departed for a myriad of personal reasons. These students were not part of the study.

IV. RESULTS

Described in this chapter are the results of the statistical analysis. It is divided into two sections. The first section reports on the selection of the independent variables. The second section reports the results of the discriminant analysis used to determine differences that exist between at-risk students who advanced into upper level studies and those who departed with a low grade point average.

Selection of Variables

Initially, 30 constructs were identified in College Freshman Survey (Halpin & Halpin, 1996) that could serve as possible non-cognitive independent variables. The number of items that measured each variable ranged from 2 to 11. An important first step was to execute a test for reliability on all measures under consideration. The outcome of this analysis determined which variables would be used in subsequent analysis.

Resulting data indicated that 25 of the 30 identified measures of non-cognitive variables met the established level of reliability (.50) using the 848 cases that reported an ACTM score that was ≤ 24 (see Table 2). These variables were used for further analyses to determine what differences existed between previously identified at-risk students who advanced into upper level engineering studies and those who departed unsuccessfully due to a low grade point average.

Table 2

Reliability of Independent Variables Based on ACTM ≤ 24 Population

Independent variables	*N*	Number of items	Α
Knowledge/confidence	704	10	.906*
Math	709	5	.878*
Leave engineering	714	5	.793*
Leave A.U.	718	3	.414
Problem solving	713	5	.778*
English	713	4	.776*
Locus of control	714	9	.766*
Study habits	714	7	.746*
Study hard	718	3	.493
Test anxiety	707	4	.726*
Communication skills	717	3	.716*
Success	710	9	.702*
Extrinsic motivation	717	6	.463
Intrinsic motivation	713	8	.695*
Social	709	6	.690*
Socializing	717	5	.350
Note taking	718	3	.681*
Academic self-concept	714	4	.674*
Perceived difficulty	709	11	.669*
Team membership	716	3	.668*
Self-appraisal	709	6	.655*
Competitive	708	6	.646*
Work ethic	704	7	.640*
Leadership	717	3	.639*
Teacher	717	4	.625*
Computer	719	2	.621*

Table 2 continued

Independent variables	*N*	Number of items	A
Academic difficulty	716	5	.590*
Need help	713	6	.587*
Organization	712	3	.555*
Structure	716	3	.407

* = meets the established level of reliability

One additional variable entitled extrinsic motivation was included in the analysis for three reasons. First, the reliability of .463 was only slightly below the established cut-off. Second, this variable receives significant treatment in educational psychology and is believed to contribute to success in the classroom. Finally, inclusion of this construct provided a contrast to the intrinsic motivation variable, which was considered in the analysis. This resulted in 26 independent variables that were used for further analysis.

Following is a description of each one of the self-reported variables that were included as independent variables in the data analysis.

Variable 1: Knowledge/confidence. Students' level of confidence about choosing engineering, the comfort they have with making this choice, and their level of decisiveness about selecting engineering.

Variable 2: Math. Students' level of self-efficacy as related to mathematics or their feelings about how well they manage the subject and how much they enjoy it.

Variable 3: Leave engineering. Students' sense of likelihood that they will depart from engineering during their undergraduate tenure or transfer to another on-campus program of study.

Variable 4: Problem solving. Students' ability to think analytically and critically and to solve unique problems, using information from different academic disciplines.

Variable 5: English. Students' report of how much they like English and how well they perform in that subject.

Variable 6: Locus of control. Students' sense of control over possible outcomes in their engineering studies. Students are asked to report on issues related to hard work, luck, study, or other matters beyond their control.

Variable 7: Study habits. Students' study habits as related to their commitment to their academic studies, and how effectively they study.

Variable 8: Test anxiety. Students' sense of anxiety as related to pressures associated with test taking.

Variable 9: Communication skills. Students' sense of how strong they are in written and oral communication.

Variable 10: Success. Students' report of how likely it is that they will succeed in engineering by meeting with faculty, earning strong grades in mathematics and science, and pursuing advanced degrees in engineering.

Variable 11: Extrinsic motivation. Students' report of their motivation to study and perform in class for the approval and recognition of others.

Variable 12: Intrinsic motivation. In contrast to Variable 11, students' level of motivation to learn for personal reward and personal pleasure derived from the pursuit.

Variable 13: Social. Students' report on the extent to which they enjoy socializing and the level at which they plan to engage in social activities outside of engineering.

Variable 14: Note taking. Students' sense of how well they take accurate notes in a classroom environment.

Variable 15: Academic self-concept. Students' self-concept as related to their mathematics ability and how well prepared they are for college studies.

Variable 16: Perceived difficulty. Students' sense of anxiety over new, difficult, and unexpected events and how well they manage their time and cope with problems.

Variable 17: Team membership. Students' willingness to work cooperatively with others, including those of another race or culture.

Variable 18: Self-appraisal. Students' level of confidence in dealing with problems and their beliefs about their strengths and weaknesses.

Variable 19: Competitive. Students' need to perform better than others and their sense of how well they perform as measured against how well others do.

Variable 20: Work ethic. Students' motivation and willingness to take on difficult tasks or their tendency to procrastinate.

Variable 21: Leadership. Students' sense of being a leader, their level of competitiveness, and the strength of their social concept.

Variable 22: Teacher. Students' perception of the teacher's impact on their performance, as related to their attribution of teacher support and interest.

Variable 23: Computer. Students' likelihood of doing well in computing.

Variable 24: Academic difficulty. Students' likelihood of not performing well academically in pre-engineering and failing to meet their academic expectations.

Variable 25: Need help. Students' likelihood of needing help in academic domains and seeking tutoring or counsel.

Variable 26: Organization. Students' level of organization through generating lists and thinking about their plans.

The dependent variable that was included in the analysis was student status. Students were classified in one of two categories: those admitted to upper level engineering studies and those who departed from the program unsuccessfully, with a grade point average < 2.2, which constitutes the minimum requirement for advancement, as established by the College of Engineering.

Differences Between Groups

Cohorts of students do not possess exactly the same characteristics nor do they consistently behave in the same manner. Within a single identifiable group, such as at-risk students, some defy the expectations of those who administer engineering programs of study. The investigation now turns to discovering what, if any, differences exist between at-risk students who follow the expected path and fail to persist into upper level studies and those who manage successfully to navigate through the curriculum and persist into an upper level engineering major. The issue for the at-risk population under study was whether any differences existed between these two groups of students with similar standardized mathematics test scores.

The non-cognitive independent variables were subjected to a statistical process, using discriminant analysis. Results demonstrated that on the non-cognitive variables that were selected, statistically significant differences existed between the two groups of students under study: those who persisted into an upper level engineering major and those who departed from the program unsuccessful, with a grade point average that failed to meet the minimum cumulative requirement of 2.2.

Collectively, the canonical correlation, which is the relationship between the optimally weighted combination of the 26 self-reported independent variables and the dichotomously classified dependent variable, was .40. Correlations between .30 and .50 are generally considered to be moderate, with correlations at or above .50 regarded as excellent, though it is rare to find such high correlations in social science research. Furthermore, although correlations below .30 may be statistically significant such relationships are typically considered to be weak. Therefore, the statistical relationship between all 26 non-cognitive variables and student classification was considered to be moderate.

A moderate correlation of .40 is noteworthy when one considers the restricted range of this study. Lower correlations are associated with a more restricted range. The sample under investigation was very select. In essence, it constituted a very small portion of all students who entered the pre-engineering program as freshmen. Only those students who scored ≤ 24 on the mathematics portion of the ACT and were considered to be at risk for failure to persist into an upper level engineering major were included in the study. This resulted in 848 students; however, the sample was further reduced to only those who completed the survey instrument. These considerations restricted the range considerably and resulted in 491 valid cases.

The resulting eigenvalue of .187 indicated the proportion of variance in the weighted combination of the 26 independent variables associated with the dichotomous dependent variable. In effect, nearly 19% of the variance in the independent variables was associated with success or failure among at-risk students in the pre-engineering program.

Results from F-tests of the bivariate relationship between each of the independent variables and the dichotomous dependent variable are reported in Table 3. Of the 26 non-cognitive variables under consideration, 6 were statistically related to student persistence ($p \leq .05$).

Table 3

Tests of the Relationship Between the Non-Cognitive Independent Variables and the Dichotomous Variable of Student Status

Variables	F	Sig.
Knowledge/confidence	.305	.581
Math	16.844	.000*
Leave engineering	1.241	.266
Problem solving	.208	.648
English	1.652	.199
Locus of control	1.860	.173
Study habits	13.016	.000*
Test anxiety	.732	.393
Communication skills	.405	.525
Success	4.346	.038*
Extrinsic motivation	.829	.363
Intrinsic motivation	4.717	.030*
Social	1.371	.242
Note taking	2.015	.156
Academic self-concept	20.052	.000*
Perceived difficulty	3.308	.070
Team membership	1.238	.266
Self-appraisal	.034	.855
Competitive	.005	.946
Work ethic	4.138	.042*

Table 3 continued

Variables	F	Sig.
Leadership	.739	.390
Teacher	.136	.713
Computer	.216	.642
Academic difficulty	.007	.933
Need help	.003	.960
Organization	2.953	.086

* $p \leq .05$

Bivariate correlations between the 6 non-cognitive independent variables that were significantly associated with either succeeding or failing to advance into upper level studies for pre-engineering students who are at risk are reported in Table 4. Three variables accounted for a moderate amount of information in classifying student status while the remaining variables accounted for a relatively small portion. With the restricted sample range, when the independent variables were considered individually, the correlations with the dichotomous dependent variable were considerably smaller.

Table 4

Bi-Variate Correlation with Classification of Success or Failure

Variables	Student Classification	Sig.
Math	.182**	.000
Study habits	.161**	.000
Intrinsic motivation	.098*	.030
Work ethic	.092*	.042
Academic self-concept	.198**	.000
Academic success in engineering	.094*	.038

** Correlation is significant at the .01 level (2-tailed).
* Correlation is significant at the .05 level (2-tailed).

The independent variable, academic self-concept, had the strongest positive correlation with to the dichotomous dependent variable, $F(1, 489) = 20.05$, $p \leq .05$. This self-reported variable is related to the students' perception of their mathematics ability and how well prepared they are academically. Nearly 4% of the variance in the academic self-concept variable was associated with group membership. At-risk students who held a stronger perception of their ability in mathematics and felt better prepared to undertake academic challenges were more likely to be admitted to upper level studies in engineering.

Mathematics has played a prominent role in literature related to success in engineering and the correlation of the math variable with the dependent variable continues to bear out its significance, $F(1, 489) = 16.84$, $p \leq .05$. Though at risk, students who reported that they felt positive about their ability to solve math problems and that it was their favorite subject were more likely to succeed in pre-engineering and be admitted to upper level studies. Nearly 3.5% of the variance in the math variable was associated with group membership.

Thus far the independent variables with the strongest relationship to student status have been associated with how students feel about their academic ability, particularly in mathematics. The third independent variable, study habits, shifted the focus to student behavior. At-risk students who reported having stronger study habits and prioritized their studies over other social activities, were more likely to persist in engineering and advance to upper level studies, $F(1, 489) = 13.02$, $p \leq .05$. Slightly more than 2.5% of the variance in the study habits variable was associated with group membership, reinforcing the need for pre-engineering students to manage their time well and prioritize the time devoted to their studies.

Although small, a statistically significant proportion of variance was associated with the three remaining independent variables. Approximately 1% of the variance in each variable was associated with success or failure among at-risk pre-engineering students. These three variables will now be discussed.

Intrinsic motivation, F (1, 489) = 4.72, $p \leq .05$, was a measure of how motivated the students were to learn material in the classroom for personal reward and the degree to which they derived pleasure from academic pursuit. To further understand the impact of motivation on student persistence, extrinsic motivation was included as a contrasting variable to intrinsic motivation, yet it failed to achieve statistical significance and was eventually dropped from consideration. Based on these results, at-risk students are more likely to succeed in pre-engineering when they find it personally rewarding to solve challenging problems and to study new material for the sake of learning, as opposed to doing so for the sake of passing a test.

The independent variable, academic success in engineering, was a measure of the students' belief that they would be successful in engineering as the result of meeting with faculty members, earning strong grades in the pre-requisite courses of mathematics and science, and pursuing advanced degrees in engineering F (1, 489) = 4.35, $p \leq .05$. At-risk students who entered the pre-engineering program with the belief that they would earn high marks in math and science and have a positive relationship with faculty were more likely to advance to upper level studies.

The final independent variable to have a statistically significant correlation with group membership was work ethic, $F\ (1, 489) = 4.14\ p \leq .05$. At-risk students who reported that they did not procrastinate nor avoided hard work, tended to be more successful in pre-engineering and advanced to upper level studies. As in the case of study habits, the importance of another behavioral measure was statistically supported.

As previously stated, the purpose of this study was to examine the relationship of non-cognitive variables among pre-engineering students that signify differences that exist among those who persist and fail to persist into upper level engineering studies, though they are identified as at risk for attrition. Results indicated that 6 non-cognitive variables were associated with either succeeding or failing to advance into upper level studies for pre-engineering students who were part of the at-risk population.

The guiding question for this research was: Do non-cognitive variables differentiate at-risk pre-engineering students who persist into upper level engineering studies from those who do not persist? Findings from this study support the hypothesis that that non-cognitive variables make a significantly weighted contribution to students who persist into an engineering major, though they are considered to be at risk.

V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter is divided into three sections. The first section provides a summary of the study. Section 2 offers conclusions based on previous findings and the current study. Section 3 provides recommendations based on the results of the study and suggests further research.

Summary

The purpose of this study was to conduct a quantitative examination of the relationship of self-reported non-cognitive variables among at-risk pre-engineering students. This study was guided by the question: What non-cognitive variables—individually and in combination—differentiate at-risk pre-engineering students who persist into an engineering major from those who do not persist? It was hypothesized that these variables—individually and in combination—would significantly differentiate between at-risk pre-engineering students who persist and those who fail to persist into an upper level engineering major.

The population of interest was at-risk students in a pre-engineering program of study. This group of students is significant because many public institutions hold a standard for admission that is below that which indicates potential for success in engineering. Based on prior research that indicates mathematics is the single greatest indicator for success, and that the ACT is the most frequently used standardized test for admission at the institution in which the students enrolled, a decision was made to use an

ACTM score ≤ 24 to categorize the at-risk population. A significantly large number of students in the study sample, 848 out of 2,276 (37%), met the criteria. More than 1/3 of the entering freshmen were considered to be at risk, with only 25% (212) advancing into upper level studies.

The independent variables used in this study were self-reported measures, from the College Freshman Survey Engineering Form (Halpin & Halpin, 1996). This 248-item questionnaire provided a wealth of pre-enrollment information on students who entered the pre-engineering program for 4 consecutive fall semesters, 2000 through 2003. This timeframe was selected, assuming that students admitted through fall 2003 had sufficient time to advance into upper level studies in engineering, considering that, with few exceptions, pre-engineering students are not permitted to continue to be enrolled in the program after achieving junior status. In other words, students are required to qualify for upper level studies prior to completing 61 credit hours, which normally requires 4 full-time semesters, averaging 15 credit hours per semester. As noted in the literature, students depart the program for several reasons. Many self-select and choose to transfer to other academic majors before qualifying for upper level studies, with a cumulative grade point average ≥ 2.2. Only those students who departed with an insufficient grade point average were considered for this study.

Discriminant analysis was the statistic of choice, and it was used to determine the optimally weighted combination of independent variables. Use of this procedure allowed for the prediction of group membership, those who persisted into upper level studies and those who failed to persist due to poor grades, based on the optimally weighted linear combination of the selected variables.

The optimum weighted combination of the 26 self-reported variables under consideration correlated .40 with success in the pre-engineering program, which is considered moderately high in social science research. However, six of the variables were noted as statistically significant.

Consistent with prior research, mathematics held one of the strongest correlations with student membership in one of two groups, those who persisted into an upper level engineering major and those who were unsuccessful due to a low grade point average. However, the mathematics variable in this study was distinctly different, in that it represented a non-cognitive characteristic, rather than raw scores on mathematics placement tests or standardized scores on nationally normed examinations. Students who scored high on this variable reported that they felt they were good in mathematics and that they enjoyed the subject.

The independent variable that correlated strongest with group membership was academic self-concept. Students who scored high on this variable were characterized as possessing a strong belief about their academic ability and that they were well prepared to undertake college level studies.

Good study habits also had a moderate correlation with success or failure among at-risk pre-engineering students. These students reported that they were able to stay on task and could determine important material when they studied. They tended not to procrastinate and study time was a priority to them. These students could be characterized as efficient learners.

Motivation is a concept that receives a considerable amount of attention in educational psychology literature. As a rule, it is studied as an intrinsic or extrinsic construct. The results of this study indicated that extrinsic motivation was not significantly correlated with group membership; however, intrinsic motivation had a small, yet statistically significant, relationship. Although the proportion of intrinsic motivation that correlated with group membership was relatively small, this variable added a unique amount of variance among students who persisted or failed to persist into upper level studies. Students with high levels of self-reported intrinsic motivation reported that it was rewarding to solve problems and learn new material. Students with this characteristic felt that it was personally satisfying to learn new material rather than simply studying for the sake of passing an examination.

The belief that one will perform well in college constituted the success variable, which also had a small but significant correlation. Although small, this construct provides a unique contribution to group membership. Students who scored high on this variable were characterized as believing that they would receive high marks in critical pre-engineering subjects such as chemistry, physics, and mathematics. For these students it was important to have a positive relationship with their teachers. They expected to like their professors and planned to interact with them outside of the classroom.

Finally, the at-risk student's work ethic made a small but unique contribution to group membership. These students reported that they would take the initiative in school and that hard work did not trouble them. When confronted with academic obstacles, these students would likely devote extra energy to succeed.

The findings of this study provided additional insight into that which is already understood about retention among at-risk students undertaking engineering studies. While much research has focused on the attrition of at-risk students, this study examined the issue of persistence and identified six non-cognitive variables that made a significant contribution to differentiating at-risk pre-engineering students who persisted and those who failed to persist into upper level engineering studies.

Further, this study was an effort to explore an apparent gap in the current body of literature on engineering retention. Admittedly, studies on cognitive variables provide a wealth of information and insight into that which predicts success, or persistence, in engineering. The literature has clearly established that students who are well prepared in mathematics and science have a greater likelihood of remaining in the program. Accordingly, it was the mathematics variable that became the impetus for determining those students who were considered to be at risk in pre-engineering.

It was further noted that contrary to models that predicted student failure before advancing into upper level engineering studies, a certain portion of this population persisted. What was it that made this group successful and enabled them to defy the probability of failure? To answer this question an effort was made to move outside the realm of conventional research to examine a set of non-cognitive characteristics within a frequently ignored group of students: those who were not expected to succeed. If uniquely identifiable variables exist for an at-risk population that persists into upper level engineering studies, then those characteristics can further aid in understanding retention.

In large part, this study was based on theories of learning in educational psychology which subscribe to the notion that individuals are a composite of that which they think (cognition), that which they feel (affect), and that which they do (behavior). Although the acquisition of certain prerequisite knowledge is fundamentally important, it is an oversimplification to reduce learning, and subsequently persistence, to that which can be represented on a standardized test. In fact, if learning were simply a matter of cognition, then it would seem that all students with high test scores in mathematics would succeed in engineering, which is untrue. Some students, with lower cognitive skills, contradict the best models at our disposal and persist as the result of behaviors that lead to success or a tenacious belief that leaves them undaunted in the face of an exceedingly large challenge.

The basic assumption being applied is that the individual is a composite of thought, feeling, and behavior that consists of a conscious and unconscious interaction between all parts. Internal and external forces influence this entity, or individual. This study therefore adopts a holistic view of learning, which also takes into account certain non-cognitive variables, including thought and feeling, as well as behavior.

Conclusions

With shrinking enrollments, engineering administrators feel pressure to retain students. Studies indicate that fewer high school seniors plan to study engineering than in the past, and those who do are less prepared than their predecessors. For those students who took the American College Test (ACT) in 2002, only 5.5% indicated engineering as a college major, as opposed to 8.6% in 1992 (Civil Engineering, 2003). Adding to the engineering dilemma, only one half of these aspiring engineering students took calculus in high school, and 10% completed only 2 years of algebra and 1 year of geometry. The conclusion for engineering is that fewer students are enrolling and those who do are not adequately prepared.

It is evident that engineering programs must respond to the challenge and deliver a recruitment message that appeals to young people who frequently view the discipline as too difficult. The focus of this study was the retention of currently enrolled students. The development of recruitment strategies must be reserved for later; however, lower interest in technical studies and inadequate preparation among high school students serves to place a special impetus on engineering colleges to develop plans for retention.

Perusal of scholarly research indicated concern for a population that experiences an exceptionally high rate of attrition. A glaring problem confronts engineering educators given that the largest percentage of attrition occurs during the pre-engineering curriculum. The high rate of attrition is problematic and continues to receive attention.

As seen in the literature, issues of retention in engineering are a growing concern (Felder, 1995; Felder et al. 1998; Felder et al. 1995; Felder et al. 1993; Felder et al. 1994; French et al. 2003; MacGuire & Halpin, 1995; Moller-Wong & Eide, 1997). Alarming to many educators in the United States are declining graduation rates in engineering while the demand for technically trained students continues to increase.

There is a plethora of literature that establishes the first year of college, for all majors, as critical to continued success. Pre-engineering studies primarily involve the first year and this group is beginning to receive greater attention in the literature (Amenkhienan & Kogan, 2004; Anderson-Rowland, 1997; Baillie & Fitzgerald, 2000; Daempfle, 2004; Hoit & Ohland, 1998; Pomalaza-Raez & Groff, 2003; Skoner & Jolongo, 1988). What we may be seeing is a change in culture that is looking for answers to high rates of attrition among first year pre-engineering students, rather than simply viewing this as period in which engineering aspirants are filtered out of the network.

To help circumvent engineering student failure, certain authors explored the use of special interventions such as tutorial programs and introductory freshman courses

(Anderson-Rowland, 1997; Hoit & Ohland, 1998; Pomalaza-Raez & Groff, 2003; Waldrop, 2000; Weatherby, 2001). Some writers placed the focus on engineering pedagogy (Amenkhienan and Kogan, 2004; Birenbaum, 1997; Conner et al. 2004; Daempfle, 2004; Derlin & McShannon, 2000). Still, others undertook the effort to predict student failure before it actually occurred (Beck & Davidson, 2001; Besterfield-Sacre et al. 1997; Herzog, 2005; Mau, 2003; Owusu, 2001).

However, as with any growing body of knowledge, certain gaps invariably exist. One such gap in current studies is a lack of information and understanding about pre-engineering students who are at risk and expected to fail, yet they manage to persist. While much can be said for the tenacity of human spirit, there are other identifiable characteristics that contribute to success. This study was an effort to examine a population that is frequently neglected in order to discover certain qualities that students who succeed possess, despite being considered at risk.

Consistent with previous research, results indicate that mathematics is a strong predictor of success in pre-engineering engineering (Benefield et al. 1996; Croft & Ward, 2001; Fletcher, 1998; Zhang et al. 2002). Uniquely, this study brings to light the importance of having a penchant toward mathematics as a discipline, as well as feeling well prepared to undertake advanced studies in the subject. This finding reinforces that which is commonly held, mainly, students tend to perform better when the subject matter is of interest and they enjoy it. In spite of achieving ≤ 24 on the ACTM, a certain portion of at-risk students succeeded as a result of the interest that they had in mathematics.

Although many 4-year institutions do not teach remedial mathematics, greater efforts can be made to identify students who are at risk in this subject area. A number of public institutions find themselves in the awkward position of admitting less qualified students ($\leq$ 24 on the ACTM) into their pre-engineering programs. Students who fall into the at-risk category may possess a strong interest in mathematics, though they are under prepared. These students do not need to be summarily dismissed, for the potential for success may exist.

It is paramount that pre-engineering students complete a rigorous series of calculus classes; however, if essential prerequisite knowledge is missing, then the student faces a daunting challenge that could be overwhelming. The importance of a strong start during the freshman year has been established. A good practice among academicians is to place students in the appropriate mathematics course during the first semester and have them succeed, rather than place them in a class for which there is inadequate preparation and have them suffer immediate failure. Requiring this population of students to take mathematics classes to strengthen their prerequisite skills seems prudent. Even without the assistance of remedial mathematics courses, students can benefit from undertaking studies in college-level algebra, pre-calculus, and trigonometry prior to launching into calculus. In addition, group or individual tutoring can supplement the learning process for students who are under-prepared and required to take these prerequisite courses.

Further, it is evident that students are more likely to succeed if they hold a strong view of their academic ability. Academic self-concept and matters of self-efficacy have been the focus of other studies (House, 2000; Lent et al. 1984; Loftin, 1993), and this research reinforces the importance of students feeling well prepared to undertake pre-engineering studies. Students who lack confidence in their preparation and ability may depart from the program prematurely, at the first sign of having to cope with a challenging curriculum.

During freshman orientation it is not uncommon for students to be told that they are undertaking a difficult major and that they must be prepared to devote a significant amount of time to their studies. For many, that is all of the counsel that they receive about study habits though previous research (Blumner & Richards, 1997; Lackey et al. 2003), and the current study indicates its importance. At stake is the matter of devoting sufficient time and working efficiently. Students can devote a substantial amount of time to their studies, only to discover that they approached the problem from the wrong direction or completely missed the objective. Quantity needs to be stressed to entering freshmen, so that they have an appreciation for the demands; however, quality cannot be ignored. Instruction needs to be provided on how to manage one's study time and optimize the effort.

Finally, intrinsic motivation, a belief that one will be successful in engineering and that one possesses a willingness to work hard, contributes to persistence. The importance of these characteristics is they all point to the student's sense of motivation. The task of the engineering college is to provide the students with a clear picture of the discipline that they desire to enter. Many students may initially possess a sense of motivation but depart from pre-engineering because they perceive engineering to be a profession devoted to solving calculus and physics problems, with little real world application.

Recommendations for Further Research

The cost of college attendance is rising more rapidly than the rate of inflation. Many students who are admitted into pre-engineering programs quickly amass a large amount of debt and have nothing to show for it when they achieve poor grades and fail to advance into their desired major. Though neglected in many studies, this population constitutes a large portion of the pre-engineering enrollment, and institutions that collect their tuition after allowing them to matriculate need to have an understanding of their characteristics and explore ways in which these students may have a greater possibility to succeed.

The purpose of this study was to examine persistence of an at-risk freshman pre-engineering population, regardless of gender or ethnicity. Further studies need to be conducted to determine gender and ethnic differences that may exist for at-risk students who persist. In addition, many transfer students enter the program as pre-engineering students. Characteristics that enable them to persist may be quantifiably different from those of freshman students. Finally, this study was conducted on entering pre-engineering freshmen at a large public institution in the southeast. This study needs to be a replicated in other regions and within private institutions to determine how well it generalizes to other student populations.

The makeup of college students has changed considerably since the inception of studies on persistence, and further research on at-risk students needs to take into account some of the neglected demographics. Reason (2003) provided a review of recent research on student retention and examined newer developments in this field of inquiry. He concluded that more emphasis needed to be placed on changing demographics, student-level variables, and merit-index scores. To be pragmatic and useful to practitioners in higher education, research must, "include such variables as sexual orientation, student status (full- or part-time), commuter status, and work/family responsibility, along with the traditional age, gender, race, and ethnicity variables, for samples to be truly representative of the current student population" (p. 176). Much of the research on retention takes traditional demographics into account; however, a large portion of that information simply serves as control variables. The experience of racial groups is different and each one is affected differently by the variables under study. Therefore, Reason concluded that the experience of students of color and White students need to be examined separately. Further, a merit-index that Reason described holds promise for issues related to retention, but its effectiveness as an admissions instrument requires further study. In considering its application Reason found that:

> The merit-index quantifies the relationship between a student's score on an admissions exam, such as the ACT or SAT, and the average score for all college-bound students within the same school during the same test administration period. A merit-index score, therefore, gives students credit for exceeding the average (score) of their high school classmates. (p. 185)

It appears that the index, which allows for weighted consideration for students from high schools with traditionally low standardized test scores, may provide more equal access to college.

There is a large segment of the at-risk population that was not part of this study and it involves the 26% who departed from pre-engineering with a grade point average ≥ 2.2. While this study was concerned only with those who departed unsuccessful, much can be learned by looking at students who transferred to other programs of study with acceptable grades as a comparison group.

Further, an examination can be conducted on the at-risk population against their mathematics background. The ACTM is a good single measure of mathematics preparation; however, multiple measures such as the highest level of mathematics completed in high school can provide greater insight into issues of persistence in engineering.

A qualitative follow-up study would also be appropriate. Quantitatively, this study determined non-cognitive variables that were statistically significant among at-risk students who persisted into upper level engineering studies. There is added value in understanding students' perceptions as to that which aided them in persisting in their engineering program of study. Interviews can be conducted with this population to gain insight into their learning behavior and discover what they think and believe about their ability to succeed.

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