THE RELATIONSHIP OF LEARNING COMMUNITIES TO ENGINEERING STUDENTS' PERCEPTIONS OF THE FRESHMAN YEAR EXPERIENCE, ACADEMIC PERFORMANCE, AND PERSISTENCE

by

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ABSTRACT

PATRICIA ANN SEPAR TOLLEY. The relationship of learning communities to engineering students' perceptions of the freshman year experience, academic performance, and persistence. (Under the direction of DR. DAVID ROYSTER.)

The purpose of this correlational study was to examine the effects of a residential learning community and enrollment in an introductory engineering course to engineering students' perceptions of the freshman year experience, academic performance, and persistence. The sample included students enrolled in a large, urban, public, research university in the fall semesters of 2005-2007. Students' perceptions regarding their choice of major, sense of community, the learning environment, academic advising, and competencies required by the Accreditation Board for Engineering and Technology (2009) were operationalized using items from the College of Engineering annual student survey. Incoming characteristics of predicted grade index and level of parental education were incorporated into the study. Structural equation modeling was used to test the goodness-of-fit of the sample data to two hypothesized models that represented competing theories or conceptualizations of the freshman year experience. A hierarchical logistic regression was also conducted to predict re-enrollment in the College of Engineering in the second semester of the sophomore year.

Results indicated that neither learning community influenced students' perceptions of the freshman year experience or sophomore year retention despite historical data that consistently demonstrate the positive effect of the residential learning community on freshman year retention rates. Of the variables considered, only students' perceptions of the major had a moderate direct effect on both outcomes. Parental education level and academic performance were also significant predictors of persistence. Of particular interest was the finding that students whose parents had not earned a four-year college degree were more than twice as likely to persist in the College of Engineering than their peers who had a least one college-educated parent.

DEDICATION

To my wonderful husband, Les, who inspires me to be my best and do my best. He has been my rock and my earthly salvation during this process.

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LIST OF ABBREVIATIONS

ABET a-k	11 Competencies Specified by the Accreditation Board for Engineering and Technology (2009) that Engineering Programs Must Demonstrate that Students Can Attain
ADVAVAIL	Indicator for ADVAIL: Students' Perceptions of Advisor Availability
ADVISE	Construct Label for Students' Perceptions of Advising
CFA	Confirmatory Factor Analysis
COECOMM	Indicator for COMM: Students' Feeling Part of the College of Engineering Community
COMFGUID	Indicator for COMM: Students' Level of Comfort in Seeking Guidance from a Faculty or Staff member
COMM	Construct Label for Students' Sense of Community
COMPDEG	Indicator for MAJOR: Students' Confidence in Their Ability to Complete Their Degree
CONFMAJO	Indicator for MAJOR: Students' Confidence in Choice of Major
CUMGPA	Cumulative GPA at the End of the Freshman Year
DFW	Final Grade of D or F or Withdrawal (W) from a Course
E	Error Term
ENGR1201	ENGR1201: Introduction to Engineering Course
ENVIRON	Construct Label for Students' Perceptions of the Learning Environment
EV	Error Variance
FLC	Freshman Learning Community
FRIENDLY	Indicator for ENVIRON: Students' Perceptions of the Learning Environment as Friendly
GPA	Grade Point Average
HS GPA	High School Grade Point Average
INFOCAR	Indicator for ADVAIL: Students' Perceptions Regarding Information for Career Development

INFOREG	Indicator for ADVAIL: Students' Perceptions Regarding Information for Registration
LEARN	Construct Label for Students' Perceptions of ABET a-k Competencies
LMT	Lagrange Multiplier Test
LVPA	Latent Variable Path Analysis
MAJOR	Construct Label for Students' Perceptions of Choice of Major
MAJORWOR	Indicator for MAJOR: Students' Perceptions that Major is Worth the Time and Effort
MAPS	Maximizing Academic and Profession Success Program
ML	Maximum Likelihood Method of Estimation
NONDISC	Indicator for ENVIRON: Students' Perception that the Learning Environment as Non-Discriminatory
NOTEXPDI	Indicator for ENVIRON: Students Have Not Experienced Discrimination
NOTWITDI	Indicator for ENVIRON: Students Have Not Witnessed Discrimination
PEL	Parental Education Level
PERSIST	Persistence as Measured by Re-enrollment in the Second Semester of the Sophomore Year
PGI	Predicted Grade Index
QUALED	Indicator for MAJOR: Students' Belief that the Quality of Their Education Makes Them Competitive in the Job Market
RECCOE	Indicator for COMM: Students' Recommendation of the College to Family and Friends
SAFE	Indicator for ENVIRON: Students' Perceptions of the Learning Environment as Safe
SATADV	Indicator for ADVAIL: Students' Overall Satisfaction with Advising
SB	Satorra-Bentler Scaling
SEM	Structural Equation Modeling
TRANSEAS	Indicator for COMM: Students' Perceptions of their Ease of Transition into the College

CHAPTER 1: INTRODUCTION

Statement of the Problem

Recruitment and retention of engineering students have escalated to a national crisis (BEST, n.d.). Dr. Rita Colwell, Director of the National Science Foundation (2002), testified before Congress that "[w]e must attract more of our youngsters, especially minorities and women, to pursue careers in science, mathematics, technology, and engineering. We must draw on our full talent pool." Nationally, only about half of all freshmen who start out in the major graduate with an engineering degree (Astin & Astin, 1992; Seymour & Hewitt, 1997; Zhang, Anderson, Ohland, & Thorndyke, 2004). According to the American Society of Engineering Education (Gibbons, n.d.) in 2006-2007 only 18% of the engineering bachelor degrees were awarded to females, which was the lowest percentage since 1996, and only 11% were earned by African American and Hispanic students combined.

Seminal research conducted by Astin (1993) revealed that: (1) Lack of community and majoring in engineering adversely affected students' overall satisfaction with college, (2) academic performance was negatively correlated with majoring in engineering, and (3) the single most influential factor in college student development was the peer group. Seymour and Hewitt (1997) also reported that women and minority students majoring in science, mathematics, engineering, and technology were less likely to feel part of the college community and were more at risk of changing majors or dropping out than their white male peers. There is also evidence that students are also at risk if neither parent earned a college degree (Pascarella, Pierson, Wolniak, & Terenzini, 2004; Pike & Kuh, 2005).

The freshman college experience provides rich opportunities for learning and development as students navigate the transition from teen-ager to young adult, dependence to independence, and career exploration to preparation. The greatest opportunities for learning and the greatest risk for attrition occur as students separate from family, incorporate into college life, and adjust to their new life emotionally, socially, and academically (Tinto, 1987, 1990; Tinto & Goodsell, 1993).

Tinto (1996) identified seven major causes of student attrition: academic difficulty; adjustment difficulty; uncertain, narrow, or new goals; weak and external commitments; financial inadequacies; lack of social or academic congruence between the individual and the institution; and isolation. He suggested that institutional efforts to retain students must focus on integrating their academic experience with their social experience. This is especially important during the first four to six weeks of college, which is a period of vulnerability and adjustment, when students' experiences can influence their decisions about whether to stay or leave. Students who successfully complete the first semester of college are more likely to return their second semester (Elkins, Braxton, & James, 2000).

Tinto (1990) also identified three principles that are hallmarks of effective retention programs: community, commitment, and education. From the outset students are integrated into social and academic communities. Student-student and student-faculty interactions in and out of the classroom are critical elements for enhancing community. Students are provided opportunities to acquire the knowledge and skills necessary for success within their communities. Effective retention programs also demonstrate their commitment to students by proactively striving to enhance their welfare rather than focusing on institutional interests only. Finally, student-centered institutions are committed to the intellectual and social growth of students; that is, they are committed to their education and not just retention.

The learning environment. A supportive learning environment can greatly influence a student's ability to adapt and succeed especially during the period of transition and vulnerability that is characteristic of the freshman college experience (Bandura, 1995; Brown, Lent, Alpert, Hunt, & Brady, 1988; Hackett, Betz, Casas, & Rocha-Singh, 1992; Lent, et al., 2003). A study conducted by Cabrera, Nora, and Castaneda (1993), for example, revealed that environmental factors significantly influenced how well students integrated socially and academically into their new community.

Amenkhienan and Kogan (2004) interviewed 34 sophomore engineering students to investigate their use and perceptions of academic activities and support services. Homogeneous groups based on gender, ethnicity, and grade point average (GPA) were purposefully created so that participants would feel comfortable sharing their experiences and perceptions among their peers. Three common themes emerged from the study. They found that freshman year academic performance was positively impacted by personal effort and involvement, peer interactions, and faculty contacts.

Zhang, Anderson, Ohland, and Thorndyke (2004) conducted a study under the auspices of the National Science Foundation that involved nine engineering institutions, including two historically black universities and one that is the site for the study reported here. They investigated the relationship between graduation and six pre-college factors: ethnicity, gender, high school GPA, SAT math score, SAT verbal score, and citizenship status. Only 15% of the students who started in engineering graduated within the major four years later. Approximately half of the students graduated within the major after six years. Overall, the six predictors were significant; however, which predictors were significant, the strength of their unique contributions to the model, and the overall variance accounted for by the combination of predictors was dependent upon the institution. The authors concluded their study by remarking that "[i]n trying to predict student success, there is certainly an upper limit on how much of the variation can be predicted from pre-existing factors…the choices student make *after matriculation* affect student success significantly” (p. 319). The phrase in italics is included in the original quote.

A study commissioned by the National Science Foundation and the Alfred P. Sloan Foundation (Goodman Research Group, 2002) found that female engineering majors needed to feel part of a caring learning community. Their self-confidence was enhanced when they perceived their environment as supportive. One-third of the females who left engineering said that a competitive environment, lack of support, and discouragement by faculty and peers contributed to their decision. Having an advisor who took the time to get to know them was an influential factor in many females’ decision to remain in the major. Although participants were generally less confident in their engineering abilities than their male peers, the academic performance of females who left engineering was comparable to their male peers who remained in the major.

Self-efficacy appraisals, attitudes, and perceptions. The ability to successfully adjust to the emotional, cognitive, and social challenges of living on one’s own for the first time, developing new friends and support networks, examining personal values and beliefs, exploring various career options, choosing and succeeding in a major, and selecting an occupation is also dependent on robust self-efficacy (Bandura, 1986, 1989; Betz & Hackett, 1981, 1987; Brown, Lent, & Larkin, 1989; Hackett, 1995; Hackett, Betz, Casas, & Rocha-Singh, 1992; Lent, Brown, & Larkin, 1986, 1987; Lent, et al., 2003; Multon, Brown, & Lent, 1991; Nauta & Epperson, 2003; Zimmerman, 1995). Bandura (1986) operationalizes self-efficacy as beliefs about one’s ability to organize and execute courses of action to achieve specific outcomes.

The rigor of an engineering curriculum is an additional stressor that affects the self-efficacy and persistence of college students, particularly for female and minority students (Goodman Research Group, 2002; Hackett, 1995; Seymour & Hewitt, 1997). Socially efficacious individuals seek out and engage in peer networks and are more resilient when faced with obstacles (Bandura, 1977a, 1977b, 1986). However, the engineering learning environment is traditionally dominated by white males. The lack of role models for female and minority students can adversely impact academic, social, and career self-efficacy appraisals. Similarly, self-efficacy appraisals of students whose parents do not have a college degree may also be compromised if they do not have other role models who can guide and help motivate them.

Studies have demonstrated that self-efficacy influences students' choice of college major and is malleable during the freshman year transition. Betz and Hackett (1983), for example, found that mathematics self-efficacy expectations were an important factor in students' choice of science-based majors in college. They also found that the mathematics self-efficacy of college females was consistently and significantly weaker than their male peers. Another study by Nauta and Epperson (2003) longitudinally tracked academically talented high school girls. Their results also suggested that high school science and math self-efficacies do not necessarily translate to college self-efficacies.

Lent, et al. (2005) examined the relationships between self-efficacy appraisals and gender and type of institution. Students were enrolled in an introductory engineering course at three universities, two of which were historically black institutions. The study revealed significant relationships between self-efficacy and gender and self-efficacy and type of institution. Self-efficacy appraisals were also found to be indirectly related to social supports and barriers. These results substantiated an earlier study (Williams & Leonard, 1988) that found that self-efficacy was a significant factor in the academic performance and progress of black students majoring in computer science and engineering.

In a more recent study (Vogt, Hocevar, & Hagedorn, 2007), the success of 713 engineering students was investigated to identify factors that influenced gender-based differences in academic performance. Although the study found no significant gender differences relative to GPA, females had lower levels of academic self-confidence, self-efficacy, and critical thinking than their male peers. They also had greater levels of perceived discrimination, effort, and help-seeking. Consistent with previous studies, self-efficacy was the strongest correlate of GPA followed by academic confidence. However, the study did not support previous research that suggested that females are at an academic disadvantage in engineering. Rather, the findings made a convincing case for enhancing the self-efficacy of all students as a means of influencing academic self-regulation and achievement.

The ability to self-regulate behaviors and exercise some control over the environment are also critical factors in developing strong social, academic, and career self-efficacies (Flammer, 1995). For example, Zimmerman (1995) and Zimmerman, Bandura, and Martinez-Pons (1992) found that students with strong academic self-efficacy were more motivated, exerted more effort, and persisted longer when faced with learning challenges.

The empirical literature is replete with evidence substantiating the relationship between self-efficacy and the learning environment, self-efficacy and academic performance, and self-efficacy and persistence. Strong self-efficacy appraisals have been shown to mediate the effects of prior academic performance, stress, gender, ethnicity, and environmental supports and barriers. Several studies (see for example, Hackett, Betz, Casas, and Rocha-Singh, 1992; Lent, Brown, and Larkin, 1986, 1987; Lent, et al., 2003) have specifically demonstrated the effect of self-efficacy on the academic performance and persistence of engineering majors.

Engineering students' attitudes and perceptions can also influence their persistence. Besterfield-Sacre, Atman, and Shulman (1997) conducted a study at a large, urban, public research university to determine the characteristics of freshmen who remained in the major versus those who left. Their results indicated significant attitude differences between the groups. Students who left engineering in good academic standing had lower general impressions of the profession and less confidence in their math, science, and engineering skills.

Engineering competencies. While recruitment and retention of freshmen are high priorities for colleges of engineering, so is achievement of learning outcomes. The Accreditation

Board for Engineering and Technology (2009) requires that engineering programs must demonstrate that students attain 11 outcomes related to technical and non-technical competencies, hereafter referred to as ABET a-k competencies:

a) an ability to apply knowledge of mathematics, science, and engineering
b) an ability to design and conduct experiments, as well as to analyze and interpret data
c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
d) an ability to function on multi-disciplinary teams
e) an ability to identify, formulate, and solve engineering problems
f) an understanding of professional and ethical responsibility
g) an ability to communicate effectively
h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
i) a recognition of the need for, and an ability to engage in life-long learning
j) a knowledge of contemporary issues
k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

Ideally, students have sufficient opportunities to practice these skills with progressive standards of performance until graduation to ensure proficiency in all 11 competencies. Formative and summative assessment and evidence of data-driven curriculum improvements are required as part of the ABET (2009) accreditation process.

The traditional freshman engineering curriculum offers a rather narrow and disaggregated view of the profession. It is composed of a seemingly disparate collection of mathematics, science, engineering, and general education courses. The lack of an integrated curriculum makes it difficult for most students to synthesize their new knowledge in a manner that gives them an appreciation of what engineers do and the competencies necessary to actually practice engineering. The rigor of calculus, chemistry, physics, and engineering courses also challenges their academic and career self-efficacies and, therefore, their level of commitment to the major. Even the best and brightest high school students often find that the engineering curriculum is more academically demanding than they expected.

Bandura (1986) suggested that individuals are more motivated to take action when they value proximal goals rather than distal goals. The prospect of opportunities afforded by an engineering degree is far removed from the daily life of most freshmen. Students are typically too focused on adjusting to their new life to be motivated by an obscure goal that is four or more years away. Instead, their motivation to persist is greatly influenced by their perceptions of the curriculum, profession, and the learning environment, including their social network which often includes non-engineering peers, and beliefs about their ability to succeed academically and professionally. It is not surprising that many students ultimately decide that an engineering degree is not worth the time and effort or they find that they cannot maintain the rigorous academic standards required to stay in the major.

Learning communities as an intervention. Many institutions have implemented various types of learning communities as a strategy for enhancing students' sense of community, promoting a positive freshman year experience, and improving academic performance and retention (Browne & Minnick, 2005; James, Bruch, & Jehangir, 2006; Johnson & Romanoff, 1999; Moller, Huett, Holder, Young, Harvey, & Godshalk, 2005; Pike, 1997; Pike, Schroeder, & Berry, 1997; Tinto, 2000; Zhao & Kuh, 2004). These include but are not limited to residential, non-residential, major-specific, course-linked, distance, and special interest groups. Information about different types of learning communities is readily available on websites such as the National Study of Living-Learning Programs (2006), the Learning Communities National

Resource Center (n.d.), and the Residential Learning Communities International Clearinghouse (2006). Many colleges and universities also have information about their learning communities posted on their websites.

Living on campus can improve freshman students' chances of being retained (Astin, 1997). Resident students are more likely to be socially and academically integrated and are significantly more satisfied and committed than commuter students; however, they may also possess pre-college characteristics that predispose them to higher levels of persistence (Pascarella & Terenzini, 1991, 2005; Schroeder & Mable, 1994).

Pike and Kuh (2005) found that students whose parents did not have a college degree tended to be less engaged and integrated with the campus experience in part because they often lived off-campus. They also found that living on campus had a direct, positive effect on the learning outcomes of students independent of whether their parents were college educated.

Pike (1997) investigated the impact of freshman residential learning communities on students' college experience and learning outcomes. He compared three different types of learning communities to traditional residence halls: (1) a four-year residential community that included on-site courses, block scheduling, and academic and co-curricular experiences such as mastery workshops and service learning projects; (2) four-year theme-related floors in residence halls, for example female engineering students; and (3) Freshman Interest Groups (FIGs) composed of about 20 students who lived on the same floor of a residence hall, took common courses including a freshman seminar, and were mentored and advised by academically successful juniors and seniors. He found that students in residential learning communities had higher levels of involvement, interaction, integration, learning, and intellectual development than students in traditional residence halls. Participation in learning communities directly affected students' involvement and interaction, thereby influencing their daily college experience. It also indirectly affected their integration of information and learning gains, thus helping to synthesize experiences and learning outcomes. He suggested that the intellectual content of students' interactions with faculty and peers and their involvement with the residence hall, clubs, and organizations contributed to their learning.

Pike, Schroeder, and Berry (1997) also investigated the relationship between residential learning communities and freshman year experiences and persistence. Two groups of students were compared: students living in traditional residence halls and students who self-selected to live in residence halls designed as FIGs. They found that the factors that influenced the academic achievement of FIG and non-FIG participants were the same in terms of type, significance, strength, and direction. Academic achievement was positively and directly associated with entering ability and academic integration. Persistence was positively and directly associated with academic achievement. However, after controlling for background variables he found that learning communities did not have a direct influence on the persistence of either group.

Tinto (2000) conducted a study under the auspices of the National Center for Teaching, Learning, and Assessment to evaluate the efficacy of learning communities. He found that students who participated in learning communities spent more time together, were more likely to be active learners both in and out of class, achieved higher levels of learning, and were more likely to be retained because they were engaged academically and socially. However, he cautioned that systematic institutional assessment was needed to more fully and carefully evaluate the impact of learning communities.

Edwards and McKelfresh (2002) found that participation in a living-learning community had a positive impact on students' academic success and persistence. Although the program did not significantly impact the GPA of female participants, the academic performance of male participants increased to the same level as that of the females. The program also eliminated an ethnicity gap. The persistence of non-white students was raised to a level that was higher than that for white students.

Stassen (2003) compared students who participated in learning communities with students who did not participate but who also lived on campus. He found that students who participated in a residential learning community or a learning community dedicated to specific majors performed better academically than their peers who did not participate, even after controlling for incoming characteristics such as high school GPA, SAT scores, and ethnicity. The study also revealed significant differences between learning community participants and non-participants relative to peer interactions, perceptions of the learning environment, and academic behaviors.

Zhao and Kuh (2004) examined the impact of learning communities on students' academic performance, engagement in a variety of educationally purposeful activities, and learning outcomes. Results of the National Survey of Student Engagement (2007) were used to explore the relationship between learning communities and freshman and senior success. They defined student success as enhanced academic performance, integration of academic and social experiences, positive perceptions of the college experience, and self-reported gains since starting college. They found that students who participated in learning communities performed better academically, were more engaged in purposeful educational activities, persisted longer, and were more satisfied with their college experience. The effect of learning communities was substantial and was stronger for freshmen than for seniors. They also found that minority students, members of fraternities and sororities, students in pre-professional majors, freshmen from families with lower levels of parental education, and students living on campus were more likely to participate in learning communities.

Helman (1999) conducted a study for a doctoral dissertation to determine if elements of a freshman residential learning community could predict fall semester GPA and academic and social adjustment to college. The sample included 174 freshman science and engineering majors at a large, urban, public university during the fall of 1997. Students were required to enroll in a one credit hour seminar course that was designed to introduce them to campus resources, help them develop academic success strategies, and introduce them to their major. They were also required to participate in extra-curricular activities as part of the seminar course. Students' adjustment was measured using items from three surveys, one of which was specifically developed for the study. One limitation of the study was the lack of a comparison group. Students who participated in the residential learning community were not compared to non-participants. Also, the engineering majors who participated in the study were participants in another study. Details of the relationship between the two studies were not disclosed so it is not clear what precautions were taken, if any, to minimize confounding variables. The "most interesting" (Helman, 1999, p. 103) finding was that none of the components of the residential learning community were significant predictors of academic adjustment.

Purpose and Research Questions

A correlational study was conducted to investigate the relationship of a residential learning community and enrollment in an introductory engineering course to engineering students' perceptions of the freshman year experience, academic performance, and persistence. The sample included 316 students enrolled in a large, urban, public, research university in the fall semesters of 2005-2007.

Educational, psychological, and anthropological theories provided a comprehensive framework for the investigation and guided the development of two structural models that represented competing theories or conceptualizations of the freshman year experience. A hierarchical logistic regression was also conducted to predict re-enrollment in the College of Engineering in the second semester of the sophomore year. The models incorporated a curricular learning community, ENGR1201: Introduction to Engineering, which is a required course that students take in their first semester of college, and an extra-curricular residential freshman learning community (FLC) which has previously demonstrated a positive impact on one-year retention rates. The models were tested to answer the following research questions:

1. Does parental education level explain students' participation in the FLC and/or their enrollment in ENGR1201?
2. Does predicted grade index (PGI) explain students' participation in the FLC and/or enrollment in ENGR1201?
3. How does participation in these curricular and extra-curricular learning communities influence students' perceptions of the freshman year experience?
4. How do students' perceptions influence their academic performance and persistence in the major?

Students' perceptions regarding their choice of major, sense of community, the learning environment, academic advising, and ABET a-k competencies were operationalized using items from the college's annual student survey, which was conducted during the spring semesters of 2006-2008. Incoming characteristics of PGI and parental education level, i.e. whether at least one parent earned a four-year college degree, were incorporated into the study. Academic performance was measured by cumulative GPA at the end of the spring semester of the freshman year. Persistence was measured as re-enrollment in a College of Engineering major in the second semester of the sophomore year. Although probationary students often re-enroll in the first semester of the sophomore year, many of them change majors or leave the university prior to the second semester of the sophomore year.

Significance of the Study

The paucity of empirical research related to *engineering* residential learning communities begs for additional research. Typically, the communities discussed in the literature involved small groups of students who were co-enrolled in classes and/or who lived together. Participation was usually restricted to specific demographic groups such as female or minority students. The findings from the empirical literature also offer mixed results regarding the impact of learning communities on students' learning, academic performance, and persistence. As a result, Talburt and Boyles (2005) challenged their perceived merits given the investment of resources that they require.

An extensive review of the literature found no evidence of previous investigations relating curricular and extra-curricular learning communities specific to engineering, i.e. a required introductory engineering course and a residential learning community, respectively, to students' perceptions of the freshman year experience, academic performance, and persistence. In addition, none of the learning community studies incorporated the ABET a-k competencies.

Most of the studies found in the literature employed traditional univariate and multivariate statistical techniques and few reported effect sizes. The American Educational Research Association (2006) recommends reporting effect sizes in addition to statistical significance testing to enhance interpretation of results. Structural modeling techniques are needed to more comprehensively examine the direct and indirect effects of students' academic and social engagement and their perceptions of the freshman year experience on their academic performance. Structural techniques also allow both observed and latent variables to be modeled and they account for measurement error, neither of which is possible with traditional univariate and multivariate analyses.

State-supported institutions of higher education are increasingly being held accountable for improving learning outcomes and achieving retention and time-to-graduation goals with limited resources. Institutional funding is usually based on enrollment growth which means that the retention of freshmen is a critical strategy for growing colleges of engineering and for meeting the demand for qualified graduates who can contribute to the economic growth of a region, state, and the nation.

While there is no doubt that the need to justify the cost/benefit of retention programs is certainly externally driven, the need to discover what works and what does not in terms of structuring an environment that is conducive to learning is paramount. This is particularly true in majors such as engineering that are plagued by high attrition rates and under-representation of female and minority students.

Summary

The purpose of this study was to investigate the relationship of a residential learning community and enrollment in an introductory engineering course to engineering students' perceptions of the freshman year experience, academic performance, and persistence. Chapter 2 provides the theoretical framework for the study based on a review of the literature. Chapters 3 and 4 describe the methodology and statistical results, respectively. A discussion of the findings, implications for practice, and suggestions for future research are presented in Chapter 5.

CHAPTER 2: LITERATURE REVIEW

Educational, psychological, and anthropological theories strongly support the notion that learner and learning environment are inextricably and dialectically bound in a mutually influential relationship. Learners exhibit behaviors that reflect who they are, what they believe, where they come from, and where they are going. They engage in the learning process or opt out of it based on personal meaning–both in terms of what they bring to the experience and by what they get from it. The didactics of education, especially engineering education given its challenges in recruiting and retaining students, is a delicate balance of epistemology and phenomenology with an appreciation of the ontogenetic and phylogenic factors that influence cognitive development.

The first year of college is an exciting period of transition that is also characterized by ambiguity and anxiety as students adjust to leaving family, friends, and community and integrate into their new academic and social environments. The theoretical framework for investigating the relationship of a residential learning community and an introductory freshman engineering course on students' perceptions, academic performance, and persistence offers a constructivist epistemology that provides valuable insights regarding the role of the environment on cognition, emotional and social adjustment, selection of college major, and commitment to choice of career.

Dewey's experience theory serves as the foundation for understanding how a student's internal needs and prior experiences influence perceptions regarding the value of learning experiences and decisions to participate in them. Cognitive theories propounded by Piaget and Vygotsky provide the context for examining how the social environment stimulates meta-cognition. Bandura's theory of social learning and Schunk's theory of self-regulatory competence, including his concept of social-self interaction, provide a broader socio-cultural perspective.

Their theories offer insights into how individuals are influenced by and respond to their environment and the resultant effect on learning and development. Finally, Mezirow's theory of transformative learning and Turner's anthropological theory of liminality examine the complexities associated with periods of transition and adjustment that precede transformation, such as the freshman college experience. Collectively, these theories provide a powerful framework for understanding the factors that influence freshman engineering students' attitudes, behaviors, and intellectual growth.

Dewey's Theory of Experience

According to John Dewey (1938; Archambault, 1964), the great American philosopher, pragmatist, and educator, education is the fundamental means by which a society progresses and reforms. The purpose of education is to successfully prepare each individual to participate in and contribute to society. Therefore, learning experiences must integrate the personal needs and life experiences of the individual and, because schools are social institutions, they must also reflect life outside of the classroom. Students who find such experiences conducive manage to learn; those who do not merely get by as best as they can (Dewey, 1938).

Dewey's (1938; Archambault, 1964) philosophy of education includes a theory of experience based on two principles, continuity and interaction. The principle of continuity posits that past experience influences present experience, individuals are transformed by their present experience, and present experience modifies the type and quality of future experience. This seamless connection between past, present, and future suggests that intellectual, physical, and moral growth resulting from each experience should be educative in function and force because there are no neutral experiences. The quality of the present experience either promotes or limits future growth and development of the individual.

By its very nature, the human experience is a social one. Dewey's (1938) principle of interaction suggests that internal conditions, such as the individual's needs and capacities, and the external environment interact to create a learning experience. An individual interprets and evaluates the value of a learning experience based on whether it satisfies an internal need or if the subject or methods are congruent with personal interests or capacities.

The combination of continuity and interaction describe what Dewey (1938) referred to as the "longitudinal and lateral aspects of experience" (p. 44) in that successive experiences either expand or contract an individual's world. The impact of an educative experience is the result of the union of the principles of continuity and interaction.

Thus, learners' previous knowledge and experiences inextricably shape their perceptions regarding the value of a learning situation and also influence their decision to engage in it. Each learning situation either moves the student toward or away from the learning goal thereby influencing choices about participation in future learning experiences.

Dewey's philosophy of education in general, and his principles of continuity and interaction in particular provide a pedagogical foundation for structuring learning environments: Curricular and extra-curricular educational experiences must be complimentary and student-centered. This approach is especially relevant in an academically demanding curriculum such as engineering. Freshmen generally find it difficult to synthesize content learned in their English, humanities, chemistry, physics, and mathematics courses within the context of their expectations of the engineering curriculum, perceptions of the profession, and their everyday life. Many students, particularly female and minority students and students whose parents do not have a college education, may not have been exposed to the engineering profession or engineering role models prior to college. They may lack a supportive family or peer network for their choice of college major. In addition, female and minority students may negatively perceive and be adversely influenced by the predominantly white male learning environment that is characteristic of engineering (Seymour & Hewitt, 1997).

Dewey's experience theory was propounded in the early part of the twentieth century and continues to influence education today. It was a powerful precursor to the constructivist philosophy that dominated cognitive and social psychology in the middle and latter part of the twentieth century. Constructivist epistemologies, such as those propounded by Piaget and Vygotsky, expanded Dewey's educational theory of experience by offering a cognitive perspective of how the learner's interaction with the environment facilitates meta-cognition and growth.

Piaget's Theory of Cognitive Development

Piaget's (1961; Gallagher, 1981) epistemology suggests that learning occurs through processes of maturation, physical experience, social interaction, and equilibration. Learning is predicated on cognitive development and occurs when individuals reflect upon their interactions with the world and then reorganize knowledge on a higher mental level through a process of abstraction.

Learning occurs through a two-stage process of abstraction. Knowledge that is acquired in the first stage, empirical abstraction, is extracted from the environment via sensory-motor input. Exogenous characteristics, such as texture, color, size, and shape, are learned through observation and interaction. The second stage, reflexive abstraction, is a process in which learners reorganize or reconstruct an experience or mental operation from a lower cognitive level, representative of knowledge acquisition, to a higher cognitive level that is manifested as understanding and transformation, such as when learners can classify, structuralize, form relationships, and associate causality. Individuals may not be consciously aware of their thought processes during reflexive abstraction.

Assimilation occurs when experiential data are easily incorporated into existing mental schemata. In some cases, new information may not be congruent with existing schemata and, therefore, may not easily assimilate. Learners may attempt to modify their mental schemata in an effort to compensate for the incongruence so that new information can comfortably be accommodated. Sometimes a problem causes a cognitive conflict or contradiction that is so strong that it cannot be accommodated. The resultant disequilibrium provokes the learner to identify new strategies or acquire new knowledge in an attempt to re-equilibrate. It is for this reason that Piaget (1961; Gallagher, 1981) contends that disequilibrium is a necessary prerequisite for development and ultimately for learning.

Piaget's epistemology emphasizes the individual's developmental stage and thought processes, whether conscious or unconscious, rather than physical experiences and social interactions as the primary mechanisms for facilitating cognitive growth. Despite Piaget's focus on individual reflection and meta-cognition, he recognized that the environment is a catalyst for cognitive disequilibrium and re-equilibration and, therefore, it is an important element in the learning process.

Vygotsky's Activity Theory

The premise of Vygotsky's (1978, 1927/1997; Kozulin, 1990) activity theory is that all learning is a function of socially mediated activities, which facilitate higher-level mental processes. Tools, symbols, or other humans may serve as conscious or unconscious mediators. A two-stage process occurs in which the learner first engages in an interpersonal experience and then an intrapersonal internalization occurs. As the learner reflects upon social experiences, external actions are internalized and create an inner dialogue that facilitates learning. While Piaget believed that learning is subordinate to development, Vygotsky believed just the opposite.

Vygotsky's concept of the Zone of Proximal Development (ZPD) was originally intended to integrate formal classroom instruction within a socio-cognitive phenomenology (Kozulin, 1990). Classroom instruction is characteristically theoretical, de-contextualized, and hierarchically and logically structured. In comparison, everyday concepts are related to learners' daily personal experiences. They are practical, concrete, highly contextualized, and are often spontaneous and unstructured. Learning is enhanced when classroom concepts are contextualized within the learner’s everyday world (Kozulin, 1990). Vygotsky’s original concept of the ZPD represented the potential that exists between classroom knowledge acquired under the auspices of an adult and everyday knowledge learned as a result of personal daily experiences.

Western psychologists enthusiastically embraced Vygotsky’s original concept of ZPD; however, they also took the liberty of broadening it (Kozulin, 1990). Now it is operationally used to describe the learning potential that exists between the learner’s independent activities and activities that are facilitated by an adult or more advanced peer. A problem that is within the learner’s scope of current knowledge and skill level is within the Zone of Current Development (ZCD). A problem that is outside the learner’s scope of current knowledge and skill level is within the ZPD. The ZPD represents the gap between learning achieved through individual problem-solving and learning that is possible when engaged in problem-solving with teachers or more advanced peers.

Harland (2003) suggested that Vygotsky’s concept of scaffolding is an effective strategy in facilitating problem solving. Scaffolding is a metaphor for the level of support provided to learners as they move through the ZPD. Initially, this level of support is high but as learners move through the ZPD, it is less intensive until eventually it is no longer needed. As learners assume more responsibility for their own work and their own learning, the role of the tutor is less critical. As the learner progresses to the next ZPD, the tutor is again needed to provide a new scaffolding structure of support. This cycling of support continues into progressive stages of ZPD.

The Piagetian and Vygotskian epistemologies are different despite the fact that both consider some of the same cognitive and social influences. The significant difference exists in the primary mechanism for generating meta-cognition. Vygotsky’s theory suggests that socially mediated activities generate higher mental processes. In contrast, Piaget’s theory of cognitive development proposes that learning occurs when individuals reflect on their interactions with the environment and then project and reorganize on a higher mental state. Despite their differences, both theorists recognized the fundamental role that the environment has on learning and development. Their theories concurrently dominated psychological research and educational discourse in the 1950’s and 1960’s and set the stage for Bandura’s social learning theory in the 1970’s.

Bandura’s Social Learning Theory

Albert Bandura's (1977a, 1977b, 1986, 1989, 1995, 2001, 2002) psychological theory of social learning is considered fundamental to understanding human development. It is based on the triadic reciprocity among behaviors, environment, and personal factors. The focal point of the theory is the construct of self-efficacy, which is central to behavioral agency. Betz and Hackett (1987) describe agency as the tendency of an individual to proactively affect rather than respond to his or her environment.

Bandura (1986) operationalizes self-efficacy as beliefs about one's ability to organize and execute courses of action to achieve specific outcomes. He suggests that competency is a function of skills and self-efficacy; however, he is careful to differentiate between beliefs about skills and beliefs about the ability to *use* skills. For example, a student may be confident in his or her ability to do mathematics but may not possess the self-efficacy necessary to successfully complete an engineering degree. Self-confidence influences self-efficacy appraisals. Bandura also distinguishes between self-efficacy and outcome expectations although the two concepts are certainly related. Outcome expectations refer to an individual's beliefs about consequences associated with the successful completion of a course of action. Individuals are motivated to take action when they value goals and expected outcomes. This is particularly true for proximal rather than distal goals. Their level of motivation is a function of self-efficacy which includes how much stress or depression they are willing to endure, the coping strategies they execute, their level of self-confidence, their persistence in the face of adversity, and the resiliency with which they recover from setbacks. Self-efficacious individuals are more motivated, set more challenging goals, exert more effort, persist longer, are more resilient, visualize success, think positively, and experience less stress and anxiety than inefficacious individuals (Bandura, 1986). When self-efficacious individuals set goals and fail they tend to attribute their performance to extrinsic factors, such as the goal was set too high.

In contrast, inefficacious individuals avoid challenging goals (Bandura, 1986). When they do pursue goals, their level of commitment and effort is dependent on a myriad of factors, many of which they perceive as threatening or outside of their locus of control. They approach goals with apprehension and anxiety, conjure failure scenarios, worry about real or perceived problems, have difficulty overcoming obstacles and recovering from setbacks, and ultimately lower or abandon their goals. They attribute poor performance to intrinsic factors such as lack of ability. Self-efficacious individuals may value a goal, be motivated to achieve it, and possess the requisite skills necessary for success but may choose not to pursue it if they lack incentives, operate in an unsupportive environment, or experience detrimental physiological states such as fear, anxiety, stress, fatigue, or pain.

Bandura (1977a, 1977b, 1986, 1989, 1995, 2001, 2002) identified four sources of self-efficacy that integrate personal, proxy, and collective agencies within a socio-cultural context: mastery experiences, vicarious experiences or modeling, verbal persuasion and other social influences, and physiological states. Vicarious experiences are essential for learning because they are an important mechanism for diffusing new ideas and behaviors. Social interactions and interdependence, model or group efficacy, and shared knowledge and skills influence individual and collective motivation, persistence, morale, and performance. Individuals make judgments about their efficacy based on personal past experiences and performance and the experiences and performance of others. Self-efficacy appraisals are enhanced when models possess characteristics similar to the observer, for example gender, ethnicity, or socio-economic status; models demonstrate competencies which the observer wishes to develop; and one observes others succeed, especially when coping strategies are used to overcome adversity. Conversely, self-efficacy is diminished by observing others fail. The impact of vicarious experiences and other social influences is a function of the level of credibility and value assigned by the observer.

Socio-cultural contexts afford or preclude the development of specific values, knowledge, interests, and competencies regardless of whether they are self-selected, imposed by others, or the result of a fortuitous circumstance (Bandura, 1986). Although each environment offers different opportunities to learn, learning is mediated by personal factors such as self-efficacy, emotional ties, and outcome expectations. The ability to self-regulate behaviors, select an environment, and exercise some control over the environment are critical factors in developing strong self-efficacy and learning (Bandura, 1986; Flammer, 1995).

Schunk's Theories of Self-Regulatory Competence and Social-Self Interaction

Schunk (1989, 1991, 1999) contends that although there is strong theoretical and empirical support for the idea that the social environment affects learning, much of the research has traditionally focused on the one-way effects of the environment on learning rather than the interactive reciprocity between learner and environment. He suggests that this reciprocity is fundamental for sustainable, long-term social-to-self transformations that facilitate knowledge transfer and behavior change. Individuals must internalize what they learn from their environment in order to be transformed by it. He operationalizes internalization as "under the learner's self-regulatory control" (p. 219). Schunk and Zimmerman (1997) described internationalization as "a process whereby individuals transform regulation by external events into regulation by internal factors" (p. 201).

Bandura's concept of triadic reciprocity is inherent in Schunk's four levels of self-regulatory competence (Schunk, 1999; Schunk & Zimmerman, 1997). The first two levels, observational and emulative, are a function of *social* influences, especially vicarious learning or modeling. The latter two levels, self-controlled and self-regulated, are primarily a function of *self* influences.

At the observational level, students acquire new knowledge but they typically cannot perform. Emulation occurs when learners can perform but they do so by mimicking the model's strategies or style rather than developing their own. Learners operating at the observational and emulative levels often seek assistance in using new knowledge and skills.

When learners can perform independently, they are operating on the self-controlled level. In this stage, learning is still within the context of the model's strategies or style rather than in a way that is personally unique. Learners may solicit guidance from more skilled practitioners such as teachers, tutors, and coaches in an effort to refine their skills. The highest level of development, self-regulation, occurs when learners can initiate and perform skills, adapt them in a way that is personally and contextually relevant, and can self-motivate to achieve outcomes. The learner's performance at each competence level subsequently influences self-efficacy.

Schunk (1999) makes three salient points about the four levels of self-regulatory competence that are worth considering. First, there can be some overlap of the levels. Second, learners may not progress through the levels in a linear fashion. Finally, self-regulated individuals are not socially independent. Learners may limit their development if they do not use their social environment.

Schunk (1999) offers a reciprocally interactive, triadic model that integrates but also expands social learning theory and the levels of self-regulatory competence. It is based on social influences (environmental variables), self-influences (personal variables), and achievement outcomes (behaviors). Models, instruction, and feedback are examples of social influences. Self-influences may include goals, self-efficacy, outcome expectations, and self-regulatory processes. Examples of achievement outcomes include monitoring goal progress, self-motivation, and achieving learning goals. The strength and type of influence, i.e. social versus self, change as the learner's skills and/or self-regulation develop. Initially they rely on social influences until new knowledge and skills are internalized. At that point, they are no longer dependent on models. They can transfer new knowledge and skills in personally meaningful and contextually relevant ways. Ultimately learners structure their environment to promote their own learning.

According to Schunk (1999), the achievement of novice learners can be enhanced by stressing process goals rather than product goals. The former help learners internalize new knowledge and skills by focusing on effective problem-solving strategies. The latter focus on achieving specific outcomes with less emphasis on the process used to achieve them. Learners need performance feedback to monitor their progress, particularly when they are implementing new knowledge and skills (Schunk, 1989; Schunk & Zimmerman, 1997). If performance criteria have been clearly articulated, they can effectively monitor their own progress. If not, they often rely on their social environment for feedback, which can either validate or invalidate their motivation and self-efficacy.

Schunk's theory suggests that self-regulation enhances learning. However, learning can be incremental or transformative depending on students' interests, prior experiences, self-efficacy, and perceptions regarding the quality and value of the learning experience. Conscientious educators proactively create environments and experiences that stimulate transformative learning with the expectation of affecting long-lasting change in knowledge, skills, abilities, and attitudes.

Mezirow's Theory of Transformative Learning

Transformative learning theory was initiated by Mezirow (1997) in the 1990's as a result of his research in the area of adult education. Transformative learning refers to the process of changing how individuals perceive the world and their place in it, how they come to know, and how they assimilate and internalize their experiences to make them personally meaningful (Imel, 1998; Mezirow, 1997; Taylor, 1998). The process challenges long-held assumptions, values, and beliefs, including those about life roles and purpose. The goal of transformative learning is to develop autonomous thinking which is achieved through critical reflection, engaging in discourse, transferring new knowledge into action, and evaluating performance (Mezirow, 1997). Transformative learning changes individuals because it “…leads us not back to the life of the mind…but to soul” (Dirkx, 2000, p. 3).

Previous life experiences synthesize to create and define each individual, usually as a manifestation of his or her socio-cultural environment. The changing nature and multiplicity of the social milieu, including technological advancements, expanded educational and career opportunities, and the proliferation of consumerism, require individuals to juggle a myriad of life roles. Students, for example, are also family members, workers, citizens, community members, church members, and consumers. The combination of life experiences and life roles creates a powerful yet discriminating frame of reference for how students view their world and their place in it (Kerka, 2001).

Dirkx (2000) suggests that every individual has multiple selves - each one having its own direction and purpose in order to fulfill a specific role. An individual may come to realize that juggling multiple roles has resulted in living a life that is not necessarily one that was intended or consciously chosen. This incongruence is manifested as internal conflict, which can lead to compulsions, obsessions, and complexes. He contends that the purpose of transformative learning is to facilitate a journey of individuation in which a unified and integrated Self emerges through emotion, symbolism, and images that are unconscious aspects of our psyche seeking expression. By bringing the unconscious to the conscious, individuals come to understand the multiple and different selves that constitute the whole Self, thus facilitating the process of individuation. This view of transformative learning is grounded in Carl Jung’s depth psychology and seeks an expansion of consciousness rather than a change in cognition (Dirkx, 2000; Grabove, 1997; Taylor, 1998).

In contrast, Mezirow (1997) propounded a rational and cognitive concept of learning based on critical social theory. Mezirow is considered to be the initiator of the transformative learning movement from which other educators and psychologists extrapolated their theories. He posits that individuals learn when they expand an existing point of view, establish a new point of view, or transform a point of view. Over time an individual's perspectives create discriminating frames of reference that are internalized into the psyche to help bring meaning and order to an otherwise chaotic and irrational life experience (Mezirow, 1997; Taylor, 1998). It is for this reason that change is often met with resistance and resentment, both of which limit the ability to learn.

However, changes in perspective do not always lead to transformative learning and not all learning experiences are transformative (Imel, 1998; Pilling-Cormick, 1997). For example, informational learning occurs when knowledge is easily assimilated into mental schemata. It results in incremental, almost imperceptible, changes in an individual. As changes in perspective accumulate over time, a slow but steady transformation may eventually become evident.

Mezirow's concept of transformative learning is generally considered a more drastic one in that it produces a noticeable paradigm shift (Imel, 2000; Robertson, 1996). This paradigm shift is often the result of a major life dilemma that either provides or forces an individual to find new direction and purpose to life. It also helps restore a sense of equilibrium and harmony following a period of disruption and disorientation. The freshman year of college is a classic example of an emotional, social, and cognitive period of disruption, disorientation, and readjustment. The primary purpose of college is to help students identify and prepare for new life roles.

The two views of transformative learning, i.e. those grounded in depth psychology and Mezirow's concept based on critical social theory, at first glance appear to be at odds with one another. Dirkx (2000), for example, describes learning that occurs when one expands consciousness as "soul work" (p. 69), which is necessary for individuation. Although Grabove

(1997) refers to Mezirow's cognitive and rational view of transformative learning as a social process rather than an individual one, she contends that the two views are not mutually exclusive. Rather, the process of transformative learning spans a spectrum that incorporates the subjective and objective, the rational and imaginative, and the cognitive and intuitive. Transformative learning occurs when individuals experience and put into practice the seemingly paradoxical yet complimentary aspects of both views.

Mezirow's (1997) rational and cognitive view of transformative learning is based on four elements: critical reflection, discourse, action, and evaluation. Students engage in critical reflection when they examine deeply held assumptions and beliefs and challenge their validity in light of new knowledge and experience (Taylor, 1998). Reflection is often the result of a cognitive contradiction that is not easily assimilated into existing mental schemata. This dissonance can bring about a new level of self-awareness, including new perspectives about the world and an individual's place in it. It can also provide insight into how and why perceptions act as a filter that distorts, accepts, or rejects external stimuli, including new knowledge. Critical reflection can be initiated in a variety of ways, such as when reading, problem-solving, or using the imagination (Mezirow, 1997; Dirkx, 2000). Students engage in discourse when they share diverse and often competing points of view as the basis for rationally analyzing evidence and arguments to ultimately achieve consensus on an interpretation or synthesis (Mezirow, 1997; Taylor, 1998). Learning is enhanced when students debate in a spirit of common understanding and with respect for individual differences. Critical reflection and rational discourse help students validate newly acquired perspectives that provide the knowledge, skills, and disposition necessary to take action. A self-assessment of actions and/or a critical evaluation by qualified others fosters continued learning as students expand or transform their perspectives to create new frames of reference and ultimately a new world view that is more inclusive and discriminating.

The goal of transformative learning is to ultimately develop autonomous thinking which Mezirow (1997) describes as the "understanding, skills, and disposition necessary to become critically reflective of one's own assumptions and to engage effectively in discourse to validate one's belief through the experiences of others" (p. 9). When individuals think autonomously, they are capable of negotiating meaning to their lives, including their values, beliefs, and purposes (Grabove, 1997; Mezirow, 1997).

Imel (2000) suggests that there is an obvious relationship between change and transformative learning. Change requires individuals to reevaluate and revise their frames of reference. Educators can help students become transformative learners by creating a supportive, student-centered learning environment that helps them successfully negotiate an often emotional and complicated change process (Imel, 2000; Robertson, 1996; Taylor, 1998).

The freshman year college experience offers a rich environment for transformative learning. It is a catalyst for change, which some students may perceive as uncomfortable or even threatening. Sometimes students fail to recognize or find it difficult to admit that their old perspective is no longer adequate and that a new paradigm is needed. They may resist and resent letting go of previously held perspectives that served them well in the past (Robertson, 1996). For example, freshmen often find that the academic success strategies that served them so well in high school do not translate to similar success in college. During the period of transition and adjustment, many students need help developing skills pre-requisite to successful self-directed learning such as time management, study, and teamwork skills. They often need help identifying specific learning objectives or resources necessary to close their learning gaps. They may encounter difficulty navigating complex and frustrating institutional systems and policies that are barriers to their learning (Pilling-Cormick, 1997). Timely and constructive feedback can help students assess their progress relative to their goals and purposes for learning. Collaborative learning environments can facilitate the critical reflection and discourse that are necessary for promoting autonomous thinking and, ultimately, life-long learning.

Taylor (1998) suggests that it is not sufficient for students to simply engage in critical reflection and rational discourse. Rather, they need to explore and validate their newly acquired perspectives and paradigms. Transformative learning is fostered when students practically apply their newfound knowledge and skills in personally meaningful ways (Imel, 2000). Feedback from trained observers such as teachers and mentors is also a critical component of learning. When combined with feedback from peers and a critical self-assessment, students have the opportunity to assess their progress using a "360 degree" evaluation process. Peer feedback also has the added benefit of facilitating learning based on the successes, challenges, and failures of others.

Thus, transformative learning theory provides a lens through which to better understand the challenges and opportunities afforded by the transition from high school student to college student. The cognitive, emotional, and social transformations that begin when students leave their family and high school communities and that they experience as they navigate through the formative first year of college have a profound impact on their ability to adjust to and integrate with their new college community. The transformative experience also inexorably influences their choice of new life roles, including academic and career choices, which can impact them for a lifetime.

Turner's Theory of Liminality

Turner's (1974; Turner & Bruner, 1986; Turner & Turner, 1985) anthropological theory of liminality provides a powerful context for the application of social learning and transformative learning theories. Liminality refers to the cognitive, emotional, and socio-cultural transformations that occur during periods of critical transition. Liminal spaces are often described as rites of passage in which individual or group metamorphosis occurs as new knowledge, new status, and new identity are acquired within a community (Meyer & Land, 2005; Terrill, 2006; Turner, 1974;

Turner & Bruner, 1986; Turner & Turner, 1985). Examples of liminal states include adolescence, the period in between childhood and adulthood, and engagement, the period between being single and married. The freshman year college experience may also be considered a liminal state as students experience the ambiguous and complex rite of passage from dependent teen-ager living and learning within the roles and rules of family, high school, and community to independent college student and young adult within a new community of peers that is typically regulated by different social status, norms, and expectations.

Turner (1974) characterizes liminal states as periods of destruction prior to reconstruction that include three phases: separation, liminality, and reaggregation. In the separation phase, individuals let go of the past and release their old identity and social status as a prerequisite to transition and transformation. They then enter an ambiguous liminal phase that has none of the attributes of the old state but neither any of the attributes of the new state. Rules of the past are no longer applicable. New rules may have to be learned and/or may be suspended until an appropriate future time. Prior status is stripped as all initiates of a liminal state enter with equal status. Liminal states may be welcomed by the initiate albeit often with apprehension. In the final phase, reaggregation, the individual transitions to the new state and is integrated into the social community as a neophyte. Although status in the new community is often, but not always, at a higher status than in the old state, social status in the liminal state stresses equality among new initiates independent of pre-liminal status. In some cases, individuals oscillate between pre- and post-liminal states as they adjust to the new community. They may mimic behaviors in an effort to more easily identify with and assimilate into the new community. Once they have crossed the threshold into the liminal space, however, they can never fully revert to the old state. During the liminal state, strong social bonds often form that can last a lifetime (Turner, 1974).

Meyer and Land (2005) characterize liminal threshold or gateway concepts as transformative, irreversible, integrative, and troublesome. In education, the central limit theorem in statistics and entropy in physics are examples of academic threshold concepts. Discourse can facilitate new thinking, reflection, and an expansion or shift in perspective that can ultimately lead to new understanding and a transformation of identity. However, pre-liminal variation influences how well students negotiate the liminal space. Educators can help learners by offering a supportive environment that includes but is not limited to scaffolding, support materials, and peer mentoring (Meyer & Land, 2005).

Liminality has an ontological as well as a phenomenological impact on learners. Although there is an assumption of growth, this is not always the case. Terrill (2006) suggests that the period of unpredictability that is characteristic of liminality is an "undetermined trajectory" (p. 166) that can result in either positive or negative transformation.

Summary

The theoretical framework provides support for the idea that the freshman year experience is an exciting period of transition that is also characterized by ambiguity and anxiety as students adjust to leaving family, friends, and community and integrate into their new academic and social environments. It offers a constructivist epistemology that provides valuable insights regarding the role of the environment on cognition, emotional and social adjustment, selection of college major, and commitment to choice of career.

CHAPTER 3: METHODOLOGY

Setting

This study involved freshman engineering students enrolled in a large, urban, public, research university located in the Southeast during the 2005-2007 academic years. The College of Engineering is one of seven colleges, four of which offer professional degrees. The college offers Bachelor of Science degrees in civil, computer, electrical, mechanical, and systems engineering; Bachelor of Science in Engineering Technology degrees in civil, electrical, fire safety, and mechanical engineering technology; and a Bachelor of Science in Construction Management degree. It also offers Master of Science and Doctor of Philosophy degrees in various engineering disciplines.

In fall 2007, 2201 undergraduate students and 342 graduate students were enrolled in the College of Engineering. Approximately two-thirds of the undergraduate students were engineering majors and one-third was, collectively, engineering technology and construction management majors. Census data indicate that enrollment in the college increased 39% during the five-year period from fall 2002 to fall 2007. Additional increases are projected as the university grows from 22,388 students in fall 2007 to its target of 35,000 students by 2020.

Historically, less than 10% of the College of Engineering freshman class is composed of African American, Hispanic, and Native American students combined and less than 10% is female. Approximately half of the college's freshmen indicate that neither parent earned a four-year college degree based on responses to a survey administered by the college each spring. Admission to an engineering program requires a predicted grade point index (PGI) of 2.0 and a SAT mathematics (SAT Math) score of 480.

Table 1 provides demographic and academic characteristics for the 930 new freshman engineering majors admitted to the college during the fall semesters of 2005-2007. Data were obtained from the university data warehouse after census. Almost 93% of the freshmen were male and 82% were white. The mean PGI and SAT Math score were 2.71 (*SD* = .38) and 601 (*SD* = 61), respectively. On average, participants had a high school GPA (HS GPA) of 3.63 (*SD* = .43). It should be noted that over the three-year period 986 new freshman engineering majors actually enrolled in the college. However, 56 students changed majors before the end of their first semester. Their original matriculation major was changed so that they are not included in Table 1.

For more than a decade, the College of Engineering has experienced drastic change. Explosive enrollment growth, an aggressive research agenda, new undergraduate and graduate programs, distribution of the college into five buildings spread across an 1100 acre campus, and state-mandated budget cuts have provided both opportunities and challenges. At the same time, public institutions of higher education in the state were challenged with improving retention rates and time to graduation. Changing student demographics, increased pressures to demonstrate learning outcomes, more rigorous professional accreditation requirements, and the addition of new undergraduate programs also contributed to change. In response, the college focused its efforts on creating a positive learning environment and data-driven continuous improvements in an effort to achieve goals associated with student recruitment, learning, and retention. The highest priority was to create a freshman year experience that helped achieve these goals.

Table 1

Demographic and Academic Characteristics of New Freshman Engineering Majors Admitted and Enrolled During the Fall Semesters of 2005-2007

	Fall 05	Fall 06	Fall 07	Overall
N	308	283	339	930
% Female	6.8	9.5	5.9	7.3
% Male	93.2	90.5	94.1	92.7
% White	82.1	80.6	83.5	82.2
% Minority	8.1	7.1	7.4	7.5
% Other Ethnicities	9.7	12.4	9.1	10.3
SAT Verbal				
N*	304	281	339	924
Mean	538	523	525	529
SD	71	71	69	70
SAT Math				
N*	304	281	339	924
Mean	603	599	600	601
SD	61	61	62	61
HS GPA				
N*	303	281	337	921
Mean	3.59	3.61	3.68	3.63
SD	0.43	0.40	0.45	0.43
PGI				
N*	303	279	336	918
Mean	2.67	2.69	2.78	2.71
SD	0.37	0.38	0.39	0.38

* SAT scores, high school GPA, and PGI were not available for some students.

The Freshman Year Experience

Beginning in 2002, the college systematically implemented an integrated and comprehensive freshman year experience designed to attract more students into engineering, facilitate their successful transition from high school, enhance their sense of community, promote a positive college experience, improve academic performance, and increase retention. Three strategies were implemented to help achieve these goals: (1) a residential freshman learning community; (2) a redesigned Introduction to Engineering course, ENGR1201, which is the only engineering course engineering majors take in their first semester of the freshman year; and (3) centralized freshman advising. These new strategies were in addition to the college's MAPS (Maximizing Academic and Professional Success) program, which offers peer mentoring, tutoring, supplemental instruction, and student organizations. All of these programs and services are operated out of the college's Office of Student Development and Success (OSDS) under the auspices of an assistant dean. OSDS is also responsible for recruiting, scholarships, a junior/senior professional development course, a student Leadership Academy, employer and alumni relations, the Fundamentals of Engineering exam, and a variety of assessments critical for professional and regional accreditation. In addition to the assistant dean, the OSDS team also includes six faculty associates, two student services specialists, and a business services specialist.

The residential freshman learning community (FLC). The FLC was implemented in fall 2002 with an initial cohort of 60 students. The program quickly expanded in response to overwhelming demand so that by fall 2007, 216 freshmen filled an entire residence hall. Currently, about half of the college's incoming freshman class self-selects to participate in the FLC, which makes it the university's largest learning community. Assessment data consistently reveal that the program has a positive impact on the one-year retention rates of College of Engineering freshmen.

The FLC residence hall is located in close proximity to the freshman engineering building on the main part of campus. FLC applicants are accepted on a first-come, first-serve basis with the only criterion for participation being admission to a College of Engineering major. In fall 2007, approximately 90% of the FLC participants were engineering majors and 10% were engineering technology and construction management majors.[1] Students live in the FLC during the fall and spring semesters of their freshman year. Although they may request roommates, the majority of housing assignments are made by the director of the FLC who is a member of the OSDS staff and/or the university Housing and Residence Life staff. Two resident advisors are assigned to each of the three floors and, when possible, they are College of Engineering majors who previously lived in the FLC.

Like all freshmen, FLC participants are co-enrolled in blocks of courses during their first semester to ensure that they have sufficient opportunities to develop peer networks. Special sections of the Introduction to Engineering course, ENGR1201, are dedicated entirely to FLC students. The FLC also offers onsite academic and professional development programming such as peer mentoring and supplemental instruction available through the MAPS program, chemistry study nights, and guest speakers. Site visits to engineering companies are also available to FLC students. Participation in these extra-curricular activities is voluntary and free of charge to the students.

A full-time faculty associate with a master's degree in engineering and previous professional experience as a practicing engineer is director of the FLC. She also teaches some of the FLC sections of ENGR1201 and is an academic advisor. The director works closely with the university Housing and Residence Life staff, the director of the College of Engineering MAPS

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[1] Engineering technology did not offer lower division programs until fall 2004. Prior to that time, the department only offered 2+2 degrees. Students were required to complete an Associate of Applied Science degree at a community college before transferring to the College of Engineering to complete the last two years of their Bachelor of Science degree. The four-year construction management program was implemented in fall 2006.

Program, and other academic support units on campus. She attends all recruiting activities to market the program to prospective students and parents. Enrollment in the FLC is typically full by the middle of June resulting in a waiting list of freshmen eager to participate in the program.

During the first week of the fall semester, the director convenes a "town meeting" with all FLC participants, the dean, and/or the associate dean to formally welcome the students and to review academic and student conduct policies for continued participation in the program. These policies are also detailed in a contract that students must sign as part of the application process. The director continues to regularly communicate with FLC participants throughout the academic year via emails, newsletters, flyers, a program website, a social networking website, and personal appearances in the FLC.

Introduction to Engineering course (ENGR1201). ENGR1201 is the first and only engineering course that students take in the fall semester of their freshman year. Although it is a two credit hour course, it requires three hours of in-class contact per week. ENGR1201 introduces students to the engineering profession and its various disciplines, basic engineering theory and mathematics, the engineering design process, project planning, cost estimating, teamwork, and oral and written technical communications. Approximately 850 students enrolled in ENGR1201 during the 2007-2008 academic year.

Prior to fall 2003, ENGR1201 was taught in a large lecture format with about 200 students enrolled in each section. This format made it difficult for faculty to get to know students and also precluded the use of meaningful collaborative learning and hands-on design projects. In fall 2003, section sizes were reduced to about 36 students and today enrollment in each section is capped at about 30. In fall 2004, the curriculum was revised to include three projects that require small teams of students to design, build, and test them. In fall 2005, a co-requisite of Calculus I, which is the first mathematics course in the freshman engineering curriculum, was implemented to ensure that students were prepared for the basic mathematics required in the course. Students' eligibility to take Calculus I and, therefore, their eligibility to also enroll in ENGR1201, are dependent on their performance on the mathematics placement exam administered during summer orientation prior to the fall semester of their freshman year. Typically about two-thirds of engineering students qualify to enroll in Calculus I and the remainder place into Pre-Calculus. Upon successful completion of Pre-Calculus in the fall semester, students take both Calculus I and ENGR1201 in the spring semester. Failure to place into Calculus I during the first semester of college adversely impacts engineering students in two important ways. First, it delays their academic progression through a curriculum that offers little flexibility because of strict accreditation requirements. Second, students are not enrolled in any engineering courses during their first semester of college. Also in fall 2005, enrollment in the course was restricted to College of Engineering majors only. Non-majors may take ENGR1201 in the spring semester assuming space is available and they meet the Calculus I co-requisite.

ENGR1201 students are evaluated on their ability to demonstrate five course learning outcomes specifically related to the ABET a-k competencies: (1) Design, construct, and test a solution that meets client requirements and performance specifications (ABET c); (2) apply basic engineering mathematics to the problem-solving and engineering design processes (ABET a); (3) productively contribute to a multi-disciplinary team to successfully accomplish project goals (ABET d); (4) effectively communicate using a variety of technical written and oral formats commonly used in engineering (ABET g); and (5) develop life-long learning habits by researching and articulating "whole life" concepts that, in addition to technical competencies, are required for the successful engineering professional (ABET i). Through in-class discussion, assignments, and design projects students are also introduced to the other six ABET competencies related to designing and conducting experiments, solving engineering problems, understanding professional and ethical responsibilities, understanding the impact of their engineering solutions, having knowledge of contemporary issues, and using the techniques, skills, and tools necessary for engineering practice.

ENGR1201 instructors are faculty associates with master's degrees in various disciplines of engineering. All have non-academic, professional experience as practicing engineers in order to infuse the curriculum with real-world experience. Collectively, the five-member teaching team has more than 75 years of experience in design, manufacturing, and performance engineering; project management; and/or leading engineering organizations. Two of the faculty are registered Professional Engineers and one has a patent. One was a senior executive in a Fortune 500 engineering company and one is a retired Air Force major who led large-scale domestic and international engineering projects. The team is composed of three females, one of whom is Hispanic, and one member is an African American male. Each member of the ENGR1201 teaching team also has significant programmatic, advising, scholarship, service, and/or administrative responsibilities.

A teaching assistant (TA) is assigned to each section of the course. TAs must have a cumulative GPA of at least 3.0, including a grade of A in ENGR1201 and an A in their freshman English courses. They must also demonstrate effective interpersonal and time management skills. TAs are hired for 10 hours per week at an average salary of $8 per hour. They attend class, grade papers, hold extra problem sessions, and serve as project managers for the team design projects. They also mentor freshmen to help them successfully navigate the challenging transition from high school to college. All TAs are required to attend a day-and-half-long training session prior to the beginning of the fall semester to learn about their role and responsibilities, course content and technologies, and requirements for grading.

ENGR1201 pedagogy emphasizes collaborative and active learning techniques using small teams of students. In an effort to ensure consistency among the many sections of ENGR1201 taught each semester, faculty develop and use a common curriculum and teaching materials. Comprehensive assignment descriptions are posted on a common course website and TAs use common grading rubrics. The faculty team meets weekly to identify opportunities for improving curriculum content and delivery. Enhancements are made real-time, if possible, or are documented for implementation the following semester. Each instructor also meets weekly with his or her TA team to monitor progress and consistency in grading, answer questions about assignments or lecture content, discuss issues related to student learning, and solicit input for continuous improvement of the course.

Student learning outcomes are assessed and evaluated at the end of each semester. An end-of-semester survey is also used to collect quantitative and qualitative feedback from students. Results consistently indicate that students struggle with the engineering mathematics required in the course. They perceive the workload in ENGR1201 to be much greater than that required in their other courses and certainly worthy of more than two hours of academic credit. The self-reported amount of time that they spend studying for all of their freshman courses is clearly much less than is recommended for success in the engineering curriculum. As a result, about 20% of the students who take ENGR1201 in the fall semester typically withdraw from the course or earn a final course grade of D or F. A grade of C or better is required to progress in the engineering curriculum.

Freshman academic advising. Surveys conducted by the college and university over a period of several years indicated that students were dissatisfied with academic advising. In fall 2003, the college implemented centralized freshman advising in an attempt to remedy the situation, particularly since first-year retention was a strategic initiative. Focus groups conducted in fall 2004 as part of a year-long process improvement project also revealed that students' perceptions of customer service were primarily related to their academic advising experience. These findings further supported the need for a centralized advising office to provide "one-stop shopping" for students.

The college's freshman advising staff is composed of six faculty associates and a student services specialist. Each academic advisor also has other teaching and/or programmatic responsibilities such as recruiting, teaching ENGR1201, planning and delivering student professional development programs, and/or administering the MAPS Program or the FLC. The faculty associate who leads the freshman advising team has a master's degree in student development in post-secondary education. Collectively, the team advises more than 900 freshmen and transfer students each year. Students matriculate from freshman advising to an academic advisor in a College of Engineering department upon successful completion of the freshman curriculum.

Advisors meet weekly to discuss policies and procedures, plan advising and communication strategies, design interventions, review data related to student success and retention, and identify opportunities for improvement. They conduct summer orientation, advising, and registration and offer individual and group advising during the fall and spring semesters. All College of Engineering students are required to meet with an academic advisor every semester in order to get their registration hold lifted and register for classes the following semester. Academic advisors also contact students who earn deficient mid-semester grades to recommend academic support programs and remind them of college progression requirements. They regularly communicate via email regarding important deadlines and opportunities for supplemental instruction, site visits to engineering companies, and special events. At the end of each semester, advisors complete pre-requisite checks to ensure that students meet departmental curriculum progression requirements and satisfy ABET (2009) accreditation standards.

The Maximizing Academic and Professional Success (MAPS) program. The College of Engineering MAPS program offers peer mentoring, supplemental instruction, tutoring, and student organizations. Although all undergraduate students are eligible to participate in MAPS, freshman, transfer, female, and minority students are aggressively targeted. Participation is voluntary and services are free of charge to the students. The MAPS Office also offers space for small groups of students to study, meet, and socialize.

Peer mentors help students successfully acclimate to the college, develop academic success strategies, connect with other students, and learn about available resources on campus. Mentors must have a 3.0 cumulative GPA and excellent interpersonal skills. They are required to participate in a day-and-a-half long training session prior to the beginning of the fall semester to learn about their role, responsibilities, and logistics associated with program administration such as marketing and tracking participation. They also attend weekly meetings facilitated by the director of the MAPS program. A MAPS "curriculum" guides mentors as they work with students.

Each mentor is typically assigned about 20 students and is available to meet with small groups of three or four students each week. In fall 2007, almost 200 students registered for a MAPS mentor, 90% of whom were freshmen. However, because participation is voluntary, only about 20% of participants attended mentoring sessions on a regular basis, i.e. every other week.

The MAPS program also offers supplemental instruction (SI), which is a non-remedial program that targets courses in which a high percentage of students earn a final course grade of D or F or who withdraw. SI is offered for a variety of freshman, sophomore, and junior courses. Freshman SI includes Chemistry, Pre-Calculus, Calculus I and II, and Physics I and II. SI leaders are students who previously earned an A in the course. They facilitate small group learning by teaching students how to apply academic success strategies to understanding and solving a variety of engineering problems. SI leaders attend class and hold three to four SI sessions outside of class each week. They meet weekly with the associate director of the university's Center for Academic Excellence who oversees the SI program for the campus. All SI leaders complete two days of training prior to the beginning of the fall semester to learn how to apply the SI model and to learn about the logistics associated with program administration such as marketing and tracking participation. Although assessment results suggest that SI does make a significant difference in students' grades, the percentage of students who regularly attend SI is disappointingly low despite efforts to increase awareness and participation. As a result, the college recently began scaling back its SI program.

Measures/Instruments

Each spring the college conducts a survey to measure students' perceptions about their learning experience. Prior to spring 2006, students were surveyed using paper instruments that were distributed in core College of Engineering courses identified by the departments. A web-based survey using *StudentVoice* (2005) was initiated in spring 2006. *StudentVoice* (2005) is used extensively throughout the campus to survey students, faculty, staff, alumni, and employers. Participants in this study completed the web-based version of the survey during the spring semesters of 2006-2008.

All College of Engineering students are invited to take the annual survey during a four-week administration period between mid-March and mid-April. Students receive an email invitation sent by the survey software company on behalf of the dean. The invitation informs them that results will be used for continuous improvement of academic programs and services and for the purpose of accreditation. It also assures them that results are confidential and will be reported in aggregate. The email includes a direct link to the survey website. Students give informed consent by voluntarily clicking on the survey link. The dean asks faculty to encourage and remind their students throughout the administration period to complete the survey. Participation is voluntary. Students are not given any incentives to complete the survey nor are they penalized if they do not complete it. Students who do not complete the survey are notified five times throughout the administration period reminding them to do so. Students can take the survey on- or off-campus, 24 hours a day, seven days week as long as they have internet access.

Student identification numbers are coded so that an individual's survey responses can be matched to demographic and academic information stored in the university's data warehouse. At the end of the semester following each administration period, survey responses are downloaded from the software company server and integrated with admission and academic data.

The survey is used to measure students' engagement in various activities, their sense of community, and their perceptions of advising, the major, the learning environment, ABET a-k competencies, and goals in the college's strategic plan. Level of parental education is determined by students' yes/no responses to the survey item "*Does at least one of your parents have a four-year college degree*?" Participation in the FLC is self-reported via the survey but for the purpose of this study cohort codes in the university's data warehouse were used to identify participants. Most of the survey items require students to rate their level of agreement using a Likert scale where 1 = totally disagree to 5 = totally agree and 0 = "N/A or Don't Know" by clicking on a radio button. Through the 2008 administration of the survey, students were also invited to provide open-ended written comments but they are not included in this study.

Twenty-eight survey items were used to operationalize five constructs relevant to the freshman year experience: Sense of Community (COMM), Perceptions of Advising (ADVISE), Perceptions of Choice of Major (MAJOR), Perceptions of the Learning Environment (ENVIRON), and Perceptions of Learning Outcomes (LEARN). Actual survey items comprising each scale are included in Appendix A in Tables A-1 through A-5. All of the items are supported by theory as they are intended to measure students' transition and adjustment to college life, ability to develop social networks, perceptions of the learning environment, and engineering self-confidence and self-efficacy. Figure 1 illustrates the relationship between each construct and the survey items that serve as its indicators.

Sense of Community (COMM) was operationalized by four survey items related to students' ease of transition into the college (TRANSEAS), comfort in seeking guidance from a

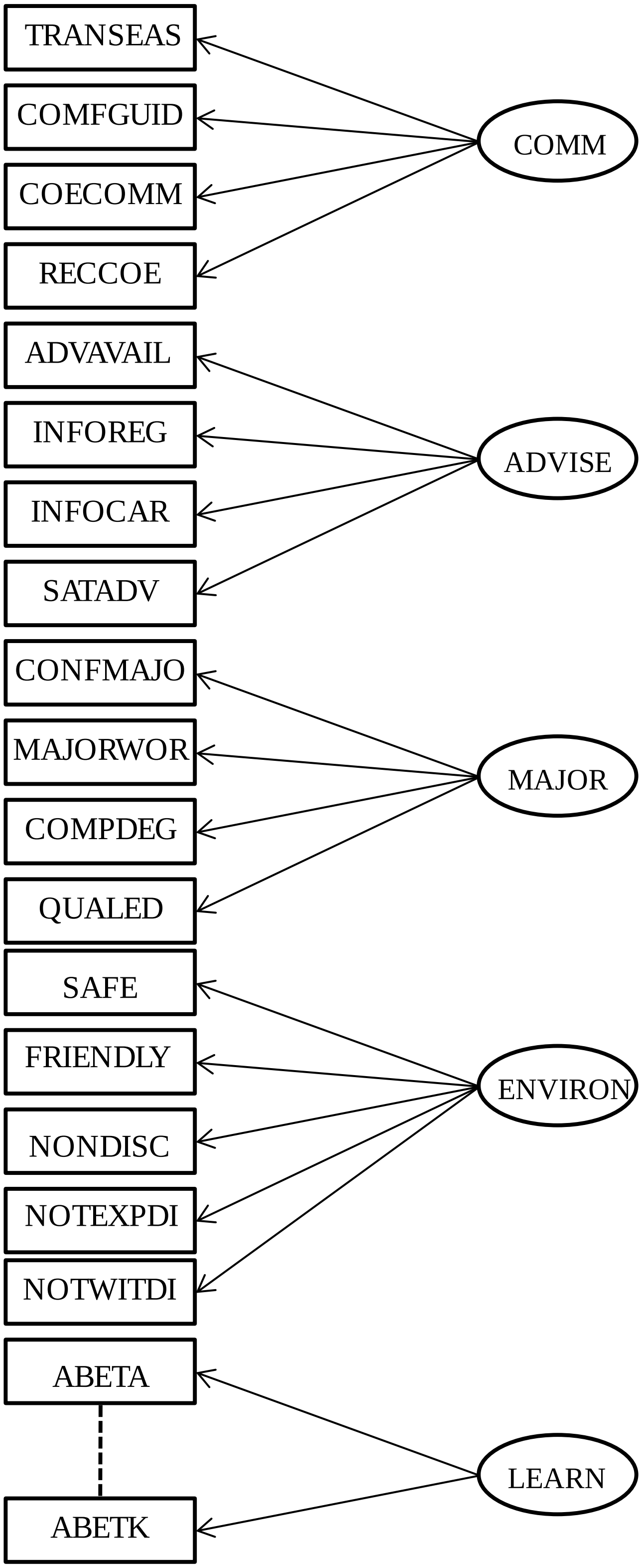


Figure1. Survey indicators used to operationalize each construct.

faculty or staff member (COMFGUID), feeling part of the College of Engineering community (COECOMM), and if they recommend the college to their family and friends (RECCOE). These items were used to measure students' ability to develop social networks and successfully navigate the critical transition from high school to college.

Perceptions of Advising (ADVISE) was operationalized using four survey items: availability of the academic advisor (ADVAVAIL), quality of information related to registration and career development (INFOREG and INFOCAR, respectively), and overall satisfaction with academic advising (SATADV). These items are consistent with the empirical literature that suggests that the quality of a student's academic advising experience can influence persistence.

Four survey items were indicators for the construct Perceptions of Choice of Major (MAJOR): confidence in choice of major (CONFMAJO), major is worth the time and effort (MAJORWOR), confidence in the ability to complete the degree (COMPDEG), and quality of education in terms of competitiveness in the job market (QUALED). These items were intended to operationalize students' engineering self-confidence, self-efficacy, and outcome expectations and, therefore, their level of commitment to their choice of major.

Perceptions of the Learning Environment (ENVIRON) was operationalized using five survey items that measured students' perceptions of the college as safe (SAFE), friendly (FRIENDLY), and non-discriminatory (NONDISC) and if they experienced or witnessed discrimination in the college (NOTEXPDI and NOTWITDI, respectively). These items also support the theoretical framework of the study in that students who perceive their environment as supportive are more likely to do well academically and persist.

The 11 ABET a-k competencies, which include technical and non-technical skills, were indicators of the construct Perceptions of Learning Outcomes (LEARN). It is important to evaluate freshman engineering students' perceptions of engineering competencies as a proxy for their perceptions of the profession. There is evidence that students who leave the major in good academic standing often have lower general impressions of the profession and less confidence in their math, science, and engineering skills than students who remained in the major (Besterfield-Sacre, Atman, & Shulman, 1997).

In addition, observed independent variables incorporated into the study included predicted grade index (PGI), participation in the FLC, and eligibility for enrollment in ENGR1201 based on performance on the mathematics placement exam. Academic performance at the end of the freshman year (CUMGPA) and re-enrollment in the second semester of the sophomore year (PERSIST) were the two observable outcome measures.

Sampling Procedure

Archival data collected during the spring 2006-2008 survey were used for this study. The sample frame included new freshman engineering majors who were enrolled in the College of Engineering in the fall semesters of 2005-2007 and who completed the annual survey in the spring semesters of 2006-2008. Engineering technology and construction management majors were excluded from the study because, unlike engineering majors, they are immersed in a variety of major-specific courses during their first semester. In addition, only about 10% of the students in the FLC are represented by these majors.

During the last week of the spring 2006 administration of the survey, which was the first year that the college used the web-based software, the method by which students accessed the survey was inadvertently changed. As a result, there were 179 participants that were unidentifiable. Based on their responses to selected survey items, it was clear that 113 students were engineering majors and 37 students were non-engineering majors. Majors for the remaining 29 students could not be determined. Of the 113 unidentifiable engineering majors, 21 students indicated that they were advised by freshman academic advisors. The remaining 92 engineering majors indicated that they were advised by their major department, which meant they had already completed the freshman curriculum. Of the 29 students for whom major could not be determined, 10 were clearly not freshmen as one had participated in programs that were not available to freshmen and nine were advised by their major department rather than by freshman advisors. The remaining 10 unidentifiable majors answered only one, two, or three of the 53 total survey items. As a result, there were 21 unidentifiable engineering majors advised by freshman academic advisors who could have been admitted as new freshmen in the fall of 2005 and, therefore, would have been included in the study. All of the other unidentifiable respondents would have been excluded from the study because they were not engineering majors, they were not freshmen, or they completed less than 10% of the survey. The final sample size from the spring 2006 administration of the survey was 121.

In spring 2007 and 2008, a total of 13 students logged into *StudentVoice* but did not answer any questions. Eleven students answered only three or fewer of the 53 survey questions. Also in spring 2008, one engineering technology major answered questions specific to engineering. When these 25 students were deleted from the dataset, the final sample sizes for spring 2007 and 2008 were 80 and 115, respectively. In total, 316 students comprised the sample for the study. Identifying information was deleted from the dataset after screening for missing values and outliers.

Data Screening and Treatment of Missing Values

Data were screened prior to analysis in SPSS 16.0 (2008) and LISREL 8.8 (Jöreskog & Sörbom, 2006) to test assumptions germane to univariate and multivariate statistical techniques. Participation in the FLC, eligibility for enrollment in ENGR1201, and persistence (PERSIST) were treated as dichotomous variables (0 = No and 1 = Yes). Parental education level (PEL) was dichotomously coded with 1 indicating that at least one parent had a four year college degree and 0 meaning that neither parent had a four year college degree. Predicted grade index (PGI) and freshman year cumulative GPA (CUMGPA), both of which were measured on a traditional 4.0 scale, were assumed to be continuous variables. All of the survey items used as indicators of latent variables were assumed to be measured on an interval/ratio scale. The use of ordinal Likert scale data as interval data is common in many statistical procedures if at least five categories are used (Garson, 2008d; Hancock & Mueller, 2008a).

The assumption of univariate normality was evaluated by examining histograms and if skew and kurtosis were between +/- 1. Multivariate normality was determined using tests of significance available in LISREL PRELIS. Scatter plots were generated to assess bivariate linearity. Box plots were used to detect univariate outliers and multivariate outliers were identified by Mahalanobis $p < .001$. Correlations were generated in SPSS and LISREL to evaluate the strength and direction of bivariate relationships. The type of correlation was dependent on the nature of the variables: Pearson product moment correlations when both variables were assumed to be continuous, polychoric when both variables were dichotomous, and polyserial when one variable was continuous and the other was either dichotomous (Byrne, 1998; Garson, 2008c; Hancock & Mueller, 2008a). Relationships were assumed to be weak if $r < .35$, moderate if $.35 \leq r \leq .65$, and strong if $r > .65$. If r was less than .35, the relationship was considered too weak to be of practical use. Multi-collinearity was considered potentially problematic as r approached .90, variance inflation factors (VIF) exceeded 4, and if condition indices were greater than 30 with at least two variance proportions per dimension exceeding .50 (Garson, 2009b; Stevens, 1999; Tabachnick &Fidell, 2007).

Survey responses of"N/A or Don't Know" and non-responses were treated as missing values. Missing values are traditionally considered to be problematic when more than 5% of the values are missing for a particular variable. Bias occurs when the missing data make the sample different from the population from which it was drawn (Wayman, 2003). The first step in the treatment of missing data is to determine why data are missing. Data may be missing completely at random (MCAR), missing at random (MAR), or not missing at random (NMAR). According to Wayman (2003), MCAR indicates that cases that have missing values are no different from cases without missing values. This type of missingness is the best possible situation because failure to account for missing data only affects power. When data are MAR, missing values are dependent on known values. This type of bias can often be reduced by accounting for missing values using known values. The most problematic situation is when data are NMAR. Missing data are the result of non-measured processes that are not within the control of the researcher and, therefore, bias the analysis. The type of missing values was evaluated with Little's MCAR test available in the Missing Values Analysis (MVA) option in SPSS using $p \leq .05$ and patterns of missingness.

Traditional methods of treating missing values include listwise or pairwise deletion or imputation of means. Listwise and pairwise deletion may reduce sample sizes to unacceptable levels, particularly in large sample techniques such as structural equation modeling. Imputing missing values with the mean of each variable reduces the variance of the variable and attenuates relationships with other variables (Wayman, 2003).

Recently more effective treatments of missing values have been proposed and multiple imputation (MI) has emerged as the preferred method (Schaefer & Olsen, 1998; Wayman, 2003; Yuan, 2000). Unlike mean substitution, MI maintains the natural variability in the data and relationships among variables. It also accounts for uncertainty caused by estimating data. Despite these benefits, however, Hancock and Mueller (2008b) recommend that data not be imputed in order to achieve unbiased results. As a result, their advice was heeded and the original dataset with missing values was used in this study.

Procedures

Structural equation modeling (SEM) was used to compare the goodness-of-fit of the survey data to two models hypothesized to represent the freshman year experience. SEM is a large sample statistical technique that combines factor analysis and multiple regression using matrix algebra (Byrne, 1998; Garson, 2008b; Ullman, 2007). It is an extension of the general linear model (GLM) that traditionally focuses on the analysis of covariance (Garson, 2008b).

More specifically, SEM evaluates the discrepancy between the covariance matrix in the hypothesized model and the covariance matrix in the sample data (Byrne, 1998).

Bryne (1998) and Garson (2008b) report several advantages of SEM over traditional multivariate techniques. Assumptions are more flexible in SEM than in multiple regression. SEM is a confirmatory rather than an exploratory approach. Models are developed a priori based on theory and tested using sample data. The confirmatory nature of SEM facilitates making inferences unlike some of the more traditional statistical techniques, such as exploratory factor analysis, that are descriptive in nature and that make hypothesis testing difficult. SEM also corrects for measurement error, which allows for more valid estimates of regression parameters. Unlike other multivariate approaches, SEM incorporates both observed and unobserved (latent) variables, which may be discrete or continuous. Despite the many benefits of SEM, however, there is one serious limitation in its use. Categorical variables cannot be used as endogenous variables. Therefore, SEM was employed to test the hypothesized models when freshman year CUMGPA was used as the dependent variable. A hierarchical binomial logistic regression was conducted to predict the dichotomous outcome PERSIST. The hierarchical approach enabled the use of two covariates, predicted grade index (PGI) and parental education level (PEL). Use of covariates allows the effects of other independent variables to be evaluated after the dependent variable is statistically adjusted for differences in the covariates (Tabachnick & Fidell, 2007). The relationship between a covariate and the dependent variable also helps to reduce the error term.

The SEM approach. SEM is a two-stage approach. In the first stage, the measurement model is evaluated. In the second stage, the structural model is evaluated. Each stage incorporates five steps: Conceptualize the model, identify parameters, estimate parameters, assess data-model fit, and respecify the model consistent with theory to achieve an optimum fit (Bryne, 1998; Hancock & Mueller, 2008a; Ullman, 2007).

SEM assumes linear relationships between each indicator and its latent variable and between latent variables (Garson, 2008b). Each latent variable should be operationally defined based on theory using at least three observable indicators that represent the construct (Costello & Osborne, 2005; Garson, 2008b; Hancock & Mueller, 2008a). In this study, each latent variable was represented by at least four survey items. When survey items are used as indicators, five or more response categories should comprise the interval scale to assume a continuous underlying structure (Hancock & Mueller, 2008a). In addition, Costello and Osborne (2005) suggest that factor analytic models have a 10:1 participant to item ratio. Both criteria were met in this study.

Two competing theories or conceptualizations of the relationships among observed and latent variables related to the freshman year experience were developed. Both models incorporated FLC and ENGR1201 as exogenous observed variables and COMM, ADVISE, MAJOR, ENVIRON, and LEARN as endogenous latent variables that, collectively, represented students' perceptions of the freshman year experience. Both models also incorporated relationships which hypothesized that: (1) Self-selection into the FLC and eligibility for ENGR1201 were associated with incoming academic preparation (PGI) and parental education level (PEL); (2) participation in the FLC and enrollment in ENGR1201 influenced students' perceptions of the freshman year experience; and (3) students' perceptions of the freshman year experience had a direct effect on their academic performance (CUMGPA).

Figure 2 depicts the first conceptualization of the freshman year experience. Measured variables are represented as rectangles. Latent variables, also referred to as factors, are represented as ovals. Survey items used to operationalize each latent variable are not included in the figure. Double-headed arrows between variables represent correlations or covariances. Correlations between exogenous variables PEL and ENGR1201, PEL and FLC, PGI and FLC, and PGI and ENGR1201 were specified with their respective error covariances set to zero. PGI was hypothesized to be positively related to enrollment in ENGR1201, i.e. students with higher

PGI scores were more likely to score higher on the mathematics placement exam thus making them eligible to take the course. Relationships between PEL and PGI and between FLC and ENGR1201 were free to be estimated. The FLC and ENGR1201 were hypothesized to directly influence students' perceptions of the freshman year experience as indicated by directional arrows. Similarly, student's perceptions were hypothesized to directly affect their academic performance (CUMGPA). Perceptions of the freshman year experience also mediated the effects of incoming characteristics and participation in learning communities.

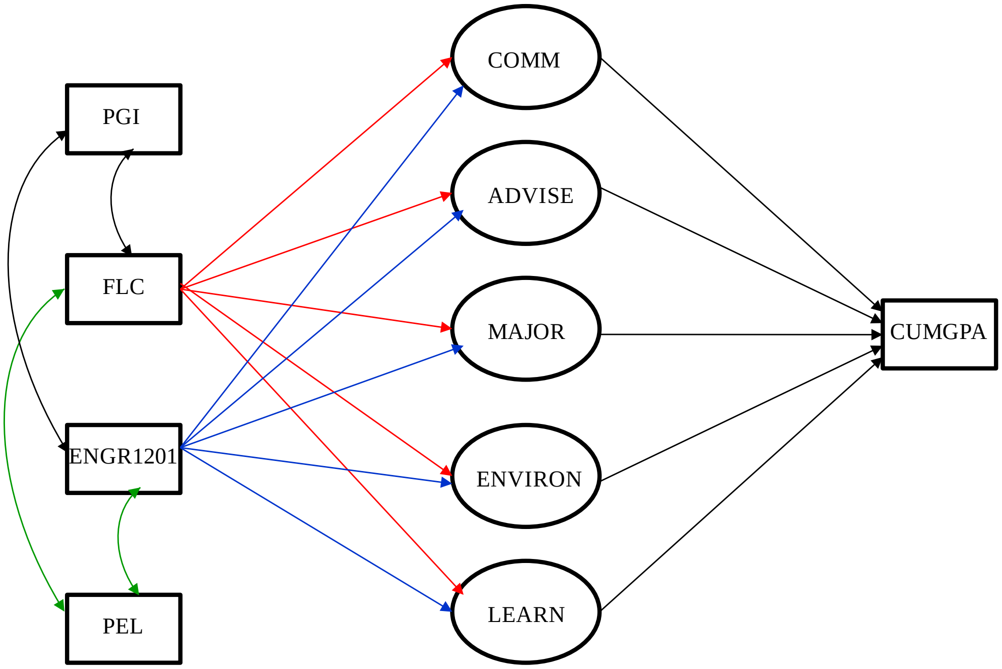


Figure 2. Model #1 of the freshman year experience.

In Model #1, none of the latent variables were hypothesized to covary. For example, although students may perceive the learning environment (ENVIRON) as safe, friendly, and non-discriminatory, it does not necessarily mean that they have positive (or negative) perceptions of academic advising (ADVISE), their major (MAJOR), or the ABET a-k competencies (LEARN). Similarly, positive responses on items related to the ABET competencies suggest that students have an appreciation of the skills required to become an engineer. However, such knowledge is not hypothesized to be related to choice of major. In fact, as students gain an appreciation of what it takes to become an engineer they may be more *or* less inclined to persist. Some may be motivated because of the opportunities afforded by the profession. Others may believe that pursuing the degree is not worth the time and effort and/or they may be less confident in their ability to complete it. Similarly, students' perceptions of academic advising (ADVISE) were not hypothesized to be related to their perceptions of the major (MAJOR) or ABET a-k competencies (LEARN). Although advisors certainly discuss curriculum and progression requirements, workplace expectations, and career opportunities, formal academic advising occurs only once each fall and spring semester. Students have more frequent interactions, both formal and informal, with ENGR1201 instructors, faculty and staff who deliver programs such as the FLC and MAPS, and their peers, all of whom are much more influential in their decision to remain in the major (Astin, 1993). Consequently, all of the relationships between factors were constrained to zero in Model #1.

The second model, illustrated in Figure 3, offered a competing conceptualization of the freshman year experience that was also consistent with theory. It hypothesized that the latent variable Sense of Community (COMM) was explained by students' perceptions of advising (ADVISE), their choice of major (MAJOR), the learning environment (ENVIRON), and ABET a-k competencies (LEARN). Therefore, COMM served as a mediator between the other latent variables and the outcome CUMGPA. Covariation among the four factors was accounted for their regression onto COMM. As in Model #1, relationships between PGI and both learning communities and between FLC and both learning communities were specified, error covariances were set to zero, and relationships between PEL and PGI and between FLC and ENGR1201 were free to be estimated.

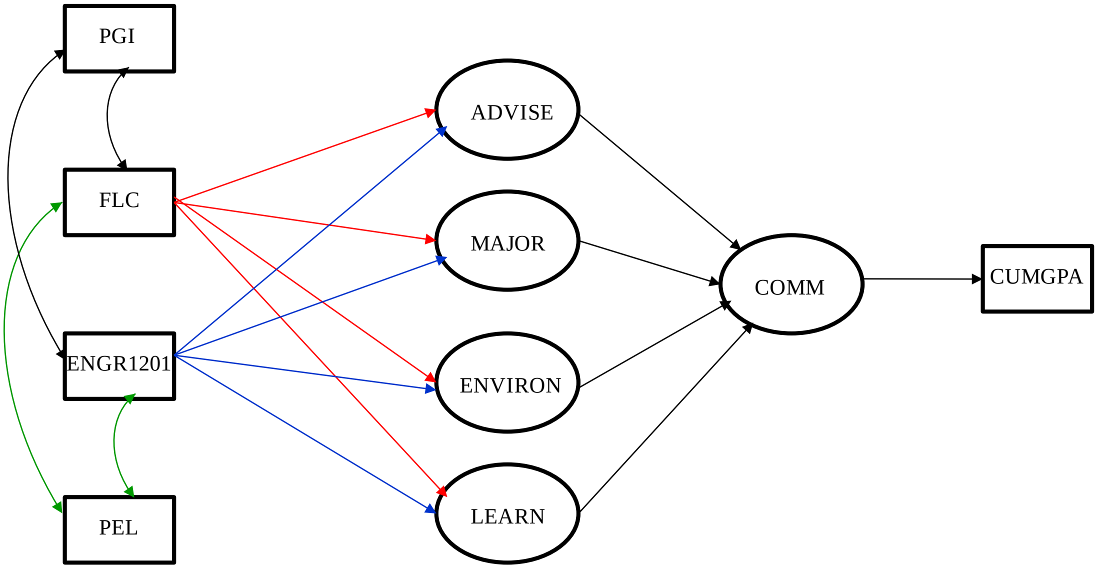


Figure 3. Model #2 of the freshman year experience.

Once models were conceptualized, the parameters were identified to ensure that they were estimable (Byrne, 1998). Estimated parameters included regression coefficients (factor loadings or path coefficients), factor and measurement error variances, and covariances (Byrne, 1998; Hancock & Mueller, 2008a; Ullman, 2007). If the number of data points exceeded the number of estimated parameters, the model was over-identified and a unique solution could be found. The number of data points was calculated as $p*(p+1)/2$ where p is the number of observed variables. Factor error variances, also referred to as disturbances, and one indicator for each factor were set equal to one by default in LISREL to serve as a scale for estimation.

The primary purpose of parameter estimation is to minimize the discrepancy between the sample and population covariance matrices (Bryne, 1998).The default method of parameter estimation is the maximum likelihood (ML) method. ML requires the use of continuous variables although categorical variables that are assumed to have a continuous underlying structure may also be used. If the model includes non-normal and/or coarse discrete data, which is often the case in the social sciences, then other estimation techniques or corrections should be used such as asymptotically distribution free (ADF), robust weighted least squares (WLS), bootstrapping, or scaling methods (Bryne, 1998; Finney & DiStefano, 2006; Garson, 2008b; Hancock & Mueller, 2008a, 2008b). Each method has inherent limitations and the decision regarding which to use is often dependent on sample size; the coarseness of the categorical data, i.e. the number of categories used; the severity of non-normality; the percentage of missing data; and the availability of optional methods in the software used for analysis. Heeding the advice of Hancock and Mueller (2008b) and Finney and DiStefano (2006), the ML method of estimation using the Satorra-Bentler (SB) scaling was used in this study. SB scaling corrects for non-normality by taking into account the kurtotic distribution of the data. The process adjusts measures of fit, described below, and standard errors so that the latter are not attenuated. SB parameter estimates are not affected by the scaling and, therefore, are equivalent to ML-based estimates (Finney & DiStefano, 2006). In combination, SB scaling and the use of the original data set without imputing missing values produce unbiased results. The SB method requires the use of observed covariance and asymptotic covariance matrices, which were generated in LISREL PRELIS prior to running the models in LISREL SIMPLIS.

The Chi-Square (χ^2) for Independence Model tests the hypothesis that the variables are unrelated (Jöreskog, 2004; Ullman, 2007). It is a test of the null model in which all of the variables are uncorrelated. It serves as a baseline against which to compare the hypothesized model to assess the improvement in fit of the data (Bryne, 1998). As such, χ^2 should not be significant. If the model is rejected by the data, i.e. $p \leq .05$, then all of the variables are uncorrelated and there is no need to conduct the analysis. Although the χ^2 statistic is a traditional goodness-of-fit test, it is sensitive to sample size and non-normality (Ullman, 2007). In large sample models, small differences can result in a significant ($p < .05$) χ^2 even when using the SB χ^2 to correct for non-normality. Therefore, data were assumed to fit the model if $\chi^2 /df < 2$ consistent with the recommendation of Ullman (2007).

Goodness-of-fit indices are also used to assess data-model fit. Hancock and Mueller (2008a) suggest selecting one measure from each of the three classes: Incremental, Absolute, and Parsimonious. Specifically, they recommend using the Normed Fit Index (NFI), Non-Normed Fit Index (NNFI), or Comparative Fit Index (CFI) from the Incremental class; the Goodness of Fit Index (GFI) or the Standardized Mean Square Residual (SMSR) from the Absolute class; and the Adjusted Goodness of Fit Index (AGFI) or the Root Mean Square Error of Approximation (RMSEA) from the Parsimonious class. In this study, the following goodness-of-fit indices and cut-offs were used to assess data-model fit: NFI, NNFI, and CFI $\geq .90$; SRMR $\leq .08$; and RMSEA $\leq .06$ (Bentler, 1992; Byrnes, 1998; Hancock & Mueller, 2008a; Hu & Bentler, 1999; Ullman, 2007). Confidence intervals for RMSEA and $p > .05$ for SB χ^2 were also used to evaluate fit.

In every SEM analysis, some misspecification occurs because the data can never perfectly fit the hypothesized model. Modification indices generated by the Lagrange Multiplier Test (LMT) were used to re-specify or improve the model. In some cases, the LMT suggested that constraints should be released or imposed, measured variables should cross-load on more than one factor, and/or error terms should be correlated. Re-specification was guided by theory to avoid moving from a confirmatory to an exploratory mode of analysis. One modification was made at a time based on expected decrease in χ^2 and then the model was rerun to evaluate the impact on all measures of fit. Modifications were restricted to two types: (1) adding indicator error covariances within their respective factor only, which was a plausible approach based on the sequential lay-out of the survey items and, in some cases, the use of a common stem phrase; and (2) adding factor error covariances in Model #2 only since factors were hypothesized to be unrelated in Model #1. Goodness-of-fit measures, standardized residuals greater than +/- 2.58, and Q-plots were used to evaluate the improvement in fit and the extent of misspecification after each modification was made.

Prior to testing the structural models, a confirmatory factor analysis (CFA) was conducted in LISREL SIMPLIS to assess the factorial validity of each theoretical construct (Bryne, 2008; Garson, 2008b; Hancock & Mueller, 2008a; Ullman, 2007). As illustrated in Figure 4, five separate CFAs were run to evaluate convergent validity and goodness of fit of each measurement model: COMM, ADVISE, MAJOR, ENVIRON, and LEARN. A measurement error term (E) was included for each indicator. Correlations among factors were also examined to evaluate discriminant validity. Ideally, relationships among factors should be relatively weak in Model #1. In Model #2, all of the latent variables should be more strongly related to Sense of Community (COMM) than to one another. Indicators that were used to operationalize a construct were expected to demonstrate moderate to strong inter-correlations and relatively weak relationships with items believed to represent other constructs.

The internal consistency reliability of each factor was considered acceptable if Cronbach's $\alpha \geq .70$ (Garson, 2008b). Cronbach's α provides an overall measure of the inter-correlation among item responses for each factor and, therefore, represents a simple composite rather than a latent factor (Hancock & Mueller, 2008a).

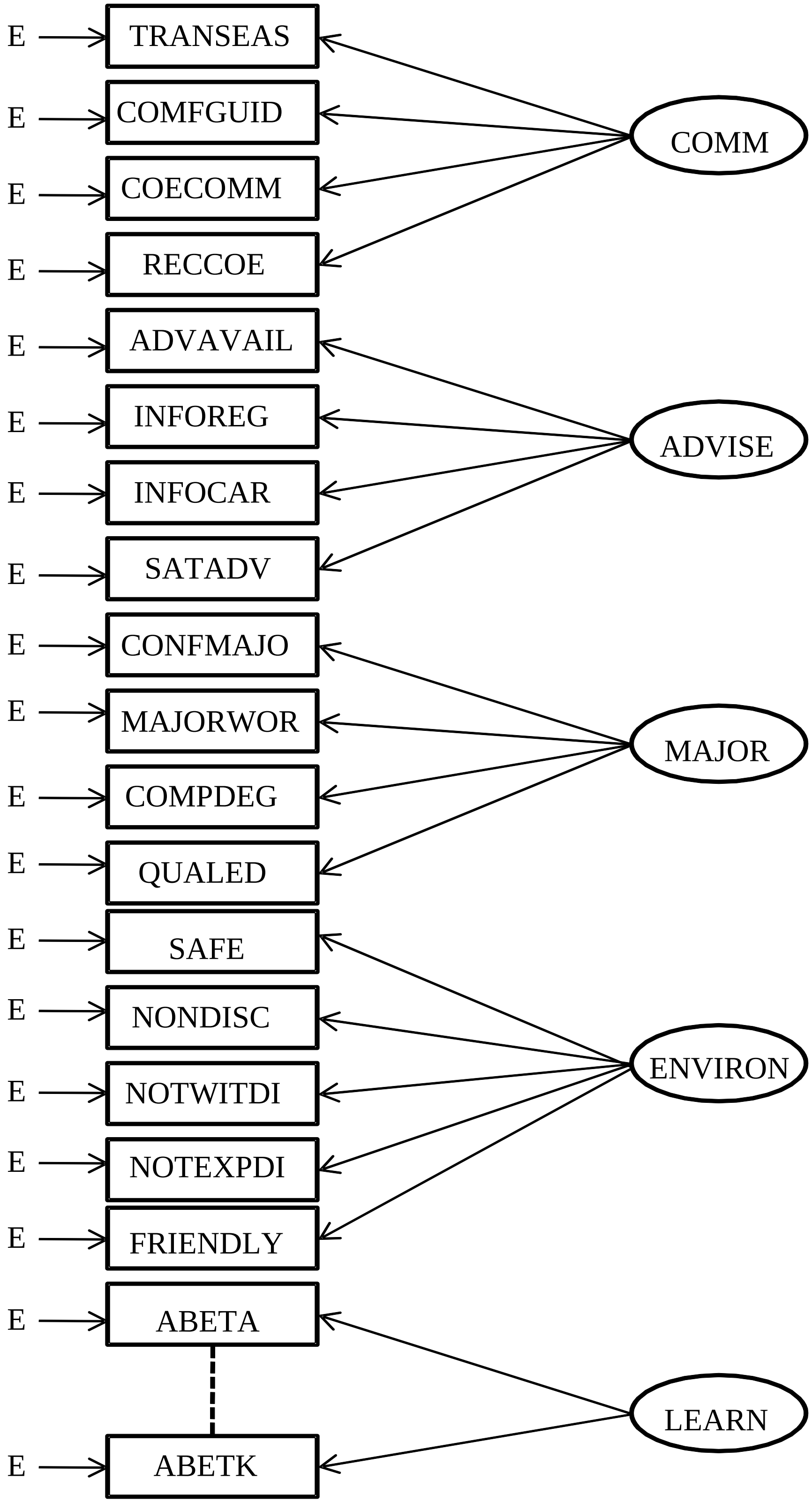


Figure 4. CFA measurement models used to evaluate convergent and discriminant validity.

Factor loadings represent the relationship between an indicator and its factor. Although there is no generally accepted cut-off for the strength of this relationship, Hancock and Mueller (2008a) suggest that standardized factor loadings should exceed 0.6 if four to six indicators are used per factor. Garson (2008a) indicates that a cut-off of 0.7 is often used; however, he is quick to point out that this is a high standard when using real-life data and that a much lower cut-off is often used, particularly in exploratory analyses. The reliability of each observed variable in terms of measuring its underlying construct is given by squaring the standardized factor loading, also referred to as the Squared Multiple Correlation (SMC) or R^2 (Byrne, 1998). R^2 is the proportion of variance accounted for in the data that is explained by the latent factor. For example, if the standardized factor loading for an indicator is 0.6 then 36% of the variance is explained; if it is 0.7, then almost half (49%) of the variance is explained. However, this amount of variance extracted may not be achievable in the social sciences (G. R. Hancock, personal communication, January 25, 2008). Heeding these warnings, a target loading of 0.5 was used so that at least 25% of the variance in the data for each indicator was accounted for by its latent factor. The strength of parameter estimates, also referred to as the path coefficients, between exogenous and endogenous variables were evaluated in the same manner as correlation coefficients. If parameter estimates were $< .35$ they were considered too weak to be of practical use. Factor loadings and parameter estimates were significant at the .05 level.

Goodness-of-fit measures, standardized residuals exceeding three standard deviations (+/- 2.58), and Q-plots were examined to identify the level of misspecification of each measurement model. Re-specification was based on modification indices generated by the LMT. Once the fit of the sample data was determined to be satisfactory, the measurement models were then incorporated into the structural models.

The structural models were then analyzed in LISREL SIMPLIS. The null hypothesis ($\alpha = .05$) was tested to determine if each hypothesized model produced an estimated population covariance matrix that was significantly different from the sample covariance matrix (Ullman, 2007). As in the CFA, goodness-of-fit of the structural models was evaluated by comparing fit indices, significant factor loadings, proportion of variance explained (R^2), and standardized residuals. Each model was compared to the null model to determine if one or both adequately fit the sample data.

Hierarchical logistic regression. Unlike other univariate and multivariate techniques, logistic regression allows for prediction of a discrete outcome, such as group membership, with few restrictions. Predictors do not have to be normally distributed, linearly related, or homoscedastic (Tabachnick & Fidell, 2007). Error terms are not assumed to be normally distributed (Garson, 2009a). Any type of variable, i.e. categorical or continuous, can serve as a predictor. However, logistic regression does not allow for the use of unobserved or latent variables nor does it correct for measurement error as in SEM. Therefore, the mean score for each latent was used as an observed predictor. For example, responses to the four survey items used to operationalize COMM were averaged for each student to provide a global measure of their sense of community. Similarly, scores for indicators of ADVISE, MAJOR, ENVIRON, and LEARN were also averaged.

Variables were entered into the logistic model in SPSS based on their temporal characteristics. PGI and PEL were entered into the first step of the model as covariates since they were incoming characteristics possessed by students prior to starting college, i.e. they were not controlled in the study. ENGR1201 and FLC were entered in the second step of the analysis since they represented students' participation in curricular and extra-curricular learning communities, respectively, at the beginning of the fall semester of their freshman year. Mean scores for latent variables, which operationalized students' perceptions of the freshman year experience, were added in the third block. From a temporal sequence, students' perceptions are formed after they have some experience on which to base them. The college's annual student survey, which is used to measure their perceptions, is conducted in the spring semester of the freshman year. Finally, CUMGPA, which is measured at the end of the spring semester of the freshman year, was entered into the model in the last step. Collectively, the variables were used to predict the dependent variable PERSIST, which was a dichotomous variable that reflected re-enrollment status in the second semester of the sophomore year.

Consistent with the approach suggested by Tabachnick & Fidell (2007), the goodness-of-fit of the model was first evaluated by comparing a constant-only model, which is one with the regression intercept only, to a full model, which is one that also includes all of the predictors. The effect of the predictors on the outcome was evaluated by comparing the difference in the constant-only and full models with $p < .05$ based on the log-likelihood test. The contribution of each individual predictor was evaluated using the Wald χ^2 test at a significance level of .05. The Nagelkerke R^2 and Cox and Snell R^2 represented the variance accounted for in the outcome by the combination of predictors. The Nagelkerke R^2 is adjusted to a scale of 0 to 1, thus it is comparable to the scale of R^2 used in the SEM analysis.

Parameter estimates are given as beta (β) coefficients of the predictors in the logistic equation. The β coefficients are also the natural logs of the odds ratio, i.e. odds ratio = e^{β}. Therefore, if a predictor changes by one unit, the odds of achieving the outcome are multiplied by e^{β}. For example, if the odds ratio for a predictor is equal to two then for every unit increase in the value of that predictor, the odds of achieving the outcome are doubled. On the other hand, if the odds ratio = 0.8, then for every 0.8 unit increase in the value of the predictor, the odds of achieving the outcome are reduced by 20%. Finally, the goodness-of-fit of the model was also evaluated based on its ability to correctly classify or predict group membership in at least 50% of the cases, which is the default in SPSS.

Summary

In summary, SEM was used to comprehensively investigate the direct and indirect effects of curricular and extra-curricular learning communities and students' perceptions of the freshman year experience on their academic performance. SEM allows both observed and unobserved variables to be used and it accounts for measurement error. Two models were specified a priori based on the theoretical framework of the study. Both models incorporated students' incoming characteristics of predicted grade index (PGI) and parental education level (PEL), participation in the FLC, enrollment in ENGR1201 based on mathematics placement exam score, perceptions of the freshman year experience using items from the college's annual survey, and academic performance (CUMGPA) as the dependent variable. The measurement model and two structural models were tested in LISREL SIMPLIS to determine the goodness-of-fit with the sample data.

A hierarchical logistic regression was then conducted in SPSS to predict students' persistence (PERSIST), which was dichotomously measured as re-enrollment in the College of Engineering in the second semester of the sophomore year. PGI and PEL were used as covariates with FLC and ENGR1201 entered into the second step. Mean scores for each latent were entered in the third step and CUMGPA was added in the final step of the analysis.

CHAPTER 4: RESULTS

The purpose of this study was to investigate the relationship of a residential learning community and enrollment in an introductory engineering course to engineering students' perceptions of the freshman year experience, academic performance, and persistence. This chapter describes the study participants, students' perceptions of the freshman year experience, and results specific to the research questions articulated in Chapter 2.

Participants

Table 2 provides demographic and academic characteristics, learning community participation rates, and persistence rates for the 316 students that comprised the sample for the study, which represented a 34% response rate. Skew and kurtosis within +/- 1 indicated academic variables were univariate normally distributed with the exception of the CUMGPA for the fall 2005 (F05) cohort which was slightly kurtotic (*kurtosis* = 1.35).

Overall, 12.3% of the participants were female and only 8.5% represented ethnic minorities, i.e. African American, Hispanic, or Native American combined. The mean SAT Verbal and SAT Math scores were 538 (*SD* = 74, *Min* = 330, *Max* = 790) and 607 (*SD* = 62, *Min* = 460, *Max* = 770), respectively. The mean HS GPA and PGI were 3.67 (*SD* = 0.43, *Min* = 2.45, *Max* = 4.85) and 2.77 (*SD* = 0.39, *Min* = 2.00, *Max* = 3.90), respectively.

Fifty-two percent of the participants lived in the FLC and 69% enrolled in ENGR1201 based on their mathematics placement exam score. Historically, about half of the college's freshmen self-select to participate in the FLC and about two-thirds of engineering majors are eligible to enroll in ENGR1201. Thus, learning community participation and ENGR1201 enrollment rates for the sample were consistent with historical trends.

Table 2

Demographic, Academic, Learning Community, and Persistence Profiles of Participants

	Fall 05	Fall 06	Fall 07	Overall
N	121	80	115	316
% Female	9.9	18.8	10.4	12.3
% White	81.8	81.2	80.0	81.0
% Minority	7.4	10.0	8.7	8.5
% Other Ethnicities	10.8	8.8	11.3	10.5
SAT Verbal (N*)	120	79	115	314
Mean	534	551	532	538
SD	71	70	78	74
Skew	0.18	0.23	0.63	0.36
Kurtosis	0.69	0.20	0.47	0.41
SAT Math (N*)	120	79	115	314
Mean	607	617	599	607
SD	59	58	67	62
Skew	0.06	-0.28	0.42	0.11
Kurtosis	-0.47	-0.43	-0.09	-0.38
HS GPA (N*)	119	79	114	312
Mean	3.63	3.69	3.70	3.67
SD	0.44	0.42	0.42	0.43
Skew	0.16	0.35	-0.09	0.11
Kurtosis	0.54	-0.24	-0.24	0.04
PGI (N)	119	77	113	309
Mean	2.72	2.80	2.81	2.77
SD	0.38	0.40	0.38	0.39
Skew	0.54	0.18	0.20	0.32
Kurtosis	-0.31	-1.00	-0.31	-0.57
Freshman Yr CUMGPA (N*)	121	80	115	316
Mean	2.87	2.83	2.92	2.88
SD	0.75	0.73	0.61	0.69
Skew	-0.97	-0.87	-0.36	-0.82
Kurtosis	1.35	0.63	-0.24	0.94
% in FLC	43.0	60.0	56.4	52.2
% in Calculus I/ENGR1201	65.3	78.8	66.1	69.0
% w/Parent w/4-Yr Degree	57.9	58.8	60.0	58.9
% Persist 2nd Semester Soph Yr	80.2	80.0	84.3	81.6

* SAT scores, high school GPA, and PGI were not available for some students.

Almost 59% of the survey respondents indicated that at least one parent had a four year college degree. On average, by the end of their freshman year students earned a CUMGPA of 2.88 (*SD* = 0.69, *Min* = 0.12, *Max* = 4.00). By the second semester of their sophomore year, almost 82% of the participants were still enrolled in the College of Engineering.

Independent *t* tests were conducted to determine if incoming academic characteristics of study participants (*N* = 316) were significantly different from those of non-participants (*N* = 614). Non-participants included all new freshman engineering majors enrolled in the college in the fall semesters of 2005-2007 who did not respond to the survey in the spring semesters of 2006-2008. The means of SAT Verbal, SAT Math, HS GPA, and PGI were compared for both groups. Because four *t* tests were conducted, a Bonferonni adjustment was made to reduce the risk of a Type I error so that $\alpha = .05/4 = .013$. Levene's test revealed that the assumption of homogeneity of variance was tenable in all four cases (*ps* > .013). Results indicated that study participants were not significantly different from non-participants relative to mean SAT Math (t =2.174, p = .030, df = 922) and HS GPA (t = 2.186, p = .029, df = 919). However, there was a statistically significant difference in mean PGI (t = 3.350, p = .001, df = 916) and mean SAT Verbal score (t = 2.829, p = .005, df = 922). The mean PGI of study participants was higher than for non-participants (2.77 versus 2.69, respectively). The mean SAT Verbal score was also higher for participants than for non-participants (538 versus 524, respectively). Cohen's *d* was calculated using pooled standard deviations to determine effect sizes. In both cases the effect was small, i.e. d = .23 for the difference in mean PGI and d = .19 for the difference in mean SAT Verbal score. This indicated that the difference in means between the two groups was less than one-fourth of a standard deviation.

Two chi square analyses were conducted with $\alpha = .025$ to determine if there were gender or ethnicity differences between participants and non-participants. Results indicated that there was not a significant ethnicity difference ($p > .025$). However, there was a significant gender difference, χ^2 (1, *N* = 930) = 17.9, *p* < .001. The percentage of survey respondents that was female (12.3%) was significantly higher than the percentage of female non-respondents (4.7%).

In summary, participants had a higher PGI and SAT Verbal score and were more likely to be female than non-participants. However, the effect of the differences in PGI and SAT Verbal score was small. There were no other significant differences between the groups on any of the other incoming demographic or academic characteristics. In addition, rates of participation in learning communities, i.e. ENGR1201 and the FLC, were consistent with historical trends. Collectively, these results suggested that participants in this study were not significantly different from non-participants which meant that non-response bias was not problematic.

Perceptions of the Freshman Year Experience

Table 3 provides descriptive statistics for the 28 survey items used to operationalize students' perceptions of the freshman year experience. Means ranged from 3.94–4.54 on the five-point rating scale and variability was within one standard deviation for all 28 items. The assumption of univariate normality was not tenable for 16 survey items based on skew and/or kurtosis > +/- 1 and examination of histograms. In addition, tests of significance in LISREL PRELIS indicated that variables were not multivariate normal. Missing values accounted for 7.9% of ADVAVAIL; 6.0% of ABETC; 5.1% of INFOCAR, ABETB, ABETE, and ABETK; and less than 5% for all other survey items. Overall, only 3.4% of the values were missing from the complete data set used for modeling. Based on Little's MCAR *p* < .05 and examination of the patterns of missingness, it was assumed that values were missing at random.

Table 3

Descriptive Statistics for the 28 Survey Items Used to Operationalize Constructs

Construct/ Indicators	N*	Mean	SD	Min	Max	Skew	Kurtosis	% ≥ Agree (≥ 4)
COMM								
TRANSEAS	306	4.02	0.90	1	5	-0.86	0.67	76.5
COMFGUID	309	4.28	0.73	1	5	-0.99	1.39	88.6
COECOMM	310	3.94	0.89	1	5	-0.61	0.23	70.4
RECCOE	303	4.19	0.74	1	5	-1.02	2.32	86.8
ADVISE								
ADVAVAIL	291	4.35	0.75	1	5	-1.37	3.10	90.1
INFOREG	308	4.33	0.78	1	5	-1.33	2.48	88.3
INFOCAR	300	4.08	0.88	1	5	-0.88	0.77	77.3
SATADV	314	4.17	0.86	1	5	-1.40	2.69	87.0
MAJOR								
CONFMAJO	309	4.17	0.88	1	5	-0.97	0.70	79.6
MAJORWOR	307	4.37	0.79	1	5	-1.50	3.14	88.6
COMPDEG	309	4.19	0.83	1	5	-1.28	2.62	84.8
QUALED	307	4.28	0.69	1	5	-0.86	1.41	89.9
ENVIRON								
SAFE	314	4.53	0.58	2	5	-0.88	0.34	96.5
NONDISC	314	4.49	0.65	2	5	-1.17	1.48	94.2
FRIENDLY	315	4.41	0.69	1	5	-1.20	2.18	92.4
NOTWITDI	309	4.50	0.67	2	5	-1.40	2.24	94.2
NOTEXPDI	309	4.54	0.65	2	5	-1.47	2.46	94.9
LEARN								
ABETA	301	4.37	0.63	1	5	-1.20	4.35	95.7
ABETB	300	4.32	0.57	2	5	-0.33	0.67	96.4
ABETC	297	4.31	0.60	2	5	-0.45	0.39	93.9
ABETD	301	4.39	0.62	2	5	-0.65	0.37	94.4
ABETE	300	4.36	0.62	1	5	-0.84	2.38	95.0
ABETF	303	4.30	0.64	2	5	-0.51	0.09	91.4
ABETG	302	4.30	0.63	2	5	-0.49	0.20	92.4
ABETH	302	4.26	0.64	2	5	-0.53	0.40	91.1
ABETI	303	4.26	0.69	1	5	-0.88	1.74	90.4
ABETJ	302	4.13	0.68	2	5	-0.42	0.10	85.1
ABETK	300	4.32	0.63	1	5	-0.77	1.96	93.3

* Some students did not respond to all questions.

Scatter plots were generated for a large number of bivariate relationships but not all of them due to the fact that 30 interval/ratio variables (28 survey items, PGI, and CUMGPA) were used. The scatter plots indicated that some relationships were linear while others were not. Although box plots and Mahalanobis *p* < .001 revealed a number of univariate and multivariate outliers, respectively, all of the survey responses fell within the range of the five-point Likert scale, PGI's ranged from 2.0 to 4.0, and CUMGPA's fell within the standard 4.0 scale. Therefore, all cases were retained for further analysis.

At least 85% of the students responded "Agree" or "Strongly Agree" (rating of 4 or 5) to 24 of the 28 survey items. Based on their responses to the ABETA through ABETK items, most of the students ($\geq$ 85%) had an appreciation of the competencies required to become an engineer despite the fact that they were only freshmen. They also felt that the college's learning environment was safe (96.5%), non-discriminatory (94.2%), and friendly (92.4%). With few exceptions, most students had not witnessed nor experienced discrimination in the college (94.2% and 94.9%, respectively). The majority of respondents felt part of the college community (70.4%), was comfortable seeking guidance from a faculty or staff member (88.6%), believed their degree was worth the time and effort (88.6%), and was confident that they could complete their degree (84.8%). Students felt their academic advisor was available (90.1%) and that their advisor gave them accurate information for registration (88.3%). It was somewhat surprising that 77.3% of the respondents reported that their academic advisor gave them useful information for career development even though they were only in the first year of the engineering program. Overall, 87.0% of the students were satisfied with their academic advising experience.

Pearson product moment correlations were generated in SPSS to determine the strength and direction of relationships and to test for multi-collinearity. Values of *r* were expected to be attenuated since some of the bivariate relationships were non-linear, outliers were retained in the dataset, and the survey items were assumed to be measured on a continuous scale (Garson, 2008c).

Inter-item correlations for the construct COMM ranged from .34 to .51 (*ps* = .01). Although internal consistency reliability was acceptable based on Cronbach's $\alpha = .72$, it barely exceeded the cut-off of .7. Students' comfort in seeking guidance from a College of Engineering faculty or staff member (COMFGUID) was moderately correlated with the other 27 survey items with values of r ranging from .35 to .58 (*ps* = .01). The strongest relationship was between COMFGUID and QUALED with the latter measuring students' belief that the quality of their education makes them competitive in the job market. Results also indicated that students were more likely to recommend the College of Engineering (RECCOE) if they perceived the college as friendly (FRIENDLY), $r = .37$, $p = .01$; were confident in their choice of major (MAJOR), $r = .44$, $p = .01$; believed that their major was worth the time and effort (MAJORWOR), $r = .49$, $p = .01$; had favorable perceptions regarding the quality of their education (QUALED), $r = .47$, $p = .01$; felt part of the college community (COECOMM), $r = .47$, $p = .01$; and believed that their education was preparing them to demonstrate the 11 ABET a-k competencies (LEARN), $.41 \leq r \leq .56$, *ps* = .01. Students' recommendation of the college (RECCOE) was not related to their perceptions of their academic advising experience based on $r < .31$ for all four ADVISE indicators.

Correlations among the four items used as indicators for ADVISE were relatively strong with r values ranging from .64 to .75. All were significant at the .01 level. Internal consistency reliability was acceptable as Cronbach's $\alpha = .90$. Relationships with all of the other survey items were weak to moderate but significant ($.22 \leq r \leq .42$, *ps* = .01). The strongest relationships were between students' perceptions that their advisor was available (ADVAVAIL) and their belief that their education is preparing them to use the techniques, skills, and tools of the engineering profession (ABETK), $r = .42$, $p = .01$; students' perception that their advisor was available

(ADVAVAIL) and their belief that their education is preparing them to design and conduct experiments as well as to analyze and interpret data (ABETB), $r = .41$, $p = .01$; students' satisfaction with advising (SATADV) and their level of comfort in seeking guidance from a faculty or staff member (COMFGUID), $r = .42$, $p = .01$; and students' satisfaction with advising (SATADV) and their feeling part of the college community (COECOMM), $r = .41$, $p = .01$.

Relationships among the four items used to operationalize MAJOR were moderate to strong with values of *r* ranging from .47 to .74 (*ps* = .01). Internal consistency reliability was acceptable based on Cronbach's $\alpha = .84$. However, relationships between MAJOR indicators and LEARN indicators were also moderate in strength with *rs* ranging from .35 to .57 (*ps* = .01). The only exception was the relationship between CONFMAJO and ABETH ($r = .33$, $p = .01$), which measured the association between students' confidence in their choice of major and their belief that their education was preparing them to understand the impact of engineering solutions in a global, economic, environmental, and societal context. This finding was not too surprising as the freshman engineering curriculum does little to give students an appreciation of the "big picture" of the profession given its focus on technical skills in calculus, chemistry, physics, and engineering courses. It was also interesting to note that indicators used to operationalize students' perceptions of their major (MAJOR) were significantly and moderately related ($.37 \leq r \leq .58$, *ps* = .01) to all of the items used to measure students' perception of community (COMM), i.e. their ease of transition in to the college (TRANSEAS), their comfort seeking guidance (COMFGUID), their feeling part of the college community (COECOMM), and if they recommend the College of Engineering to their family and friends (RECCOE).

Values of *r* among the five items that operationalized ENVIRON ranged from .50 to .88 (*ps* = .01). Internal consistency reliability was acceptable as Cronbach's $\alpha = .89$. Although relationships with all the other survey items were significant, they were weak to moderate in strength ($.21 \leq r \leq .52$, *ps* = .01). Weak correlations (*rs* < .35) existed between ENVIRON indicators, i.e. those items used to measure students' perceptions of the college as safe, friendly, and non-discriminatory, and indicators of: (1) Students' satisfaction with academic advising (SATADV); (2) their belief that their major is worth the time and effort (MAJORWOR); and (3) and their confidence in their ability to complete their degree (COMPDEG). However, students' belief that the college was friendly (FRIENDLY) was moderately correlated with their level of comfort in seeking guidance from a faculty or staff member (COMFGUID), $r = .52$, $p = .01$; feeling part of the college community (COECOMM), $r = .47$, $p = .01$; and their perceptions regarding the quality of their education (QUALED), $r = .44$, $p = .01$.

Relationships among the 11 ABET a-k competencies (LEARN) were moderate to strong with r values ranging from .45 to .78 and all were significant at the .01 level. Internal consistency reliability was acceptable based on Cronbach's $\alpha = .95$. Of particular interest was the relationship of ABETE, which is the ability to identify, formulate, and solve engineering problems, with all of the other 27 survey items used to operationalize students' sense of community (COMM) and their perceptions of academic advising (ADVISE), the environment (ENVIRON), and their major (MAJOR); $.35 \leq r < .57$, $ps = .01$. None of the other 10 ABET competencies demonstrated such consistent relationships.

All of the correlations between PGI and each of the 28 survey items and between CUMGPA and each of the 28 survey items were either insignificant ($ps > .05$) or too weak to be of practical use ($rs < .35$). However, the relationship between PGI and CUMGPA was significant and moderate in strength ($r = .45$, $p = .01$). This finding was expected based on previous studies conducted by the college.

PERSIST was found to be significantly and moderately related with students' confidence in their choice of major (CONFMAJO: $r = .35$, $p = .01$) and with their freshman year academic performance (CUMGPA: $r = .37$, $p = .05$). The associations between PERSIST and all other variables were either too weak to be of practical use, i.e. $r < .35$, or they were not statistically significant.

In summary, data screening revealed evidence of non-normality, univariate and multivariate outliers, and non-linear bivariate relationships. Inter-item correlations for each construct were, generally, moderate to strong and internal consistency reliabities were acceptable with Cronbach's α ranging from .72 to .95. Although there was strong evidence for convergent validity for each latent variable, there was also evidence to suggest that some indicators might be highly related to other factors. For example, the strength of relationships between items used to operationalize students' sense of community (COMM) and their perceptions of the major (MAJOR) were similar to inter-item correlations within each construct. This suggested that there might not be sufficient discriminant validity between some of latent variables. The following section describes the results of the CFA used to evaluate the measurement model prior to conducting the latent variable path analysis (LVPA).

Measurement Model

Prior to conducting the CFA, parameters were identified and each measurement model was found to be over-identified, i.e. the number of data points exceeded the number of parameters to be estimated, which meant that a unique solution could be found. A CFA was then conducted on each of the five factor-analytic models using the original data set with missing values and ML estimation with SB scaling to obtain unbiased results. Results are summarized in Tables 4 and 5. Target values for measures of fit are provided in parenthesis for comparison with actual values. Results suggested a good fit of the data with the models based on values of NFI, NNFI, and CFI $\geq .97$; SRMR $< .07$; significant standardized factor loadings $\geq .54$ ($ps < .05$); and $R^2 \geq .29$. Further evidence of fit was provided by RMSEA $< .06$ for four of the models and few standardized residuals beyond three standard deviations (+/- 2.58).

Table 4

CFA Results for the Five-Factor Measurement Model Using SB Scaling (N= 316)

Measure (Target)	COMM	ADVISE	MAJOR	ENVIRON	LEARN
Effective *N*	287	298	297	302	307
# Indicators	4	4	4	5	11
Std Loadings (≥ .5)	0.54-0.71*	0.80-0.89*	0.58-0.86*	0.56-0.96*	0.72-0.87*
SB χ^2 / *df* (< 2)	0.93	0.21	1.66	4.83	1.89
p (> .05)	0.40	0.81	0.19	0.00	0.00
NFI (> .90)	0.99	1.00	0.99	0.99	0.99
NNFI (> .90)	1.00	1.01	0.99	0.97	0.99
CFI (> .90)	1.00	1.00	1.00	0.99	1.00
RMSEA (< .06)	0.000	0.000	0.046	0.110	0.053
90% CI	0.0-0.11	0.0-0.069	0.0-0.13	.058-0.17	0.034-0.072
SRMR (< .08)	0.020	0.0052	0.021	0.070	0.037
R^2 (≥ .25)	0.29-0.51	0.64-0.79	0.34-0.73	0.32-0.93	0.52-0.75
Smallest Std Residual	-2.04	-0.18	-0.48	-0.35	-4.14
Largest Std Residual	0.71	0.09	0.87	3.80	3.96
# Std Res > +/- 2.58	0	0	0	2	4
# Error Covar Used	0	0	0	2	7

* All were significant at the .05 level.

Table 5

Internal Consistency Reliabilities of Factors and CFA Standardized Factor Loadings

	COMM	ADVISE	MAJOR	ENVIRON	LEARN
Cronbach's α	.72	.90	.84	.89	.95
COMFGUID	.71				
COECOMM	.67				
RECCOE	.62				
TRANSEAS	.54				
INFOREG		.89			
INFOCAR		.86			
SATADV		.82			
ADVAVIL		.80			
MAJORWOR			.86		
CONFMAJO			.84		
COMPDEG			.75		
QUALED			.58		
NOTWITDI				.96	
NOTEXPDI				.91	
NONDISC				.76	
FRIENDLY				.58	
SAFE				.56	
ABETE					.87
ABETK					.86
ABETB					.81
ABETH					.81
ABETJ					.77
ABETI					.76
ABETA					.75
ABETD					.74
ABETF					.74
ABETG					.73
ABETC					.72

Note. All factor loadings were significant at the .05 level.

In some cases, goodness-of-fit measures and modification indices suggested that the data would better fit the model by allowing some error terms to covary. Only one error covariance was suggested for COMM but it was not used because the model was an excellent fit without it. Although several error covariances were suggested for ENVIRON, only two were ultimately used to improve the overall fit. The final model for LEARN included seven error covariances; none of the others suggested by the LMT sufficiently improved the model. No modifications were suggested for ADVISE or MAJOR. These error covariances were incorporated into the base structural models, i.e. they were added to the LISREL SIMPLIS syntax prior to running the initial latent variable path analyses.

Relationships among the five factors, which included the seven error covariances from the CFA, were evaluated using listwise deletion via the Full Information Maximum Likelihood (FIML) method of estimation in LISREL. As indicated in Table 6, factor correlations were generally moderate to strong ranging from .36 to .72 (*ps* = .01) with two exceptions. Lack of discriminant validity was potentially problematic in two of the relationships as *r* = .91 for COMM and MAJOR and *r* = .86 for COMM and LEARN. This finding offered support for Model #2 in that COMM may be explained by the other four latent variables with covariation accounted for by their regression onto COMM. Therefore, despite these high correlation coefficients, each latent variable was treated as a separate construct.

Table 6

CFA Factor Correlations

	COMM	ADVISE	MAJOR	ENVIRON	LEARN
COMM	1.00				
ADVISE	0.62*	1.00			
MAJOR	0.91*	0.44*	1.00		
ENVIRON	0.55*	0.36*	0.38*	1.00	
LEARN	0.86*	0.53*	0.72*	0.46*	1.00

* $p = .01$

In summary, internal consistency reliabilities, goodness-of-fit indices, factor loadings, the percent of variance accounted for in the data (R^2), and standardized residuals indicated that the five latent variables were well constructed by the survey items. Path diagrams for each CFA are illustrated in Figures A-1 through A-5 in the Appendix. The following section describes results of the evaluation of the structural models.

Structural Models

Prior to conducting the latent variable path analyses (LVPA), parameters were identified and it was determined that unique solutions were possible for both structural Models #1 and #2. Error covariances for ENVIRON and LEARN specified by the CFA were added to the structural models prior to analysis. The ML method of estimation using the Satorra-Bentler (SB) scaling was then used to estimate parameters.

Model #1. Results for Model #1 are provided in Table 7. Target values for measures of fit are noted in parenthesis for comparison with actual values. Although the LMT suggested a number of modifications, none were added because they did not sufficiently improve the data-model fit to justify their inclusion.

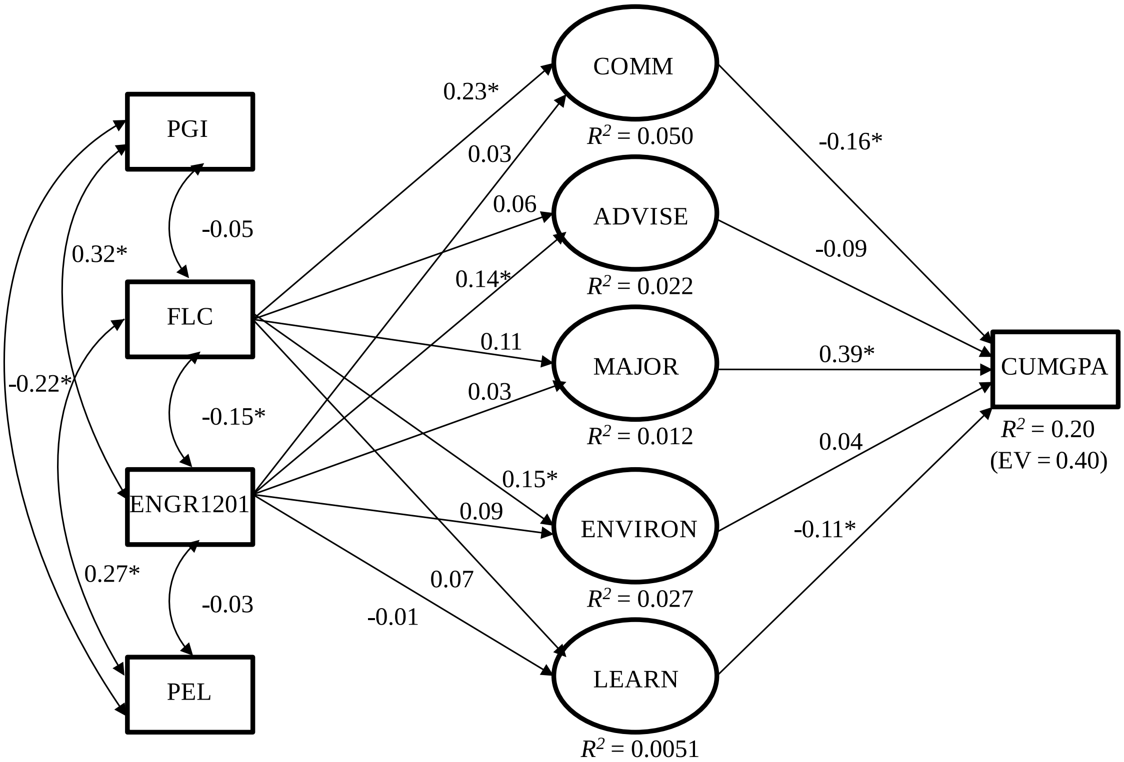
Table 7

Structural Model #1: LVPA Results

Measure (Target)	Value / Range
SB χ^2 / df (< 2)	3.54
p (> .05)	0.000
NFI (> .90)	0.93
NNFI (> .90)	0.94
CFI (> .90)	0.95
RMSEA (< .06)	0.090
90% CI	0.085-0.095
SRMR (< .08)	0.27
IV-Latent Standardized Parameter Estimates	-0.01-0.23
# Significant Paths ($p \leq .05$)	3 of 10
Standardized Factor Loadings ($\geq .5$)	0.54-0.96*
R^2 ($\geq .25$)	0.29-0.93
Latent-CUMGPA Standardized Parameter Estimates	-0.16-0.39
# Significant Paths ($p \leq .05$)	3 of 5
CUMGPA R^2	0.20
Range of Standardized Residuals	-41.67-10.00
# Standardized Residuals > +/- 2.58	321
# Error Covariances Used**	N/A

* All were significant at the .05 level. ** In addition to those specified by the CFA.

Overall, results indicated marginal support for Model #1 based on goodness-of-fit measures. NFI = .93, NNFI = .94, and CFI = .95 all exceeded the target value of .90. Standardized factor loadings ranged from .54 to .96, which exceeded the target of .5, and all were significant at the .05 level. The proportion of the variance explained (R^2) by the latent in each indicator ranged from .29 to .93, all of which exceeded the target of .25. However, SB χ^2 / df = 3.54, RMSEA = .090, SRMR = .27, and an unacceptably large number of standardized residuals beyond three standard deviations (+/- 2.58) clearly indicated that the data marginally fit Model #1. The path diagram with standardized parameter estimates and variance accounted for (R^2) in the each latent variable and the outcome is provided in Figure 5. Paths significant at the .05 level are indicated by an asterisk. Measurement indicators for each latent variable are not illustrated.



*$p \leq .05$

Figure 5. Structural Model #1 with standardized parameter estimates and variance explained (R^2).

Although relationships between some of the exogenous variables (i.e. PGI, FLC, ENGR1201, and PEL) were significant, correlation coefficients fell below the cut-off of r =.35 which indicated that they were too weak to be of practical use. Thus, Model #1 failed to support the hypotheses that PGI and parental education level (PEL) are related to self-selection into the FLC and eligibility for enrollment in ENGR1201.

Significant path coefficients of 0.23 and 0.15 from FLC to COMM and ENVIRON, respectively, provided support for the hypothesis that the extra-curricular residential learning community directly affects students' sense of community and their perceptions of the learning environment (ENVIRON). The significant path coefficient of 0.14 from ENGR1201 to ADVISE also supported the hypothesis that the curricular learning community directly contributes to students' perceptions of advising. However, none of the other paths were significant and the overall variance explained in the data by both learning communities was negligible based on $R^2 < 1\%$ for each latent. Consequently, virtually all of the variability in students' perceptions of the freshman year experience was unexplained by the model.

However, the model did explain 20% of the variance in CUMGPA. Student's sense of community (COMM), perceptions of the major (MAJOR), and perceptions of the ABET a-k competencies (LEARN) were significant ($ps \leq .05$) direct effects of freshman year academic performance. MAJOR made the largest contribution to CUMGPA with a standardized parameter estimate of 0.39. As indicated by the signs of the coefficients, MAJOR was the only positive predictor of academic performance while COMM and LEARN were negative predictors. The error variance (EV) of CUMGPA indicated that 40% of the variability in academic performance remained unexplained by the model. Structural equations with standardized parameters estimates for the paths from FLC and ENGR1201 to each latent are given in Equations 1-5 with significant predictors in bold font.

$$\text{COMM} = 0.026*\text{ENGR1201} + \mathbf{0.23*FLC} \qquad R^2 = 0.050 \tag{1}$$

$$\text{ADVISE} = \mathbf{0.14*ENGR1201} + 0.057*\text{FLC} \qquad R^2 = 0.022 \tag{2}$$

$$\text{MAJOR} = 0.027*\text{ENGR1201} + 0.11*\text{FLC} \qquad R^2 = 0.012 \tag{3}$$

$$\text{ENVIRON} = 0.092*\text{ENGR1201} + \mathbf{0.15*FLC} \qquad R^2 = 0.027 \tag{4}$$

$$\text{LEARN} = -\ 0.014*\text{ENGR1201} + 0.068*\text{FLC} \qquad R^2 = 0.0051 \tag{5}$$

Equation 6 represents the measurement equation for the paths from the latent variables to the outcome CUMGPA. It includes unstandardized parameter estimates, which retain their original metrics. Therefore, holding all other independent variables constant, a unit increase in a predictor will increase or decrease the outcome by the value of the parameter estimate. For example, if a student's perception of the major increases by one point on the Likert scale, his or her CUMGPA would be expected to increase by more than one-quarter of a letter grade (0.28 points). Significant predictors are noted in bold font.

$$\begin{aligned}\text{CUMGPA} = &\ \mathbf{-\ 0.11*COMM} - 0.064*\text{ADVISE} + \mathbf{0.28*MAJOR} + \\ &+ 0.025*\text{ENVIRON} \mathbf{\ -\ 0.078*LEARN} \qquad R^2 = 0.20\end{aligned} \tag{6}$$

In summary, there was marginal support for Model #1 based on goodness-of-fit measures, standardized residuals, and the number of significant predictors. The FLC significantly contributed to students' sense of community and their perceptions of the learning environment. ENGR1201 significantly contributed to students' perceptions of advising. Overall, 20% of the variance in academic performance was explained by students' perceptions of the freshman year experience. Students' sense of community, perceptions of the major, and perceptions of ABET a-k competencies were significant predictors of cumulative GPA. However, their perceptions of the major had the greatest direct effect on academic performance and it was the only positive significant predictor.

Model #2. Results for Model #2 are provided in Table 8. Target values for measures of fit are noted in parenthesis for comparison with actual values. Since a number of modifications were made based on the LMT, results for both the original and revised models are provided.

Originally, the sample data marginally fit hypothesized Model #2 based on goodness-of-fit measures. NFI = .94, NNFI = .96, and CFI = .96 all exceeded the target value of .90. Standardized factor loadings ranged from .44 to .96, only one of which did not exceed the target of .5, and all were significant at the .05 level. The proportion of the variance accounted for (R^2) in each indicator by its respective latent ranged from .20 to .92. Only the variance explained for TRANEAS ($R^2 = .20$) failed to meet the target of .25. However, SB χ^2 / df = 2.74, RMSEA = .074, SRMR = .25, and an unacceptably large number of standardized residuals beyond three standard deviations (+/- 2.58) clearly indicated marginal data-model fit.

Table 8

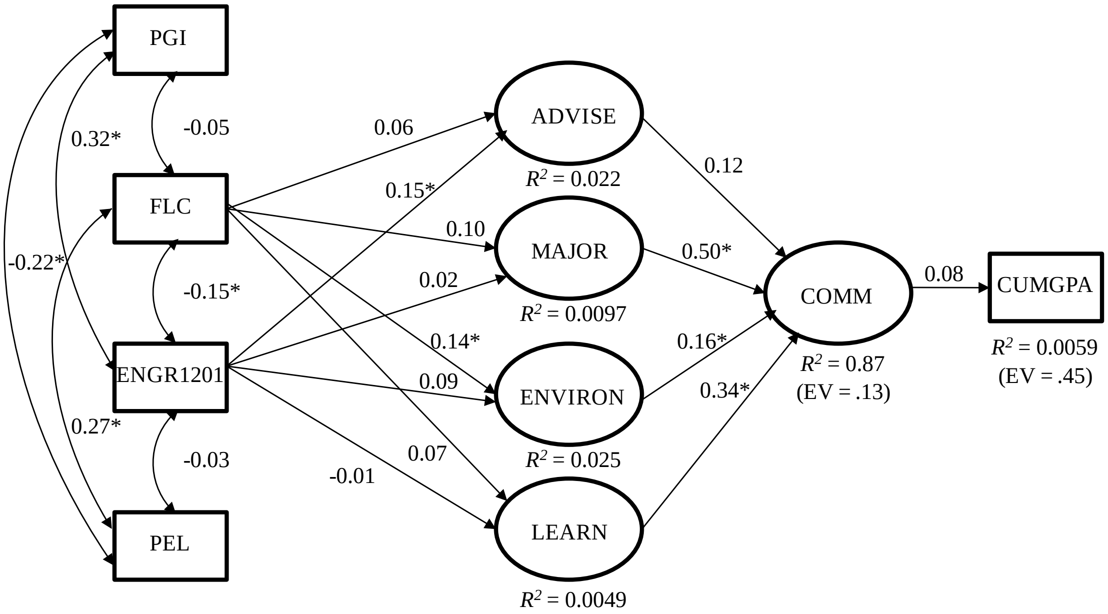
Structural Model #2: LVPA Results

Measure (Target)	Original	Respecified
SB χ^2 / *df* (< 2)	2.74	1.93
p (> .05)	0.000	0.000
NFI (> .90)	0.94	0.96
NNFI (> .90)	0.96	0.98
CFI (> .90)	0.96	0.98
RMSEA (< .06)	0.074	0.054
90% CI	0.070-0.079	0.049-0.060
SRMR (< .08)	0.25	0.071
IV-Latent Standardized Parameter Estimates	-0.01-0.15	-0.01-0.15
# Significant Paths ($p \leq .05$)	3 of 8	2 of 8
Standardized Factor Loadings ($\geq .5$)	0.44-0.96*	0.53-0.97*
R^2 ($\geq .25$)	0.20-0.92	0.28-0.94
Latent-COMM Std Parameter Estimates	0.17-0.83	0.12-0.50
# Significant Paths ($p \leq .05$)	4 of 4	3 of 4
R^2	0.96	0.87
COMM-CUMGPA Std Parameter Estimate	0.07 (ns)	0.08 (ns)
Range of Standardized Residuals	-21.52-10.00	-20.08-10.49
# Standardized Residuals > +/- 2.58	302	66
# Error Covariances Used**	N/A	13

* All were significant at the .05 level. ** In addition to those specified by the CFA.

Respecification was conducted using LMT modification indices. Only indicator error covariances within latents and error covariances between latents were added to improve the fit. The error covariance that produced the greatest decrease in χ^2 was added first and then the model was rerun after each modification to evaluate the improvement in fit. The first two attempts involved error covariances between indicators MAJORWOR and CONFMAJO and between latents LEARN and MAJOR. Each modification produced the same negative error variance (COMM $R^2 > 1$). This was likely due to high correlations between the indicators ($r = .74$) and/or between the latent variables (MAJOR and COMM, $r = .91$; COMM and LEARN, $r = .86$; and LEARN and MAJOR, and $r = .72$). The error covariance between MAJORWOR and CONFMAJO was added four more times during the respecification process based on expected decrease in χ^2. Each time it was removed because it continued to produce the negative error variance. Also, five times the LMT suggested adding an error covariance between NOTWITDI and FRIENDLY. However when it was added, it caused the error covariance between FRIENDLY and NONDISC to become insignificant ($p > .05$). Consequently, it too was removed each time because: (1) It did not sufficiently improve the fit, (2) the error covariance between FRIENDLY and NONDISC was previously significant based on the CFA and the structural LVPA analysis until that point, and (3) retaining the error covariance between FRIENDLY and NONDISC ensured consistency in how CFA results were used in structural Models #1 and #2. Ultimately, seven indicator error covariances (four within MAJOR, two within LEARN, and one within ENVIRON) and all six latent error covariances were added. The revised model included a total of 22 error covariances, nine from the CFA and 13 from the structural LVPA.

There was a very good fit of the sample data with respecified Model #2 based on goodness-of-fit measures: NFI = .96, NNFI = .98, CFI = .98, SB χ^2 / df = 1.93 (p = 0.000), RMSEA = .054 (90% CI: 0.049-0.060) and SRMR = 0.071. Standardized factor loadings ranged from .53 to .97, which exceeded the target of .5, and all were significant at the .05 level. The proportion of the variance in each indicator explained by its respective latent ranged from an R^2 of .28 to .94, all of which exceeded the target of .25. The improvement in fit from the original model reduced the number of standardized residuals from 302 to 66. This suggested that although there was excellent data-model fit, some misspecification still existed; however, the sample and asymptotic (population) covariance matrices were not expected to be an exact match. Figure 6 illustrates Model #2 with standardized parameter estimates and variance accounted for in the five latent variables and the outcome CUMGPA.



*$p \leq .05$

Figure 6. Structural Model #2 with standardized parameter estimates and variance explained (R^2).

Correlation coefficients between exogenous variables PGI, FLC, ENGR1201, and PEL fell below the cut-off of .35 which indicated that they were too weak to be of practical use. The significant path coefficient of 0.14 from the FLC to ENVIRON indicated that the learning community positively contributed to students’ perceptions of the learning environment. Similarly, the significant path coefficient of 0.15 from ENGR1201 to ADVISE provided support for the hypothesis that the freshman engineering course directly influenced students’ perceptions of academic advising. Neither the FLC nor ENGR1201 had a direct effect on student’s perceptions of the major (MAJOR) or their perceptions of the ABET a-k competencies (LEARN) (*ps* > .05). All of these results are consistent with those from Model #1.

Unique to Model #2 was the hypothesized relationship between students’ sense of community (COMM) and the other four latent variables. Overall, 87% of the variance in COMM was accounted for by students’ perceptions of advising (ADVISE), the major (MAJOR), the learning environment (ENVIRON), and ABET a-k competencies (LEARN). However, only MAJOR, ENVIRON, and LEARN significantly contributed to COMM. ADVISE was not a significant predictor ($p > .05$). MAJOR made the largest contribution to COMM, as indicated by a standardized path coefficient of .50, followed by LEARN (.34) and then ENVIRON (.16). However, the path from COMM to the outcome CUMGPA was not significant ($p > .05$). Thus, Model #2 did not support the hypothesis that students’ sense of community directly affected their academic performance. Structural equations with standardized parameter estimates for the paths from FLC and ENGR1201 to each of the four latent variables are given in Equations 7-10. The standardized equation representing the paths between the four latent variables and COMM is given in Equation 11. Significant predictors are indicated in bold font in each equation.

$$\text{ADVISE} = \mathbf{0.15*ENGR1201} + 0.060*\text{FLC} \qquad R^2 = 0.022 \tag{7}$$

$$\text{MAJOR} = 0.022*\text{ENGR1201} + 0.100*\text{FLC} \qquad R^2 = 0.0098 \tag{8}$$

$$\text{ENVIRON} = 0.093*\text{ENGR1201} + \mathbf{0.14*FLC} \qquad R^2 = 0.025 \tag{9}$$

$$\text{LEARN} = -\,0.0078*\text{ENGR1201} + 0.068*\text{FLC} \qquad R^2 = 0.0053 \tag{10}$$

$$\text{COMM} = 0.12^{*}\text{ADVISE} + \mathbf{0.50^{*}MAJOR} + \mathbf{0.16^{*}ENVIRON} + \mathbf{0.34^{*}LEARN} \qquad R^2 = 0.87 \qquad (11)$$

Equation 12 represents the measurement equation for the unstandardized path from COMM to the dependent variable CUMGPA. As indicated in Figure 6, sense of community was not a significant predictor of academic performance. Less than 1% of the variance in CUMGPA was accounted for by COMM.

$$\text{CUMGPA} = 0.051^{*}\text{COMM} \qquad R^2 = 0.0059 \qquad (12)$$

The indirect effects of the FLC and ENGR1201 on student's sense of community (COMM) were not significant (*ps* > .05). As indicated in Equation 13, only 1% of the variance in COMM was accounted for by the learning communities.

$$\text{COMM} = 0.041^{*}\text{ENGR1201} + 0.10^{*}\text{FLC} \qquad R^2 = 0.011 \qquad (13)$$

In summary, the data marginally fit original Model #2. Six latent error covariances and seven indicator error covariances were added per the LMT. Goodness-of-fit indices, factor loadings, the percent of variance accounted for (R^2), and standardized residuals indicated that there was a very good fit between the respecified model and the sample data. Results were generally consistent with Model #1. However, there were two findings that clearly differentiated the models. In Model #1, 20% of the variance in students' academic performance was explained by the five latent variables that collectively represented students' perceptions of the freshman year experience. In comparison, in Model #2 less than 1% of the variance in CUMGPA was accounted for by students' sense of community even though 87% of the variance in COMM was explained by the regression of the other four factors.

Logistic Regression

A hierarchical logistic regression was conducted in SPSS to predict persistence (PERSIST) in the second semester of the sophomore year. PEL and PGI were entered as covariates in step 1. In step 2, FLC and ENGR1201 were entered. Mean scores for students' sense of community (MEANCOMM) and their perceptions of advising (MEANADV), the major (MEANMAJ), the learning environment (MEANENV), and the ABET a-k competencies (MEANLRN) were entered in step 3. In the final step, academic performance was entered. Overall, 81.6% of the participants were retained in the College of Engineering in the second semester of their sophomore year.

Pearson correlations and a multiple regression were conducted in SPSS to determine if multi-collinearity among the mean scores had an inflationary effect on odds ratios. All of the variables used in the logistic regression were entered into the multiple regression as independent variables. SAT Verbal was arbitrarily selected as the dependent variable for the purpose of checking multi-collinearity per the procedure outlined by Tabachnick and Fidell (2007). Relationships among the five mean scores were moderate to strong with r ranging from .41 to .77 and all were significant at the .01 level. Results of the multiple regression indicated that VIF < 3.31 for all 10 variables. Six dimensions had condition indices greater than 15 with four being greater than 30. However, none of the dimensions had two or more variance proportions greater than .50. Consequently, multi-collinearity was not considered problematic.

A test of the logistic model with all 10 predictors versus a constant-only model was statistically significant, χ^2 (10, N = 297) = 67.74, p < .01, indicating that the predictors reliably distinguished between students who persisted and those who did not. The variance accounted for in persistence was moderate with Nagelkerke R^2 = .337 and Cox and Snell R^2 = .204. The model was able to correctly classify 98.4% of those who were retained in the college (PERSIST = 1) and 36.5% of those who were not retained (PERSIST = 0) for an overall success rate of 87.5%. Table 9 shows the logistic regression coefficient, Wald test, and odds ratio for each of the predictors. A .05 level of significance was used to identify significant predictors.

In the first step, PGI was significant ($p < .01$) but PEL, the other covariate, was not significant ($p = .14$). In the second step, PGI was again a significant predictor ($p < .01$) but PEL, ENGR1201, and FLC did not significantly contribute to the model (*ps* > .05). In the third step, only PEL ($p = .03$), PGI ($p =.01$), and MEANMAJ ($p < .01$) had significant partial effects. In the final step, only PEL ($p = .02$), MEANMAJ ($p < .01$), and CUMGPA ($p < .01$) contributed to the model. None of the other predictors were significant (*ps* > .05). MEANMAJ ($\beta =1.71$) had the greatest effect on persistence followed by CUMGPA ($\beta = 1.21$) and then PEL ($\beta = -0.96$).

The odds ratio for MEANMAJ indicates that when holding all other variables constant, a student's probability of being retained in the college was 5.51 times more likely with each one point increase in mean score. For example, a student with a mean score of 4 for the four indicators used to operationalize perceptions of the major was 5.51 times more likely to persist than a student whose mean score was 3. Students who persisted had a significantly higher mean score ($N = 255$, $M = 4.35$, $SD = 0.56$) than those who were not retained in the college ($N = 56$, $M = 3.74$, $SD = 0.93$); $t = 6.44$, $p < .01$, $df = 309$.

Similarly, the odds ratio for CUMGPA suggested that when holding all other variables constant, a student's likelihood of persisting was 3.35 times higher for each grade point increase. A student with a 3.5 CUMGPA, for example, was 3.35 times more likely to persist than a student with a 2.5 CUMGPA. Students who persisted had a significantly higher mean CUMGPA ($N = 258$, $M = 3.00$, $SD = 0.57$) than those who did not ($N = 58$, $M = 2.35$, $SD = 0.92$); $t = 6.99$, $p < .01$, $df = 314$.

Table 9

Results of Logistic Regression Predicting Persistence (PERSIST)

	β	SE	Wald χ^2	*df*	*p*	Exp(β)
Step 0						
Constant	1.55	0.15	103.06	1	0.00	4.71
Step 1						
PEL(1)	-0.49	0.33	2.17	1	0.14	0.61
PGI	1.35	0.45	8.87	1	0.00	3.86
Constant	-1.81	1.25	2.08	1	0.15	0.16
Step 2						
PEL(1)	-0.59	0.34	3.00	1	0.08	0.55
PGI	1.41	0.47	9.09	1	0.00	4.09
ENGR1201(1)	-0.15	0.35	0.18	1	0.67	0.87
FLC(1)	0.52	0.32	2.64	1	0.10	1.69
Constant	-2.07	1.27	2.68	1	0.10	0.13
Step 3						
PEL(1)	-0.81	0.38	4.60	1	0.03	0.45
PGI	1.35	0.53	6.55	1	0.01	3.86
ENGR1201(1)	-0.09	0.37	0.05	1	0.82	0.92
FLC(1)	0.46	0.35	1.70	1	0.19	1.59
MEANCOMM	-0.95	0.52	3.30	1	0.07	0.39
MEANADV	0.01	0.28	0.00	1	0.97	1.01
MEANMAJ	2.10	0.45	21.50	1	0.00	8.18
MEANENV	0.03	0.39	0.01	1	0.95	1.03
MEANLRN	-0.37	0.49	0.56	1	0.45	0.69
Constant	-5.21	2.14	5.95	1	0.01	0.01
Step 4						
PEL(1)	-0.96	0.40	5.78	1	0.02	0.38
PGI	0.43	0.61	0.50	1	0.48	1.54
ENGR1201(1)	-0.05	0.39	0.01	1	0.91	0.95
FLC(1)	0.70	0.38	3.44	1	0.06	2.01
MEANCOMM	-0.77	0.54	2.07	1	0.15	0.46
MEANADV	0.15	0.30	0.27	1	0.61	1.17
MEANMAJ	1.71	0.46	13.52	1	0.00	5.51
MEANENV	0.02	0.41	0.00	1	0.96	1.02
MEANLRN	-0.35	0.51	0.47	1	0.50	0.71
CUMGPA	1.21	0.30	16.53	1	0.00	3.35
Constant	-5.79	2.21	6.87	1	0.01	0.00

Inverting the odds ratio for PEL revealed that students were 2.63 times *less* likely to be retained in the college if one parent had a four year college degree. This result was certainly unexpected but was substantiated by a follow up Pearson chi square test. Only 78.0% of the students who had a college educated parent persisted compared to 86.9% of first-generation college students, which represents a significant difference; χ^2 (1, N = 316) = 4.11, p = .043.

Summary

Results of the CFA indicated that the five latent variables were well constructed by the survey items based on internal consistency reliabilities, goodness-of-fit indices, factor loadings, the percent of variance accounted for in the data (R^2), and standardized residuals.

There was marginal support for Model #1 based on goodness-of-fit measures. In this model, the FLC significantly contributed to students' sense of community and their perceptions of the learning environment and ENGR1201 significantly contributed to students' perceptions of advising. Overall, 20% of the variance in academic performance was explained by students' perceptions of the freshman year experience. Students' sense of community, their perceptions of the major, and their perceptions of ABET a-k competencies were significant predictors of cumulative GPA. However, perceptions of the major had the greatest direct effect on academic performance and it was the only positive significant predictor.

Although the sample data marginally fit original Model #2, there was a very good fit when the model was respecified. In general, results were consistent with Model #1. However, in this model less than 1% of the variance in CUMGPA was accounted for by students' sense of community even though 87% of the variance in COMM was explained by the regression of the other four factors.

The logistic regression revealed that a test of the full model with all 10 predictors versus a constant-only model was statistically significant, which indicated that the predictors reliably distinguished between students who persisted and those who did not. The variance accounted for in persistence was moderate with Nagelkerke R^2 = .337 and Cox and Snell R^2 = .204. The model was able to correctly classify 98.4% of those who were retained in the college and 36.5% of those who were not retained for an overall success rate of 87.5%. Parental education level, students' perceptions of the major, and freshman year cumulative GPA were significant predictors of retention in the second semester of the sophomore year.

CHAPTER 5: DISCUSSION

This final chapter discusses results of the study relative to its purpose, existing research, and methodology. Implications for practice, limitations of the study, and future research are also presented.

A correlational study was conducted to investigate the relationships between participation in the extra-curricular residential FLC and enrollment in ENGR1201 to students' perceptions of the freshman year experience, academic performance, and persistence. The sample included 316 students enrolled in the College of Engineering at a large, urban, public, research university during the fall semesters of 2005-2007. Students' sense of community and their perceptions regarding their choice of major, the learning environment, academic advising, and 11 engineering competencies specified by the Accreditation Board for Engineering and Technology (2009) were operationalized using items from the college's annual student survey conducted during the spring semesters of 2006-2008. Incoming characteristics of predicted grade index and parental education level, i.e. whether at least one parent had earned a four-year college degree, were also incorporated into the study. Academic performance was measured by cumulative GPA at the end of the spring semester of the freshman year. Persistence was measured as re-enrollment in a College of Engineering major in the second semester of the sophomore year.

Educational, psychological, and anthropological theories provided a comprehensive framework for the investigation and guided the a priori development of a measurement model and two structural models. The two structural models represented competing conceptualizations of the freshman year experience. Structural equation modeling was used to comprehensively investigate the direct and indirect effects of both learning communities and students' perceptions of the freshman year experience on their academic performance. A two-stage approach was employed with each stage incorporating five steps: Conceptualize the model, identify parameters, estimate parameters, assess data-model fit, and respecify the model consistent with theory to achieve an optimum fit (Bryne, 1998; Hancock & Mueller, 2008a, 2008b; Ullman, 2007). Structural equation modeling allowed both observed and unobserved variables to be used in the analyses and it accounted for measurement error. The maximum likelihood method of estimation with Satorra-Bentler scaling was used with the original data set, i.e. without imputing missing values, to produce unbiased results. The measurement model and both structural models were tested in LISREL SIMPLIS to determine the goodness-of-fit with the sample data.

In the first stage of structural equation modeling, the measurement model was evaluated to determine goodness of fit with the sample data via a confirmatory factor analysis. Results indicated that the five latent variables comprising the hypothesized measurement model were well constructed by the survey items based on internal consistency reliabilities, goodness-of-fit indices, factor loadings, the percent of variance accounted for in the data, and standardized residuals. In the second stage, the structural models were evaluated. Results indicated a marginal fit of the sample data with Model #1 and an acceptable fit with Model #2 but only after the latter was respecified based on theory using the modification indices suggested by the Lagrange Multiplier Test.

A hierarchical logistic regression was then conducted in SPSS to predict students' persistence, which was dichotomously measured as re-enrollment in the College of Engineering in the second semester of the sophomore year. Predicted grade index and parental education level were used as covariates in the logistic model with participation in the FLC and enrollment in ENGR1201 entered into the second step. Mean scores for each latent variable were entered in the third step and freshman year cumulative GPA was added in the final step of the analysis. The following sections discuss results for each of the research questions posed in Chapter 2.

Research Question #1: Does parental education level explain students' participation in the FLC and/or their enrollment in ENGR1201?

Results for both hypothesized structural models revealed a significant and positive relationship between parental education level and participation in the FLC. This suggested that FLC students were more likely to come from families where at least one parent had earned a four-year college degree. However, the correlation coefficient ($r = 0.27$) below the cut-off of .35 which meant that it was too weak to be of practical use for making programmatic decisions. Thus, based on this sample of students, parental education level was not related to students' self-selection into the FLC.

Students who scored 18 or higher on the mathematics placement exam were eligible for Calculus I and, therefore, met the co-requisite for the Introduction to Engineering course, ENGR1201. Results of both structural models indicated that there was no relationship between parental education level and performance on the mathematics placement exam. First-generation and second-generation college students performed similarly on the mathematics placement exam thus making them equally eligible to enroll in ENGR1201 during their first semester of college.

These findings are somewhat surprising given the literature on first-generation college students. Compared to their peers whose parents are college-educated, first-generation students are generally at a disadvantage in terms of academic preparation; knowledge about how institutional processes work; strategies for overcoming bureaucratic obstacles; financial and parental support; academic and social adjustment; outcome expectations; and persistence (Pascarella, Pierson, Wolniak, & Terenzini, 2004; Pike & Kuh, 2005). The differences between first-generation and other students are even more pronounced if both parents are college educated (Pascarella, Pierson, Wolniak, & Terenzini, 2004).

Research Question #2: Does predicted grade index (PGI) explain students' participation in the FLC and/or enrollment in ENGR1201?

The correlation between PGI and FLC was not significant in either structural Model #1 or Model #2. Therefore, based on this sample of students, incoming academic preparation as measured by PGI was not a significant predictor of participation in the FLC. This suggested that students of varying academic backgrounds equally self-selected to participate in the residential learning community. Some students may have chosen to live in the FLC precisely because it was a structured extra-curricular learning environment that offered special programming, academic support services, and a convenient social network of engineering peers. Alternately, students may have chosen to live at home, in off-campus apartments nearby, or in other on-campus residence halls that attracted a broader diversity of majors.

Although the relationship between PGI and enrollment in ENGR1201 was significant and positive (r = .32) in both models, the strength of the correlation was relatively weak. Thus, performance on the mathematics placement exam and subsequent enrollment in ENGR1201 was not necessarily associated with prior academic preparation. Students of varying academic backgrounds were equally eligible to enroll in the introductory engineering course during their first semester of college. This finding was unexpected as the PGI calculation is heavily weighted by SAT scores and high school GPA with the latter carrying the most weight. However, high school self-efficacy does not necessarily translate to academic self-efficacy in college (Nauta & Epperson, 2003) and students' academic preparation can vary greatly based on their high school experience (DeMarrais & LeCompte, 1999). Anecdotal evidence also indicates that many students are anxious about taking the mathematics placement exam during summer orientation as it is usually their first academic experience on a university campus. They are also keenly aware that their performance has important consequences in terms of which mathematics course they can take and their eligibility to enroll in their first engineering course. Consequently, it is quite conceivable that students who performed well in mathematics courses in high school and on the SAT Math test may not have performed well on the mathematics placement test.

Research Question #3: How does participation in curricular and extra-curricular learning communities influence students' perceptions of the freshman year experience?

Model #1 hypothesized paths from ENGR1201, the curricular learning community, and the FLC, the extra-curricular learning community, to all five latent variables used to operationalize students' perceptions of the freshman year experience. Results indicated that participation in the FLC directly and significantly affected students' sense of community and their perceptions of the learning environment. Enrollment in ENGR1201 directly and significantly influenced students' perceptions of academic advising. However, in all three cases, the path coefficients were too weak to be of practical use as they fell far below the cut-off of .35. None of the other paths from either learning community to the latent variables was significant. Overall, the variance accounted for in each latent variable was negligible (< 1%).

In Model #2, students' sense of community was hypothesized to be explained by the other four latent variables with covariation accounted for by their regression onto COMM. Consistent with Model #1 participation in the FLC directly affected students' perceptions of the learning environment, and enrollment in ENGR1201 directly influenced students' perceptions of academic advising. Although both path coefficients were significant, the direct effects were minimal. Also consistent with Model #1, virtually all of the variance in students' perceptions of academic advising, the major, the learning environment, and the ABET a-k competencies were unexplained by the model. In general, both models failed to support the hypothesis that participation in the FLC and enrollment in ENGR1201 directly affected students' perceptions of the freshman year experience.

However, results of Model #2 indicated that students' sense of community within the College of Engineering was significantly and moderately affected (path coefficient of .50) by their perceptions of the major. If students were confident in their choice of major and their ability to complete their degree, if they thought their major was worth the time and effort, and if they believed that their education made them competitive in the job market they were more likely to feel part of the College of Engineering community. Students' perceptions of the learning environment as safe, friendly, and nondiscriminatory also had a significant direct effect on their sense of community; however, the path coefficient of .34 fell just short of the cut-off of .35. Students' perceptions of the ABET a-k competencies significantly influenced their sense of community but the overall contribution to the model was weak. There was no evidence in either model that students' perceptions of academic advising directly affected their sense of community within the college.

Overall, Model #2 supported the hypothesis that students' sense of community could be explained by the other four latent variables. The total variance accounted for in the latent variable was 87% which indicated that only 13% of the variability in the data was unexplained by the model. There was no evidence that the FLC or ENGR1201 indirectly affected students' sense of community. Both paths were insignificant and less than 1% of the variance in students' sense of community was accounted for by the two learning communities.

Collectively, results from both models indicated that, based on this sample of students, virtually all of the variance in their perceptions of the freshman year experience was unexplained by participation in the FLC and enrollment in ENGR1201. This finding was somewhat surprising for two reasons. First, the FLC and ENGR1201 are two very visible learning community experiences offered in the freshman year. A significant amount of human and financial resources are dedicated to both efforts as an integrated strategy for connecting students with their major and with their peers. Second, this finding failed to support a major hypothesis of the study, which was developed based on the existing research literature. For example, Astin (1993) found that students' overall satisfaction with college was adversely affected by a lack of community and by majoring in engineering. He also found that the single most influential factor in college student development was the peer group. Vicarious experiences, modeling, verbal persuasion, and other social influences that one would expect from learning communities such as the FLC and ENGR1201 are also powerful sources of self-efficacy (Bandura, 1977a, 1977b, 1986, 1989, 1995, 2001, 2002). Vicarious experiences are essential for learning because it is one mechanism for diffusing new ideas and behaviors. Social interaction, interdependence, model or group efficacy, and shared knowledge and skills also influence motivation, persistence, morale, and performance.

Research Question #4a: How do students' perceptions influence their academic performance?

In Model #1, paths from three of the five latent variables to freshman year cumulative GPA were significant. However, only students' perceptions of the major had a direct and moderate effect on academic performance as indicated by a path coefficient of .39. All of the other paths were either too weak to be practically useful or they were not significant. Thus, students' perceptions of the major had a much greater influence on their academic performance than any of the other variables associated with the freshman year experience considered in this study. It is interesting that 20% of the variance in students' cumulative GPA was collectively explained by this particular model of the freshman year experience. Given the complexities and challenges associated with the transition into college and the rigor of the engineering curriculum, this level of variance accounted for by the model suggested important implications. However, this result should be interpreted with caution given the fact that the sample data marginally fit Model #1 based on goodness-of-fit measures.

In Model #2, students' sense of community did not affect academic performance as indicated by a path coefficient that was not significant. Overall, less than 1% of the variance accounted for in academic performance was explained by the model. Virtually all of the variability in freshman year GPA was due to other variables not considered in this study. For example, many College of Engineering students work while going to school. Pike, Kuh, and

Massa-McKinley (2008) found that working on or off campus and working 20 or more hours per week had a significant and negative impact on academic performance even after controlling for students' background and levels of engagement. In addition, data collected by the College of Engineering indicate that many students struggle to pass their freshman calculus, chemistry, and physics courses with a grade of C or better. The percentage of students who earn a final grade of D or F or who withdraw (DFW rate) has been as high as 30-50% in some semesters. Neither of these important elements of the freshman year experience was included in this study.

Research Question #4b: How do students' perceptions influence their persistence in the major?

Results of the logistic regression revealed that only parental education level, students' perceptions of the major, and academic performance were significant predictors of re-enrollment in the second semester of the sophomore year. None of the other variables, including predicted grade index, enrollment in ENGR1201, and participation in the FLC significantly contributed to the model. The latter finding was somewhat unexpected given historical data obtained by the College of Engineering that demonstrate that the FLC has a positive impact on freshman year retention rates. These findings in combination with the existing literature offer mixed results regarding the efficacy of learning communities, particularly their long-term effects after the freshman year. Pike, Schroeder, and Berry (1997), for example, found that learning communities did not have a direct influence on persistence even after controlling for background variables. Conversely, Tinto (2000) found that students who participated in learning communities spent more time together, were more likely to be active learners both in and out of class, achieved higher levels of learning, and were more likely to be retained because they were engaged academically and socially.

The logistic odds ratios offer insight into the unique contribution of each significant predictor to the model. The probability of a student being retained in the College of Engineering was 5.51 times more likely with each one point increase in the mean score of items used to operationalize students' perceptions of the major. This finding was consistent with results from the structural models and with the existing literature that suggested that students' attitudes and perceptions about the major have a powerful influence on their persistence. Besterfield-Sacre, Atman, and Shulman (1997) and Seymour and Hewitt (1997) found significant differences in attitude between students who persisted and those who did not. Students who left engineering in good academic standing had lower general impressions of the profession and less confidence in their mathematics, science, and engineering skills. In addition, this study found that a student's likelihood of persisting in the major was 3.35 times more likely for each grade point increase in cumulative GPA when all other variables were held constant.

Of particular interest from the logistic regression was the finding that, based on this sample of students, they were 2.63 *less* likely to be retained in the College of Engineering if one parent had earned a four year college degree. This result was certainly unexpected given the retention literature on first-generation college students (Ishitanti, 2006; Pascarella, Pierson, Wolniak, & Terenzini, 2004; Pike & Kuh, 2005). For example, Ishitanti (2006) found that first-generation college students were 1.3 times more likely to leave college than their non-first-generation peers. Family income, educational outcome expectations, academic preparation, type of institution (public or private), and admission selectivity were significant predictors of persistence. Students with a family income between $20,000 and $34,999 were 72% more likely to drop out of college than students from families with household incomes of $50,000 or more. Students who attended public institutions were less likely to persist than those who attended private institutions. The greatest risk of attrition was in the second year of college when first-generation students were 8.5 times more likely to leave. However, an interesting finding of Ishitanti's (2006) study was the fact that students who received financial aid and work-study were more likely to persist, particularly the further along they were in their academic careers. This could help explain why first-generation participants in this study were more likely to be retained, i.e. many of them may have received financial aid and/or participated in on-campus work-study programs which would be consistent with previous data collected by the College of Engineering.

Other Relationships Not Hypothesized but Free to Be Estimated

Two other relationships not originally hypothesized were free to be estimated in the structural models: (1) participation in the FLC and enrollment in ENGR1201 and (2) predicted grade index and parental education level. Results for both models were consistent. The relationships were significant and inverse (r = -.15 and r = -.22, respectively) but were too weak to be of practical use. Thus, self-selection into the FLC was not associated with enrollment in ENGR1201. Similarly, academic preparation as measured by predicted grade index was independent of parental educational level.

Implications for Practice

The traditional freshman engineering curriculum offers a rather narrow and disaggregated view of the profession. It is composed of a seemingly disparate collection of mathematics, science, engineering, and general education courses. The lack of an integrated curriculum makes it difficult for most students to synthesize their new knowledge in a manner that gives them an appreciation of what engineers do and the competencies necessary to practice the profession. The rigor of the freshman curriculum challenges their academic and career self-efficacies and, therefore, their level of commitment to the major. Even the best and brightest high school students often find that the major is more academically demanding than they expected. Many students ultimately change to a non-College of Engineering major. This study suggests that those who leave engineering in good academic standing may do so because they do not feel the major is worth the time and effort. Others may leave because they are not confident in their choice of major or their ability to complete their degree.

Students who successfully navigate the freshman engineering curriculum also encounter academic challenges in the first semester of the sophomore year when they enroll in "gateway" courses such as Statics and Network Theory. At this institution, gateway courses require a grade of C or better to progress in the curriculum. However, DFW rates of 30-50% are not uncommon, which means that many students have to retake these courses. The challenge of the freshman year experience followed by the rigor of these gateway engineering courses in the sophomore year is a powerful deterrent to a student's persistence. Many students find themselves in academic difficulty by the end of their third semester of college and/or reevaluating their choice of major. Some students, particularly those on probation, ultimately leave the university. Although institutions are rightly concerned with improving first year persistence, the second year also deserves considerable attention. It should not be prematurely assumed that if students successfully navigate the difficult transition from high school to college that they are no longer at risk of attrition. Engineering educators in particular must recognize that the sophomore year experience is also one of vulnerability and transition that must also be addressed within the wider context of retention efforts.

This study revealed that the FLC was not a significant predictor of freshman year academic performance and persistence in the second semester of the sophomore year. However, previous data collected by the College of Engineering indicate that the FLC does have a positive impact on freshman year retention rates. There are also other tangible and intangible benefits of the program. It is clearly a successful recruiting strategy as evidenced by demand that often exceeds availability of spaces and College of Engineering enrollment increases that have recently been double that of the university. The FLC brings together students who share a common purpose thus making them less susceptible to the myriad of distractions that exist on a large, urban university campus. Supplemental instruction, tutoring, and chemistry study nights offered through the FLC help students develop academic success strategies by teaching them to work smarter–not harder. Interactions with employers via site visits to local companies and employer panel discussions held in the FLC residence hall allow participants to develop an engineering identity early in their academic career. Collectively, the FLC experience provides a supportive extra-curricular learning environment that is focused on the curriculum. FLC survey results consistently indicate that participants enjoy their freshman year experience, make friends, and study with other FLC peers. Based on results of this study, the FLC director should continue to focus on and, if possible expand, activities that enhance students' perceptions of the major rather than socialization.

The findings from this study indicate that students' perceptions of the major are a significant factor in their persistence. Therefore, K-12 teachers, counselors, parents, and students must be equipped with information about admission requirements, the curriculum, employment opportunities, and salaries. Such information will better prepare high school graduates to make educated choices about pursuing an engineering major and, hopefully, align their expectations with the reality of the curriculum thereby strengthening their commitment to it. Students also need to be educated about the altruistic value of the profession as their personal values influence career choices. For example, Weisgram and Bigler (2006, 2007) found that middle school girls were less likely to pursue a career in science because they perceived it as less altruistic than other professions such as teaching or social work. They also found that the views of the middle school girls were not highly malleable. Once they formed an opinion about the altruistic value of a profession it was difficult to change their perceptions even when they were confronted with evidence to the contrary. Thus, efforts to recruit students into engineering should begin in elementary school before their career interests are influenced by socio-cultural and engendered stereotypes.

Engineering educators should also reconsider how the curriculum is designed and delivered. A recent study commissioned by the Carnegie Foundation for the Advancement of Teaching (Sheppard, Macatangay, Colby, & Sullivan , 2009) found that "the undergraduate engineering education in the United States is holding on to an approach to problem solving and knowledge acquisition that is consistent with practice that the profession has left behind" (p. xxi). Engineering pedagogy is essentially linear and deductive with an emphasis on knowledge acquisition. Faculty are in control of learning content and context, the rate at which knowledge is transmitted, and the mode of delivery. The pace and workload are overwhelming for most students, especially freshmen, which is a primary reason that they lose interest in the major (Seymour & Hewitt, 1997). Instead, an integrated, iterative, and inductive project-based approach that focuses on problem solving, interactive design, and professional practice similar to that used in medical education is needed in engineering education (Sheppard, Macatangay, Colby, & Sullivan, 2009). In comparison to traditional "chalk and talk" lectures, such an approach more effectively engages students, stimulates their interest, and promotes meta-cognition, including deep learning strategies and self-regulation (Schunk, 1999; Sheppard, Macatangay, Colby, & Sullivan, 2009; Stepien & Gallagher, 1993), all of which can enhance students' commitment to the major. Clearly, faculty education and incentives that promote and reward curricular innovation are paramount for institutionalizing such wide-spread curriculum reform.

Results of this study also indicate that students' confidence in their ability to complete their degree is a significant indicator of academic performance and persistence. Freshman and sophomore students would benefit from interactions with junior and senior students beyond what is currently offered through the College of Engineering MAPS program. For example, they could shadow a junior or senior student for a day, including observing laboratory experiments. They could also attend senior design presentations and expos that showcase capstone engineering projects. Both strategies would offer neophytes important insights as to how they will apply their new knowledge later in their academic career. Such vicarious experiences and modeling also enhance their interest, motivation, and confidence, all of which can influence their ability to develop coping strategies, overcome adversity, and persist (Bandura 1977a, 1977b, 1986, 1989, 1995, 2001, 2002).

Students' belief that engineering is worth the time and effort is a significant and powerful predictor of their academic performance and persistence. Surveys conducted by the College of Engineering indicate that, on average, ENGR1201 students do not study three hours for every hour in class as is generally recommended. In fact, many freshmen indicate that they study less than 10 hours per week for *all* of their freshman courses. Students may be more motivated to invest the time and effort necessary to succeed if they believe the return on investment is worth it. For example, Jackson, Gardner, and Sullivan (1993) found that freshman GPA and expected salaries were the two best predictors of female engineering students' persistence. Ishitanti (2006) also found that outcome expectations of first-generation college students were an important predictor of their persistence. Students may be more motivated to persist if they have access to practicing engineers who can share their experiences about the benefits and opportunities afforded by a career in the profession. Panel discussions, career expos, and site visits to local companies are just some of the many venues for networking.

Students' attitudes and perceptions about engineering as a major and profession can be evaluated via a pre- and post-questionnaire such as that developed by Besterfield-Sacre, Atman, and Shulman (1997). The questionnaire could be administered in an Introduction to Engineering course at the beginning of the freshman year and again at the end of the semester. Results of the pre-questionnaire could be used to engage students in classroom discussions, research, and/or projects that expose stereotypes about engineers, correct misperceptions and myths about the profession, and educate students about the exciting and rewarding career opportunities that await them.

Perhaps the most surprising finding of this study was the fact that participants were more than twice as likely to be retained in the major if neither parent earned a four-year college degree. As suggested by Ishitanti (2006), it is plausible that these students were motivated to persist by outcome expectations, such as multiple career opportunities and lucrative salary offers. It is also highly likely that they were dependent on financial aid to fund their education. If so, such an investment may positively influence their level of commitment to the major and their personal level of responsibility for succeeding. In addition, parents of first-generation college students may not possess the knowledge, experience, and/or financial resources necessary to assist their children when they encounter obstacles. Consequently, first-generation college students may, out of necessity, be forced to develop coping strategies earlier in their academic career than their peers whose parents are college-educated. Engineering educators can assist first-generation college students by making themselves available to answer questions and direct them to appropriate resources as necessary.

Limitations of the Study

Non-random selection and assignment are clearly obvious limitations of this study. Non-random sampling limits the external validity or generalizability of results to the population of freshman engineering students from which the sample was drawn. Non-random assignment compromises internal validity because systematic bias exists between treatment and control groups and within group error is also present. For example, students who self-select to participate in the FLC may possess characteristics that predispose them to more positive perceptions of the freshman year experience than non-FLC participants. Students who were eligible to enroll in ENGR1201 based on their mathematics placement score may be predisposed to positive perceptions of the major.

Students who did not complete the college's annual survey, switched to non-College of Engineering majors, or who left the university were not eligible to participate in this study. Standard tests of significance indicated that the differences between participants and non-participants were negligible. However, students who chose to complete the survey may be significantly different from non-respondents relative to other characteristics not considered in this study.

The complexities of the freshman year college experience also make it a challenge to develop parsimonious models. There are many personal and environmental factors, both academic and non-academic, that can influence engineering students' perceptions, performance, and persistence (Astin, 1993; Goodman Research Group, 2002; Seymour & Hewitt, 1997). For example, students' gender, ethnicity, and socio-economic status; working while going to school; participating in academic support programs such as MAPS; and performance in freshman mathematics, chemistry, and physics courses are confounding variables that were not considered in this study. Hancock and Mueller (2008a) caution about making specification errors when developing structural models. External specification errors occur when irrelevant *variables* are included in the model or important variables are omitted from it. Internal specification errors occur when unimportant *relationships* between variables are included or relevant ones are omitted. The two parsimonious models developed for this study were based on the theoretical framework presented in Chapter 2. Both incorporated some, but not all, of the important aspects of the freshman year college experience.

Prior to spring 2006, freshmen were directly admitted to an engineering program if their predicted grade index and SAT Math score met minimum requirements. Students who were eligible for admission to the college but who were denied admission to a program were admitted to the college as freshman engineering (FEGR) majors with their intended program of study listed as a concentration on their transcript. In fall 2005, approximately 37% of the newly admitted freshmen were FEGR majors. Effective spring 2006, the admission policy was revised so that all FEGR majors were reclassified to their desired engineering major. At the time participants responded to the annual survey in spring 2006, they had already been reclassified. Although this reclassification could be considered a confounding variable, it is highly unlikely that it affected results of this study.

Finally, there are also several statistical considerations that are worth mentioning. First, some of the variables were skewed and/or kurtotic which likely affected the strength and direction of relationships and overall fit of the models. Second, structural equation modeling assumes relationships are linear. It is plausible that modeling some of the relationships as non-linear and/or incorporating interaction effects might have improved the fit of Model #1 which showed the most promise in terms of variance accounted for in freshman academic performance. Third, 21 unidentifiable engineering majors who participated in the spring 2006 administration of the survey were not included in the study. It is not clear what, if any, impact their exclusion may have had on results.

Future Research

The models presented in this study should be adapted or expanded to include: (1) performance in freshman calculus, chemistry, and/or physics courses and (2) the number of hours students work while in school. Both play an important role in students' academic performance and persistence. Future research should also investigate group comparisons by gender and ethnicity to evaluate how well the models fit data for female versus male students and for white versus minority students. Given the underrepresentation of female and minority students in engineering, it is very likely that it will be years before a sufficient sample size is available to conduct such a study at this institution. Therefore, it would be interesting to conduct an inter-institutional study, including at least one historically black institution, to determine how well the models performed given various institutional and student characteristics.

Conclusions

The purpose of this correlational study was to examine the effects of a residential learning community and enrollment in an introductory engineering course to engineering students' perceptions of the freshman year experience, academic performance, and persistence.

Academic performance was measured as cumulative GPA at the end of the freshman year. Persistence was measured as re-enrollment in the College of Engineering in the second semester of the sophomore year.

Based on the two structural models and the logistic model developed for this study, the effects of both learning communities were either insignificant or negligible despite the fact that the FLC has historically demonstrated a positive impact on freshman year retention rates. In addition, academic performance and persistence were not explained by students' perceptions of the freshman year experience except for their perceptions of the major which had a moderate direct effect on both outcomes. Parental education level and freshman year academic performance were also significant predictors of persistence. Of particular interest was the finding that students whose parents had not earned a four-year college degree were more than twice as likely to persist in the College of Engineering than their peers who had a least one college-educated parent.

This study extends the engineering education research base in three important ways. First, it examined the direct and indirect effects of curricular and extra-curricular learning communities, i.e. an introduction to engineering course and a large residential learning community, respectively, on students' perceptions of the freshman year experience, academic performance, and persistence. Second, it incorporated students' perceptions of the 11 ABET a-k competencies. Finally, in contrast to standard univariate analyses, this study used structural equation modeling to account for latent variables and measurement error.

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APPENDIX

Table A-1

Survey Items for Sense of Community (COMM)

1. My transition into the college was easy. (TRANSEAS)
2. I feel comfortable seeking guidance from a College of Engineering faculty or staff member. (COMFGUID)
3. I feel part of the College of Engineering community. (COECOMM)
4. I recommend the College of Engineering to my family and friends. (RECCOE)

Table A-2

Survey Items for Perceptions of Advising (ADVISE)

1. My academic advisor is generally available during office hours, by phone, or by email. (ADVAVAIL)
2. My academic advisor provides me with accurate information for registration. (INFOREG)
3. My academic advisor provides me with useful information for career development. (INFOCAR)
4. Overall, I am satisfied with my academic advising experience. (SATADV)

Table A-3

Survey Items for Perceptions of Choice of Major (MAJOR)

1. I am confident in my choice of major. (CONFMAJO)
2. My major is worth the time and effort. (MAJORWOR)
3. I am confident in my ability to complete my degree. (COMPDEG)
4. The quality of my education makes me competitive in the job market. (QUALED)

Table A-4

Survey Items for Perceptions of the Learning Environment (ENVIRON)

1. The College of Engineering provides a learning environment that is safe. (SAFE)
2. The College of Engineering provides a learning environment that is friendly. (FRIENDLY)
3. The College of Engineering provides a learning environment that is non-discriminatory. (NONDISC)
4. I have not witnessed discrimination in the College of Engineering. (NOTWITDI)
5. I have not experienced discrimination in the College of Engineering. (NOTEXPDI)

Table A-5

Survey Items for Perception of Learning Outcomes (LEARN)

My education is preparing me to:

1. Apply knowledge of mathematics, science, and engineering. (ABETA)
2. Design and conduct experiments, as well as to analyze and interpret data. (ABETB)
3. Design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability. (ABETC)
4. Function on multi-disciplinary teams. (ABETD)
5. Identify, formulate, and solve engineering problems. (ABETE)
6. Understand professional and ethical responsibility. (ABETF)
7. Communicate effectively. (ABETG)
8. Understand the impact of engineering solutions in a global, economic, environmental, and societal context. (ABETH)
9. Recognize the need for and be able to engage in life-long learning. (ABETI)
10. Have knowledge of contemporary issues. (ABETJ)
11. Use the techniques, skills, and modern engineering tools necessary for engineering practice. (ABETK)

Note. Adapted from the Accreditation Board for Engineering and Technology (2009).

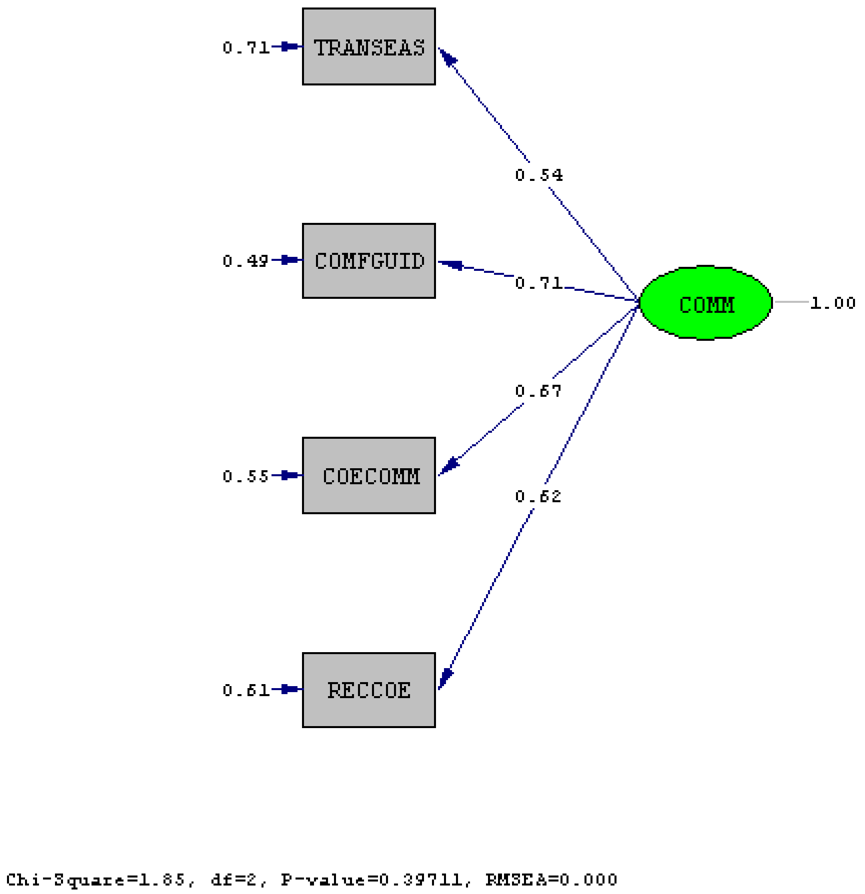


Figure A-1. CFA results with SB scaling for COMM. Standardized factor loadings and error terms are signficant at the .05 level.

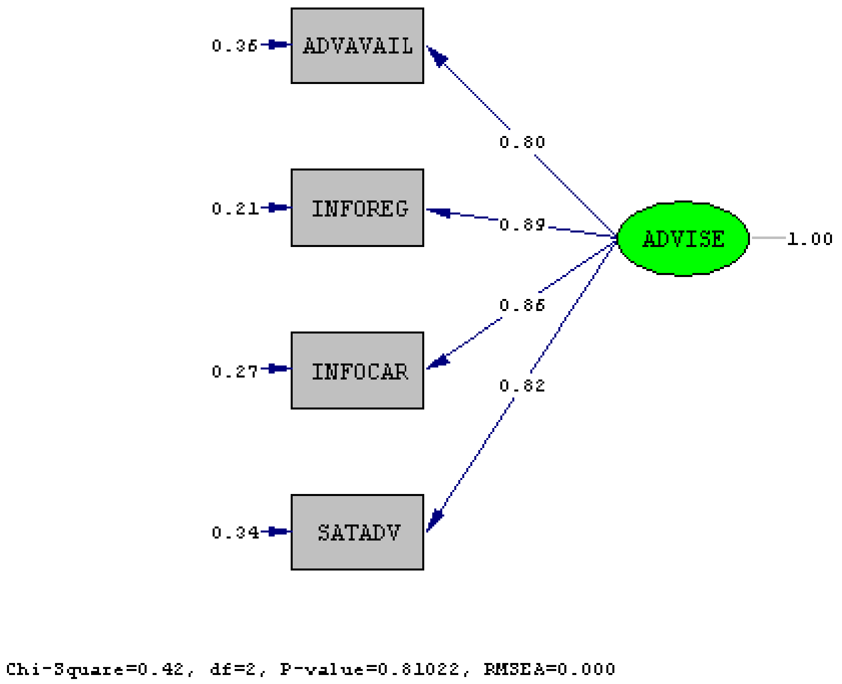
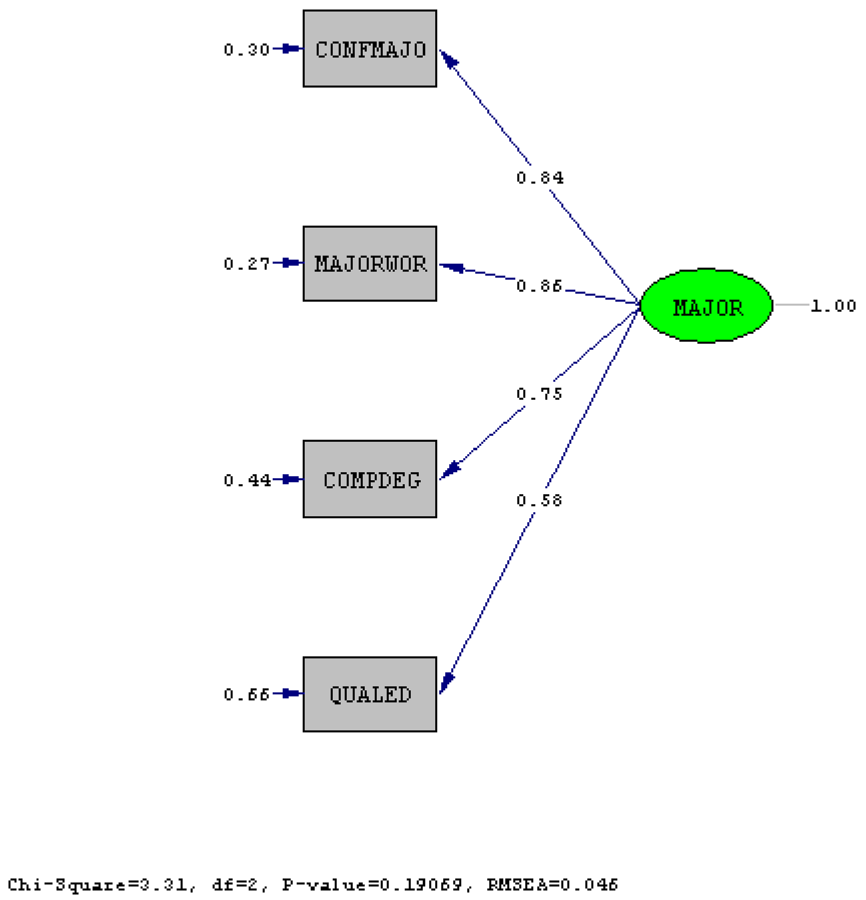


Figure A-2. CFA results with SB scaling for ADVISE. Standardized factor loadings and error terms are signficant at the .05 level.



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Chi-Square=3.31, df=2, P-value=0.19069, RMSEA=0.046
```

Figure A-3. CFA results with SB scaling for MAJOR. Standardized factor loadings and error terms are signficant at the .05 level.

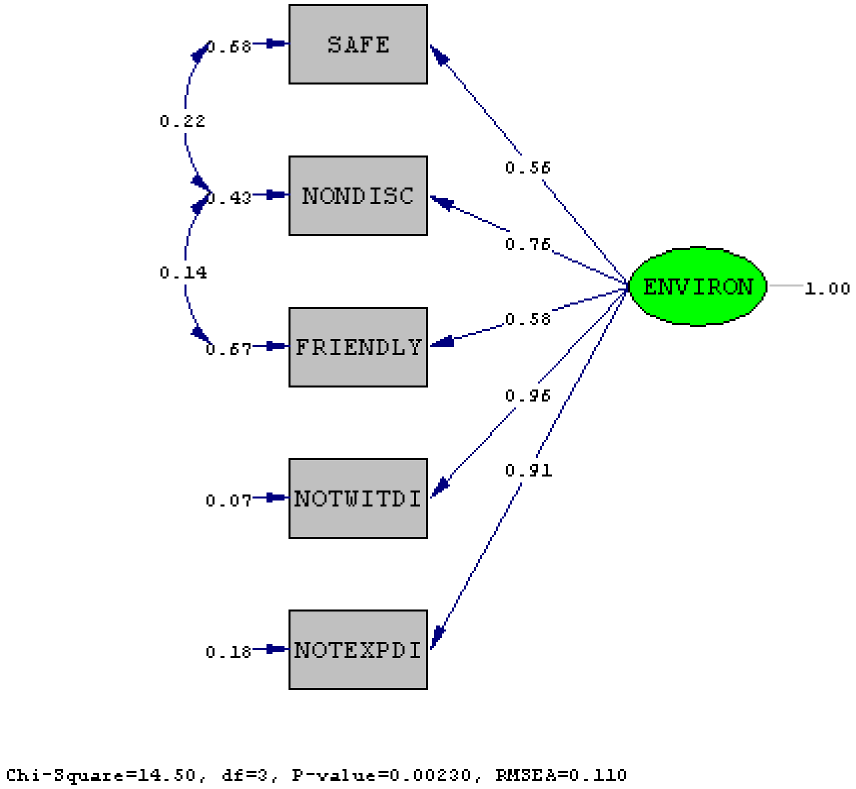

Figure A-4. CFA results with SB scaling for ENVIRON. Standardized factor loadings and error terms are signficant at the .05 level.

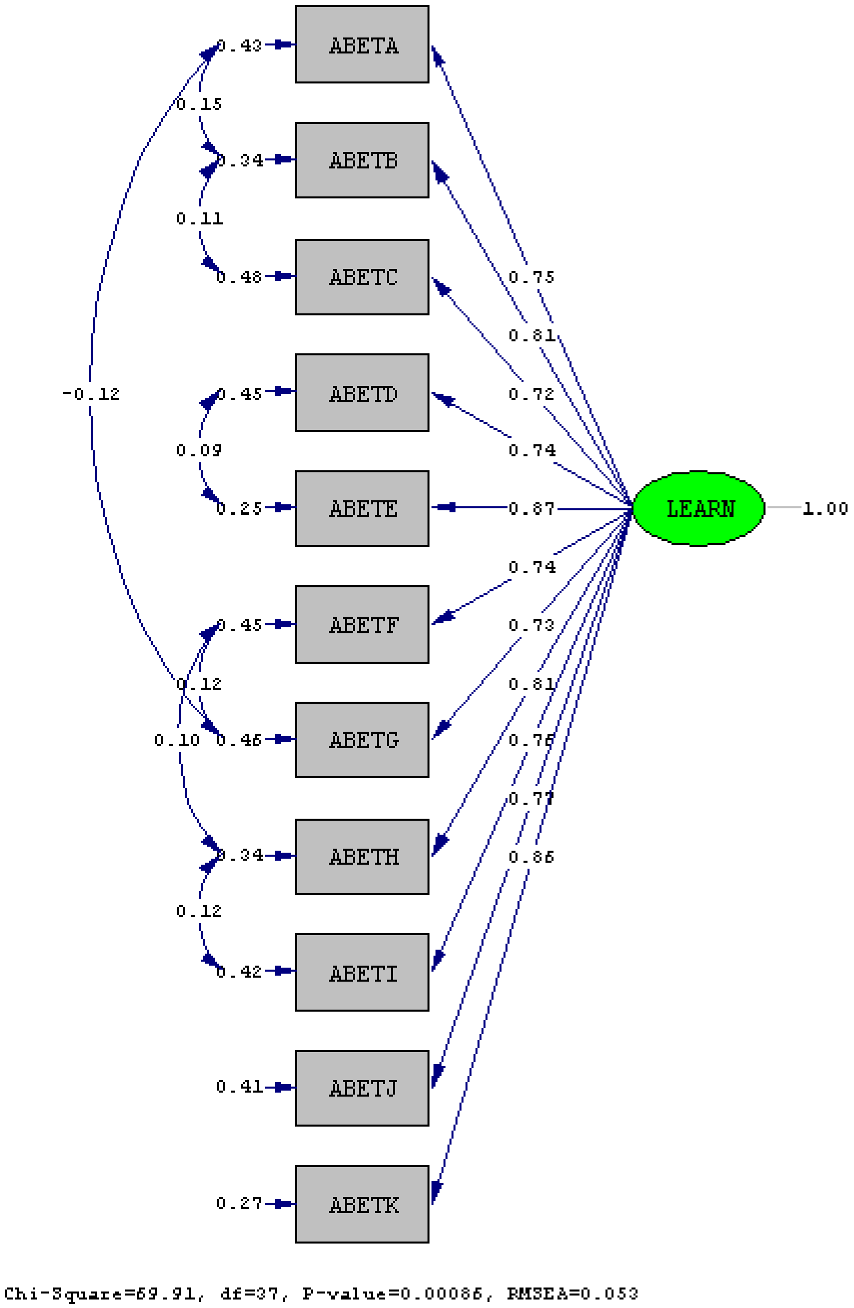

Figure A-5. CFA results with SB scaling for LEARN. Standardized factor loadings and error terms are signficant at the .05 level.