2012

An Analysis of Retention Factors In Undergraduate Degree Programs in Science, Technology, Engineering, and Mathematics

Mike H. Johnson
The University of Montana

AN ANALYSIS OF RETENTION FACTORS IN UNDERGRADUATE DEGREE PROGRAMS IN SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS

By

MICHAEL H. JOHNSON

B.S., Montana College of Mineral Science and Technology, Butte, MT, 1990
MBA, University of Montana, Missoula, MT, 1997

Dissertation

Presented in partial fulfillment of the requirements
for the degree of

Doctor of Education
in Educational Leadership

The University of Montana

Missoula, MT

Spring 2012

Dissertation Committee:

Dr. Roberta D. Evans, Chair
Dean, Phyllis J. Washington College of Education and Human Sciences, University of Montana

Dr. Douglas Coe
Dean of the College of Letters, Sciences and Professional Studies, Montana Tech

Dr. William P. McCaw
Department of Educational Leadership, University of Montana

Dr. John Matt
Department of Educational Leadership, University of Montana

Dr. Frances L. O’Reilly
Department of Educational Leadership, University of Montana

ABSTRACT

Johnson, Mike, Ed.D. Spring 2012 Educational Leadership

An Analysis of Retention Factors In Undergraduate Degree Programs in Science, Technology, Engineering, and Mathematics

Chairperson: Roberta D. Evans, Ed.D.

This mixed-methodological study explored the factors that predict a student's likelihood to complete an undergraduate program in a STEM discipline at one campus reliant upon that mission. Offered in response to a national imperative for the U.S. to compete globally, researchers contend educators must better prepare a STEM foundation and inspire STEM careers. This study employed a quantitative and qualitative approach to (a) identify key indicators of success for students entering a STEM discipline, (b) determine that living in the residence hall had an impact on success, and (c) identify quantifiable drop-out rationale for students who did not complete their STEM program.

A discriminate function analysis was applied to the data extracted from the subject university. At the 95% confidence level, three indicators surfaced as significant. A student's entering high school GPA has a meaningful correlation to eventual graduation; an incoming student with a 3.0 high school GPA who declares a STEM major is 10.3 times more likely to graduate than a student entering with a 2.0 GPA. In this study, due to its at-risk target population, there emerged a negative correlation with enrollment in the College Orientation Course. The third predictor identified that living in the residence halls has significant predictive value on STEM graduation. An incoming freshman who declares a STEM major and lives in the residence hall is 2.2 times more likely to be successful than a STEM student who does not live in a residence hall.

A qualitative analysis was used to elicit the significant drop-out rationale of students who did not finish their STEM-declared major or dropped out of college entirely. A post-hoc, purposefully selected group of respondents derived from interviews with successful graduates identified students who had declared a STEM major but failed to graduate. They cited financial pressures, math and science challenges, and poor choices as their primary drop out themes. Successful graduates were also interviewed in the qualitative portion of this study to determine factors that influenced their success. Cited most often were interaction with key faculty, working less than 15 hours per week, and involvement in clubs and industry-sponsored organizations.

DEDICATION

This work is dedicated to my wife Kami and my two sons, Cameron and Cole. Your unwavering love, support, and commitment to my passions have been critical to my success. This process has been progressing for most of my sons' lives, and I am now certain that they better understand the value of hard work and the purpose of academic excellence.

I also dedicate this work product to a kind and gentle soul that always supported and encouraged me in all aspects of life. Gary did not live to see this dissertation completed, having passed just a few weeks before its defense. However, I am certain that his strength and guiding hand played a key role in making this happen. This one is for you Gary!

ACKNOWLEDGEMENTS

During the journey of this dissertation I have come into contact with so many people that have assisted me in countless ways. There are many people to thank and recognize for their assistance, and I only hope that I do not miss anyone. I know I cannot thank them all, but it is important to highlight a few.

First, I must acknowledge my wife. Kami, you are the most amazing person I have ever met and I am so thankful that you are my life partner. You have given me everything that matters in life and I could not be more grateful for all that you do for me. Many personal sacrifices were offered during this journey and I want you to be as proud as I am about having reached the end. Congratulations my dear, you deserve it!

Cameron and Cole, although you are too young to fully appreciate the magnitude of the efforts invested to reach this terminal degree, I know someday you will understand better why I was not always available, gone to Missoula, or buried in a book or laptop. This work was important to me and I thank you for your sacrifices and support. Always remember, I love you the most!

The challenge of taking on a dissertation is immense. No student can make it through the rigors of the process without the assistance, encouragement, and guidance of a chair. I was honored to be supported by one of the hardest working people I have ever known - Roberta Evans, Professor and Dean of the Phyllis J. Washington College of Education and Human Sciences. Bobbie, you were the first professor I encountered in the EDLD department, and your influence on me has grown from that point forward. I was so proud the day you agreed to chair this dissertation and your support and friendship has permanently cemented you in my heart. Thanks for all the hours of counseling, all of the professional guidance, and most importantly, thank you for sharing your knowledge and wisdom.

The faculty and staff within the Educational Leadership Department of the University of Montana are second to none. This group of people is truly dedicated to the success of each and every student. You are a talented crew and I am a better person for having been in your classroom. Drs. McCaw, Matt, and O'Reilly, thanks for all that you do to make this world better.

I also appreciate the willingness of Dr. Doug Coe to participate in this research effort. You are a great educator and I am proud to be associated with you.

Other education professionals have also participated in this project and need to be acknowledged. Melissa, you are the master of the data and your work is more than impressive. Jerry and Chip, the statistics are easy for you and I am grateful for your work in making them easier for me. Dr. Frank Gilmore provided constant encouragement during this journey and I am truly a better leader for having been under his tutelage.

The members of Cohort VII have also become important members of my education family. Tim, Kitty, Vicki, Sean, Lynette, Cheri, and Jin – thanks for making all of those weekends away an enjoyable and valuable experience.

It is not possible to list everyone that has played a part in this work product. So in short, thanks to everyone for their support, encouragement, and patience.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER ONE

INTRODUCTION TO THE STUDY

Without question, U.S. competitiveness in the global economy has weakened over the last decade. The Committee on Science, Engineering and Public Policy (2007), U.S. President Barack Obama, and many others have called for new investments in higher and post-secondary education to create a significantly larger, more diverse talent pool of individuals interested in engineering and technical careers. *The World is Flat* (Friedman, 2005) described the U.S. lack of focus on preparing for the global, technology-intensive economy as "the quiet crisis" (p. 253).

There has been significant national press regarding the importance of STEM education in America and the criticality of success in these fields if our country is going to continue to compete in this global economy. Thus, it is critical that institutions of higher learning understand the path to success for students interested in pursuing degrees in any STEM discipline. The U.S. Bureau of Labor Statistics reported in 2007 that occupations in science, technology, engineering, and mathematics (STEM) are expected to grow by 22% between the years 2004 and 2014. In comparison, the job growth for all other occupations is 13%.

There are multiple reasons for the comparatively low percentage of STEM undergraduate degrees in the U.S., including well-documented declining student interest in these fields. Ability may not be a factor. Seymour and Hewitt (1997) found that students who leave the sciences have similar grades in STEM classes as those students who persist. The most prevalent reasons cited for the lack of STEM educated graduates are the lack of K-12 preparation for the rigor of STEM education, the social complexity and new-found freedom of young people entering college, and the failure of universities to plan appropriate social and academic transitions for the new students.

Studies on this subject, to date, have yet to employ a methodology with a sample that could provide their own stories or messages as to students' reasons for their decisions to stop out or drop out of a STEM major. It is in these stories that education leaders may learn what social or academic programming may need to be designed and implemented to limit or mitigate the departure of students from STEM majors. An in-depth examination of these messages may lead to changes in recruiting practices, a restructuring of course offerings, an emphasis or de-emphasis on living-learning communities, and/or an adaption of social programs for students within specific disciplines.

This mixed-methodological study investigated the successful 2010 graduates from one post-secondary institution and examined entrance information, demographics, and undergraduate students' paths through their respective curricula. A subset, volunteer sample of these students was also interviewed for a qualitative examination of their experiences in college. During these interviews, the graduates were asked to identify elements of their time on campus that contributed to their success. Thus, these were designed to determine both people and important social factors that might have been perceived as influential. While identifying influential individuals, the matriculated students also identified students who dropped-out, despite their having had the apparent skills to succeed.

Voluntary post-hoc interviews were completed from the snowball sample that resulted from the conversations with the 2010 graduates. These students were asked to uncover the significant barriers that prevented their successful completion of a STEM-related degree. These personal stories unveiled invaluable information for educational leaders attempting to improve the persistence and graduation rates of STEM students. Because of the national reputation, accreditation and Carnegie classification of the institution studied, these findings may foster new examinations among colleges nationwide.

There is considerable research concerning the importance and the significance of students living on campus sometime during the collegiate journey. Additionally, there is a growing national trend toward the development of living-learning communities as a response by universities to the retention and graduation rate dilemma. Specifically, this study examined the living-learning community that began in the residence halls. There were 54 graduates who lived in the dorms, came as freshmen no later than Fall 2005, were not international, and graduated in 2010 with a Bachelor's degree in Biology (BISI), Chemistry (CH), Computer Science (CS), Electrical Engineering (EE), Environmental Engineering (EN), General Engineering (GE), Geophysical Engineering (GP), Geological Engineering (GL), Mining Engineering (MN), Metallurgical Engineering (MTME), Occupational Safety (OSH), Petroleum Engineering (PT), or Software Engineering (SE). The student demographic information included the data point of residence hall living within the quantitative portion of this study to determine if the university's living-learning community significantly contributed to the likelihood of success.

Rationale and Purpose of the Study

Declining STEM graduation rates are a significant and growing problem for colleges all across the nation. This problem is aggravated by the national imperative to graduate more students with a STEM background. Economic prosperity erodes and competitiveness has declined as the United States industries continue outsourcing higher-skilled work to other nations.

Concurrent to these economic challenges, students in the U.S. are dropping out of college for a variety of reasons, and university administrators must mitigate the controllable issues so as to increase retention and eventually increase the number of STEM graduates earning undergraduate degrees. Predicting student graduation is of great value to universities and has enormous potential use for targeted intervention.

The purpose of this study was to explore and understand the factors that may predict a student's likelihood to complete an undergraduate program in a STEM discipline at one university reliant upon that mission. This research investigated and summarized the relationship between academic and social characteristics of the students as it predicted success factors in a STEM discipline.

Research Questions

The following research questions framed this investigation:

Research Question One

What are the indicators of success for a student entering a STEM program at the subject institution? Included in this analysis were demographic descriptors (gender, race, and , in-state versus. out-of-state fee status), secondary-level profile (high school GPA, size of high school, high school class rank, entering math-SAT or math-ACT scores), socio-economic status (federal financial aid received), residence hall living, and whether a student participated in the university's College Orientation Course (designed to orient incoming students). Each of these was also examined to determine if they were significant indicators of the level of success.

Research Question Two

Was living on campus in a residence hall the first year significantly related to the success rate of graduates in this cohort (2010 graduates in one of the university's STEM programs)?

Research Question Three

What was the stop-out or drop-out rationale for those students who did not finish college or completed a degree outside a STEM discipline?

Sub Question 1: Are the reasons for stop-out for the students beginning in the residence hall consistent with the drop-out rationale of all students failing to graduate?

Significance of the Study

Admitting students who are most likely to persist takes advantage of one of the earliest opportunities to affect institutional retention rates (Bean, 1980). Colleges can strategically aim to increase the percentage of students who persist by admitting students who have academic and social characteristics aligned with the factors linked to success. Such matching principles may do more to reduce attrition than any post matriculation program (Bean, 1985). Research regarding the likelihood of student persistence based upon precollege characteristics can assist institutions in the identification of which students are likely to persist. In addition to the many university administrators who seek to learn about these issues, there are leaders of K-12 educational systems who are eager for guidance as they provide adequate preparation for success and mold curricula and students to achieve these benchmarks. In total, the solution to this problem is complicated and multi-faceted.

Definitions of Key Terms

Definitions of important terms in this study are presented below:

STEM Program. A "Science, Technology, Engineering, or Mathematics" curriculum (Ramaley, 2001). For the purpose of this research, STEM programs are Biology (BISI), Chemistry (CH), Computer Science (CS), Electrical Engineering (EE), Environmental Engineering (EN), General Engineering (GE), Geological Engineering (GL), Geophysical Engineering (GP), Mining Engineering (MN), Metallurgical Engineering (MTME), Occupational Safety (OSH), Petroleum Engineering (PT), or Software Engineering (SE).

Successful completion. The award or acceptance of an academic degree or diploma (Guralnik, 1987). Graduation from the subject university in 2010, continued enrollment at any college or university, or graduation from any four-year college or university on or before 2010.

Stop-out or drop-out students. A dropout is a student who enters a college or university with the intention of graduating, and, due to personal or institutional shortcomings, leaves school for an extended period of time (Tinto, 1982). For the purpose of this research, students who identified STEM as their first major but did not graduate by the spring of 2010, did not graduate with a bachelor's degree from another university, or are not continuously enrolled in a STEM program at the subject university are considered a stop out/drop out.

First-time, full-time student. A student who enrolls in the fall semester for the first full-time postsecondary educational experience. For this study, a student taking 12 credits or more is considered full time by the institution itself.

Persistence. A student's ability to enter as a first-time student and continue his or her enrollment through graduation (Tinto, 1982).

Delimitations of the Study

This mixed-methodological study was delimited to the students who enrolled at the subject university in the fall semesters of 2005 and 2006. The subject institution is a small, regionally accredited public institution located in the western United States with a mission and long-standing reputation of STEM education. The successful graduates are defined as those who completed a STEM degree in May, 2010. The research is delimited to the institution itself, given the general composition of the students who enroll there. Approximately 81% of the students hail from within the state of the subject institution; 11% come from the other 49 states. Due to inconsistencies in international secondary-level transcripts and testing and the lack of demographic data related to these students, the 8% of students from other countries were not considered. Thus, this study is also delimited to students from the United States.

Limitations of the Study

This study is limited by the quality of the inputs entered into the database managed by the subject institution. These limitations also extend to the data gathered and managed by the National Clearinghouse. Data are voluntarily reported to the

Clearinghouse, thus, it is possible that some students have graduated from a different institution without their records within the National Clearinghouse recognizing this fact.

Chapter Summary

Today, perhaps more than ever before in history, there are numerous national imperatives for universities in the United States to produce more graduates in the STEM disciplines of Science, Technology, Engineering, and Mathematics. Our state and country's economic well-being will be diminished if we do not address the significant reduction in engineers and scientists earning undergraduate degrees. Institutions with specific missions targeting the education of these professionals are expected to provide a portion of the solution to this problem. Eager to support the nation's economy and position as a leader in these fields globally, university executives are eager to learn what elements of their programs for academic and student life might be correlated with students' progress toward degrees. The institution serving as the focus of this research has a rich heritage and history as a campus whose graduates focus on Science, Technology, Engineering, and Mathematics disciplines. The group examined by this research was the students who graduated in 2010 and were admitted in either 2005 or 2006, having then declared their intention of completing a STEM degree program. This research determined the indicators or predictors of success in completing a STEM program within this cohort. For the purpose of this research, STEM programs were defined as Biology (BISI), Chemistry (CH), Computer Science (CS), Electrical Engineering (EE), Environmental Engineering (EN), General Engineering (GE), Geophysical Engineering (GP), Mining Engineering (MN), Metallurgical Engineering

(MTME), Occupational Safety (OSH), Petroleum Engineering (PT), or Software Engineering (SE).

CHAPTER TWO

REVIEW OF THE RELEVANT LITERATURE

There is a great deal of literature surrounding STEM education graduation and persistence rates of college students in America. However, much of these data focus on underserved, minority, and underprivileged students. For these issues to be well understood, a more comprehensive assessment is important. There is little research on predictability of graduation in comprehensive, STEM-focused, masters-granting universities.

In today's higher education marketplace, there is a growing focus on accountability for universities as measured by educational outcomes such as retention rates, graduation rates, and preparation for employment after graduation. Graduation rates are an increasingly important measure of institutional success in an era in which students, media, legislators, and administrators expect greater accountability for educational outcomes (Goenner & Snaith, 2004). Furthermore, the Federal Student Right-to-Know and Campus Security Act of 1991 (FERPA) require institutions to disclose completion or graduation rates of degree-seeking, full-time students to all students, parents, and prospective students.

This review of literature is divided into four major sections. The first is a look at the historical work on studies of persistence, retention, and graduation rates. The second section examines the research on STEM education. The third component of the review focuses upon the higher education drop-out literature. The final section outlines the residence hall living component of higher education social life, including contemporary approaches to fostering strong campus communities.

Traditional Studies of Persistence, Retention, and Graduation Rates

According to Ryan (2004), traditional studies of persistence, attrition and retention were based on student-behavior and were built from the following works: Tinto's (1975) concepts of academic and social integration, Pascarella and Terenzini's (1991) student interactions, Astin's (1993) student involvement, Bean's (1980) student satisfaction and attrition and Kuh's (2001) student engagement. Many of these theories are focused on important factors, such as student pre-college characteristics and student integration in the college. Although student level factors are important to explain college persistence, administrators and policy-makers often want to examine performance measures at the institutional level, such as graduation rate and retention rate. Seminal research on college student attrition was conducted many years ago (Rootman, 1972; Spady, 1970, 1971; Tinto, 1975) and is essential in understanding the causes of the dropout rates in American colleges and universities.

Student-Focused Research on College Attrition

Most research on college retention can be traced back to Tinto’s (1975) seminal work on college dropouts. Based on the previous works by Spady (1970, 1971) and Rootman (1972), Tinto developed a comprehensive model of the theories examining dropouts from college. The model was built upon Durkheim's theory of suicide and the cost-benefit analysis of economics of education. According to Durkheim, suicidal behavior was related to the individual's insufficient integration into the society (Tinto, 1975).

Vincent Tinto held that Durkheim's theory of suicide explained college dropout because a college was viewed as a social system in which individual students integrated with the academic and social components. According to Tinto, when a student failed to integrate into the academic and social structure of the college, he or she would drop out, either voluntarily or by academic dismissal. Tinto (1982) later clarified that his theory was primarily concerned with differences, including those within academic institutions, between dropouts as academic failure and as voluntary withdrawal. Tinto focused on the characteristics which institutions themselves were at least partially responsible for and identified how colleges and universities could change their policies to reduce such attrition. His model was developed to explain the process of particular forms of dropout behavior rather than to maximize its explanation of variance in dropout behavior. To Tinto, what was important was how the integration process helped explain the dropout rates, leading to what kinds of interventions administrators could implement to facilitate social and academic success in their institutions.

Tinto (1998) identified individual characteristics relevant to persistence included background characteristics (such as social status, high school experiences, community of residence, and individual attributes like gender and race/ethnicity), as well as motivational attributes (such as career and educational goals). An individual's educational goal commitment and institutional commitment were the two main factors determining dropout decisions. Goal and institutional commitment were, in turn, determined by the individual’s academic and social integration into the college. Academic integration was measured in terms of grade performance. Extracurricular activities linked to the academic system provided both social and academic rewards. Student interaction with faculty was more important in the student's major field than in other areas. Tinto indicated that while both social and academic integration affected the rate of dropout from college, academic integration was the more important factor because it related more closely to direct and tangible rewards in the educational system. Tinto went on to suggest that one would expect permanent dropout rates at private universities to be smaller than those at public institutions if only because of the greater financial commitment people make in attending private institutions.

Over the years, many researchers have pointed out different problems in Tinto's early work. First, Pascarella and Terenzini (1983) pointed out the differences in gender on the persistence or withdrawal behavior and the effect on academic and social integration as well as on institutional commitment. Bean (1985) emphasized the important effect of dropout intention on college persistence. Bean examined a combination of intent to leave, discussion of leaving, and actual attrition to develop an explanatory model of college student dropout. Brunsden et al. (2000) argued that the main weakness of Tinto's theory was inadequate conceptualization. That is, the concepts of social and academic integration were not clearly defined, nor were they defined in terms of individual student's perceptions. Several researchers pointed out the impact of financial aid on college persistence and graduation, where clearly the absence of support meant inevitable withdrawals from college (Alon, 2005; Alon & Tienda, 2005; Cabrera, Nora & Castaneda, 1992; Chen & DesJardins, 2008; DesJardins, 2001). All of these criticisms were not ignored by Tinto. In fact, Tinto had earlier recognized the limitations of his theory in two areas, even though he had chosen not to explicitly include them in his model. First, Tinto acknowledged that external impacts from outside the college, such as the changing supply and demand in the job market, could also affect the individual's decision to stay in college. Second, institutional characteristics varied, which affected college dropout at the aggregate level, included the institution’s type, resources, facilities, structural arrangements and composition of its members. Public institutions tended to have higher dropout rates than private institutions. Two-year colleges also tended to have higher dropout rates than four-year colleges. Furthermore, in 1982, Tinto ultimately recognized the following shortcomings in his theory: (a) insufficient emphasis on finances in student decisions concerning higher education persistence, (b) failure to highlight the important effects of gender, race and social status backgrounds on college persistence, and (c) not dealing with the specific issues peculiar to two-year college sector.

Over time, these shortcomings were clarified and analyzed. First, the role of finances in student disengagement may vary in different stages of the student's experience in college education. For example, financial needs in early college years had greater and more long-term impact on the students. Financial needs occurring closer to degree completion were viewed as short-term and easier to overcome. Second, comparisons of dropout rates among different groups of students were important to discover specific social and institutional disadvantages which disproportionally diminished retention rates among particular minority groups. It was not sufficient to include gender and race variables into the regression equation, but rather specific models needed to be developed for specific groups to capture the factors relevant to them. It was argued that those results would reveal how policy could be changed to correct the groups’ disadvantages.

Bean (1980) built his student attrition theory based upon the turnover theory in work organizations. He claimed that student attrition was analogous to employee turnover in work organizations. In his model, Bean formulated four categories of variables: student background, organizational determinants, intervening variables and dependent variables having their causal relationships in that order and direction.

The major findings of Bean's study were two-fold: first, males and females left school for different reasons but both shared institutional commitment as the most important intervening variable; and second, that opportunity variables such as options for transfer were important in determining institutional commitment. In another study, Bean (1985) developed a causal model to predict a “dropout syndrome,” which was measured by an individual’s intent to leave. Bean used four categories of variables: academic factors, social-psychological factors, environmental factors and socialization/selection factors. Bean tested his model on four groups of college students divided by their year levels. He was able to explain variances in dropout syndrome for the four groups as follows: 47% for freshmen, 35% for sophomores, 27% for juniors and 35% overall. This model had more explanatory power on the dropout intention among the freshmen group compared with the other three groups. In summary, the longer a student stayed in an institution, the more factors existed to influence his or her dropout decision. The variance explained in persistence by this study was higher than the variance explained by previous studies. Although Tinto and Bean developed their models based upon different theoretical frameworks, they shared many similar characteristics, such as academic factors, social-psychological factors and student background characteristics.

Building upon Tinto's and Bean's works, Cabrera, Nora and Castaneda (1992) examined the role of finances on college persistence using a causal model to analyze the data collected from a sample of 2,453 freshmen at a large public institution. In Cabrera's and his associates work they learned that financial aid may provide recipients with enough freedom to engage in social activities and to become fully integrated into the social realm of the institution. In addition to the financial effects on persistence, Cabrera and Nora (1993) also found the positive effect of encouragement from significant others upon social integration and goal commitment. Significant others' influence affected the student's academic and social integration, because such encouragement developed educational aspirations among high school students was further associated with subsequent postsecondary social integration. They also found that pre-college academic performance was correlated with academic integration, and that non-causal relationships existed between social and academic integration as well as goal and institutional commitment. Cabrera and Nora went on to explain that a concerted effort on the part of the institution in bringing together the different student support services to address student attrition is needed. Cabrera and his associates enhanced Tinto's theory by clarifying the roles of financial aid and significant others' influences on persistence.

In a test of Tinto's (1975) theory, Pascarella and Terenzini (1977) used regression analysis to investigate the pattern of student-faculty informal interaction beyond the classroom between the college persisters and voluntary leavers in a 1975 fall sample of 355 first-time students at Syracuse University, New York. The findings showed that students who persisted had significantly higher informal interaction with faculty, particularly in matters related to intellectual and academic interest. The results supported the informal student-faculty interaction part of Tinto's theory of college withdrawal, although the relationship between informal student-faculty interaction and persistence had not been directly tested earlier.

After conducting two partial tests on Tinto's theory, Pascarella and Terenzini (1983) used path analysis to test the validity of Tinto's (1975) model as a whole, based on a sample of 763 freshmen (402 males and 361 females) from a residential university. They fit the model on the overall sample, then on the male and female groups separately. The results generally supported Tinto's theory on the gender effect on persistence/withdrawal behavior and the compensatory effects between academic and social integration and between institutional and goal commitment. For female students, social integration appeared to be a stronger factor than academic integration, whereas the opposite was true for male students. In another path analytical study to validate Tinto's model, Pascarella and Chapman (1983) used a multi-institutional sample of 2,326 freshmen from 11 postsecondary institutions. The results generally confirmed the validity of Tinto's theory. Social integration exerted stronger influence on persistence at four-year primarily residential institutions, while academic integration was a more important factor at two and four-year commuter institutions.

This theory of student involvement can be traced back to Astin's (1975) study of college drop-outs to identify factors that significantly affected the student's persistence in the college environment. According to Astin (1999), "student involvement refers to the amount of physical and psychological energy that the student devotes to the academic experience" (p. 518). "The persister-dropout phenomenon provides an ideal paradigm for studying student involvement" (p. 524). For example, living in a campus residence was positively related to retention, because the student living on campus had more time and opportunity to get involved in all aspects of campus life. Participation in social fraternities and extracurricular activities was also positively related to retention, because these activities allowed students to develop friendships with peers and to become more involved in campus life. Likewise, holding a part-time job on campus increased retention, because those kinds of work activities enhanced the student's involvement within the campus. On the other hand, off-campus, full-time work diminished retention, because they were competing objects that drained students' time. Furthermore, a student's ability to identify with the institution had a positive impact on retention. This was why commuter colleges had higher dropout rates; their students spent less time on the campus and were less involved in campus activities. The level of learning and development that a student could achieve was directly proportional to the amount of time and effort he or she put into the process. Student time was also a finite resource, and its allocation was a zero-sum game. When a student committed his or her time to certain activities, that student would have less time to spend on other activities. Therefore, Astin suggested administrators and faculty members recognize that all institutional policies and practices could affect the way students spent their time and the amount of effort they invested in academic activities. Kuh, Gruce, Shoup, Kinzie and Gonyea (2008) developed a student engagement theory which was built upon the basic principles of Astin's (1984) student involvement theory.

Kuh and his associates (2008) used multiple regression analyses to examine the effects of engagement in purposeful educational activities during the first year of college on first-year GPA and second-year persistence. Between 2000 and 2003, they used the National Survey of Student Engagement (NSSE) and campus institutional research records to collect data from a sample of 6,193 students who enrolled in 18 baccalaureate-granting colleges and universities with differing institutional characteristics. They also examined the interaction effect between first-year engagement and race/ethnicity. The results showed that student engagement was positively related to academic outcomes and persistence. Student engagement also had a compensatory effect on academic outcomes and persistence. For example, the time spent on educational activities more than compensated for a pre-college SAT/ACT disadvantage. Compared with white students, Hispanic students were benefited more in GPA by the same amount of increase in engagement. Kuh et al. (2008) concluded, "Student engagement in educationally purposeful activities during the first year of college had a positive, statistically significant effect on persistence, even after controlling for background characteristics, other college experiences during the first college year, academic achievement, and financial aid" (p. 551).

Student involvement is an all-encompassing concept to explain student development in higher education. There are different types and intensity of student involvement. Most of these studies addressed larger issues than those which previously focused on the student-level factors such as personal characteristics, intention to persist, socioeconomic status, commitment, self-perceived degree of social and academic integration, and faculty-student interaction. However, different institutions and states may have structural differences that could also affect student persistence in college. As a result, institutional-level research is required in order to examine these structural factors.

Institution-Focused Research on Graduation Rate

Institutional characteristics are important sources of analyses of student graduation rates. Gansemer-Topf and Schuh (2006) stated that much of the research on retention has focused on the characteristics or traits (i.e. academic ability, experiences or financial need) of students. Significantly less research has examined how institutional behavior rather than student characteristics or experiences is related to retention and graduation (p. 614). Nonetheless, it is increasingly clear that student graduation rates are affected by institutional level factors.

According to the Integrated Postsecondary Education Data System (IPEDS) definition, graduation rate is calculated as the total number of completers within 150% of normal completion time, divided by the number of students in the cohort, minus any allowable exclusion (Knapp et al., 2008). Graduation rate is the most commonly used measure of institutional performance and is often used in institutional ranking systems. Still, many experts continue to disagree about using graduation rate as an appropriate performance measure of higher education institutions. Bailey, Calcagno, Jenkins, Leinbach and Kienzl (2006) listed two reasons for rejecting the use of graduation rate to measure the performance of community colleges. First, they contend that many of the students who attend community colleges did not seek degrees or transferred to baccalaureate institutions. Second, many factors that thwarted students' graduation were beyond the control of the colleges, including family and work responsibilities and deficient academic preparation. Earlier, Gillmore and Hoffman (1997) had proposed to use the graduation efficiency index (GEI) as an accountability measure to replace the traditional time-to-degree measure. According to Gillmore and Hoffman, efficiency was defined as the ratio of the effective or useful output to the total input in any system. In the context of higher education, the output referred to the minimum required degree credits, and the input referred to the credits attempted. The traditional measure of efficiency was a time-to-degree measure, which used time as the input. For example, graduation rate was the ratio of students who graduated within a period of time (e.g., four years or six years), compared with the total number of students who enrolled as first semester freshmen. The main problem of the time-to-degree approach was that time was not the best indicator of educational activity. Degree credit, it was argued, could better represent educational effort and activity. Furthermore, the time-to-degree approach as an accountability measure had some negative consequences. For example, more students needed to work part-time because of higher tuition and living costs. Measured by graduation rate as their efficiency index, many community colleges were seemingly punished by admitting nontraditional students who took longer to graduate or who never earned degrees.

In addition to the graduation rate, Jacoby (2006) devised the overall degree ratio and the net graduation rate to account for the effects of transfer students and part-time students on graduation rate. The graduation rate was based on the ratio of first-time, first-year (FTFY) students who graduate within 150% of normal completion time relative to the FTFY cohort. The net graduation rate was the same as the NCES graduation rate, but the FTFY cohort was reduced by the number of students who had transferred to other institutions. The overall degree ratio was based on the number of students who graduated in a given year relative to a college's total FTE student enrollment. Given the debate about the use of graduation rate as an institutional performance measure, the graduation rate provided by IPEDS was still, by far, the most widely-used measure. Several limitations should be heeded when IPEDS data are used to study graduation rates, however. First, IPEDS does not include measurement of student ability and motivation as well as other student-level characteristics, except for gender and ethnicity information aggregated at the institution level. Second, IPEDS does not provide any tracking information about the whereabouts of transfer students, thereby weakening the ability to study the success or failure of transfer students. Third, IPEDS does not account for the graduation or dropout of part-time students. Although IPEDS has its limitations, it provides the institution's summary graduation data for subgroups based upon gender, ethnicity, athletic affiliation, and other descriptors. It can be used to discover differences among colleges because it contains data about most of the higher education institutions in the United States; IPEDS is broad-based.

Graduation rate could be a valid measure to compare performance of one institution to its peers. However, if taken out of context, graduation rate could be very misleading. Astin (1997) warned that an institution’s retention rate could be a misleading indicator of its capacity to retain students because more than half of the variance in the retention rate was attributed to students’ characteristics prior to enrollment rather than to any differential institutional effect. He argued that an institution’s effectiveness in retaining students should be measured by its actual retention rate compared with its expected retention rate.

Goenner and Snaith (2003) contended that past studies on student attrition were primarily focused on the effects of student characteristics and largely ignored the role of institutional characteristics. They used both student and institutional characteristics as predictors in a multiple regression model to predict the graduation rate based on a sample of 258 Carnegie I research universities. The results showed that both student and institutional characteristics accounted for significant amount of variances in the graduation rates. The institutional characteristics included in this study were the percentage of full-time faculty, total educational and general expenditures, student-faculty ratio, weighted tuition and fees. The student characteristics were the percentage of students in the top 10% of their high school classes, 25th percentile of student SAT scores, the percentage of out-of-state students and the average age of the students.

Blose (1999) used logistic regression to compute the expected graduation rates of the State University of New York (SUNY) based on student characteristics (e.g., gender, race, age and family income) and academic performance measures (e.g., student's high school average GPA, rank in high school class and SAT/ACT scores). He then compared the actual and expected graduation rates to evaluate the relative performance of institutions. The point was to create a logistic regression model to predict students' graduation probability based on a set of student attributes and data from all institutions. Then the model was applied to each institution to calculate its predicted graduation rates based on its student profiles. The institution's predicted graduation rate was used to compare with its actual graduation rate. The underlying rationale of this method was that the more selective institutions, those with better prepared students, should have higher graduation rates than institutions with less well-prepared students, and vice versa. Blose found that students at the most selective institutions tend to exceed performance expectations. He went on to speculate that the academic distinctions among students at these selective institutions are lost or blurred once the students enroll. This suggests that some institutions would have higher persistence if they created an environment that engendered respect for students, treated the students as academically capable, and held those students to high standards (Blose, 1999).

In IPEDS, student demographics include gender and ethnicity, which characterized the graduation rates and degree completion rates, as well as the average age variable. The average age of students was negatively related to graduation rates; because older students were further removed from the materials learned in high school and may also have experienced additional family and work burdens beyond those faced by than traditional students (Goenner & Snaith, 2003). Students' non-traditionality was measured by the percentage of part-time attendance, the percentage of commuter students and the average age of students. These three measures were related to social attachment of student involvement in campus life.

Another piece of demographic information that had impacts on the graduation rate was a student's socioeconomic status (SES). Astin and Oseguera (2004) defined student's SES by parental income level and parental educational level. The 25th percentile and 75th percentile of parental income were computed to classify the parental income level as highest (25%), middle (50%), or lowest (25%). The parental educational level was defined in a three-category scale: low, the level where both parents never attended college, high, the level where both parents had college degrees, and middle, the remaining combinations.

As was generally expected, students' SES was related to academic outcomes by affecting their educational aspirations and limiting the resources available to the students. Students’ SES was also correlated to other student attributes such as academic preparedness and their personal goals in education.

Institutional selectivity has an enormous impact on an institution’s graduation rate. Astin and Oseguera (2004) defined institutional selectivity narrowly as the mean SAT score (verbal plus mathematical composite) of the entering class. The highly selective, least selective and middle selective institutions were defined by the top 10%, bottom 30% and remaining 60% of the institutions. Using this definition, Astin and Oseguera (2004) examined the income group representation in the most selective institutions from 1985 to 2000 as follow: a steady increase in the representation of high-income students; a steady decrease in the representation of middle-income students; and little change in the representation of low-income students. The inequity of educational opportunities among students at different SES levels had increased, despite the expansion of remedial efforts such as student financial aid, affirmative action and outreach programs. The underlying reasons were not clear but were partially attributed to the increasing competitiveness among prospective college students for admission to the most selective institutions.

In addition to the common use of entering students’ SAT/ACT scores as indicators of institutional selectivity, some researchers also used tuition to reflect institutional selectivity. Tuition reflected both institutional resources and selectivity (Scott et al., 2006). The weighted average tuition and fees represented the cost of not graduating in a given time frame. Delayed graduation led to higher accumulated tuition costs. Tuition may also reflect perceived quality of the institution. Therefore tuition was positively correlated to graduation rates (Goenner & Snaith, 2003).

Literature on college retention indicates that academic and social attachment were the two most important factors affecting persistence and attainment (Pascarella & Terenzini, 1991). As a result, institutional social policy designed to increase retention was often focused on strengthening student attachment through student services and high-quality residential life. Pascarella and Terenzini (1991) found the following factors to have a positive impact on graduation rate: entering SAT scores, family income, private and residential institutions and other institutional characteristics promoting social integration such as residential campus.

Astin (1997) also found that several institutional factors associated with retention rates were a student's major field, the percentage of new students living in residence halls during their first year, and institutional size. Institutions with more students in business, psychology, or other social sciences tended to have higher retention rates whereas institutions with more students in engineering tended to have lower retention rates. Institutions with more first-year students living in residence halls tended to have higher retention rates, and vice versa. Institutional size tended to have a negative effect on retention.

Most of the studies conducted on student retention were based on single institution samples. The results of these studies may not be generalizable to other institutions (Caison, 2007). Kuh et al. (2008) had the same concern, pointing out most of the research examining the connections between student engagement and college outcomes is based on single institution studies that do not always control for student background characteristics, limiting their generalizability to specific institutions or institutional types (p. 542).

According to Tinto (2006), contemporary theories of student retention utilized abstractions and variables, such as social and academic integration, which were often difficult to use in the guiding of retention practices within institutions. Other variables, such as student high school experiences and family background, were out of direct control or influence by the institutions. Faculty members did not feel responsible for student retention because it was not connected to student learning, perceived as within the faculty's responsibilities. Therefore, investment in faculty development was not tied to student retention, and most institutions had not been able to translate theory into action in the area of student retention. Three lessons were learned: first, it was one thing to understand why students left; it was another to know what institutions could do to help students stay and succeed. Second, while specific actions had been identified, campuses found them difficult to implement in ways that significantly enhanced student retention over time. Third, low income students were still less likely to graduate than their high-income counterparts even though the gap between them for access had narrowed.

Concerning retention programs, Tinto (1982) recommended three characteristics of successful initiatives: they were often longitudinal in nature; they were almost always closely tied to the admission process; and their implementation generally involved a wide range of institutional factors.

An extensive review of the literature regarding student persistence and graduation rates has been presented. From a theoretical perspective, Tinto's model analyzing those who drop out from college was the most successful model and elicited more research than any other. Tinto (1998) concluded with the following four known effects concerning student persistence: first, involvement mattered. Persistence increased as interaction between students and faculty increased. Second, social and academic integration not only influenced persistence separately, but their synergy could generate a greater effect on persistence. Third, social and academic integration had different effects on two-year and four-year institutions. Fourth, involvement mattered most during the first year of college. Many researchers had examined the effects of institutional attributes on graduation rates, but few had studied the interrelationship of these institutional attributes nor developed theoretical models to explain them as a whole.

Understanding College Dropouts

Clemson University is the home of the National Dropout Prevention Center (NDPC). According to the NDPC, dropping out of school is related to a variety of issues that can be classified in four domains: individual, family, school, and community factors (Marshall & Havice, 2008).

Esther Marshall (2010) asserted the hurdle of getting into college is just as important as being able to complete four years of college and earn a degree. Marshall indicated that there are a number of reasons why students drop out of college, and students who are aware of these reasons before they begin college can help ensure success of their college years. These reasons are a lack of motivation; many students can't handle the amount of freedom they have when they enter college; and they are not able to establish a proper mix of social and academic life.

Marshall (2010) further claimed that many freshmen do not have the study and academic skills to cope with the increased workload that comes in college. Reading and writing assignments in college are considerably more complex than in high school classes and lectures are more complicated. Martindale (2010) indicated that getting accepted to a university is only the first step in an uphill battle toward a degree. Persevering long enough to graduate can be just as challenging.

The U.S. Department of Education found that 41% of low-income students enrolled in a four-year institution managed to graduate within five years. For higher income students, this jumps to 66%. Of the low income students who did not return, 47% left in good academic standing (Martindale, 2010).

Though research links financial difficulties to drop-out rates, there are a number of factors reportedly accounting for why students decide to leave school. Students tend to drop out because their expectations of college – academically, socially or both – don’t match up with the reality once they arrive on campus. They also suffer from lack of motivation, inadequate preparation and poor study skills. The U.S. Commission on Civil Rights recommended that colleges warn students whose academic credentials are less than the institution’s median about the impact of that deficit, and urged high school counselors to advise students on the problems they would face entering a STEM program at an institution where they fall below the academic level of the typical student (Kiley, 2010).

Few students who drop out eventually finish their educations. Those who do return to college usually don’t do so immediately. Approximately 12% of the undergraduate population consists of re-entry students, defined as those over the age of 25 who return to college to pursue a degree.

Many college students – especially dropouts – are burdened with debt accumulated from loans that could have been avoided or minimized by choosing other education and training options. Debt from student loans is associated with longer-lasting disadvantages faced by those who never finish college. Most dropouts are left with big debts and mediocre job prospects (Martindale, 2010).

Fewer than half (47%) of all college officials responding to an ACT survey say they have established a goal for improved retention of first-year students, and only a third (33%) say they have established a goal for improved degree completion. In addition, only around half (52%) say they have an individual on staff that is responsible for coordinating retention strategies.

It is estimated that 40% of college students will leave higher education without getting a degree, with 75% of these students leaving within their first two years of college. Freshman class attrition rates are typically greater than any other academic year and are commonly as high as 20-30%. These statistics show a need for colleges to do something about retention rates (Martindale 2010). A 2011 report prepared by the Office of the Commissioner for Higher Education on data for the subject institution's reported an average retention rate for the academic years 2005-2009 at approximately 70%. This means that 30% of the first-time, full-time freshman attending the subject institution did not return for their third semester. This retention rate was comparable with the other four-year institutions in the state; indeed, the retention rate of this subject institution increased to an average of 78% when transfers within the system were considered. This fact demonstrated that 8% of the institution's first-time, full-time students attended there for only one year, and then transferred to another higher education unit within the same state.

According to Martindale (2010), students who were well prepared for college coursework were more likely to stay in school. He further underscored the need for colleges to offer programs and services that integrate first-year students into the social fabric of the college community, to ensure they feel a part of campus life from the very start of their college experiences. These institutional efforts are new initiatives on many campuses.

Predicting Graduation within STEM Disciplines in America

Academic retention in STEM majors is not pre-determined or readily predicted. Retention discussions are informed by on-going, interactional processes among the individual, cultural and peer influences, social dynamics, and environmental factors (Byars-Winston, et al. 2008). Byars and her colleagues went on to explain their analysis of the significant factors that influence a student's intention to graduation in a STEM discipline:

1. Students who believed that a STEM major was worth the effort were more likely to enter a STEM program.
2. Students who believed they had the ability to complete their degree were more likely to be interested in a STEM major.
3. Positive expectations regarding the payoffs of a STEM degree and its usefulness to future employment were important in a student's intent to graduate with a STEM degree.

4. According to the interviews conducted, successful students felt safe and comfortable in classes and in labs.
5. Students were more confident about succeeding in their major in the short term (next semester), but progressively less confident about succeeding in the long term.
6. Students reported feeling less able to cope with the lack of support from professors or advisors (p. 4).

In 2010, the National Science Foundation (NSF) stated the country needs to be more concerned about the high-end of the student population, namely those most likely to become leading STEM professionals and perhaps the creators of significant breakthroughs in scientific and technological understanding. NSF also asserted that too many American students conclude early in their education that STEM subjects are boring, too difficult, or unwelcoming, leaving them ill-prepared to meet the challenges that will face their generation, their country, and the world. The solutions – which includes a new federal agency to promote digital learning, higher salaries for the cream of the nation's teaching corps, and the creation of 1,000 STEM-focused schools – must be up to that challenge, asserted Eric S. Lander (president of the Broad Institute of Harvard University) and S. James Gates, Jr. (Professor of Physics at the University of Maryland, College Park.). The cost of implementing those reforms is estimated to be $1 Billion a year and anything less risks falling short of the goal (Mervis, 2010).

College graduation has become an important part of the national agenda, with politicians and philanthropic leaders challenging higher education to do a better job of helping students earn high-quality degrees. That, of course, requires a solid understanding of the national college graduation rate. There are two primary ways to measure this. One way is to calculate an attainment rate – the percentage of some population (e.g., adults ages 25 to 64) who attained degrees. That's the number that often gets cited in international comparisons, particularly in recent years as many countries have narrowed and in a few cases surpassed the United States historical lead. When President Obama has stated he wants to retake the international lead in college graduation by 2020, this is what he's been addressing. This number is regularly updated by the Census and runs about 40%; that is, roughly 30% of working age adults in America have a bachelor's degree and another 10% have an associate's degree (Carey, 2010).

The other often-used number is the graduation rate of those students who start college and the percent who finish within a defined amount of time. The overall national graduation rate is calculated less often, because while an individual college can tell you how many entering students get a degree from that institution, it doesn't always know if students who left before graduating transferred elsewhere and earned a degree somewhere else. Thus, the most reliable source for this number is the Beginning Postsecondary Survey (BPS), which is periodically administered by the National Center for Education Statistics (NCES) of the U.S. Department of Education and tracks a representative sample of students who enter college for the first time in a given year. The BPS survey, which began in 1996 and tracked students through 2001, defined six years as the standard time frame for measuring college graduation (Carey, 2010).

The BPS found that 62.7% of 1996 students who began at a four-year college seeking a bachelor's degree earned one by 2001. Recently, NCES released the first results from the newest BPS, which tracked students from 2003 to 2009. It chronicled a nearly identical national graduation rate: 63.2%. Of the remaining students, 4% earned an associate's degree or certificate, 8.8% were still enrolled at a four-year institution, 2.9% were enrolled at a two-year institution, and 21% had dropped out. This represented a small upward movement in bachelor's degree attainment, from 28.8%, but it was balanced out by a decline in associate's degrees and particularly certificates, which fell from 12% (Lederman, 2010).

The bachelor's degree graduation rate for students who started at public four-year institutions was 59.5%. Of the recent high school graduates, 45% earned a bachelor's degree in six years. Most four-year students in the bottom income quartile didn't earn bachelor's degrees on time (47.1%), whereas three-quarters of top quartile students (76.4%) did (Carey, 2010).

More than 25 years ago, the report *A Nation at Risk: The Imperative for Educational Reform* sounded an alarm about America's K-12 (early education through pre-college) educational system. Subsequent studies have highlighted poor performance of the United States in STEM education as assessed by comparative student achievement. This has been of special concern because it was science and technology that propelled most of the increase in U.S. per capita income in the past century (Lander & Gates, 2010).

The National Academy of Sciences has distilled research about how students learn math and science, providing a base of knowledge for moving forward. In 2010, 36 states and the District of Columbia adopted common mathematics education standards, and shared science standards are under discussion. Students need to experience technology and engineering early in elementary education, educators reported. By starting early, teachers enable young people to become excited and confident in math and science. By using technology, innovation, design and engineering in school, context can be more meaningful, thus capturing the hearts and minds of children. Because of the complexity of today's technological processes, children need to learn early in their school experience to explore the differences between the human-constructed world and the natural world (Lander & Gates, 2010).

Waiting until middle school to attract students into the future afforded by a quality STEM education is too late, experts have argued. Rather, the inclusion of innovation and design through STEM should begin in early elementary school and be nurtured on through middle school, high school, college, and beyond (Marshall & Havice, 2008).

Some 50% of American college students who declare a major in a STEM discipline leave their chosen discipline before completion, and the persistence rates for women and people of color are lower than those of their white male classmates (Lowery, 2010). Reducing the dropout rate from STEM-field majors may well be the single most efficient way to increase the supply of college graduates with STEM degrees, stated Ronald Ehrenberg, the Irving M. Ives Professor of Industrial and Labor Relations and Economics at Cornell and director of the Cornell Higher Education Research Institute (CHERI), which hosted the conference, "Analyzing the Factors That Influence Persistence Rates in STEM Field Majors." Among the findings that researchers reported at the conference were the following:

- African-American students are more likely to persist in STEM field majors if their introductory class professor is African-American;
- Most racial differences in persistence in STEM fields are due to differences in precollege preparation;
- The decision to persist based on grades varies by gender;
- The research intensity of an academic institution -- and the importance of its graduate programs relative to its undergraduate programs -- adversely affect persistence; and
- Gender differences in persistence differ in the physical sciences and engineering but not in the life sciences. (Lowery, 2010, p. 1)

Ben Ost, a third-year Cornell economics Ph.D. student and a presenter at the 2010 conference argued that a substantial grading differential exists between science and non-science courses. According to Ost, even students who eventually become science majors receive much higher grades in their non-science courses than their major field courses. This gap in grading standards discourages students from pursuing and completing a science degree (Lowery, 2010).

In a study that analyzed how such institutional characteristics as research expenditures and the gender or racial makeup of different departments are related to students' choices to remain a STEM major, the researchers found that institutions with more of a focus on undergraduate education seem to have higher persistence rates of STEM majors. Overall, it appears that institutions interested in increasing persistence rates of STEM majors may want to increase their focus on undergraduate education, and that female students may be helped by an increased probability of finding a female role model or mentor in the graduate student body in their department (Lowery, 2010).

For decades, some have claimed Americans have taken for granted the United States' position as the world leader in the development of new technologies. This includes the innovations that resulted from research and development during World War II and later were critical to the prosperity of the nation in the second half of the 20th century. Those innovations, upon which virtually all aspects of current society now depend, were possible because the United States then led the world in mathematics and science education. Today, however, they agree that despite increasing demand for workers with strong skills in mathematics and science, the proportions of degrees awarded in science, math, and engineering are decreasing (Thiel, Peterman & Brown, 2008).

Indeed, the decline in degree production in STEM disciplines seems to be correlated with the comparatively weak performance by U.S. children on international assessments of math and science. Many students entering college have weak skills in mathematics. According to the 2005 report of the Business-Higher Education Forum, "A Commitment to America's Future: Responding to the Crisis in Mathematics & Science Education," 22% of college freshmen must take remedial math courses, and less than half of the students who plan to major in science or engineering actually complete a major in those fields. Students in underrepresented minority groups, who suffer disproportionately in terms of weak math skills, are particularly underrepresented among college graduates in math, science, and engineering. The result has been a decrease in the number of American college graduates who have the skills, especially in mathematics, to power a workforce that can keep the country at the forefront of innovation and maintain its standard of living. With the declining performance of American students in math and science has come increased competition from students in other countries that strongly support STEM education. Many more students earn degrees in the STEM disciplines in developing countries, especially China, than in the United States (Thiel, Peterman & Brown, 2008).

College students' success in a course depends on many factors, including their ability and previous knowledge of the subject, the effectiveness of the instruction, and their motivation to work hard enough to succeed. Introductory courses, including many that satisfy general-education requirements, often pose a particular problem for students who are not interested in the subject or fear failure based on their high-school experiences. Students' low success rates nationally in mathematics courses are particularly damaging because these courses are a gateway to many majors and hence a major stumbling block to students' achievement (Thiel, Peterman & Brown, 2008).

The ability to predict whether or not a student will be successful in a STEM major is highly influenced by that given student's own resiliency and self-efficacy. Resilience typically refers to the development of competence in the face of diversity. Self-efficacy means the capacity to produce a desired result or effect. Albert Bandura (1981) has been a pioneer in self-efficacy research. Bandura has conceptualized self-efficacy as individuals' beliefs in their capabilities to mobilize the motivation, cognitive resources, and agency to exert control over a given event. It is the belief in one's own capabilities to produce a certain outcome or goal that is seen as the foundation of human agency (Bandura, Pastorelli, Barbaranelli & Caprara, 1999).

Thus, unless people believe they can produce desired goals through their actions they will have very little incentive to persevere in the face of difficulties. Presumably then, self-efficacy would be an important trait in the development of competence when facing adversity. Perceived self-efficacy likely affects individuals' ability to adapt and deal flexibly with difficult situations, and also affects individuals' aspirations, analytical thinking, and perseverance in the face of failure (Bandura & Schunk, 2001).

For over a half century, science-based innovation has powered America's economy, creating good jobs, a high standard of living, and U.S. economic and political leadership. Yet, our nation's global share of activity in STEM-focused industries is in decline, jeopardizing our status as the world's leader in innovation. Moreover, there is clear evidence that the U.S. is consistently unable to produce enough of its own STEM workers in key fields (e.g., computer science or electrical engineering), even though the best universities for studying these subjects are based in the U.S. While increasing the quantity and quality of U.S. STEM graduates will not by itself solve the problem of declining U.S. innovation-based competitiveness, it is an important component of a larger national innovation strategy. Consequently, there is increasing concern over how to provide more American students stronger STEM skills and get them into STEM jobs (Atkinson & Mayo, 2010).

Virtually every report and call to action on STEM education is based on what could be called a "Some STEM for All" approach. In other words, the prevailing view is that the way to ensure that more American students have the needed STEM skills is to make sure that along every step of their education, from K to 8, to high school, to college and to graduate school all students get as much high-quality STEM education as possible. Interventions grounded in this approach include boosting K–12 STEM teacher quality (increasing teacher pay, requiring higher STEM teacher qualifications), imposing more rigorous STEM standards (expanding requirements for STEM courses, more testing and assessment), improving curriculum (including further studies of the most effective STEM pedagogies and learning materials), and boosting awareness among students of the importance and attractiveness of STEM careers (Atkinson & Mayo, 2010).

Rather than base STEM policy on the “Some STEM For All” paradigm, Atkinson and Mayo propose that it be based on an “All STEM for Some” approach. In this approach, the purpose of driving STEM education is not principally to create economic opportunity for individuals; it’s to provide the “fuel” needed to power a science and technology driven U.S. economy. Without the right number and quality of STEM-educated Americans, the U.S. innovation economy will continue to falter, and with it, economic opportunity—not just for STEM graduates, but for tens of millions of other Americans employed in industries enabled by American science and technology. Thus, the “All STEM for Some” framework suggests a different approach. This approach proposes to work actively to recruit those students who are most interested in and capable of doing well in STEM and to provide them with the kind of educational experience they need to make it all the way through the educational pipeline—a B.S. in a STEM degree or advanced STEM graduate degree—and come out ready, able, and willing to contribute to growing the U.S. innovation economy (Atkinson & Mayo, 2010).

The Significance of Residence Hall Life on College Campuses

Although many departments within a university offer unique educational opportunities for students, none have the potential to influence as many students as residence life departments (Winston et al., 1993). Residence hall facilities, staff, and programs can influence the quality of students' educational and personal development (Blimling, 1999; Chickering, 1974; Zheng et al., 2002). Significant research has been conducted to determine if students who live in residence halls perform better academically than those who live at home or commute to college (Blimling, 1999; Chickering, 1974). Blimling revealed that students who live in residence halls consistently persist and graduate at higher rates than students who have not had this experience. Astin (1999) reported that the positive effects of living in residence halls during the freshman and sophomore years increase the probability that college students would complete their college programs and increase students' feelings of self-confidence. Chickering's (1974) studies on resident versus commuter students consistently show that resident students take more credit hours, have higher grade point averages, and persist and graduate with a higher rate. He found that these differences still exist, even when controlling for initial differences such as socioeconomic status, academic ability, and past academic performance. Ballou, Reavill, and Schultz (1995) found that students who have lived in university housing during their first year were 12% more likely to complete their undergraduate education.

Living on campus maximizes opportunities for social, cultural, and extracurricular involvement. In comparison with commuters, those living in residence halls often report being more satisfied with the institution and their educational experiences. Chickering’s (1974) research went on to indicate that residence hall students have significantly more social interaction with peers and faculty and are more likely to be involved in extracurricular activities and to use campus facilities. Chickering (1974) went on to say that commuter students showed lower positive self-ratings at the end of the first year on academic self-confidence, public speaking ability, and leadership skills when compared with students living in residence halls.

Residence halls staff have the responsibilities to support the academic goals and mission of the institution through the services and programs they provide. Winston and Anchors (1993) suggested that residence halls should provide a living-learning environment, programs and services that enhance individual growth and development of students as whole persons.

Pascarella and Terenzini (2005) also concluded that students living on campus are more likely to persist and graduate than students who commute. Their research showed the relationship remained positive and statistically significant even when a wide array of precollege characteristics were taken into account, including precollege academic performance, socioeconomic status, educational aspirations, age, and employment status.

The issue of student retention and the focus on the first-year experience has continued to grow in importance throughout the history of higher education. Over the last twenty years, few issues across American colleges and universities have garnered as much attention by administrators as student retention (Barefoot, 2004). Making this issue even more obvious is the fact that major publications that rank colleges and universities have added retention and graduation rates to their published statistics.

Previously considered a badge of honor for institutional status on selectivity, the inclusion of these figures with respect to institutional quality has reversed this notion (Barefoot, 2004). The first-year experience can be greatly enhanced by residence hall living. The involvement of students in social communities early in their academic careers increases their likelihood of retention through the incorporation of confidence building and social integration by the programs and services often provided by college and university residence hall staff (Hotchkiss, Moore, & Pitts, 2006).

College Orientation Course

The Boyer Commission Report (1998) stated that the first year of a university experience needs to provide new stimulation for intellectual growth and a firm grounding in inquiry-based learning and communication of information and ideas. This report went on to say that the focal point of the first year should be a small seminar taught by experienced faculty aimed at topics that will stimulate and open intellectual horizons and allow for opportunities to learn in a collaborative environment.

The subject university has employed a specific orientation course designed to teach students proper study habits, emphasize and encourage attendance in all courses, and to better prepare students emotionally and academically for the challenges of college. At this institution, some first-year students and most students struggling academically (at any point in their educational journey) are advised into this course as a normal course of action. It is a one-credit course and will fit into most students' schedules. The focus of the course is to assist in the development of practical knowledge and skills to apply to the challenges often faced by students unprepared for the rigors of college course work. The topics covered include, but are not limited to, written and oral communications, critical thinking, time management, study techniques, campus and community resources, personal and relationship management, and general test taking. For the purposes of this research, this course will be referred to as the College Orientation Course.

Chapter Summary

The body of literature surrounding the topic of student persistence and retention is extensive. College student departure poses a long-standing problem to colleges and universities across the nation. These rates of departure negatively affect the stability of institutional enrollments, budgets, and the public perception of the quality of colleges and universities (Braxton, Hirschy, & McClendon, 2004). The research cited in this chapter outlines much of the significant work on student attrition, retention, institutional and social characteristics that effect student departure, the ability to influence STEM graduation, and the importance of living on campus during the pursuit of a degree. With all of this research, understanding and reducing college student departure remains a significant challenge for universities.

Despite the fact that the research on these topics extends for many decades, no clear-cut approach has been developed to manage the issue of college student departure, and likely never will. The imperative to stimulate interest in math and science in young people and ultimately produce more STEM educated graduates makes this a problem of national interest. This study is designed to examine one institution and subsequently assist many other STEM-based institutions in examining their own efforts with regard to student recruitment, academic programming, and retention efforts.

CHAPTER THREE

METHODOLOGY

In this mixed-methodological study, a Discriminate Function Analysis was used on the quantitative data to determine predictors of success in a STEM program at one university in the Western United States. The subjects of this research were the population of students who entered the institution in 2005 and 2006 and graduated by May, 2010.

Charts and graphs illustrate the results of the research, and commentators employ words such as variables, populations, and results as part of their daily vocabulary . . . we know this is part of the process of doing research. Research, then as it comes to be known publically, is a synonym for quantitative research. (Bogdan & Biklen, 1998, p. 4)

Quantitative research allows the researcher to become more familiar with the problem to be studied. In this paradigm there is an emphasis on facts and outcomes of behavior (Bogdan & Biklen, 1998) and the information is in the form of numbers that can be quantified and summarized. The quantitative researcher attempts to fragment and delimit phenomena into measurable or common categories that can be applied to all of the subjects of wider or similar situations (Winter, 2000).

In addition, a qualitative analysis was performed to determine the drop-out or stop-out rationale for students within this group. Telephone interviews were conducted with matriculated and non-matriculated students, and their comments and stories were hand scribed. All of the comments were coded, themes were later identified, and inferences were drawn from the data as sense was made from the overall data set. The paradigm is “a research method for subjective interpretation of the content of text data through a systematic classification process of coding and identifying themes or patterns” (Hsieh & Shannon, 2005, p. 1278). Patton (2002) indicated that qualitative research is “any qualitative data reduction and sense-making effort that takes a volume of qualitative material and attempts to identify core consistencies and meanings” (Patton, 2002, p. 453). Thus, qualitative analysis is not just a mere counting words or an extraction of objective content but allows the researcher to examine meanings, themes, and patterns that are manifest in the data. In this process the researcher is evincing social understanding in a subjective but logical manner. Qualitative analysis is mainly inductive, as it is grounding the examination in topics or themes and the inferences drawn from them, in the data (Bogdan & Biklen, 1998). The unit of analysis was the basic text that was codified during the content analysis. As Miles and Huberman (1994) indicated the initial list of general categories were generated from the responses and the categories were modified within the course of analysis as new categories emerged inductively. Categories in the analysis were defined in a way that they were internally as homogeneous as possible and externally as heterogeneous as possible (Lincoln & Guba, 1985). Tesch (1990) noted that qualitative research analysis allows you to assign a response (data) unit to more than one category simultaneously.

Post hoc interviews were performed from a snowball sample developed from interviews of the successful graduates. During these interviews, the matriculated students were asked about the influential people and other social factors that contributed to their success. In this dialogue, non-matriculated students were identified by members of their cohort. Permission was sought from these non-matriculated students to discuss their education experiences at the institution and to seek their perceptions in the identification of obstacles that prevented or deferred graduation.

The purpose of this study was to explore and understand the factors that may predict a student's likelihood to complete an undergraduate program in a STEM discipline at one university reliant upon that mission. As a result, this study will inform recruitment and retention efforts on the campus and others like it, so as to appropriately and efficiently guide staff activities to the highest and best use of their time and dollars. This study does not identify problems or errors in the university placement processes or issue an analysis of current recruitment and retention efforts. Instead, the intent of the research is future-focused on continuous improvement.

Research Design and Target Studies

This research effort is divided into two distinct components. The first is a quantitative analysis of the 2010 graduates using a discriminate analysis of the entrance data associated with each student. The dependent, dichotomous variable in this analysis will be the matriculation or non-matriculation of each student. The potential predictor variables (the independent variables) that will be analyzed are:

- Gender
- Size of high school using the number of students reported by the State Department of Education
- Residency Status
- High school grade point average
- High school class rank determined as a ratio of student's rank to total number of students in high school class

- Entering ACT math score
- Entering SAT math score
- Completion of the College Orientation Course
- Federal Financial Aid received in the form of Pell Grant or subsidized student loan
- Living in a Residence Hall

The second component of this research is a qualitative analysis of data offered by matriculated and non-matriculated students. The matriculated students were asked to identify influential people and important social factors that contributed to their success. In the interview process of matriculated students, they were also asked to identify members of their cohort that they knew did not complete a STEM program. The non-matriculated students were asked to identify reasons why they did not succeed in STEM programs at the institution. Those who entered a STEM program but failed to graduate were identified from a snowball sample taken from interviews of the matriculated students. It is from this snowball sample that the questions of barriers and stop-out rationale were explored.

Methods of Data Collection and Analysis

The data for this study was extracted from the institution's student database management system. This system contains all of the data associated with students' demographic information as well as their entire academic record of performance. A query of the database mined the data necessary to complete this study. The data was readily available and easily queried for this study.

Once extracted, the data were divided into the following four categories for analysis:

- STEM graduate – student is a graduate from the university in a STEM program as of the spring of 2010.
- Bachelor degree earned at another institution in a STEM program – The student did graduate from another institution with a Bachelor's degree. This category of data is determined to be a successful student (graduate) for the purpose of this study.
- Continuous enrollment at this institution or another institution in the state, as identified by the institution's database or by the National Student Clearinghouse.
- Stop-out or drop-out of STEM program – every student who identified STEM as their first major but did not graduate by the spring of 2010, did not graduate with a Bachelor's degree somewhere else, or who was not continuously enrolled in a STEM program at this institution.

The National Student Clearinghouse was used to identify the students who have left the subject institution following their enrollment in 2005 or 2006. Despite the fact that participation in the clearinghouse is voluntary, nearly all college students in America are tracked within the National Student Clearinghouse. The data in the clearinghouse lists students who started at the subject institution and later entered another institution. These data will also demonstrate whether transfer students did or did not successfully complete a STEM program.

The contact information that was required for the qualitative portion of this study was gathered from the institution's alumni database. These data were available and easily queried. If the data were not contained within the database, other publicly-held information was sought. This included, but was not be limited to, Facebook, internet searches, other student references, and Alumni Finder software.

All of the data used in this study were carefully protected for confidentiality by the researcher. Names were never used, only the database code. This code identifier was used to link all student information. During the qualitative portion of the study, only a sequential number was used to track the respondents and their respective comments. Names were never recorded in the compilation of the data.

An examination of the data demonstrated in Figure 1 shows that 266 students entered the subject institution in 2005 and Figure 2 shows 320 students began their educational journey in 2006. A look at the data set through Figure 1 and Figure 2 reveals specific data for each category of the 2005 and 2006 cohorts respectively. As depicted in Figure 1 and 2, 75% of the 2005 cohort and 67% of the 2006 cohort entered the subject institution intending to major in a STEM discipline.

Figure 1

2005 Cohort:

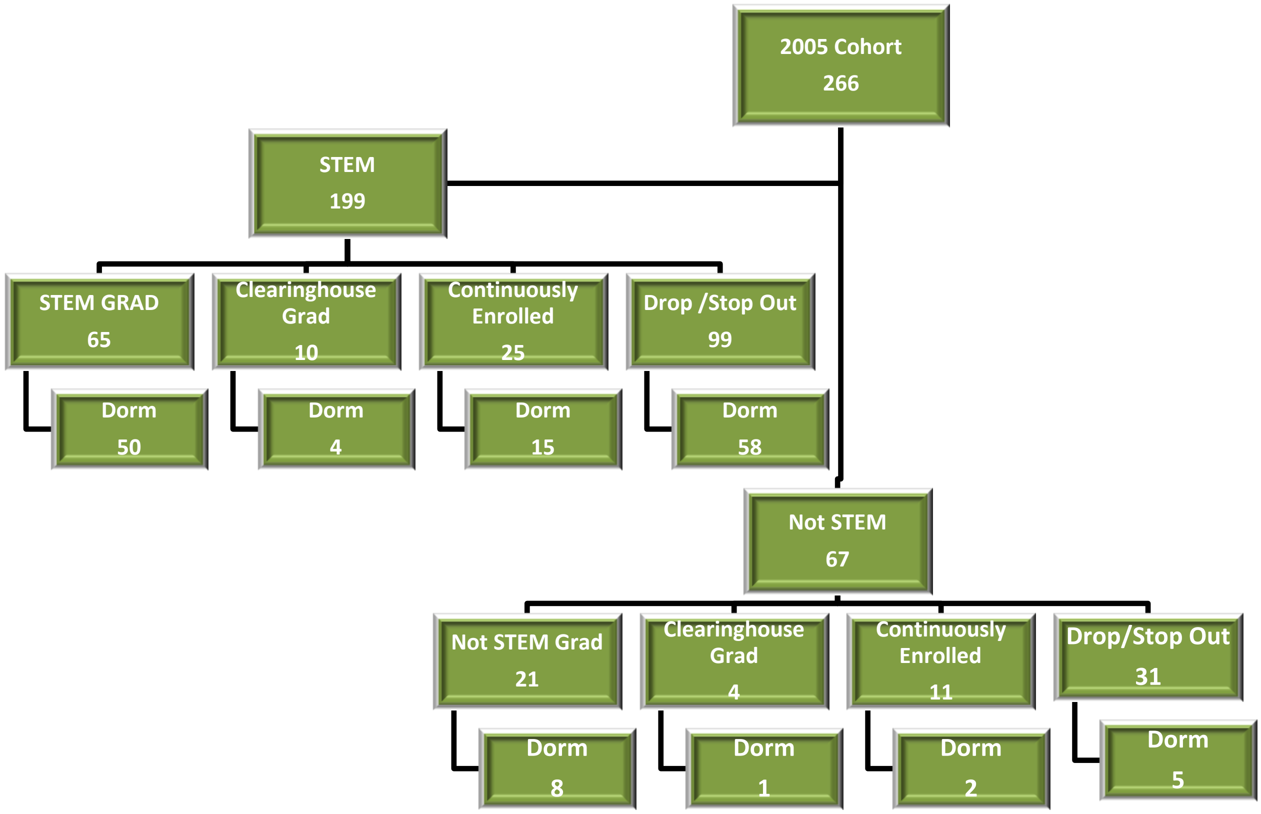
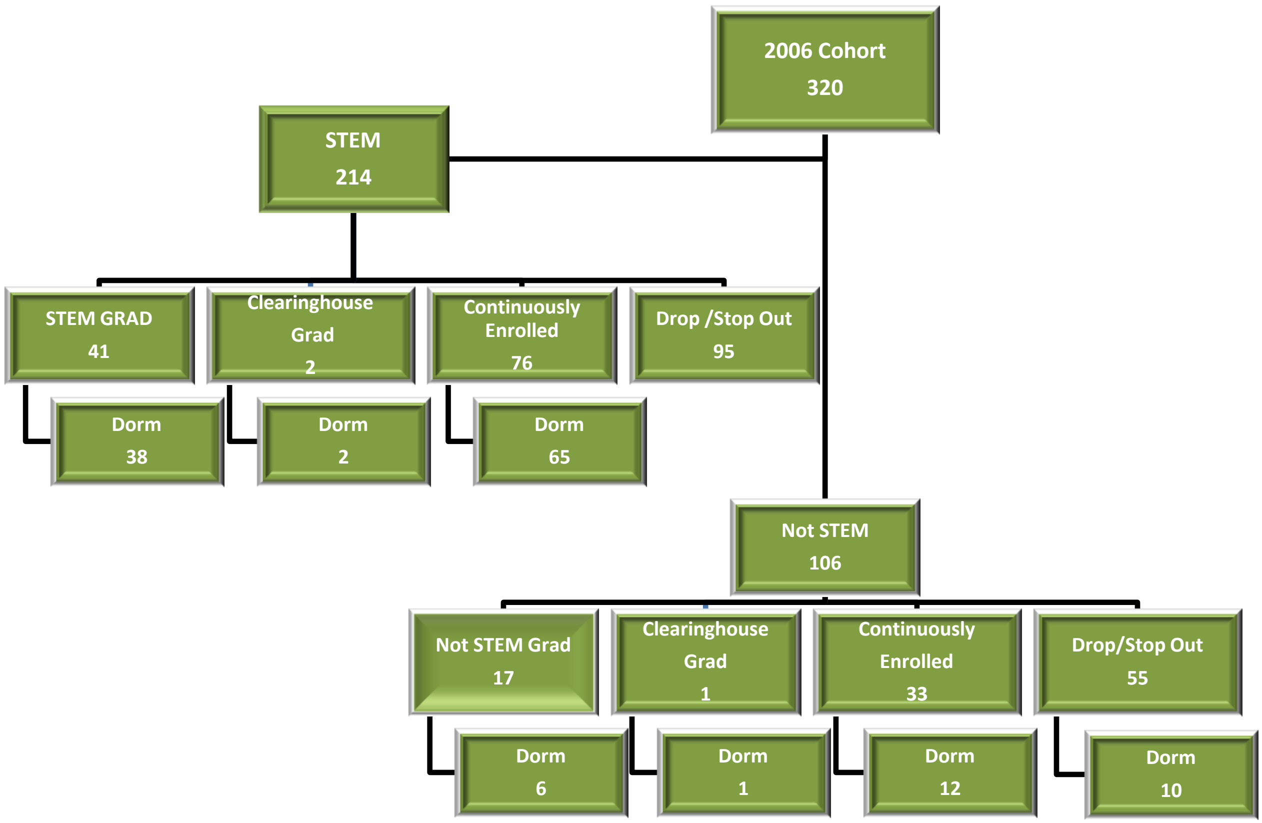


Figure *2*

2006 Cohort:



Interview Protocols

During the qualitative portion of this research, a volunteer group of purposefully-selected respondents was interviewed. Two interview protocols were designed for use in this study. The first interview protocol (Appendix A) was conducted with successful graduates to identify specific social and institutional factors that aided their success. Included in this protocol were questions designed to identify students whom they believed had the abilities to succeed but did not graduate for some reason. This snowball sample was the basis for the second protocol.

The second interview protocol (Appendix B) was designed to understand the social, institutional, and environmental factors that influenced the stop-out or drop-out of students identified by the students interviewed with the first protocol. It is from this qualitative analysis that issues with the greatest impact on their departure from the institution were identified and analyzed.

Chapter Summary

This chapter outlined the methodological design of this study. Using a mixed-methodology, this study was designed to examine data and demographic information using a regression analysis. This discriminative analysis further examined all entering characteristics of STEM-minded students and determined which of these best predicted success in their respective disciplines. In this data analysis, careful consideration was given to the data point identifying the student as having lived on-campus during their tenure at the institution.

The qualitative portion of this study examined the success factors for those who graduated and then attempted to determine what social and institutional characteristics most greatly impacted their successful campus experience. At the same time, this portion of the study was also used to examine the factors that caused the stop-out or drop-out from college for students within this group. It was expected—and indeed proved true—that many factors contributed to the drop-out or stop-out of students.

CHAPTER FOUR

FINDINGS

This mixed-methodological research had two distinct components. The first was a quantitative analysis of entrance data of first-year students intending to complete a STEM degree at a university in the Western United States, with STEM as a primary aspect of its mission. The statistical model determined what factors significantly influenced the success of full-time incoming students who declared a major in STEM programs. The second component of this research was a qualitative analysis of interviews of both students who completed their STEM education and those students who stopped out or dropped out of their STEM education for some reason. This component of the research was conducted via teleconferences with individual graduates of the class of 2010, asking them to respond to a series of questions regarding their educational journeys. This chapter will define the results of the statistical treatment of the quantitative data and report on the outcomes of the conversations with successful graduates as well as with students who had begun but did not finish their STEM education.

Unit of Study

The subject institution is a small, regionally accredited, four-year or above, public institution that is primarily nonresidential with some graduate coexistence. This college is located in the Western United States with a mission and long-standing reputation of STEM education. The enrollment is roughly 2,200 students with a predominantly undergraduate instructional focus. The basic Carnegie Classification for this university is baccalaureate with diverse fields.

Quantitative Analysis

A logistic regression was used to model the probability that full-time, first-year students who declared a STEM major will successfully obtain a four-year degree in a STEM program at the university serving as the unit for this study. Hosmer and Lemeshow (1989) offer an excellent reference for the technical aspects of logistic regression.

A total of 10 potential predictor variables were included in the regression model. That is, these variables were examined to determine how much influence they have when predicting the probability a first-time student will successfully complete a STEM program.

- Whether the student was classified as in-state or out-of-state.
- The student’s high school GPA.
- The student’s high school percentile rank.
- The total size of the student’s high school.
- The student’s Math ACT score. The student’s SAT-math score found in the data set was converted to an equivalent ACT score using the methodology outlined by Dorans (1999).
- The student’s gender.
- The student’s race.
- Whether the student obtained a Pell grant or subsidized student loan.
- Whether the student lived in a residence hall.
- Whether the student completed the institution’s College Orientation Course.

Tables 1 and 2 presented below offer the summary statistics for the quantitative predictors and the categorical predictors used in this statistical analysis. In Table 1, “N” represents the number of data points obtained from the unit of study, mean represents the mathematical average of the data points, and the final two columns report the minimum and maximum value within the data set. Table 2 outlines the variable and the frequency and percentage of each within the data set used for this analysis.

Table 1

Summary Statistics for the Quantitative Predictors:

Variable	N	Mean	Min	Max
Total HS Size	282	899.21	12	2,537
HS GPA	288	3.43	1.92	4.26
HS Percentile Rank	277	69.53	4	100
ACT Math	278	24.05	14	35

Table 2

Summary Statistics for the Categorical Predictors:

Variable	Frequency/%	
Residence Hall	Yes:	211/67.63%
	No:	101/32.37%
Gender	Female:	75/25.32%
	Male:	233/74.68%
Race	Asian:	2/0.64%
	Hispanic:	3/0.96%
	Indian:	1/0.32%
	Missing:	46/14.74%
	Other:	6/1.92%
	White:	254/81.41%
Financial Aid	No:	188/60.26%
	Yes:	124/39.74%
College Orientation	No:	200/64.10%
	Yes:	112/35.90%

Table 3 provides the correlation coefficient for the quantitative variables. An asterisk (*) following the correlation coefficient indicates a significant correlation.

Table 3

Correlation Coefficients for Quantitative Analysis:

	Total HS Size	HS GPA	Percentile Ranking	ACT Math
Total HS Size	1	-0.08	0.08	0.07
HS GPA	-0.08	1	0.88*	0.43*
% Ranking	0.08	0.88*	1	0.41*
ACT Math	0.07	0.43*	0.41*	1

The full model was initially used with the following parameter estimates and corresponding p-values being obtained as shown in Table 4.

Table 4

Parameters, Estimates, and p-values:

Variable	Estimate	*p*-value
HS Size	0.000979	0.0004
HS GPA	2.6466	0.0040
HS percentile	-0.00833	0.6235
ACT Math	0.0846	0.0572
Residence Hall	0.6339	0.0024
Gender	0.2831	0.1342
Ethnicity	-0.8319	0.9267
College Orientation	0.6399	0.0019
Financial Aid	0.1203	0.4806
Residency	-0.2879	0.2045

The logistic procedure with a backward elimination technique was used to identify significant predictors on a data set of size $N = 258$ with 105 successes and 153 STEM failures. Table 5 shows the predictor variables included in the final model (using a 0.10 significance level) and the associated parameter estimates as follows.

Table 5

Significant Predictors Variables:

Variable	Estimate	*p*-value
Intercept	-12.12	<0.0001
HS Size	0.001	0.0002
HS GPA	2.45	<0.0001
ACT Math	0.07	0.0944
Residence Hall	0.53	0.0055
College Orientation	0.66	0.0008

Appendix C demonstrates an example of how to use these predictors when estimating the probability that an incoming first-year student will be successful in a STEM major.

Table 6 depicts the corresponding odds ratio estimates at a 90% confidence level.

Table 6

Odds Ratio at 90% Confidence Level:

Predictor	Estimate	90% Confidence Limits	
		Lower	Upper
HS Size	1.001	1.001	1.001
HS GPA	11.594	4.835	27.799
ACT Math	1.072	1.001	1.147
Residence Hall: yes vs. no	2.895	1.541	5.437
College Orientation: no vs. yes	3.766	1.966	7.214

An interpretation of the significant odds ratio estimates presented in Table 6 follows:

1. At the 90% confidence limits, if 1.0 is contained in the interval, then the ratio is not significant.
2. If 1.0 is not in the interval, then the odds ratio indicates how much greater the likelihood of success is for students within respective groups.

Outcomes at the 90% confidence levels:

- High School (HS) Size predictor: The estimated odds ratio is very close to 1. Thus, when all other variables are identical for two incoming freshmen, they have essentially equal likelihood of being successful in a STEM major regardless of the HS size. This is assuming all of the other variables are identical.

- GPA predictor: An incoming first-year student with a 3.0 HS GPA who declares a STEM major is approximately 11.59 times as likely to be successful as a 2.0 HS GPA incoming first-year student who declares a STEM major, all other variables being equal.
- ACT Math predictor: An incoming first-year student with a 28 ACT math score who declares a STEM major is approximately 1.07 times as likely to be successful as a 27 ACT math score incoming first-year student who declares a STEM major, all other variables being equal.
- Residence Hall predictor: An incoming first-year student who declares a STEM major and lives in a residence hall is approximately 2.9 times as likely to be successful as an incoming first-year student who declares a STEM major and does not live in a residence hall, all other variables being equal.
- College Orientation Course predictor: An incoming first-year student who declares a STEM major and does not take the College Orientation Course is approximately 3.77 times as likely to be successful as an incoming first-year student who declares a STEM major and does take the College Orientation Course, all other variables being equal.

Note the parameter estimate associated with high school size is significant, yet small. That is, high school size does not appear to be an important variable when predicting STEM success. Also, the parameter estimate associated with ACT Math is only slightly significant. Removing these two predictors produces the following results, based on data set of size $N = 288$ with 109 successes and 179 STEM failures results in the parameter estimates outlined in Table 7.

Table 7

Parameter Estimates:

Variable	Estimate	*p*-value
Intercept	-9.24	<0.0001
HS GPA	2.34	<0.0001
Dorm	0.39	0.0169
College Orientation	0.78	<0.0001

Table 8 outlines the outcomes at the 95% confidence level for each of the three remaining predictor variables. The following describes the importance of these statistical outputs:

- HS GPA predictor: An incoming first-year student with a 3.0 HS GPA who declares a STEM major is approximately 10.34 times as likely to be successful as a 2.0 HS GPA incoming first-year student who declares a STEM major, all other variables being equal.
- Residence Hall predictor: An incoming first-year student who declares a STEM major and lives in a residence hall is approximately 2.2 times as likely to be successful as an incoming first-year student who declares a STEM major and does not live in a residence hall, all other variables being equal.
- College Orientation Course predictor: An incoming first-year student who declares a STEM major and does not take the College Orientation Course is approximately 4.78 times as likely to be successful as an incoming first-year

student who declares a STEM major and does take the College Orientation Course, all other variables being equal.

Table 8

Odds Ratio at 95% Confidence Level:

Predictor	Estimate	95% Confidence Limits	
		Lower	Upper
HS GPA	10.341	4.433	24.122
Residence Hall: yes vs. no	2.197	1.152	4.191
College Orientation: no vs. yes	4.779	2.294	9.957

A reasonable logistic discrimination rule for classifying the risk of an incoming first-year student being successful in STEM major would be to say the risk is "good" when the estimated probability of obtaining a degree exceeds 0.5; otherwise the risk is "bad". When applying this rule to the 288 students in the data set used to determine the reduced model containing three predictors, this model would correctly classify 67.89% of the "good" students and 78.21% of the "bad" students. Thus, the model appears to work reasonably well in predicting incoming first-year students as likely to succeed or fail in STEM majors.

Qualitative Data Survey Analyses

The qualitative analyses were broken down into two distinct segments. The first was a conversation with students (n=31) who matriculated in a STEM program and completed their degree program. The second series of conversations was conducted with a smaller group of students (n=10) who did not finish a STEM degree, and stopped out or dropped out of their education at some point during the journey. The results of both sets of these conversations are outlined as follows.

Matriculated Students

Approximately 157 phone calls were made to complete 31 conversations with students that graduated in 2010 and completed a STEM education at the subject institution. The purpose of these discussions was to better understand what these students considered to be key factors in their successful completion of a STEM education.

Of these 31 successful students, eleven completed a degree in general engineering, seven finished with a petroleum engineering degree, six with a metallurgical engineering degree, five completed environmental engineering, one in geological engineering, and one in geophysical engineering.

It was also noted that 22 of these 31 respondents lived in the residence hall during some of their time on campus. The average stay in the hall was 2.6 semesters. Nine of the respondents reported not having lived in the residence hall. The primary reason for not living in the dorm was the fact that they lived with a relative or parent residing within 30 miles of the campus.

The amount of time these students worked while taking classes was also explored. Only six of the 31 respondents indicated that they did not work at all during the school year. On average, the remaining 25 students reported having worked an average of 15.4 hours per week during the fall and spring academic semesters. Every student reported having worked in the summer, with most offering summer internships as a significant economic factor in their eventual success. Of the six reported non-working students, four were petroleum engineering students and the other two were general engineering students.

These graduates were also asked about their preparation for college while still in high school. Each respondent was asked whether or not they participated in a Jump-start course or completed an advanced-placement (AP) course while in high school. For further clarification, each graduate was asked to define the courses to determine whether or not these courses were math or science based. Of the 31 successful graduates, 19 completed a Jump-start or AP course before entering college. However, only 12 of these 19 individuals concentrated these courses in math or science.

These successful graduates were asked to identify specific individuals that were influential in their success. In the initial list of general categories initial comments (top-of-mind comments) were placed into the categories outlined within Table 9 and the corresponding percentage of students listing these groups of people is noted. For example, 93.5% of the students mentioned a faculty member as a person of influence during their studies. At the same time, only 16.1% of the respondents cited a staff member or an administrator.

Table 9

Influential Individuals for STEM Graduates:

Faculty:	93.5%
Parents/Family:	45.2%
Other Students:	38.7%
Administration:	16.1%
Staff:	16.1%

Social factors, a category strongly represented in the literature, were also explored with these graduates to determine what important success factors may have been driven by things or events outside the classroom. An open-ended question was posed to each graduate asking them to identify social factors that influenced their success. More than 50% of the students mentioned their involvement in outside student clubs and organizations as key elements in their success in college. More than 70% of the students cited interaction with their faculty outside of the classroom as a huge advantage offered to students of this university. This interaction was as simple as a conversation in the faculty member's office or as complicated as social interaction (formal and informal) with the faculty off campus.

In addition to the open-ended question regarding social factors, these graduates were asked to rank the following items on a scale of 1 to 5, with 5 being the most impactful on their success and 1 being the least impactful. The resulting average score for each factor is reported within Figure 3.

Figure 3

Important Social Factors for STEM Graduates:

Social Factor	Average Score
Family	4.65
Senior Design Project	4.06
Career Services Office	3.73
Library	3.23
Learning Center	2.71
Local Party Scene	2.42
Residence Hall	2.35
Athletics	1.95
College Orientation Course	1.26

The final point discussed with this group of graduates was another open-ended question intended to gather any other important point(s) not already addressed in the conversation. More than 70% of the respondents reinforced that the open-door policy of faculty, the hands-on education offered, and the small class sizes were critical elements in their success. Nearly 55% of the respondents cited their summer internships as an important success factor. These internships are facilitated by the staff of the college, and students found the opportunity to secure these internships rather straight forward. Many companies come to the campus each year looking for interns, and students make it clear they are interested by submitting a resume and cover letter. Many of these graduates used the money earned during the summer to assist in the financing of their education.

Non-matriculated Students

Approximately 81 calls were conducted to successfully complete ten calls with students who started with the intention of earning a STEM degree, but for some reason failed to complete. This snowball sample was derived from the 31 respondents (Matriculated Students) reported above. The successful graduates were asked if they could identify a student(s) within their cohort that appeared to have the skills and abilities to complete a STEM major, but for some reason stopped out or dropped out of the program. This group was difficult to identify and once identified, extremely challenging to find and to seek agreement for participation.

The degree programs sought by the non-matriculated respondents were: general engineering (8), software engineering (1), and petroleum engineering (1). Of these ten individuals, 20% (2) have completed an associate’s degree in either metals fabrication or civil engineering technology. One finished a bachelor's degree in a non-STEM field, elementary education.

This group was also asked to identify the amount of outside work they were doing during the fall and spring academic semesters. Ninety percent of this group admitted to being employed during the academic semester. The average amount of time reported on the job was 25 hours per week. This group of respondents did not cite summer internships as significant employment opportunities. In order to earn an internship, most companies assign a minimum GPA as threshold criteria. Admittedly, most of these students struggled with grades.

The use of residence halls was also discussed with this group. Sixty percent of the respondents did not live in the residence hall during their time on campus. The reasons cited by these six people were either they were non-traditional students or their primary residence was close to the campus.

The final question presented to this group was an open-ended question offering the respondent the opportunity to further explain their departure from a STEM major. Each was asked to identify and prioritize the primary reasons for stopping out or dropping out of their chosen STEM major. Figure 4 identifies the list of general categories generated from the responses (Miles & Huberman, 1994). The theme of the responses and the number of times that reason was prioritized in a students' top three responses are presented in Figure 4. Financial pressures were listed most often, while personal health was mentioned only once.

Figure 4

Stop-out or Drop Out Rationale:

Departure Themes	#
Financial Pressures	7
Math & Science Challenges	6
Partying, Drinking, & Poor Choices	5
Institutional Processes & Decisions	5
Personal Reasons	4
Loss of Interest in Engineering	3
Job Market for BISI Students was Poor	1
Family Crisis	1
Military Deployment	1
Personal Health	1

This question allowed for greater analysis of the stop-out or drop-out rationale of these students as presented in Figure 4. After coding and drilling down on the students' responses, it is clear that financial considerations have a great deal to do with success in college. Seven of the ten students cited financial issues as one of the primary reason for their departure. The students' voices are clear in the following comments:

> Fred [respondent 21 pseudonym] stated, "The financial pressure was too much. I funded my education entirely on my own, and I just could not continue to balance the need to work with the need to study."

> Helga noted, "I lost my scholarship due to the fact that my grades fell below the required threshold. This made it impossible for me to afford college."

> Matthew said, "I needed to work full-time in order to make ends meet. This did not allow for the time I needed to study. I made the choice to pay some bills, save some money, and someday return to school better prepared financially."

> Bob added, “The financial aid process is burdensome and complex. My life is complicated and the process to obtain financial aid did not conform well to my specific circumstances. This was definitely an impediment to my continuing school.”

This researcher also found that many students came into a STEM major believing they were prepared for the rigors of these curricula. After a period of time, it was evident to the student that these courses were more challenging and demanding than they expected. Thus, the subject matter itself is a primary reason for departure. From the findings of this research it clear that the math sequence and parallel science requirements within technical degree programs is interdependent, challenging, and often more than some students can handle.

> Joyce proclaimed, “Calculus III and Statics were very challenging. I could not get through this combination of courses, so I realized that I needed to change my plans.” Joyce went on to say, “Some Chemistry teachers are far better than others. The one that flashes PowerPoint slides the entire class did not serve me well. I much preferred the faculty member that used examples and worked out problems on the board for the entire class to see and question.”
>
> Ingrid added, “I struggled with math. This caused me to fall behind in the science sequence and soon I was spiraling out of control. This death spiral caused me to look around and find an associate’s degree that was a better option for me. I intend to return and finish what I started.”
>
> Larry contributed, “Student placement in the appropriate math and science sequence is critical. I took pre-calculus in high school, but I was not ready for

> calculus at [the subject university]. The advising I received throughout my time was nothing more than a scheduling mechanism. No one ever asked me how I felt about my readiness for any course."
>
> Linda spoke to the quality of faculty by saying, "Statics was very discouraging. This faculty member is long past his prime and should be asked to leave. He is not doing this school any favors."

In further analysis of the themes that emerged, it is also apparent to this researcher that the students' individual choices have a significant impact on their educational journey. Students that make the choice to party too often, skip classes, and underperform are not going to find an easy path to a degree in a STEM field.

> "I drank too much and did not focus on my coursework. I missed far too many classes to ever be successful. I have only 36 credits left and I intend to finish", reported Fred.
>
> Ken said, "I did not go to class enough. Engineering is brutal and you cannot succeed if you do not make it to class."

The institutional processes, policies, and practices have a significant impact on the students. Students cited examples of ways in which they felt the institution influenced their stop-out decision.

> "The Petroleum Department did me a favor. The field camp at the beginning of my sophomore year clearly demonstrated to me that I needed to work with something more exciting than a hole in the ground", stated Joyce. This student went on to say that, "The reporting of mid-term grades should be required for all

students, not just freshman. I need to know how I am doing and I am motivated by feedback. Too often, I did not know how I was doing."

Helga claimed, "I had a significant health crisis during one academic semester and needed surgery immediately. The college should be more lenient when it comes to medical withdrawals."

Matthew again offered, "The learning center is a good thing, but the school needs to recognize that one tutor cannot help 15 or more students at the same time. They need to staff this place differently and not rely on a small number of tutors for calculus and physics."

Larry went on to say, "My interest in engineering waned as I started with the general courses. I could not see a practical or applied reason for what I was doing with the math and science, so I lost interest. The school should apply engineering earlier."

Chapter Summary

The purpose of this chapter was to present the findings of the qualitative and quantitative analysis of students who pursued a STEM degree at the subject institution during the years 2005 through 2010. This chapter described the statistical treatments to the entrance data associated with first-year students entering declaring a STEM major. This chapter also presented the outcome of more than 40 conversations with students designed to understand success factors for those that graduated and the hurdles discovered by those who did not finish.

The results reveal that only three quantitative predictors can be used at the 95% confidence level to predict success. This research finds that high school GPA, the use of a residence hall, and not being advised into the at-risk group of students enrolled in the university-designed College Orientation Course are the three most important predictive variables when seeking success in a STEM program. Students with a higher high school GPA are 10 times more likely to succeed than those with a lower entering GPA, with all other variables held equal. If a student lives on campus in a residence hall, that student is more than two times more likely to succeed than those that do not live on campus. The final predictor variable is NOT being placed in the College Orientation Course will result in success nearly five times greater than those advised into this course.

On the qualitative side of this study, successful students supported the quantitative findings that living in on campus contributed to their success. They continued that thought with consistent comments regarding on-campus involvement in clubs and industry-related organizations as key elements of success. Social factors were also explored with the successful graduates. During these discussions, it was learned that working during the academic year, entering college with credits already earned, family support, and group project later in their education process proved critical to being a successful graduate.

On the other side of the coin, discussions were also held with students who intended to graduate from a STEM program, but did not succeed. These non-matriculated students cited financial pressures, math and science deficiencies, too much social interaction and poor choices, and institutional issues as the primary reasons for their departure from a STEM discipline.

CHAPTER FIVE

CONCLUSION

This chapter presents a detailed discussion of the results of this study, outlines implications and recommendations on the recruiting and retention practices of schools similar to the institution studied, and provides suggestions for future research that could potentially expand the body of knowledge surrounding STEM education in America.

The purpose of this study was to explore and understand the factors that predict a student's likelihood to complete an undergraduate program in a STEM discipline at one campus that is reliant upon that mission. This research investigated and summarized the relationship between academic and social characteristics of the students as it predicted success factors in a STEM discipline. Examining three research questions, the study employed a quantitative and qualitative approach to (a) identify key indicators of success for entering in a STEM discipline, (b) determine that living on campus in the residence hall for some part of their journey had a significant impact on the eventual outcome of students, and (c) identify quantifiable stop-out or drop-out rationale for students who were not able to complete the desired STEM program. This chapter presents a detailed discussion of the results of this study, its implications, and recommendations for future research that may be employed to expand on the topics introduced here.

The Quantitative Findings and Interpretations

Research question one asked, "What are the indicators of success for a student entering a STEM program at the subject institution?" This question sought to identify the statistically significant characteristics that a student brings with them prior to entering a STEM major. A logical regression model was applied to the data extracted from the Banner Student system. At the 95% confidence level, three indicators surfaced as significant. A student's entering high school GPA has a very meaningful correlation to eventual graduation. An incoming first-year student with a 3.0 high school GPA who declares a STEM major is approximately 10.3 times more likely to be successful than a student entering with a 2.0 grade point average.

This researcher found that students will have equal likelihood of being successful in a STEM major regardless of the size of their high school. The ACT (SAT) predictor was very marginal. At the 90% confidence level, the ACT (SAT) variable produced only a slight predictive value, at an interval of 1.072. This means that an incoming freshman with a 28-ACT math score is approximately 1.07 times more likely to be successful as a student with a 27-ACT math score, with all other variables held equal. The ACT (SAT) variable was not significant at the 95% confidence interval.

The second predictor of success that fell within the 95% confidence level was a student's registration in the College Orientation Course.   This predictor indicated that a student is nearly five times more likely to graduate if they DO NOT take the College Orientation Course. This result was expected due to the fact that this course contains an at-risk population by design. The College Orientation Course was developed by the administration as a course intended to lift up students that appear to be struggling with grades, time management issues, poor study skills, or other academic or social challenges. Clearly, this course collects those students that are struggling, and if a student does find themselves in this course, they are less likely to graduate than if they would not have been advised into this course.

The third predictor was the fact that the student lived in the residence hall. This portion of the analysis also addresses the second research question of this study, “Was living on campus in a residence hall the first year significantly related to the success rate of graduates in this cohort?” Looking at the results of the logical regression, and applying odds ratios to the data at the 95% confidence level, living in the residence hall does have significant predictive value. In fact, an incoming freshman who declares a STEM major and lives in the residence hall is 2.2 times more likely to be successful as an incoming first-year student who declares a STEM major and does not live in a residence hall, all other variables held equal.

The third research question was designed to elicit stop-out or drop-out rationale for students who did not finish their STEM-declared major or dropped out of college entirely. Ten students that had declared a STEM major were identified by a snowball sample of successful students and queried as to their educational journey. The intent of these interviews was to identify the primary reasons for leaving a STEM discipline or exiting college entirely. Successful graduates were also interviewed in the qualitative portion of this study to determine factors that influenced their success.

The Qualitative Findings and Interpretations

More than 40 interviews were performed in order to identify success factors and unveil potential reasons for not completing a STEM education. The students who earned a STEM degree offered many insightful factors that they determined to be influential in their success.

The first important finding within this portion of the study was the fact that 71% of the students who were successful in their pursuit of a STEM education spent time living in one of the residence halls. In fact, the average length of stay was greater than the required one year that a student must live on campus if they are from a community more than 30 miles away from campus. The average length of stay was slightly more than 2.6 semesters. This finding is consistent with the quantitative data that says living on campus predicts success. On the opposite end of this spectrum is the outcome of the discussions with the students who failed to complete a STEM degree. In this group, 60% of the respondents did not live in the residence hall. Again, this finding supports the predictive value of living in a campus residence hall.

It is a well-known fact that in today's environment most students must work in order to fund their living expenses and/or tuition while achieving a college degree. What was interesting and compelling about this research was that 80% of the successful students reported working an average of 15.4 hours per week while attending classes. In addition, all of the students reported the need to work during the summer, either on a paid internship or some other employment, as a financial necessity to fund college expenses. It is important to note that four petroleum engineering students (of the six total students who did not work during the school year) all offered that their summer internship was lucrative enough to pay tuition, fees, and expenses for the entire year and they did not need to work during the school year. In contrast, 90% of the students who did not complete their STEM education reported having a job during the school year. The significant difference in the two groups was that the stop-out group worked a reported average of 25 hours per week, nearly 10 hours a week more than the successful group. It was also interesting to note that none of the stop-out respondents spoke to lucrative summer internships. It can be surmised that these internship opportunities are available to the students that meet specific criteria, including a minimum GPA threshold. Most of the stop-out students admitted to struggling with their coursework and falling behind their cohort. Thus, they were probably not prime candidates for these summer employment options.

In all of the interviews, the respondents were asked about their participation in Jump-start courses or advanced placement (AP) classes while in high school. Of the successful graduates, 61% of this group completed some Jump-start or AP offerings. However, only 39% achieved college credit in math or science before entering the subject institution. These data are in stark contrast to the results obtained from the stop-out group. Within this group, only 20% took advantage of the college credits while in high school. In this group, only 10% achieved credit in math or science before entering college.

During the interviews with the graduates, it was very apparent that a relationship with at least one faculty member was critical to success. Top-of-mind comments were recorded when respondents were asked about specific people whom they believed to have been influential in their success. Approximately 93% specifically named a faculty member and conveyed a story of that individual's impact on their life or their career. Nearly half of the graduates acknowledged support from their family was a necessity in completing their program. As an extension of the support group, nearly 40% mentioned the name of a fellow student or students that impacted their success. Study groups and homework partners were mentioned numerous times as mechanisms to get through the difficult days of an engineering student.

Expanding on the social factors broached above, the successful students reported the most important social factor influencing their success was a supportive family. This support did not always mean financial. In fact, most of the respondents stating family support was critical did so in the context of emotional and motivational support.

As articulated in the Boyer Commission Report (1998), the final semester(s) should focus on a major project and utilize to the fullest the research and communication skills learned in the previous semesters. The graduates from the subject institution supported this notion and cited during their interviews that the senior design project group was a very important social factor. Most students begin working on this project at the beginning of their senior year and spent their entire last year working with a group on a single, complex engineering project. Although this project has a significant educational component, it also carries a heavy social burden. The individuals working on this project will spend up to 40 hours per week working together outside of the classroom. It is critical that all of these project participants get along well, delegate work fairly, and follow through on commitments they have made. This real-life academic and social project prepares graduates very well for the working world they are about to enter.

On the career note, Career Services Office also ranked very high among the successful graduates. Most students begin an engineering discipline with the hopes of a lucrative career in industry. One of the gateways of this transaction is the Career Services Office. This service is vital to most students and the respondents’ relative ranking during the interviews solidifies the role of this office as a critical interface for employers to meet, process, and select personnel for their companies. Successful students recognize the value provided by this group of dedicated staff.

A little lower on the ranking, yet still significant, is the role of the library. This item received the most polarizing scores of any on the list. The successful students both recognized the importance of this service and took advantage of it, or they never used it and see it as “a waste of campus real estate” (Chuck). For those who used the library, it was noted that the majority liked the quiet place to study and the dedicated study rooms for group projects. In fact, a few graduates suggested expanding the study areas by eliminating some of the space dedicated to periodicals and hard-copy books. The perception was all of this is available electronically, and taking up space for these items is expensive and wasteful.

In the middle of the ranking was the Learning Center. Again, this service received much the same reaction as the library. Either students used it and were aided by the offering of tutoring or they never stepped foot into the facility. If the Learning Center was ranked highly by the respondent, it was usually acknowledged that the value was achieved early in their academic career. Most of the use of tutors was for calculus and physics during the first two years of the degree program. For the successful graduates, the remaining social factors of partying, residence hall, athletics, and the College Orientation Course ranked at the bottom of the list.

It is important to the findings to note that the three athletes that responded to the survey ranked Athletics at 3.5 (on a five-point Likert scale), which is only slightly higher than the entire group ranked the library. One athlete cited that despite the fact that her sports program paid for her education, she saw it as a necessary means to an end. In many ways her involvement in athletics detracted from her studies and made it difficult to achieve her professional goals. She knew that the end of her athletic career was near, and was often challenged by the pressure placed on her to travel, practice, compete, and still balance all of the demands placed on her by faculty (Debbie).

When winding down the discussion with the graduates, each was asked to comment on other success factors not already discussed. The resulting conversations produced three distinct themes. A majority of the respondents expressed great enthusiasm regarding the faculty and their willingness to assist students. The open-door policies of faculty are well regarded and considered a difference-maker to more than 70% of the graduates surveyed. The hands-on educational experiences and small class sizes aided the relationship building of students and faculty. Approximately 20% of the graduates noted that they now work with engineering graduates from other STEM-producing universities, and they cited many ways in which the students from the subject university stand out amongst the work group. Their practical education sets them apart in the workplace. Another important factor to the majority of the graduate group was the fact that summer internships were readily available. This opportunity was not just a financial benefit. These internships offered first-hand, real-life job opportunities to upcoming engineers that often shaped future employment strategies for these students.

Reasons for Stopping Out or Dropping Out

Analyzing the data provided by the stop-out group regarding their reasons for departure from a STEM major was a daunting task. At the core of each story was a unique and specific set of circumstances that led each student away from a science or engineering discipline. Close attention should be provided to the themes that presented within the data.

Financial pressures were the most often cited reason for leaving college. The cost of a college education has never been higher, and the reality of paying for this privilege often rests on the student. These pressures forced students to work more hours than they could afford to offload and ultimately limited their ability to study and keep up with the rigors of engineering. Compounding this phenomenon is the requirement to maintain a certain GPA to continue scholarship and athletic aid. When their grades fell below that threshold, scholarship aid was revoked; this further aggravated the financial pressure. The cost of college is a given number at the beginning of every semester. It should be very clear to a student pursuing a science or engineering degree that working more than 15 hours a week will increase the likelihood that they will not complete their education.

In addition to educating a student upfront regarding the cost of education, it is vital that every student be enrolled in the correct courses, commensurate with their current skills and abilities. Advising and placement are critical elements to success. Advising should not be relegated to a scheduling exercise. The relationship with an advisor is very important to the long-term success of any student. A conversation about progress and readiness is needed every semester and should be mandated by the administration in order to ensure the greatest likelihood of success for STEM majors.

The challenges faced by science and engineering students with calculus, physics, and chemistry are well documented. The stop-out group reinforced these challenges in their responses to the questions posed to them. Calculus remains a difficult math sequence, and many students remarked on the inconsistent methods used to teach and deliver the curricula. Many of the students noted taking the same course multiple times. The strategy to complete the course was to find the instructor that taught in a manner more conducive to their learning style. Unfortunately, on this small campus, it was impossible to avoid the only teacher that taught a specific course semester after semester. Calculus III and Chemistry were noted as examples of challenging courses or sequences that were never taught by different people, thus, the option to seek a different teaching style was not presented.

Another significant point raised by the stop-out group was the poor choices made by them in deciding to party too much and subsequently not attend classes on a regular basis. It was very clear to these respondents that going to class, actively participating in the discussion, and interacting with other students would have aided their pursuit of an engineering degree. Striking a balance between studying and playing is a necessity for all college students. This group of respondents recognized the errors of their ways and understands how this contributed to their poor performance.

The most remarkable item learned during the discussions with the stop-out group was the fact that the vast majority of them has already returned or intends to return to school. In fact, 40% cited an intention to return to a STEM major as soon as they can remove the financial or personal hurdles that have been placed in front of them. With this knowledge, it seems obvious that universities dedicated to the STEM mission should keep track of these “lost” potential scientists and engineers and continue a dialogue with them regarding their future intentions. The tax payers and the campuses have already invested substantial money, time, and human resources into these students, and returning them to campus would benefit all involved.

Recommendations

The recommendations section of this chapter is constructed into two sections. The first is aimed at national policy makers and education leaders at a more global level. The second is a series of recommendations for STEM colleges across the nation, especially administrators at the institution studied and with implications for all others that are similar.

Recommendations for National Policy Makers

There is a national crisis facing this nation that does not get enough time in the national debate. The competitiveness of our country on a global scale is deteriorating at an alarming rate. We as a country are not producing the required number of scientists and engineers to simply accommodate attrition, let alone grow our national presence. The resulting decline in technical expertise will place our country at a distinct disadvantage as we look to compete in a global economy. The President of the United States and the U.S. Congress must address this issue directly by creating specific programs for students that desire a STEM education. Expand the issuance of Pell Grants or create a STEM grant for qualifying students that encourage the pursuit of a technical degree. This encouragement must go beyond the bachelorette level, to the masters and doctoral levels as well. The creation of a nationally-funded STEM incentive could be a huge remedy to the problem faced today within the higher education community.

The national policy makers and political leaders could also work with STEM-producing institutions across the country to find philanthropic partners that will invest in endowments, or other permanent trusts, that will provide a consistent and predictable stream of dollars that could be used to purchase and maintain the expensive equipment and tools needed to deliver a STEM education, provide scholarships and fellowships to students, and supplement the salaries of outstanding faculty that earn less than their industry counterparts. This will only work if the national players have the courage to identify a specific number of STEM-based institutions and place a national priority on their success and graduate production.

Recommendations for STEM-based Colleges Across the Nation

Ensuring a pipeline full of prospective scientists and engineers is critical if we are going to increase the number of technical graduates in this nation. Thus, the STEM-based institutions nationwide must look to the K-12 system and nurture their future crop. Encouraging elementary, middle school, and high school students to pursue learning in science and math courses is the first step. These courses must be relevant, practical, and motivating. Although science and engineering will not excite all students, we must work together to make these technical fields more appealing to young people. Knowing that interaction with faculty is a key to success in STEM majors, college STEM professors should be encouraged to visit local school districts within their regions and share their expertise and enthusiasm for their disciplines. It is likely that many K-12 educators and students would embrace the opportunity to have a college professor teach a lesson and offer their insight into the discipline they represent. Taking it even further, Jump-start and AP courses should be the norm for high school students in America. These courses should focus on math and science and be the incentive for students to continue a STEM education when they reach a college campus. With credits already earned and confidence in their abilities, it is more likely that students will pursue and complete a technical degree offering.

STEM colleges should recognize that it is the students at or near the top of the high school GPA scale that will likely be successful in STEM-based disciplines. Armed with this knowledge and the goal of maximizing STEM enrollment, college recruiters should focus their efforts on making sure these highly-desirable students receive the best financial package available, have the full attention of the faculty within the desired area of study, and are given every opportunity to explore a science or math-based curricula. Too often, all students are treated equally, when in fact high school students with a clear science or engineering acumen and a high GPA should be placed on a priority recruiting track, offered the highest amount of scholarship dollars, and given more personal attention than others within the recruitment pipeline.

The senior design project was noted as a significant educational and social element of the successful graduates' journey. This project should remain a vital component of all engineering curricula and serve as a potential for cross-disciplinary groups to be formed to broaden the social impact of this academic assignment.

As the evidence presented within this research indicates, living on campus has a profound impact on the success of students within a STEM major. Campuses should heed this message and build adequate residence hall space for incoming freshman and upper classmen that need and want this living/learning community environment. The social and academic impacts are well worth the investment in bricks and mortar required to serve this need.

As Tinto (1998) asserted, involvement matters. The research outlined here supports this theory very well. Successful graduates cited as top-of-mind their connection to student clubs, outside organizations, and industry related events as critical elements to their eventual success. College campuses should encourage the presence of clubs and organizations that serve the respective industry, i.e., the Society of Mining Engineering, while promoting an academic mission at the same time. These organizations create excellent networking opportunities and provide invaluable access to industry professionals for career advice and guidance.

Every STEM-based institution should conduct exit interviews annually with students that depart the campus and seek to understand the circumstances that caused them to stop out or drop out. Often, these situations are personal and temporary. Many of these individuals desire the opportunity to return to finish what they started. If campuses were aware of the circumstances and able to mitigate some of the challenges, it is entirely possible that more STEM graduates would result from this effort.

Recommendations for Further Research

The national imperative that this research begins to touch upon is one reaching a critical point. Thus, the further research needed to better understand the future is boundless. The state should continue to examine carefully its production of scientists and engineers to determine if this state is fulfilling its potential. In cooperation with the State Department of Education, further research should be conducted regarding the tools and mechanisms that would stimulate interest among K-12 students in science, technology, engineering, and mathematics. This idea may be expanded to include a longitudinal K-16 study of curriculum alignment.

Further research is needed in the development of a nation-wide clearinghouse to track “lost” engineers and scientists. This research demonstrated that a considerable number of students that stopped their education have a strong desire to rekindle the flame. If even a fraction of these stopped-out students returned, our country’s production of technical graduates would increase significantly.

Further research into the best practices surrounding advising and placement of students into initial math and science sequences could prove invaluable for campuses that struggle with this task. Overburdened faculty asked to take on yet another duty like advising often find it challenging to serve students in the capacity necessary to ensure proper alignment of skills and abilities with course expectations. A best practices research study would allow campuses to accommodate the best models around the nation and have an immediate impact on their students.

Faculty makes a big difference in the life of a student, both positive and negative. Based on the comments of a few respondents in this study, every STEM program chair should take a hard look at the faculty who are teaching within their program and analyze carefully the quality of those professors. A research study looking across STEM universities to analyze students’ grades, student evaluations, and peer reviews would assist in developing criteria aimed at ensuring quality delivery of STEM material.

More time should be spent better understanding the effect of the residence halls on student success. A further examination of the residence hall population to determine the local versus non-local influence, the party scene, and other social issues could be beneficial to all universities.

Summary and Conclusions

This mixed methodological study explored the ability to predict successful graduates of a STEM program by modeling entrance and demographic data of incoming first-year students, examined the impact of living on campus in a residence hall, discovered significant success factors from conversations with successful STEM graduates, and learned about circumstances and issues that prevented graduating in an engineering or technical field.

This research demonstrated that the most significant predictive tool for determining a STEM graduate is a student's high school GPA. It has also been confirmed that living on campus in a college-provided residence hall has excellent predictive value when seeking to determine if a student is likely to graduate in a STEM discipline.

On the qualitative side of the research, this study demonstrated the countless lessons that can be learned from talking to graduates and those students that did not quite make it. It is suggested that repeating a process like this every year could develop a meaningful body of data that could be mined to gather invaluable insight into the development and nurturing of STEM students.

The findings suggest that the national policy leaders and state educational leaders take a much more active role in finding a solution to our shortage of science and engineering graduates. The recommendations invite policy makers to make significant investments in time and money to improve our current standing in the world. It is a matter of national security and it should be treated as such.

REFERENCES

Alon, S. (2005). Model mis-specification in assessing the impact of financial aid on academic outcomes. *Research in Higher Education, 46*(1), 109-125.

Alon, S., & Tienda, M. (2005). Assessing the "mismatch" hypothesis: Differences in college graduation rates by institutional selectivity. *Sociology of Education, 78*(4), 294-315.

Astin, A. W. (1975). *Preventing students from dropping out (1st ed.).* San Fransisco, CA: Jossey-Bass.

Astin, A. W. (1984). Student involvement: A development theory for higher education. *Journal of College Student Development, 25*, 297-308.

Astin, A. W. (1993). *What matters in college? : Four critical years revisited (1st ed.).* San Fransisco, CA: Jossey-Bass.

Astin, A. W. (1997). How "good" is your institution's retention rate? *Research in Higher Education*, *38*(6), 647-658.

Astin, A. W. (1999). Student involvement: A developmental theory for higher education. *Journal of College Student Development*, *40*(5), 518-529.

Astin, A. W., & Oseguera, L. (2004). The declining "equity" of American higher education. *Review of Higher Education*, *27*(3), 321-342.

Atkinson, R. D., & Mayo, M. (2010, November 30). *Intelligent Community Forum.* Retrieved January 20, 2011, from intelligentcommunity.org: http://www.intelligentcommunity.org

Bailey, T., Calcagno, J. C., Jenkins, D., Leinbach, T., & Kienzl, G. (2006). Is Student-right-to-know all you should know? An analysis of community college graduation rates. *Research in Higher Education, 47*(5), 491-519.

Ballou, R. A., Reavill, L. K., & Schultz, B. L. (1995). Assessing the the immediate and residual effects of the residence hall experience: Validating Pace's 1990 analysis of on-campus and off-campus students. *Journal of College and University Housing*, *25*, 16-21.

Bandura, A., & Schunk, D. H. (1981). Cultivating competence, self efficacy, and intrinsic interest through proximal self-motivation. *Journal of Personality and Social Psychology*, *41*(3), 586-598.

Bandura, A., Barbaranelli, C., Caprara, G. V., & Pastorelli, C. (1999). Self-efficacy pathways to childhood depression. *Journal of Personality and Social Psychology, 76*(2), 258-269.

Bandura, A., Barbaranelli, C., Caprara, G. V., & Pastorelli, C. (2001). Self-efficacy beliefs as shapers of children's aspirations and career trajectories. *Child Development, 72*(1), 187-206.

Barefoot, B. O. (2004). Higher education's revolving door: Confronting the problem of student drop out in US college and universities. *Open Learning, 19*, 9-19.

Bean, J. P. (1980). Dropouts and turnover: The synthesis and test of a casual model of student attrition. *Research in Higher Education, 12*(2), 155-187.

Bean, J. P. (1985). Interaction effects based on class level in an explanatory modle of college student dropout syndrome. *American Educational Research Journal, 22*(1), 35-64.

Blimling, G. S. (1999). A meta-analysis of the influence of college residence halls on academic performance. *Journal of College Student Development*, *40*, 551-561.

Blose, G. (1999). Modeled retention and graduation rates: Calculating expected retention and graduation rates for multicampus university systems. *New Directions for Higher Education*, 69.

Bogdan, R., & Biklen, S. (1998). *Qualitative Research in Education; an introduction to theory and methods (3rd edition).* Needham Heights, MA: Allyn & Bacon.

Boyer Commission. (1998). *Reinventing Undergraduate Education: A Blueprint for America's Reserach Universities.*

Braxton, J. M., Hirschy, A. S., & McClendon, S. A. (2004). *Understanding and reducing college student departure.* San Francisco, CA: Jossey-Bass.

Brunsden, V., Davies, M., Shevlin, M., & Bracken, M. (2000). Why do HE students drop out? A test of Tinto's model. *Journal of Further & Higher Education, 24*(3), 301-310.

Bureau of Labor Statistics. (2007, June 28). *STEM occupations and job growth*. Retrieved April 26, 2009, from The Editor's Desk: http://www.bls.gov/opub/ted/2007/jun/wk4/art04.htm

Byars-Winston, A., Estrada, Y., & Howard, C. (2008, February). *Incereasing STEM retention for underrepresented students: Factors that matter.* Retrieved November 2010, from University of Wisconsin - Madison The Center on Education and Work: www.cew.wisc.edu/sloan

Cabrera, A. F., Nora, A., & Castaneda, M. (1993). College persistence: Structural equations modeling test of an integrated model of student retention. *Journal of Higher Education, 64*(2), 123-139.

Cabrera, A. F., Nora, A., & Castaneda, M. B. (1992). The role of finances in the persistence process: A structural model. *Research in Higher Education, 33*(5), 571-593.

Caison, A. L. (2007). Analysis of institutionally specific retention research: A comparison between survey and institutional database methods. *Research in Higher Education, 48*(4), 435-451.

Carey, K. (2010, December 2). *College grad rates stay exactly the same.* Retrieved January 2, 2011, from The Chronicle of Higher Education - Brainstorm: http://chronicle.com

Chen, R., & DesJardins, S. (2008). Exploring the effects of financial aid on the gap in student dropout risks by income level. *Research in Higher Education, 49*(1), 1-18.

Chickering, A. W. (1974). *Commuting versus resident students.* San Francisco, CA: Jossey-Bass.

Committee on Science, Engineering, and Public Policy. (2007). *Rising above the gathering storm: Energizing and employing America for a brighter economic future.* Retrieved November 2011, from National Academies Press: http://www.nap.edu/catalog/11463.html

DesJardins, S. L. (2001). Assessing the effects of changing institutional aid policy. *Research in Higher Education, 42*(6), 653-678.

Dorans, N. J. (1999). Correspondence Between ACT and SAT I Scores. *College Board report*, 1-18.

Friedman, T. L. (2005). *The world is flat: A brief history of the twenty-first century.* New York, NY: Farrar, Straus and Giroux.

Gansemer-Topf, A. M., & Schuh, J. H. (2006). Institutional selectivity and institutional expenditures: Examining orginazitional factors that contribute to retention and graduation. *Research in Higher Education, 47*(6), 613-642.

Gillmore, G. M., & Hoffman, P. H. (1997). The graduation efficiency index: Validity and use as an accountability and research measure. *Research in Higher Education, 38*(6), 677-697.

Goenner, C. F., & Snaith, S. M. (2003). Predicting graduation rates: An analysis of student and institutional factors at doctoral universities. *Journal of College Student Retention: Research, Theory & Practice, 5*(4), 409-420.

Goenner, C. F., & Snaith, S. M. (2004). Accounting for model uncertainty in the prediction of university graduation rates. *Research in Higher Education, 45*(1), 25-41.

Guralnik, D. B. (Ed.). (1987). Webster's New World Dictionary. 264. New York, NY: Simon & Schuster.

Hosmer, D., & Lemeshow, S. (1989). *Applied Logistic Regression.* New York: John Wiley & Sons.

Hotchkiss, J. L., Moore, R. E., & Pitts, M. M. (2006). Freshman learning communities, college performance and retention. *Education Economics, 14*(2), 197-210.

Hsieh, H., & Shannon, S. (2005). Three Approaches to Qualitative Content Analysis. *Qualitative Health Research*, *15*(9), 1277-1288.

Jacoby, D. (2006). Effects of part-time faculty employment on community college graduation rates. *Journal of Higher Education, 77*(6), 1081-1103.

Kiley, K. (2010, December 6). *Civil-rights panel weighs in on where minorities fare best in STEM fields.* Retrieved January 2, 2011, from The Chronicle of Higher Education - Government: http://chronicle.com

Knapp, L. G., Kelly-Reid, J. E., Ginder, S. A., & Miller, E. S. (2008). *Enrollment in postsecondary institutions, fall 2006; graduation rates, 2000 & 2003 cohorts; and financial statistics, fiscal year 2006 (NCES 2008-173).* Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education .

Kuh, G. D. (2001). *The national survey of student engagement: Conceptual framework and overview of psychometric properties.* Bloomington, IN: Indiana University Center for Postsecondary Research & Planning.

Kuh, G. D., Cruce, T. M., Shoup, R., Kinzie, J., & Gonyea, R. M. (2008). Unmasking the effects of student engagement on first-year college grades and persistence. *Journal of Higher Education, 79*(5), 540-563.

Lander, E. S., & Gates Jr., S. J. (2010, October 8). *Prepare and inspire.* Retrieved November 2010, from Science AAAS: www.sciencemag.org

Lederman, D. (2010, December 2). *New data, no better results.* Retrieved January 2, 2011, from Inside Higher Ed: http://www.insidehighered.com

Lincoln, Y., & Guba, E. (1985). *Naturalistic Inquiry*. Beverly Hills, CA: Sage Publications.

Lowery, G. (2010, April 2). *Tougher grading is one reason for high STEM dropout rate.* Retrieved January 2, 2011, from Cornell Chronicle Online: http://www.news.cornell.edu/stories/April10/CHERIConference.html

Marshall, E. (2010, January 6). *What's behind the college drop-out rate?* Retrieved January 2, 2011, from Article Online Directory: http://www.articleonlinedirectory.com/Art/233308/442/what-s-behind-the-college-drop-out-rate.html

Marshall, J., & Havice, W. A. (2008, November 2). *Guest column: Students thrive with STEM: Program can help solve our dropout problems.* Retrieved January 10, 2011, from Independent Mail: http://www.independentmail.com/news/2008/guest-column-students-thrive-stem-program-can-help/

Martindale, G. (2010, February 3). *College drop out rates - Who's to blame.* Retrieved January 2, 2011, from Discover Your Blueprint: http://www.discoveryourblueprint.com/2010/02/03/college-drop-out-rates-whos-to-blame/

Mervis, J. (2010, September 24). *A way to heal science education, but is there the political will.* Retrieved November 2010, from Science AAAS: www.sciencemag.org

Miles, M., & Huberman, A. (1994). *Qualitative Data Analysis.* Thousand Oaks, CA: Sage Publications.

Pascarella, E. T., & Chapman, D. W. (1983). A mulit-institutional, path analytic validation of Tinto's model of college withdrawl. *American Educational Research Journal, 20*(1), 87-102.

Pascarella, E. T., & Terenzini, P. T. (1977). Patterns of student-faculty informal interaction beyond the classroom and voluntary freshman attrition. *Journal of Higher Education, 48*(5), 540-552.

Pascarella, E. T., & Terenzini, P. T. (1983). Predicting voluntary freshman year persistence/withdrawl behavior in a residential university: A path analytic validation of Tinto's model. *Journal of Educational Psychology, 75*(2), 215-226.

Pascarella, E. T., & Terenzini, P. T. (1991). *How college affects students: Findings and insights from twenty years of research.* San Francisco, CA: Jossey-Bass.

Pascarella, E. T., & Terenzini, P. T. (2005). *How college affects students: A third decade of research* (Vol. 2). San Francisco, CA: Jossey-Bass.

Patton, M. Q. (2002). *Qualitative Research and Evaluation Methods.* Thousand Oaks, CA: Sage.

Ramaley, J. A. (2001). *Teaching Institute for Excellence in STEM*. Retrieved June 15, 2011, from What is STEM Education?: http://www.tiesteach.org/stem-education.aspx

Rootman, I. (1972). Voluntary withdrawl from a total adult socializing organization: A model. *Sociology of Education*, *45*(3), 258-270.

Ryan, J. F. (2004). The relationship between institutional expenditures and degree attainment at baccalaureate colleges. *Research in Higher Education*, *45*(2), 97-114.

Scott, M., Bailey, T., & Kienzl, G. (2006). Relative Success? Determinatents of college graduation rates in public and private colleges in the U.S. *Research in Higher Education, 47*(3), 249-279.

Seymour, E., & Hewitt, N. M. (1997). *Talking about leaving: Why undergraduates leave the sciences.* Boulder, CO: Westview Press.

Spady, W. G. (1970). Dropouts from higher education: An interdisciplinary review and synthesis. *Interchange, 1*(1), 64-85.

Spady, W. G. (1971). Dropouts from higher education: Toward an emperical model. *Interchange, 2*(3), 38-62.

Tesch, R. (1990). *Qualitative Research Analysis Types & Software Tools.* Abingdon, Oxon: Routledge Falmer.

Thiel, T., Peterman, S., & Brown, M. (2008, July-August). *Addressing the crisis in college mathematics: Designing courses for student success.* Retrieved January 20, 2011, from Change The Magazine of Higher Learning: http://www.changemag.org

Tinto, V. (1975). Dropout from higher education: A theoretical synthesis of recent research. *Review of Educational Research, 45*(1), 89-125.

Tinto, V. (1982). Limits of theory and practice in student attrition. *Journal of Higher Education*, 53(6), 687-700.

Tinto, V. (1998). Colleges as communities: Taking research on student persistence seriously. *Review of Higher Education, 21*(2), 167-177.

Tinto, V. (2006). Research and practice of student retention: What next? *Journal of College Student Retention: Research, Theory and Practice,* 8(1), 1-19.

Winston, R. B., Anchors, S., & Associates. (1993). *Student housing and residential life: A handbook for professionals committed to student development goals.* San Francisco, CA: Jossey-Bass.

Winter, G. (2000). *A Comparative Discussion of the Notion of Validity in Qualitative and Quantitative Research*, 4(3&4). Retrieved April 01, 2012, from http://www.nova.edu/ssss/QR/QR4-3/winter.html

Zheng, J. L., Saunders, K. P., Shelley, M. C., & Whalen, D. F. (2002). Predictors of academic success for freshman residence hall students. *Journal of College Student Development*, *43*, 267-283.

APPENDIX A

Interview Protocol 1

Matriculated Students:

The number of interviews was 31.

Good afternoon/evening. My name is Mike Johnson and I am a student conducting research in pursuit of my doctoral degree from the University of Montana. I am seeking your permission to take a few minutes of your time to discuss my research regarding students who successfully completed a degree in science, technology, engineering, or mathematics. I am seeking to understand the success factors of students that have achieved a technical degree.

The results of this conversation will contribute to a body of data that I will later summarize and determine conclusions. Your specifics will never be used within my research as I intend to fold your comments into a pool of data for eventual evaluation. I assure your anonymity.

Are you willing to answer a few questions for me? It will take approximately 15 minutes to complete. Is there a better time that I can reach you?

If you are ready, here is the first question:

1. Did you graduate?
2. When?
3. In what degree program?
4. Did you live in the Residence Hall during your time on campus?
5. Prior to entering, did you complete a Jump-start course or an AP class while in high school?
6. Did you work on campus during your educational journey? Off campus?
7. Can you identify specific individuals who were influential in your success while on campus?
    a. Faculty
    b. Administrators
    c. Staff
    d. Other Students – can you recall a good student that you believe did not graduate?
    e. Parents
8. Can you identify any social factors that influenced your success?
    a. Athletics

   b. Residence Hall
   c. Library
   d. Senior Design Project Course
   e. Learning Center Tutors
   f. College Orientation Course
   g. Your Family
   h. The local Party Scene
   i. Career Services
   j. Any others
9. Please rank the respective social factors on a scale of 1 -5 with 5 being the highest.
10. Do you have any other comments that would help identify success factors for you during your time on campus? If respondent struggles with question, ask:
    What advice might you give a student that is starting a STEM major today?

APPENDIX B

Interview Protocol 2

Non-matriculated Students:

The number of interviews was 10.

Good afternoon/evening. My name is Mike Johnson and I am a student conducting research in pursuit of my doctoral degree from the University of Montana. I am seeking your permission to take a few minutes of your time to discuss my research regarding students who studied science, technology, engineering, or mathematics. I am seeking to understand your higher education journey.

The results of this conversation will contribute to a body of data that I will later summarize and determine conclusions. Your specifics will never be used within my research as I intend to fold your comments into a pool of data for eventual evaluation. I assure your anonymity.

Are you willing to answer a few questions for me? It will take approximately 20 minutes to complete. Is there a better time that I can reach you?

If you are ready, here is the first question:

1. Did you attend college during the period 2005-2010?
2. When we you there?
3. When you entered, what did you plan to study?
    a. Please explain your journey. What happened and when?
4. Prior to entering, did you complete a Jump-start course or an AP class while in high school?
5. Did you leave this institution prior to graduation?
6. Did you attend another institution of higher learning after leaving? If so, did you graduate from that school? In what discipline?
7. Did you live in the Residence Hall(s) during your time on campus?
8. Did you work while attending college? If yes, on or off campus?
9. What were the primary reasons for stopping out or dropping out of your education? List all items mentioned.
10. In order of priority, with the first item being the most influential, please put the list in order from most to least impactful.
11. Are there any other reasons that might explain your departure?
    a. Do you intend to finish your STEM education in the foreseeable future?

12. Is there anything that this school could have done or should have done that would have allowed you to stay in a STEM discipline?

APPENDIX C

Predicting the Probability of Success

The estimated model for predicting the probability of first-year student success in STEM majors is given by the following:

$$P(success) = \frac{e^{(b0+x'b1)}}{1+e^{(b0+x'b1)}}$$

where

$(b_o + x'b_1) = -12.12 + 0.001(\text{HS Size}) + 2.45(\text{HS GPA})$
$+0.069(\text{ACT Math}) + 0.53(\text{RH}) + 0.66(\text{College Orientation})$

Note that the Residence Hall (RH) and College Orientation are "dummy" variables, taking values 1, -1. For example, when a freshman STEM major lives in a Residence Hall, the variable RH equals 1. If that student takes College Orientation, then the variable College Orientation equals -1.

Suppose an incoming student who declares a STEM major comes from a HS of size 1533 with a HS GPA of 2.52. Suppose this student has an ACT math score of 23, does not live in a dorm, and takes the College Orientation Course. Then, for this student,

$(b_0 + \text{'}b_1) = 12.12 + 0.001(1533) + 2.54(2.52)$
$+0.069(23) + 0.53(-1) + 0.66(-1) = -4.016$

The probability that this student will be successful in STEM program is estimated as

$$P(success) = \frac{e^{(-4.016)}}{1+e^{(-4.016)}} = 0.017$$