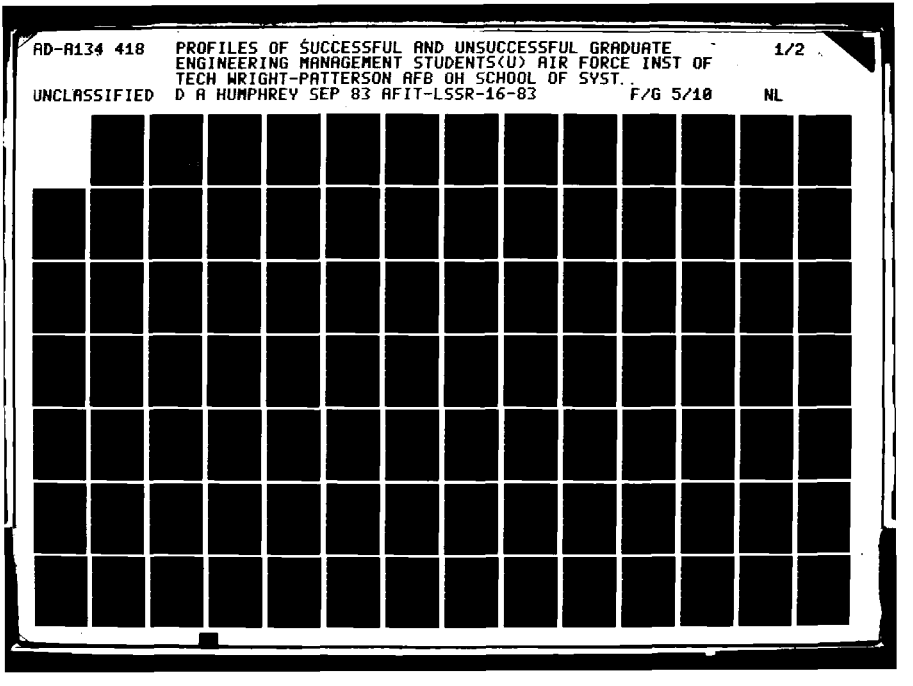
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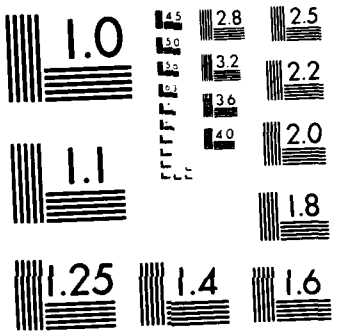

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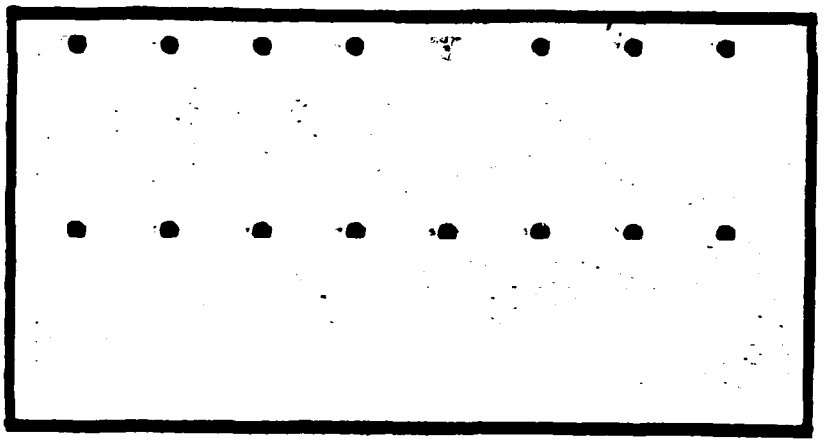

DEPARTMENT OF THE AIR FORCE

AIR UNIVERSITY

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

PROFILES OF SUCCESSFUL AND UNSUCCESSFUL GRADUATE ENGINEERING MANAGEMENT STUDENTS

David A. Humphrey, 1st Lieutenant, USAF

LSSR 16-83

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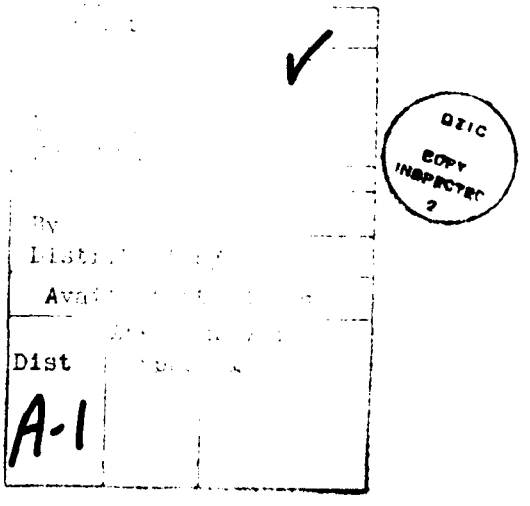

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The Air Force makes a large investment when it sends a person to the Air Force Institute of Technology (AFIT) School of Systems and Logistics Graduate Engineering Management (GEM) program; therefore, it is important to minimize the number of unsuccessful students. This research project determined both the characteristics present in successful GEM students (students who completed the program on schedule) and those characteristics which could be used in predicting academic success. A variety of personal, military, attitudinal, and educational characteristics was used to develop profiles of successful and unsuccessful students. Several statistical analysis techniques were used to test for differences among these profiles. Seven student characteristics (years in the military, AFIT engineering GPA, AFIT socio-humanistic GPA, AFIT analytical GPA, cumulative AFIT GPA, advisor advised in past three years, and where an advisor works) were found statistically different between the successful and unsuccessful students. Factor and discriminant analyses were used to determine the best predictors of success. Nine student characteristics (age, years in the military, months since undergraduate degree, architectual degree, months since undergraduate math, aviation cadet, "other" engineering degree, and undergraduate GPA) were good predictors of performance in the GEM program.

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PROFILES OF SUCCESSFUL AND UNSUCCESSFUL GRADUATE ENGINEERING MANAGEMENT STUDENTS

A Thesis

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirement for

Degree of Master of Science in Engineering Management

BY

David A. Humphrey, BS
1st Lieutenant, USAF

September 1983

This thesis, written by

1st Lieutenant David A. Humphrey

has been accepted by the undersigned on behalf of the Faculty of the School of Systems and Logistics in partial fulfillment of the requirement for the degree of

MASTER OF SCIENCE IN ENGINEERING MANAGEMENT

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To my wife, Lisa, I express my sincerest gratitude for her encouragement, understanding, and infinite hours of patience.

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CHAPTER I

INTRODUCTION

Background

The Air Force Institute of Technology (AFIT) Graduate Facilities Management Program was developed in 1971 in order to fulfill a need for a masters level management program for Civil Engineering personnel. The Graduate Facilities Management (GFM) program provided "military and civilian engineering managers with the knowledge and analytical skills necessary to perform effectively in middle and upper level management assignments within the Air Force Civil Engineering career field" (Lee and Steward 1980, p. 2-1). This program provided students who held an undergraduate engineering degree with a graduate education designed to improve their abilities to manage engineering programs and activities (Lee and Steward 1980, p. 2-1).

The Facilities Management Program was a 12-month program with 57 hours of graduate work, including a thesis requirement. In April 1980, the Facilities Management program was extended to 15 months and the name changed to the Graduate Engineering Management (GEM) Program. In 1982, the program contained 60 quarter hours of graduate work, including the thesis requirement. Although the curriculum has

gone through a number of changes, the Facilities Management and Engineering Management curriculums are basically the same (Lee and Steward 1980, p. 2-1).

Current Admission Criteria

> The Graduate Engineering Management program is open to Air Force officers in the rank of lieutenant through lieutenant colonel, civilians in comparable civil service grades, equivalent grade officers of the other U.S. services, and qualified foreign military officers [Lee and Steward 1980, p. 4-1].

The Air Force officers must be in the 55XX Air Force Speciality Code (Civil Engineering). A person is eligible for the program (although not necessarily selected for it) if he meets the following academic requirements:

1. A baccalaureate degree or equivalent in engineering.

2. A cumulative undergraduate grade point average of at least 2.5 on a 4.0 scale.

3. An acceptable score on either the Graduate Management Admission Test (GMAT) or the Graduate Record Examination (GMAT score of 500 or GRE score of 1000).

4. Mathematics through calculus with a grade of at least "C" (AFIT 1982-1984 Catalog, p. 10; Lee and Steward 1980, p. 4-2).

Tradeoffs between these requirements are permitted. For example, a prospective student with a undergraduate GPA of less then 2.5 might be eligible if he has a very high GRE or GMAT score. The AFIT Director of Admission judges each case

on an individual basis and has the authority to waive certain acceptance requirements (AFIT 1982-1984 Catalog, p. 10; Lee and Steward 1980, p. 4-2).

Problem Statement

The U.S. Air Force makes a large investment when it sends a person to the Graduate Engineering Management program. The government must pay school expenses, moving costs to Wright-Patterson Air Force Base, and salary for 15 months. For example, the 1982 GEM class cost the Air Force an average of $65,200.46 per student (Average Training Cost Per Graduate Report 1982). The program can also be costly to the student. Although no study has looked at the effects on an officer who failed to successfully complete the program, it is possible that the failure has a negative effect on his career, since training reports are written for all attendees. In cases where students attempt but cannot complete the program, the time they spent at AFIT could have been better used improving their promotability by gaining added job experience. Therefore, it is beneficial to both the Air Force and the student that the number of students who enroll but fail to complete the course of study be kept to a minimum.

Definitions

In this study, a successful Graduate Engineering Management student is defined as a student who completes all requirements for the degree on schedule. This definition was chosen because it is the Air Force's expectation that a student will complete the program on time. If a student does not fulfill this expectation, then he can not be considered a successful AFIT student.

Among those students defined as successful by the above definition, different levels of success can be defined on the basis of grade point average at graduation. This study uses three categories of successful students: high successful (4.00 - 3.67 GPA), middle successful (3.66 - 3.33 GPA), and low successful (3.32 - 3.00 GPA). A similar classification was used successfully by Covert and Chansky (1975) in a study of Master of Education students. These three successful categories, together with the unsuccessful category, make up the four achievement levels that were analyzed in this study.

Purpose Of This Study

The purpose of this research project is to determine both the specific characteristics present in successful GEM students and those characteristics which the AFIT Director

of Admissions can use in predicting academic success for the program. This investigation looked at a variety of personal, military, attitudinal, and educational characteristics in order to develop a profile for each achievement level. The results of this research project will be of interest to the Director of Admission, the Academic Standards Committee, and the GEM Program Manager because it will provide them information about both the effectiveness of the current admission standards and the previous academic performance by GEM students. These officials can use this information to evaluate the current admission criteria and possibly make changes to improve it.

Objectives

The following are the objectives of this study:

1. To identify the characteristics present in successful Graduate Engineering Management students which are not present or are present to a different degree in the unsuccessful students.

2. To identify the student characteristics for each of the academic achievement levels and determine whether or not there are differences among these levels.

3. To identify which characteristics available to the AFIT Director of Admissions best predict success among

applicants for the GEM program.

Scope And Limitations

This study is based on the records of all of the past Facilities Management and Engineering Management students. The class that graduated in September 1982 is the last class for data collection.

The following is a list of student characteristics used in this study.

1. GRE/GMAT scores
2. Undergraduate GPA
3. Age
4. Unmarried/married
5. Time in the military
6. Rank in the military
7. Source of commission
8. Previous graduate work (yes/no)
9. Time since undergraduate degree (months)
10. Time since last calculus course (months)
11. Calculus undergraduate GPA
12. Undergraduate credit hours of calculus
13. Squadron Officers School (no/residence/correspondence)
14. Undergraduate College Attended (USAFA/ Other colleges)
15. Aeronautical Rating (yes/no)
16. Type of undergraduate degree
    a. Electrical
    b. Mechanical
    c. Architectural
    d. Civil
    e. Industrial
    f. Other
17. Number of courses transferred to AFIT for credit
18. Thesis advisor characteristics:
    a. Had he advised a thesis in the past 3 years
    b. Academic background (PhD or Masters Degree)
    c. Where he works
        1) Engineering School
        2) Logistic School
        3) Civil Engineering School
        4) Other

19. Type of thesis the student did
    a. Pure CE (CE problem and database)
    b. Partial CE (General Problem & CE Database or CE problem & General Database)
    c. Non-CE
20. Finished thesis (On Time, Late, Never)
21. Graduated (On Time, Late, Never)
22. Deficiencies (None, GPA, courses(s), Thesis)
23. AFIT GPA
24. AFIT GPA in the following categories:
    a. Applied engineering
    b. Socio-humanistic
    c. Analytical

The next chapter is a review of the literature on predicting academic success and developing profiles. Chapter three (Methodology) provides definitions for each of the student characteristics presented above and the methodology used to meet the objectives of this study.

CHAPTER II

LITERATURE REVIEW

This chapter provides a review of the literature on predicting academic success and developing profiles. The first section is on previous prediction attempts, including both the results and the statistical techniques used in predicting academic success. The second section on profiling, emphasizes the statistical techniques used in developing profiles.

Previous Prediction Attempts

One of the most commonly used predictors of academic success in graduate school is the Graduate Record Examination score. The Graduate Record Exam (GRE) is required by many graduate schools as a prerequisite for admission because the schools use it to identify potentially successful students. The GRE-Aptitude test (GRE-AT) is designed to measure promise for graduate work. The GRE-AT consists of two subsets: a verbal ability test (GRE-V), and a quantitative ability test (GRE-Q). The sum of the scores from the two subsets is the GRE-AT score (Thacker and Williams 1974, p. 940). There are also GRE-Advanced tests which evaluate a student's achievement level in a certain field; therefore,

the contents of these tests vary depending upon the subject field. (Willingham 1974, pp. 273-278).

Thacker and Williams (1974) reviewed twelve studies concerning the use of GRE scores to predict success. Graduate grade point average (GPA) was used as a measure of academic success in many of these studies. After reviewing six studies done between 1957 and 1967, including two on doctoral education programs which used "graduated/ not graduated" as the measure of success, Thacker and Williams (1974, p. 940) stated that "the correlations between GRE and graduate GPA's were either not significant or so low that they were inefficient in forecasting power from a practical standpoint." The two doctoral studies revealed that only GRE-Q was significantly correlated with success. Thacker and Williams (1974, p. 943) concluded that "the weight of the evidence in the articles reviewed suggests that the wide usage of the GRE as a selection instrument must be questioned" and there are "serious doubts about the validity of the GRE in identifying potentially successful graduate students."

Willingham (1974) reviewed forty-three correlation studies done between 1952 and 1972 that dealt with predicting academic success. These studies used verbal and quantitative GRE scores, undergraduate GPA's, comprehensive departmental examinations, and letters of recommendation as

predictors of graduate GPA. The following are observations Willingham made after reviewing the studies:

1. "The undergraduate GPA is a moderately good predictor of graduate GPA."

2. "The GRE-Q test is typically a better predictor than the GRE-V test in those scientific fields where quantitative ability counts most."

3. "The GRE-V tends to be more valid than the GRE-Q in verbally oriented disciplines."

5. "Recommendations appear to be a fairly poor predictor of success."

6. "Comprehensive departmental examination seems a somewhat more predictable criterion than the others examined."

7. "The composite GPA and GRE provides substantially more accurate predictions than does undergraduate GPA alone." (Willingham 1974, p. 275)

Willingham suggested that more predictors should be used and that the existing predictors should be improved. For example, use of undergraduate GPA has shortcomings because the range of the grade average is restricted by selection criteria, and the grade scale varies considerably depending on the undergraduate school a student attended. In summary, Willingham (1974, p. 278) states "the evidence suggests that the accuracy of predicting academic success based upon a test or grade record is often no better than

modest" and the "best way to improve selection criteria for graduate students is to develop improved success criteria."

In most of the literature, graduate GPA is used as a measure of academic success. Grade point average provides a continuous scale of success and thus can be used with many statistical techniques. Two of the more common statistical techniques used in predicting graduate GPA are bivariate correlation, and multiple regression and correlation. The rest of this section will discuss studies that used these and other statistical techniques to predict academic success.

Bivariate Correlation

Bivariate correlation was used by Humphreys and Taber (1973), and Nagi (1975) in predicting success in graduate programs. Bivariate correlation produces a correlation coefficient which summarizes the strength of a relationship between two variables. (Nie [1975, pp. 276-300] provides a useful discussion on bivariate correlation.) Humphreys and Taber looked at the relationships between graduate GPA's for eight semesters. They found that the senior grades had the highest correlation with first-year graduate GPA's. Nagi (1975) attempted to predict the success of doctoral candidates by using bivariate correlation with GRE and Miller Analogies Test (MAT) scores as predictor variables.

Correlation coefficients of 0.140 for GRE and 0.087 for MAT failed to reach statistical significance at the 0.05 level. Nagi (1975, p. 472) concluded "that GRE and MAT scores are not substantially valid predictors of program completion."

Multiple Regression

Multiple regression is a statistical technique which analyzes the relationship between a dependent variable and a set of independent variables to find the best linear prediction equation. (Both Nie [1975, pp. 321-367] and Harnett [1982, pp. 541-594] discuss multiple regression in detail.) In the literature, multiple regression is the most frequently used statistical technique for predicting academic success. Kirnan and Geisinger (1981, p. 817) used multiple regression to predict success on the Master's Comprehensive Examination (MACOMP) in a graduate psychology program. Their regression analysis found that the GRE-V was a significant predictor, with a correlation coefficient of 0.44. Kirnan and Geisinger also determined that undergraduate GPA did not correlate with MACOMP performance.

Bean (1975) used GRE-V, GRE-Q, and undergraduate GPA as predictors of graduate GPA in an educational psychology master's degree program. A stepwise regression analysis determined that combining GRE-Q, undergraduate GPA, and GRE-V failed to significantly increase the predictability of

graduate GPA. Only GRE-Q alone was a significant predictor of graduate GPA. Bean found that undergraduate GPA failed to be significant in predicting graduate GPA. Covert and Chansky (1975) used the same three predictors as Bean in a study of a master's of education program. They found that GRE-V, GRE-Q, and undergraduate GPA accounted for no more than 20 % of the variance in graduate GPA (Covert and Chansky 1975, p. 950).

A research study by Federici and Schuerger (1974) used multiple regression to predict graduate GPA in a master's psychology program from undergraduate GPA, GRE scores, and letters of recommendation. Only GRE-Advanced and undergraduate GPA were found to be significant predictors of graduate GPA. The GRE-Q scores and letters of recommendations failed to contribute to the prediction of graduate GPA while GRE-V had only a modest relationship (Federici and Schuerger 1974, p. 949).

In a study of 94 colleges, Baird (1975) looked at a large amount of biographical, personal, attitudinal, and educational information about students in an attempt to predict graduate GPA. He looked at six different graduate fields of study and found that each had different predictors of success. For example, his multiple regression analysis of the Physical Science field determined that the order of significance of predictors was (1) undergraduate GPA in

major field, (2) GRE-V scores, and (3) GRE-Q scores. The order of predictors in the Arts and Humanities field was (1) undergraduate GPA in all courses, (2) GRE-Q , and (3) parental level of education (Baird 1975, pp. 944-945).

Other Statistical Methods

Hunt (1977) proposed the use of the Wald classification statistic as a practical tool for predicting academic performance. The Wald classification statistic uses the variance-covariance matrix to contrast one schema with another. (Hunt [1977, pp. 272-279] presents a detail discussion on the Wald statistic.) He used Scholastic Aptitude Test scores, and freshman and sophomore cumulative GPA's as predictors. Hunt based his decision rule on cost minimization of a classification error. Although Hunt's study dealt only with predicting high school student's success in college, his novel approach may be applicable to predicting success in graduate school.

Sexton and Goldman (1975) used discriminant analysis to predict college GPA from high school transcripts. Discriminant analysis weights and linearly combines discriminating variables in such a way that the groups are forced to be as statistically different as possible. (Nie [1975, p. 435-467] discusses discriminant analysis in detail.) They divided high school transcripts into five categories by

subject area: English, mathematics, science, history, and foreign language. The grade average and the number of courses in each category were used as independent variables. A multivariate analysis indicated that "college success was related to high school grades but not to the pattern of preparation" (Sexton and Goldman 1975, p. 30).

Keith (1977) used multiple regression, automatic interaction detection analysis, and discriminant analysis to predict success in the AFIT Graduate Systems Management and Graduate Operations Research programs. The automatic interaction detection analysis decomposes a set of data into mutually exclusive subgroups. (McNichols [1980, pp. 8-1 to 8-65] presents a good discussion of the automatic interaction detection analysis.) Keith used graduate GPA and degree receipt/ nonreceipt as the criteria of academic success. The following are findings of Keith's (1977, p.41-44) study:

1. "The Graduate Management Admission Test quantitative score proved to be the best predictor of graduate GPA."

2. "The best predictor of degree nonreceipt was a single [unmarried person] nonvolunteer" for the program.

3. Motivation (Volunteer status) was a good predictor of success.

Pickens (1971) used the logistic quantal response model to estimate the functional relationship between the probability of achieving a master's degree and the GRE aptitude test scores. The logistic quantal response model is a means of estimating the functional relationship between two variables. (Prickens [1971, pp. 8-23] provides a good discussion on this model.) Data from the AFIT Graduate Systems Analysis, Graduate Aeronautical-Mechanical Engineering, and Graduate Logistics Management programs were used in this study. Pickens found the mean weighted score for failures was only 38 points lower than the mean weighted score for successes and that several successful students had very low GRE scores. From these observations, Pickens (1971, p. 38) concluded that "a reasonable policy would be to cease requiring applicants to submit GRE aptitude scores."

The final study discussed in this section involves the use of an interesting approach to determining successful completion of graduate work. Lewis (1974) classified undergraduates into four groups based on high or low academic aptitude and high or low academic achievement (GPA). Academic aptitude was determined from the Iowa Placement Test scores. The groups were further divided by sex. The percentage of undergraduates in the four ability-achievement groups that had completed an advance degree was calculated. Then the differences between percentages were tested for

significance using the chi-squared statistic. The chi-squared statistic tests how closely a set of observed frequencies corresponds to a given set of expected frequencies. (Harnett [1982, pp. 708-718] provides a good discussion on the chi-squared statistic.) Lewis (1974, p. 385) found that "low aptitude-high achievement males were second only to high aptitude-high achievement males in successfully completing an advanced degree."

Summary of Previous Prediction Attempts

In the literature reviewed, no one set of variables could be used to predict success in graduate programs. Each graduate field of study seems to have its own set of predictor variables. Undergraduate GPA, GRE-V scores, and GRE-Q scores were the most often used predictor variables. However, the order of importance of these variables in predicting success varied according to the field of study.

Several different statistical techniques were also used in predicting success. Multicollinearity between the predictor variables caused problems in using some of statistical techniques such as multiple regression. Multicollinearity is the situation created when two or more of the independent variables are highly intercorrelated. In summary, each researcher should use the predictor variables and statistical techniques which can best predict success in the field

of study he or she is investigating.

Profiling

This section of the literature review will summarize three studies which developed profiles of students. These three studies provide good examples of the statistical techniques used in developing profiles and for determining differences between profiles.

Riech (1976) conducted a study which used the results from the California Psychological Inventory test to develop a profile of 94 first-year law students. Inventory tests measure a person's personality traits, aptitudes, and skills. The profile consisted of a table which presented the means and standard deviations of all inventory scales and the correlations of all inventory scales with Law GPA, undergraduate GPA, Law Aptitude scores, Law SAT Writing Ability scores, and Law General Background scores. The correlation coefficients were Pearson product-moment correlation coefficients. None of the inventory scales were significantly correlated to first-year Law GPA, which meant there was no significant relationship between personality dimensions measured by the inventory and first-year legal achievement.

The Millon-Illinois Self-Report Inventory Form P, the

State-Trait Anxiety Inventory, and the Personal Orientation Inventory were used by Dods and Treppa (1978) to develop profiles of male and female medical students. These tests were administered to 155 male and 37 female students. The profiles contained score means and standard deviations for each scale of the inventory tests. A t-test of the means was conducted to determine whether significant differences existed between the scale means for male and female students. The t-test compares the means of two independent samples to see if any significant differences exist. (Harnett [1982, pp. 378-380] and Nie [1975, p. 269] discussed this test in detail.) Three levels of significance were examined: less than 0.10, less than 0.05, and less than 0.005. Eight of the twenty-three scales were significantly different at the 0.10 level. The results of this study were

> that female medical student's style of interpersonal functioning was characterized by less emotional indifferences and uninvolvement, less competitiveness and self-centeredness, less constriction and authoritarianism, and more impulsivity and negativism than that of their male counterparts [Dods and Treppa 1978, p.6].

Demographic and socio-psychological profiles of both Army ROTC students and non-ROTC students were developed by Card (1977) in an attempt to determine if differences existed between these two groups of students. The sample consisted of a nationwide random sample of high school seniors and college students from schools/colleges which

offered ROTC. A total of 1089 high school seniors filled out the survey questionnaire; of these, 102 were in Junior ROTC. A total of 1633 college students participated in the study, and 754 of them were in ROTC. The survey measured 200 various demographic and socio-psychological factors which were hypothesized to be related to ROTC/Army career participation. Differences between ROTC and non-ROTC students were evaluated for significance by the chi-squared statistic (for nominal variables) or the t-test for the differences in means (for ordinal variables). Card also performed a discriminant function analysis to identify the characteristics which best differentiated ROTC from non-ROTC students. This study found that "ROTC cadets differed from their classmates in their demographic background, their aptitudes, their social environment, and especially their socio-psychological profile" (Card 1977, p. 213).

In summary, the literature revealed that three statistical techniques have been used to develop profiles: 1) means and standard deviations, 2) relative frequencies, and 3) correlation coefficients. Means and standard deviations were used to profile ordinal scale variables, while relative frequencies were used to profile nominal scale variables. Correlations were used to show if any significant relationship existed between the independent and dependent variables. The three statistical techniques used to test for

differences between profiles were the chi-squared statistic, the t-test, and the discriminant function analysis. The chi-squared statistic was used to examine differences in relative frequencies, while the t-test tested for differences in the sample means. Discriminant analysis was used to identify the variables which best differentiated between two profiles. The studies discussed above, along with several other studies not mentioned (Bird 1979; Brooks and Avila 1973; Buhmeyer 1978; Kelly and King 1978; Scott and Anadon 1980; Ward, Cunningham, and Summerlin 1978), all used one or more of these statistical techniques to develop profiles or to test for differences between profiles.

CHAPTER III

METHODOLOGY

This chapter will discuss the methodology used in this research project. The methodology will be discussed in the following three parts: composition of the population, the student characteristics, and the specific analytical techniques used.

Population

The population examined included all U.S. Air Force officers who began either the Graduate Engineering Management program or the Graduate Facilities Management program. A total of 207 students have attended these programs; however, only 196 were USAF officers. The non-USAF students consisted of seven U.S. Marine Corp officers, one civilian, and three foreign students. Two USAF officers were dropped from the population because they transferred from the GFM program to another program in the Logistics School. These two officers had good grades in the GFM program, so their reason for transferring was not due to academic difficulties. Therefore, the total number of students in the population is 194, and all of them are male. The population contains 12 persons who failed to graduate on time. One of these unsuccessful students resigned from the program prior

to his graduation date. Six of the twelve students graduated late. The other five never graduated.

The data selected for evaluation were obtained from the individual student records which are maintained in the AFIT Registrar's office. These records contain undergraduate transcripts, GRE and/or GMAT scores, AFIT transcripts, and basic biographical facts. Information about theses and thesis advisors was gathered from records kept in the School of Systems and Logistics Department of Communication and from old AFIT catalogs. All personal data were handled according to the provisions of the Privacy Act of 1974. A copy of the data collection form used in this study is provided in Appendix A.

Student Characteristics

Twenty-three student characteristics were used to develop profiles for each of the achievement levels. These characteristics provided a variety of academic and biographical information on each of the students. A number of characteristics were included because some factors other than academic ability might have an influence on success at AFIT. Such things as work experience, time since undergraduate degree, marital status, source of commission, or age might have an impact on whether a person successfully completes the GEM program. All the characteristics were used

in determining a profile of a successful GEM student; however, a subset of these characteristics was used in predicting success at AFIT since only 18 of these characteristics are available to the Director of Admission at the time an individual applies for admission. The following is a list of the student characteristics. Definitions and reasons for including them in this analysis are included where needed.

1. Undergraduate GPA: Undergraduate grade point average is one of the most commonly used predictors of success for graduate school admission. All undergraduate GPAs in this analysis were computed on a 4.0 scale.

2. GRE Scores: The Graduate Record Exam scores are also a widely used predictor of success in graduate school. Three different scores were gathered from this standardized test. The GRE verbal and quantitative scores were recorded on a point basis and a GRE-Total score was calculated by adding the GRE-V and GRE-Q scores together. Scores were recorded on a point basis because a GRE-Total score of 1000 points is required for admission to AFIT's School of Systems and Logistics graduate programs (AFIT 1982-1984 Catalog, p. 10).

3. GMAT Scores: The Graduate Management Admission Test is another frequently used criterion for graduate student selection. Scores were recorded on a point basis. A GMAT

score of approximately 500 is required for admission to AFIT's School of Systems and Logistics graduate programs (AFIT 1982-1984 Catalog, p. 10).

4. Age: The student's age was his age in years at AFIT entry. Age was rounded down to the nearest whole year.

5. Marital Status: Marital status is defined as either married or single at AFIT entry. No attempt was made to further divide marital status into divorced or separated.

6. Time In Military: The time in military includes both commissioned and enlisted time served before entering AFIT. Time was measured in years, and partial years were rounded down.

7. Military Rank: The military rank of the student was his rank upon arrival at AFIT. This characteristic will be highly correlated to time in the military.

8. Source of Commission: The three main sources of Air Force commissions are the United States Service Academies (USSA), Reserve Officer Training Corp (ROTC), and Officer Training School (OTS). This characteristic was selected to investigate the relationship between a undergraduate education in a rigid environment, such as in an USSA, and graduate school performance. The ROTC officers had military training during their undergraduate program but the training

not as rigid as the USSA training. The OTS officers did not go through military training until after they graduated from college.

9. Squadron Officer School: Squadron Officer School (SOS) is one of the professional military education courses which AF officers either attend in residence or take by correspondence. This school is designed to improve oral and written communication skills, leadership abilities, and management techniques. Some of these topics are taught in the GEM program, so this characteristic was included to see if having attended SOS had any relationship to success in the GEM program.

10. Aeronautical Rating: Aeronautical rating is a dichotomous characteristic (one which divides the population into two parts). The GEM program was developed for civil engineering officers, but each year several rated officers attend the program before going into the civil engineering career field. This characteristic was used to see if the officers with previous civil engineering experience are more or less successful at AFIT than the rated officers, who customary have less CE experience. No distinction was made between types of rating (pilot or navigator).

11. Time Since Undergraduate Degree: This characteristic was selected to investigate the possible influence of

academic staleness. The time is the number of months between receipt of the Bachelor degree and entry into AFIT.

12. Time Since Last Math (Calculus) Course: Like time since undergraduate degree, this characteristic was selected to investigate the possible influence of mathematical staleness. Calculus is not used on a day-to-day bases in either the civil engineering or the flying career fields; therefore, a perspective GEM student probably has not used calculus extensively since his last calculus course. The GEM program has several courses that are very quantitative in nature, requiring a good mathematical background. The time in months was measured from the completion of the last calculus level course to AFIT entry.

13. Mathematical Undergraduate GPA: Mathematical GPA was chosen as a measure of previous mathematical performance. Only calculus level and higher math courses were included in this grade point average.

14. Mathematical Credit Hours: This characteristic was selected to give a better understanding of a person's previous mathematical (calculus) background. Quarter credit hours were converted to semester hours (one and a half quarter hours equaled one semester hour) to standardize the unit of measure.

15. Undergraduate College: The college a student

attended was examined to see how U.S. Air Force Academy students performed with respect to students from other colleges.

16. Previous Graduate Work: This characteristic was selected to investigate the influence of previous graduate work on performance in the GEM program. Previous graduate work is defined as any master's level course work which a student had completed before attending AFIT.

17. Transferred Courses: The number of courses transferred in for credit was used as a measure of the amount of previous graduate work done in the Engineering Management area. AFIT restricts the number of course hours that can be transferred in for credit, so this variable is limited in its ability to measure previous graduate work.

18. Type of Undergraduate Degree: Students in the GEM program are supposed to have an undergraduate degree in engineering. The types of undergraduate engineering degrees were investigated to see if they related to success in the GEM program. The five major types of engineering degrees found in the civil engineering career field are civil, mechanical, electrical, industrial, and architectural.

The following five student characteristics were used only in developing profiles of GEM students. These characteristics were chosen because they represent possible areas

for differences between a successful and a unsuccessful GEM student.

19. Thesis Advisor Characteristics: Since the completion of a thesis is a requirement for graduation, the characteristics of a student's thesis advisor were investigated to see if they related to a student's successfully completing his or her thesis. The three characteristics investigated were academic background, school that advisor works in, and thesis advising experience. Academic background was measured by the highest degree an advisor had received. There are three different schools in AFIT: the School of Systems and Logistics, the School of Civil Engineering, and the School of Engineering. The GEM program is in the School of Systems and Logistics, but an advisor can be from one of the other schools. The schools operate under different rules and regulations. Where an advisor works was investigated to determine whether there was any relationship to a student's successfully completing a thesis. Thesis advising experience was investigated to determine if there was a relationship between an advisor's knowledge of the thesis process and a student's completing a thesis. It was assumed if a professor advised a thesis within the previous three years, he was experienced and had a good idea of the current thesis procedures.

20. Type of Thesis: The three types of thesis

investigated in this analysis were a pure civil engineering thesis, a partial civil engineering thesis, and a non-civil engineering thesis. A pure CE thesis has both a CE problem and CE database, while a partial CE thesis contains only one or the other of these two characteristics. Any problem or database related to civil engineering activities, personnel, or responsibilities was considered a CE problem or database. For example, this study would be considered a pure civil engineering thesis because it examines a CE graduate education program and uses a database made up of CE officers. A non-CE thesis deals with a subject totally unrelated to civil engineering.

21. GPA In Engineering Courses: The courses that a student took in the GEM program were divided into three categories to determine how successful students were in each of them. A GPA was then calculated for each category. Engineering is the first of these three categories. All engineering design courses and courses related directly to the civil engineering career field were included in this category. The following are examples: Contracting for Engineers, Pavements, Environmental Issues, Engineering Economy, Engineering Management Applications, and Energy.

22. GPA In Analytical Courses: The second category contained analytical courses. The analytical/quantitative courses not included in the engineering category were put in

this category. The following are examples of courses included in this category: Applied Statistics for Managers, Quantitative Decision Making, Fortran and Simulation, and Production Management.

23. GPA In Socio-Humanistic Courses: The socio-humanistic courses make up the final category. This category contains the management, writing, and economics courses. Some examples of courses in this category are Management and Behavior in Organization, Concepts and Techniques of Research, Communication for Managers and Analysts, and Managerial Economics.

Analysis Techniques

Introduction

Analysis of the data involved a three-step process. The first step was to develop profiles for each achievement level through the use of means, standard deviations, relative frequencies, and correlation coefficients. The second step involved using a t-test, a chi-squared statistic, or an analysis of variance (one-way) to determine whether or not statistically significant differences existed between the achievement levels. The final step in the process was to perform a factor analysis and a discriminant analysis to identify which characteristics best predict success among

applicants for the GEM program.

The subprograms contained in the Statistical Package for the Social Sciences (SPSS) version 8.3 (Nie 1975) were used to perform the statistical analysis in this research project. This study used an alpha of 0.05 to determine if a statistical test was significant. Therefore, a five percent probability of having a Type I error is used in this research project.

Profile Development

Means And Frequencies

Three major statistical techniques were used to develop student profiles for each achievement level. The first technique used the SPSS subprogram CONDESCRIPTIVE to obtain descriptive statistics for the continuous scale characteristics. This subprogram provides means, standard deviations, maximum values, minimum values, and a number of other descriptive statistics for each variable (Nie 1975, p. 190). The maximum and minimum values were very helpful in checking for any out-of-range responses caused by mistakes in loading the data base.

The second technique was to obtain frequency distributions with descriptive statistics for the characteristics which were classified into a limited number of values or

categories. The SPSS subprogram FREQUENCIES provides a frequency distribution table, a number of descriptive statistics, and a histogram of the relative frequencies for each variable. The relative frequencies, in percentages, were calculated both with missing values included and without the missing values (Nie 1975, p. 198).

Correlation

The final technique was to perform a bivariate correlation analysis between the student characteristics and the achievement levels. Achievement levels were used instead of AFIT GPAs because a person might have a cumulative GPA above 3.00 but still be unsuccessful due to not finishing a thesis. This analysis was done to evaluate what (if any) linear relationship existed between each of the continuous scale characteristics and the achievement levels. Bivariate correlation provides a population correlation coefficient (ρ) which summarizes the strength of a linear relationship between two variables. The value of ρ can range from -1 to +1. The extreme values, -1 and +1, indicate perfect negative linear correlation and perfect positive linear correlation respectively. An ρ-value of zero indicates the variables are not significantly linearly related (Harnett 1982, p. 520-521).

The significance of each coefficient was determined by

the "Student's t" statistic. A two-tailed test for significance was performed because the hypotheses being tested were

$$H_o: \rho = 0$$
$$H_a: \rho \neq 0$$

where:

ρ = population correlation coefficient.

Therefore, if the calculated significance was 0.05 or below, the relationship between the two variables was considered significant.

The Pearson product-moment correlation coefficient (r) is the sample statistic used to estimate the population correlation coefficient. The sample correlation coefficients were calculated using the PEARSON CORR subprogram. If the Pearson r is squared, it becomes a measure of the proportion of variance in one variable "explained" by the other (Nie 1975, p. 525).

The Pearson correlation coefficient for two variables is calculated by dividing the sample covariance by the product of the standard deviations. The mathematical expression

for r is

$$r = \frac{S_{xy}}{S_x S_y} = \frac{\frac{1}{N-1}\sum_{i=1}^{N}(X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(X_i - \bar{X})^2}\ \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(Y_i - \bar{Y})^2}}$$

where:

S_{xy} = sample covariance of variables x and y
S_x, S_y = sample standard deviations of variables x and y respectively
N = number of observations
X_i = ith observation of variable x
Y_i = ith observation of variable y
$\bar{X}$ = mean of variable x
$\bar{Y}$ = mean of variable y

Differences Among Achievement Levels

After the achievement level profiles had been developed, three statistical techniques (t-test, analysis of variance, and chi-squared statistic) were used to determine whether significant differences existed among achievement levels. These statistical tests were also used to check for differences between a unsuccessful student profile and a successful student profile. A t-test or an analysis of variance was performed on the continuous characteristics while the chi-squared statistic was used to test the categorical characteristics.

The t-test was used to test for differences between the unsuccessful and successful student profiles, since only the means of two independent samples were being examined. However, an analysis of variance was used to test for

differences among the four achievement levels because the t-test does not control experiment-wide Type I errors when more than two treatments (achievement levels) are tested. The four achievement levels would have required six t-tests to be performed, each at an alpha equal to 0.05. The Type I error for this experiment would have been 0.26 instead of 0.05: P(reject Ho/ Ho true) = 1 - P(fail to reject Ho/ Ho true) = $1 - (1 - 0.05)^6 = 0.26$. Therefore, an analysis of variance was used so the Type I errors could be controlled at the 0.05 level. The t-test and the analysis of variance are discussed in detail below.

t-Test

The SPSS subprogram T-TEST was used to perform the t-test analysis. The t-test was used to compare the means of the continuous scale characteristics in the successful and unsuccessful student profiles to determine if significant differences existed. The assumptions involved with the t-test are that both parent populations are normally distributed, their variances are equal, and they are independent. (Nie 1975, p. 269; Harnett 1982, pp. 378-380). The null and alternative hypotheses were

$$H_o: \mu_1 = \mu_2$$
$$H_a: \mu_1 \neq \mu_2$$

Therefore, the null hypothesis is rejected only if the two-tailed probability is less than alpha.

If the variances in the normal parent population are equal, the t-statistic is

$$t_{(N1+N2-2)} = \frac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)}{\sqrt{\frac{(N1-1)S1^2+(N2-1)S2^2}{N1+N2-2}\left(\frac{N1+N2}{N1\,N2}\right)}}$$

where:

N1 = sample size of sample one
N2 = sample size of sample two
$\bar{X}_1$ = sample mean of variable X1
$\bar{X}_2$ = sample mean of variable X2
μ_1 = population mean for variable X1
μ_2 = population mean for variable X2
S1 = sample variance for X1
S2 = sample variance for X2

$$\left(S=\sqrt{\frac{\Sigma(X_i-\bar{X})^2}{n-1}}\right)$$

When the variances in the normal parent population are unequal, the t-statistic cannot be computed for the differences in the sample means. Instead, an approximation to t is computed using the following formula (Nie 1975, p. 270):

$$t = \frac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)}{\sqrt{S1^2/N1 + S2^2/N2}}$$

The T-TEST subprogram provides t-values and 2-Tailed

probabilities for both a population with equal (pooled) variances and one without equal (separate) variances. An F-test of the sample variances is also performed by the T-TEST subprogram to determine whether the variances are equal or not. If the probability for F is greater than alpha, the variances are considered equal and the pooled-variance estimate is used. The value of F is equal to the ratio of the variance of two independent random samples drawn from normal parent populations. Otherwise, the separate variance estimate must be used (Nie 1975, p. 270).

Analysis of Variance

The analysis of variance is a "method of estimating how much of the total variation in a set of data can be attributed to certain assignable causes of variation and how much can be attributed to chance" (Harnett 1982, p. 650). The one-way analysis of variance involves the comparing of groups (called treatments) to determine whether significant differences exist between them with respect to the dependent variable. The model and null hypothesis for the one-way analysis are

$$Y_{ij} = \mu + \tau_{ij} + \epsilon_{ij}$$

$$\text{Ho: } \tau_1 = \tau_2 = \cdots = \tau_j$$

where:

y = dependent variable
μ = grand mean of the combined populations
τ_{ij} = treatment effects associated with a particular population
ϵ_{ij} = random error term

An F-statistic was used to test the null hypothesis. The ratio of the Mean Squared (MS) Between to the Mean Squared Within is equal to the F-statistic. Nonzero treatment effects will tend to increase the MS Between, thus rejecting the null hypothesis for large values of F (Harnett 1982, p. 659-660). The SPSS ONEWAY subprogram provides the MS Between, the MS Within, the F-statistic, and the F-probability.

An analysis of varaiance does not tell which groups are significantly different when it rejects the null hypothesis. Therefore, a posteriori contrast test was performed along with the analysis of variance in order to determine which of the groups were significantly different. A posteriori contrast test is a systematic procedure for comparing all possible pairs of group means so that overall experimental error is controlled. Several posteriori contrast tests exist; however, the more common ones are the Duncan, Tukey, and Scheffé. The Scheffé posteriori contrast test was used in this analysis because it was the only one of the three that could be used with unequal group sizes. The group sizes in this analysis were unequal. Scheffé uses a single

range value for all comparisons; therefore, this test can examine all possible linear combinations of group means, not just paired comparisons (Nie 1975, pp. 426-428). The ONEWAY subprogram outputs the categories into subsets, thus showing which groups are significantly different from one another (Nie 1975, pp. 426-428).

Chi-Squared Statistic

The chi-squared statistic is used to test how closely a set of observed frequencies corresponds to a given set of expected frequencies; therefore, it is considered a "goodness of fit" test. The null and alternative hypotheses for the chi-squared test used in this analysis were

Ho: The categories in the categorical characteristics were independent of the academic achievement levels.

Ha: The categories in the categorical characteristics were not independent of the academic achievement levels.

This statistic determines whether a relationship exists between two variables by comparing the expected frequencies to the observed frequencies according to the following formula (Harnett 1982, pp. 713-718; Nie 1975, pp. 223-224):

$$\chi^2_{(r-1)(c-1)} = \sum_{i=1}^{r} \sum_{j=1}^{c} \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

where:

C = number of columns
r = number of rows
E_{ij} = expected frequencies
O_{ij} = observed frequencies

When the fit is good, the numerator will be relatively small, hence a small chi-squared value. Conversely, if the fit is not good, then the numerator will be large and the chi-squared value will also be large. Therefore, the critical region for this test statistic "will always be in the upper tail of the chi-squared distribution because we want to reject the null hypothesis whenever the difference between Ei and Oi is relative large" (Harnett 1982, p. 709). When using the chi-squared statistic, it is important to be careful not to use categories that have small expected frequencies because the chi-squared test is an approximation test. The rule of thumb in chi-squared testing is "that the expected frequency should be at least five; recent research, however, has indicated that an expected value of one or more in a category is usually sufficient" (Harnett 1982, p. 711).

The SPSS CROSSTABS subprogram was used to perform the chi-squared tests. CROSSTABS provides chi-squared values and significances for each comparison of expected frequencies to observed frequencies. If the significance is less then alpha, the null hypothesis is rejected, which means there is a significant difference among the achievement levels. Only the categorical characteristics were tested using

the chi-squared statistic.

Identifying Predictor Characteristics

Two statistical techniques were used to identify which of the 19 student characteristics available to the AFIT Director of Admission best predict success among applicants for the GEM program. These two techniques were factor analysis and discriminant analysis.

Factor Analysis

Factor analysis is a statistical tool for analyzing correlated variables. This technique examines the correlation structure of a set of observed variables (called manifestation variables) to determine if the observed correlations can be reproduced from a smaller set of hypothetical variables called factors. If successful, this technique will reduce a set of variables to a smaller set of factors or components, which then can be used as source variables in some other statistical analysis (Nie 1975, p. 469; McNichols 1980, p. 6-71).

The principal component technique was used to produce uncorrelated factors. This technique attempts to define a set of uncorrelated new variables (called principal components) as a linear combination of the manifestation vari-

ables (McNichols [1980, pp. 6-1 to 6-73] provides a good discussion about the principal component technique). A Varimax with Kaiser normalization rotation was accomplished to make it easier to name the factors. The manifestation variables most highly correlated with the factor loadings were used to define the factors (McNichols 1980, pp. 6-71 to 6-73).

This study used the SPSS FACTOR subprogram to reduce the 19 highly correlated characteristics down to a smaller number of uncorrelated factors. These factors were then used as source variables in a discriminant analysis.

Discriminant Analysis

Discriminant analysis is a method to statistically distinguish between two or more groups of cases. A set of discriminating variables that measure characteristics on which the groups are expected to differ is used to develop a discriminant function. The objective of discriminant analysis is to weight and linearly combine discriminating variables in such a way that the groups are forced to be as statistically different as possible (Nie 1975, p. 435). The SPSS DISCRIMINANT subprogram was used to build the discriminant function. A linear discriminant function was built by using a stepwise selection of variables. The stepwise method seeks to maximize the Mahalaobis's distance between

the groups (McNichols 1980, p. 7-48). Several discriminant functions can result when there are more than two groups. The number of functions will be equal to one less than the number of groups or the number of variables, whichever is smaller. The discriminant function associated with the largest eigenvalue will do the best job of discriminating between groups. However, there may be several alternative functions with nearly equal power (McNichols 1980, p. 7-3).

Once a discriminant function has been derived, it can be used to analyze the data or classify new cases. The discriminant coefficients can be interpreted in the same manner as the factor loadings were in factor analysis. The standardized discriminant function coefficients help identify the variables which contribute most in differentiating between the groups. The coefficients represent the relative contribution of each variable in the discriminating process. Also, a discriminant function can be used to classify new cases into groups without the investigator knowing which group they actually belong to. The DISCRIMINANT subroutine provides a classification table which reports the percentage of the cases correctly classified. This table is useful in evaluating the effectiveness of the discriminant function to correctly classify cases (Nie 1975, pp. 445-446).

Two discriminant analysis were accomplished -- one with the factors from the factor analysis, and the other with the

19 student characteristics. The purpose of the discriminant analysis was to determine which characteristics or factors contributed most in predicting the success of an applicant for the GEM program.

This chapter presented the methodology used in this study. The next chapter will provide the results obtained from the statistical techniques discussed in this chapter.

CHAPTER IV

RESULTS

This chapter provides the results of the data analysis. The results are presented in three parts: the student profiles, the differences among profiles, and the predictor characteristics. The database used in this analysis is provided in Appendix B.

Student Profiles

As was stated in Chapter III, three different statistical techniques were used to develop student profiles: means and standard deviations, frequencies, and correlations. Six student profiles were developed from means and standard deviations, and frequencies. The six profiles were of 1) the population, 2) all successful students, 3) high successful students, 4) middle successful students, 5) low successful students, and 6) unsuccessful students. The successful student profile is a composite of the high, middle, and low successful profiles. Since several profiles were developed by each statistical technique, the student profiles are presented according to the statistical technique used to create them. Table 1 shows the number of students in each one of the profiles.

Table 1

Number of GEM Students In Each Profile

Profile	Number of Students
Population Profile	194
Successful Student Profile	182
High Successful Student Profile	87
Middle Successful Student Profile	67
Low Successful Student Profile	28
Unsuccessful Student Profile	12

Mean And Standard Deviation Profiles

Means and standard deviations for the continuous scale characteristics were used to create six student profiles. These six profiles are presented in Tables 2 through 7. Maximum and minimum values for each characteristic were included in the profiles in order to provide information about the range of these characteristics. Several of the minimum values appear to be incorrect because they are smaller then what would be expected given the AFIT admission requirements. However, these values are correct and the reason for their being small is that the minimum admission requirements were waived for several of the GEM students.

Table 2

Profile of the AFIT GEM Student Population

Variable	Mean	Standard Deviation	Maximum	Minimum
Age	29.33	4.37	40	21
Years In Military	7.02	4.58	20	0
Undergraduate GPA	2.74	0.41	3.87	1.96
Months Since Undergraduate degree	76.37	43.61	216	0
GRE-V	520.50	85.22	760	310
GRE-Q	661.00	70.89	820	480
GRE-Total	1181.50	117.25	1520	900
GMAT	531.73	75.12	683	381
Months Since Math	99.89	45.44	234	6
Math Credit Hours	12.53	3.93	28	0
Math UGPA	2.58	0.75	4.00	0.67
Engineering GPA	3.78	0.28	4.00	3.00
Socio-Humanistic GPA	3.53	0.29	4.00	2.73
Analytical GPA	3.50	0.38	4.00	2.60
Cumulative AFIT GPA	3.60	0.26	4.00	2.98

Table 3

Profile of Successful AFIT GEM Students

Variable	Mean	Standard Deviation	Maximum	Minimum
Age	29.17	4.37	40	21
Years In Military	6.80	4.46	20	0
Undergraduate GPA	2.74	0.41	3.87	1.96
Months Since Undergraduate degree	76.57	44.60	216	0
GRE-V	521.15	85.07	760	310
GRE-Q	663.85	69.07	820	480
GRE-Total	1185.00	115.59	1520	900
GMAT	533.34	75.09	683	381
Months Since Math	100.31	46.37	234	6
Math Credit Hours	12.60	3.88	28	2
Math UGPA	2.56	0.75	4.00	0.67
Engineering GPA	3.80	0.27	4.00	3.00
Socio-Humanistic GPA	3.55	0.29	4.00	2.73
Analytical GPA	3.53	0.37	4.00	2.60
Cumulative AFIT GPA	3.63	0.24	4.00	3.05

Table 4

Profile of High Successful AFIT GEM Students

Variable	Mean	Standard Deviation	Maximum	Minimum
Age	28.54	3.58	37	21
Years In Military	6.08	3.11	13	0
Undergraduate GPA	2.77	0.41	3.87	1.96
Months Since Undergraduate degree	75.87	37.02	168	0
GRE-V	525.30	89.72	760	310
GRE-Q	676.82	65.83	820	510
GRE-Total	1202.12	112.28	1520	950
GMAT	538.43	67.63	683	390
Months Since Math	100.31	41.35	192	15
Math Credit Hours	13.36	4.05	28	4
Math UGPA	2.59	0.79	4.00	0.67
Engineering GPA	3.95	0.11	4.00	3.50
Socio-Humanistic GPA	3.77	0.19	4.00	3.22
Analytical GPA	3.81	0.17	4.00	3.20
Cumulative AFIT GPA	3.84	0.10	4.00	3.68

Table 5

Profile of Middle Successful AFIT GEM Students

Variable	Mean	Standard Deviation	Maximum	Minimum
Age	29.55	4.88	40	22
Years In Military	7.21	5.35	20	0
Undergraduate GPA	2.72	0.43	3.73	2.03
Months Since Undergraduate degree	74.69	49	216	0
GRE-V	531.09	76.54	690	360
GRE-Q	648.70	70.60	810	480
GRE-Total	1179.78	114.22	1500	900
GMAT	534.38	79.68	654	381
Months Since Math	99.50	51.09	234	6
Math Credit Hours	12.26	3.47	20	5
Math UGPA	2.57	0.69	4.00	1.50
Engineering GPA	3.75	0.27	4.00	3.00
Socio-Humanistic GPA	3.43	0.20	3.86	2.73
Analytical GPA	3.39	0.23	4.00	2.80
Cumulative AFIT GPA	3.52	0.10	3.67	3.34

Table 6

Profile of Low Successful AFIT GEM Students

Variable	Mean	Standard Deviation	Maximum	Minimum
Age	30.21	5.15	39	21
Years In Military	8.07	5.36	18	0
Undergraduate GPA	2.67	0.35	3.47	1.96
Months Since Undergraduate degree	83.21	55.19	194	1
GRE-V	480.56	80.91	600	310
GRE-Q	655.00	71.31	750	500
GRE-Total	1135.56	121.86	1320	940
GMAT	507.60	96.20	622	405
Months Since Math	102.50	51.53	224	25
Math Credit Hours	10.79	3.74	17	2
Math UGPA	2.46	0.79	4.00	1.00
Engineering GPA	3.47	0.27	4.00	3.00
Socio-Humanistic GPA	3.18	0.14	3.50	3.00
Analytical GPA	2.96	0.20	3.43	2.60
Cumulative AFIT GPA	3.23	0.09	3.32	3.05

Table 7

Profile of Unsuccessful AFIT GEM Students

Variable	Mean	Standard Deviation	Maximum	Minimum
Age	31.67	3.68	37	24
Years In Military	10.25	5.40	19	1
Undergraduate GPA	2.81	0.36	3.42	2.20
Months Since Undergraduate degree	73.42	24.94	102	25
GRE-V	512.00	91.38	690	380
GRE-Q	624.00	87.20	740	490
GRE-Total	1136.00	135.34	1430	1010
GMAT	456.00	0.00	456	456
Months Since Math	93.27	26.88	135	44
Math Credit Hours	11.46	4.72	17	3
Math UGPA	2.88	0.72	4.00	2.00
Engineering GPA	3.40	0.27	3.00	3.86
Socio-Humanistic GPA	3.24	0.22	3.53	2.93
Analytical GPA	3.06	0.37	3.67	2.60
Cumulative AFIT GPA	3.24	0.20	3.71	2.98

The means and standard deviations for the GRE and GMAT scores were calculated using only the students who took each test. The AFIT admission office had no record of 25 students' having taken either a GRE or a GMAT test. A hundred and forty students took the GRE test, and 48 students took the GMAT. Nineteen students took both tests.

Seven GEM students never had calculus in their undergraduate degree programs. These seven students were not included in the means of the characteristics dealing with previous mathematical background (time since last calculus course, mathematical credit hours, and mathematical UGPA). Four of the seven students who did not have calculus were architects. Also, the student who dropped out of AFIT before graduation was not included in the AFIT GPA means (engineering GPA, analytical GPA, socio-humanistic GPA, and cumulative AFIT GPA) because he completed only one quarter at AFIT.

Frequency Profiles

The number of students and the relative frequencies for each of the categorical characteristics were used to develop six GEM student profiles (population, all successful, high successful, middle successful, low successful, and unsuccessful). These six profiles are presented in Tables 8 through 13.

Table 8

Profile of the AFIT GEM Student Population

Variable	Number of Students	Relative Frequency (percentage)
Married		
Yes	149	77.0
No	45	23.0
Rank		
2LT.	17	9.0
1LT.	35	18.0
Capt.	123	63.0
Maj.	16	8.0
Lt. Col.	3	2.0
Source of Commission		
USSA	34	18.0
ROTC	111	57.0
OTS	48	25.0
Other	1	1.0
Rated Officer		
Yes	50	26.0
No	144	74.0
Previous Grad. Work		
Yes	18	9.0
No	176	91.0
Type of Undergraduate Degree		
Electrical	19	10.0
Mechanical	31	16.0
Architectural	14	7.0
Civil	93	48.0
Industrial	14	7.0
Other	23	12.0
Advisor Advised In Past 3 Years		
Yes	142	74.0
No	51	26.0

Table 8 (Continued)

Profile of the AFIT GEM Student Population

Variable	Number of Students	Relative Frequency (percentage)
Advisor's Acad. Background		
PhD	114	59.0
Masters	79	41.0
Where Advisor Works		
Eng. School	5	3.0
Log. School	158	82.0
CE School	30	15.0
Type of Thesis		
Pure CE	117	60.0
Partial CE	30	16.0
Non-CE	46	24.0
Undergraduate College		
USAFA	31	16.0
Other College	163	84.0
Number Of Courses Transferred In		
Zero	182	94.0
One	5	2.5
Two	5	2.5
Three	1	0.5
Four	1	0.5
SOS		
No	38	20.0
Residence	25	13.0
Correspondence	23	12.0
Unknown	108	56.0

Table 9

Profile of Successful AFIT GEM Students

Variable	Number of Students	Relative Frequency (percentage)
Married		
Yes	138	75.8
No	44	24.2
Rank		
2LT.	16	8.8
1LT.	34	18.7
Capt.	113	62.1
Maj.	16	8.8
Lt. Col.	3	1.6
Source of Commission		
USSA	33	18.1
ROTC	105	57.7
OTS	43	23.6
Other	1	0.5
Rated Officer		
Yes	48	26.4
No	134	73.6
Previous Grad. Work		
Yes	17	9.3
No	165	90.7
Type of Undergraduate Degree		
Electrical	17	9.3
Mechanical	30	16.5
Architectural	11	6.0
Civil	90	49.5
Industrial	14	7.7
Other	20	11.0
Advisor Advised In Past 3 Years		
Yes	138	75.8
No	44	24.2

Table 9 (Continued)

Profile of Successful AFIT GEM Students

Variable	Number of Students	Relative Frequency (percentage)
Advisor's Acad. Background		
PhD	108	59.3
Masters	74	40.7
Where Advisor Works		
Eng. School	5	2.7
Log. School	153	84.1
CE School	24	13.2
Type of Thesis		
Pure CE	110	60.4
Partial CE	28	15.4
Non-CE	44	24.2
Undergraduate College		
USAFA	30	16.5
Other College	152	83.5
Number Of Courses Transferred In		
Zero	172	94.5
One	3	1.6
Two	5	2.7
Three	1	0.5
Four	1	0.5

Table 10

Profile of High Successful AFIT GEM Students

Variable	Number of Students	Relative Frequency (percentage)
Married		
Yes	67	77.0
No	20	23.0
Rank		
2LT.	4	4.6
1LT.	20	23.0
Capt.	57	65.5
Maj.	6	6.9
Lt. Col.	0	0.0
Source of Commission		
USSA	20	23.0
ROTC	50	57.5
OTS	17	19.5
Other	0	0.0
Rated Officer		
Yes	25	28.7
No	62	71.3
Previous Grad. Work		
Yes	8	9.2
No	79	90.8
Type of Undergraduate Degree		
Electrical	9	10.3
Mechanical	11	12.6
Architectural	4	4.6
Civil	48	55.2
Industrial	9	10.3
Other	6	6.9
Advisor Advised In Past 3 Years		
Yes	71	81.6
No	16	18.4

Table 10 (Continued)

Profile of High Successful AFIT GEM Students

Variable	Number of Students	Relative Frequency (percentage)
Advisor's Acad. Background		
PhD	50	57.5
Masters	37	42.5
Where Advisor Works		
Eng. School	3	3.4
Log. School	76	87.4
CE School	8	9.2
Type of Thesis		
Pure CE	55	63.2
Partial CE	12	13.8
Non-CE	20	23.0
Undergraduate College		
USAFA	20	23.0
Other College	67	77.0
Number Of Courses Transferred In		
Zero	83	95.4
One	1	1.1
Two	2	2.3
Three	1	1.1
Four	0	0.0

Table 11

Profile of Middle Successful AFIT GEM Students

Variable	Number of Students	Relative Frequency (percentage)
Married		
Yes	51	76.1
No	16	23.9
Rank		
2LT.	8	11.9
1LT.	10	14.9
Capt.	41	61.2
Maj.	6	9.0
Lt. Col.	2	3.0
Source of Commission		
USSA	10	14.9
ROTC	39	58.2
OTS	17	25.4
Other	1	1.5
Rated Officer		
Yes	18	26.9
No	49	73.1
Previous Grad. Work		
Yes	6	9.0
No	61	91.0
Type of Undergraduate Degree		
Electrical	7	10.4
Mechanical	16	23.9
Architectural	2	3.0
Civil	33	49.3
Industrial	1	1.5
Other	8	11.9
Advisor Advised In Past 3 Years		
Yes	52	77.6
No	15	22.4

Table 11 (Continued)

Profile of Middle Successful AFIT GEM Students

Variable	Number of Students	Relative Frequency (percentage)
Advisor's Acad. Background		
PhD	41	61.2
Masters	26	38.8
Where Advisor Works		
Eng. School	1	1.5
Log. School	57	85.1
CE School	9	13.4
Type of Thesis		
Pure CE	41	61.2
Partial CE	10	14.9
Non-CE	16	23.9
Undergraduate College		
USAFA	9	13.4
Other College	58	86.6
Number Of Courses Transferred In		
Zero	63	94.0
One	2	3.0
Two	1	1.5
Three	1	1.5
Four	0	0.0

Table 12

Profile of Low Successful AFIT GEM Students

Variable	Number of Students	Relative Frequency (percentage)
Married		
Yes	20	71.4
No	8	28.6
Rank		
2LT.	4	14.3
1LT.	4	14.3
Capt.	15	53.6
Maj.	4	14.3
Lt. Col.	1	3.6
Source of Commission		
USSA	3	10.7
ROTC	16	57.1
OTS	9	32.1
Other	0	0.0
Rated Officer		
Yes	5	17.9
No	23	82.1
Previous Grad. Work		
Yes	3	10.7
No	25	89.3
Type of Undergraduate Degree		
Electrical	1	3.6
Mechanical	3	10.7
Architectural	5	17.9
Civil	9	32.1
Industrial	4	14.3
Other	6	21.4
Advisor Advised In Past 3 Years		
Yes	15	53.6
No	13	46.4

Table 12 (Continued)

Profile of Low Successful AFIT GEM Students

Variable	Number of Students	Relative Frequency (percentage)
Advisor's Acad. Background		
PhD	17	60.7
Masters	11	39.3
Where Advisor Works		
Eng. School	1	3.6
Log. School	20	71.4
CE School	7	25.0
Type of Thesis		
Pure CE	14	50.0
Partial CE	6	21.4
Non-CE	8	28.6
Undergraduate College		
USAFA	1	3.6
Other College	27	96.4
Number Of Courses Transferred In		
Zero	26	92.9
One	0	0.0
Two	2	7.1
Three	0	0.0
Four	0	0.0

Table 13

Profile of Unsuccessful AFIT GEM Students

Variable	Number of Students	Relative Frequency (percentage)
Married		
Yes	11	91.7
No	1	8.3
Rank		
2LT.	1	8.3
1LT.	1	8.3
Capt.	10	83.3
Maj.	0	0.0
Lt. Col.	0	0.0
Source of Commission		
USSA	1	8.3
ROTC	6	50.0
OTS	5	41.7
Other	0	0.0
Rated Officer		
Yes	2	16.7
No	10	83.3
Previous Grad. Work		
Yes	1	8.3
No	11	91.7
Type of Undergraduate Degree		
Electrical	2	16.7
Mechanical	1	8.3
Architectural	3	25.0
Civil	3	25.0
Industrial	0	0.0
Other	3	25.0
Advisor Advised In Past 3 Years		
Yes	7	63.6
No	4	36.4

Table 13 (Continued)

Profile of Unsuccessful AFIT GEM Students

Variable	Number of Students	Relative Frequency (percentage)
Advisor's Acad. Background		
PhD	5	45.7
Masters	6	54.3
Where Advisor Works		
Eng. School	0	0.0
Log. School	5	45.7
CE School	6	54.3
Type of Thesis		
Pure CE	7	63.6
Partial CE	2	18.2
Non-CE	2	18.2
Undergraduate College		
USAFA	1	8.3
Other College	11	91.7
Number Of Courses Transferred In		
Zero	10	83.3
One	2	16.7
Two	0	0.0
Three	0	0.0
Four	0	0.0

The student who dropped out of AFIT did not have a thesis, so the thesis and thesis advisor characteristics are missing one case (student).

The population profile shows that no information was available from 56% of the student records on whether the students had taken SOS. Therefore, this characteristic was eliminated from the study. A list of undergraduate colleges and the number of GEM students who attended each is presented in Appendix C.

Correlation Profile

The correlation profile was developed from the Pearson product-moment correlation coefficients. This profile was the result of a correlation analysis between the student characteristics and the four achievement levels (high successful, middle successful, low successful, and unsuccessful). A correlation analysis requires the independent and dependent variables be continuous; therefore, only the continuous scale student characteristics were used to create this profile. The correlation profile is in Table 14. The two-tailed significance level for each correlation coefficient was also included in the profile. If the significance of the correlation coefficient was less than or equal to 0.05, then a significant linear relationship existed.

Table 14

The GEM Student Characteristics
Correlated With The Four Achievement Levels

Variable	Correlation Coefficient	Significance
Age	-.1968	.006
Years In Military	-.2366	.001
Rank	-.0111	.878
GRE-V	.1103	.197
GRE-Q	.2080	.014
GRE-Total	.2060	.015
GMAT	.1575	.285
Undergraduate GPA	.0422	.559
Months Since Undergraduate Degree	-.0216	.765
Months Since Math	.0160	.828
Math Credit Hours	.2118	.004
Math Undergraduate GPA	-.0230	.755
Number of Courses Transferred In	-.0379	.601

Differences Between Profiles

Three statistical techniques (t-test, analysis of variance, and the chi-squared test) were used to test for significant differences among the achievement levels, and the successful/unsuccessful student profiles. The results of the tests between the successful and unsuccessful profiles are presented first.

Differences Between Successful/Unsuccessful Profiles

The t-test was performed to test the continuous scale student characteristics for significant differences between the successful and unsuccessful student profiles. Table 15 shows the results of the t-tests. For this research project, if the two tailed probability for the t-value is less than or equal to 0.05, then there was a statistically significant difference between the successful and unsuccessful students for that student characteristic. The F-value and its probability were used to decermine if the two variances were equal or not. If the F-value probability was less than 0.05, then the separate variance estimate of t was used; otherwise, the pooled-variance estimate for t was used.

Table 15

t-Test Between Successful
And Unsuccessful AFIT GEM Students

Variable	F-Value	2-Tailed Prob.	t-Value	2-Tailed Prob.
Age	1.41	.539	-1.93	.055
Years In Military	1.46	.297	-2.56	.011
Undergraduate GPA	1.27	.699	-0.59	.554
Months Since Undergraduate Degree	3.20	.035	0.40	.696
GRE-V	1.15	.660	0.33	.745
GRE-Q	1.59	.247	1.72	.087
GRE-Total	1.37	.416	1.28	.204
GMAT	0.00	1.00	1.02	.313
Months Since Math	2.98	.059	0.50	.620
Math Credit Hours	1.48	.301	0.94	.351
Math Undergraduate GPA	1.09	.958	-1.36	.175
Number of Courses Transferred In	1.67	.343	0.38	.702
Engineering GPA	1.01	1.00	4.84	.000
Socio-Humanistic GPA	1.64	.391	3.49	.001
Analytical GPA	1.02	.862	4.09	.000
Cumulative AFIT GPA	1.54	.457	5.08	.000

The chi-squared test was used to test the categorical student characteristics for statistically significant differences. Table 16 shows the results of the chi-squared test. For this study, if the significance of the chi-squared value is less than or equal to 0.05, then a statistically significant difference exists between the successful and unsuccessful profiles for that characteristic.

The chi-squared test requires that the expected value for each category be at least one. Therefore, categories with expected values of less than one had to be eliminated or combined with another category. Since the expected value for a industrial engineering degree (type of undergraduate degree characteristic) was equal to zero, the students with an industrial engineering degree were placed into the "other" degree category. The expected value for Major and Lt. Colonel (rank characteristic), and engineering school (where advisor works characteristic) were also equal to zero, so these three categories were eliminated from the analysis since they could not reasonably be placed into another category.

Differences Among Achievement Levels

An analysis of variance was used to test the continuous scale characteristics for differences among the academic achievement levels.

Table 16

Chi-Squared Test Between Successful And Unsuccessful AFIT GEM Students

Variable	Chi-squared Value	Significance
Marital Status	.82139	.3648
Rank	1.21413	.5449
Source of Commission	2.20296	.3324
Rated Officer	.16316	.6863
Previous Grad. Work	.01357	.9073
Type of Undergraduate Degree	8.33008	.0802
Advisor Advised In Past 3 Years	6.40218	.0114
Advisor's Acad. Background	.09865	.7535
Where Advisor Works	10.09622	.0015
Type of Thesis	.22607	.8931
USAFA/ Other Colleges	.11534	.7341

Table 17

Analysis of the Variance
For Achievement Levels

Variable	F-Value	F-Sign.	Achievement Levels Between Which Differences Existed
Age	2.600	.0535	None
Years In Military	3.904	.0098	High - Unsuccessful
Undergraduate GPA	.612	.6080	None
Months Since Undergraduate Degree	.282	.8383	None
GRE-V	1.682	.1737	None
GRE-Q	2.594	.0552	None
GRE-Total	2.160	.0956	None
GMAT	.559	.6449	None
Months Since Math	.107	.9561	None
Math Credit Hours	3.350	.0202	High - Low
Math Undergraduate GPA	.816	.4866	None
Number of Courses Transferred In	.097	.9619	None
Engineering GPA	53.385	0.0	High - Unsuccessful Middle - Unsuccessful High - Low High - Middle Low - Middle

Table 17 (Continued)

Analysis of the Variance
For Achievement Levels

Variable	F-Value	F-Sign.	Achievement Levels Between Which Differences Existed
Socio-Humanistic GPA	96.475	0.0	High - Unsuccessful Middle - Unsuccessful High - Low High - Middle Low - Middle
Analytical GPA	145.492	0.0	High - Unsuccessful Middle - Unsuccessful High - Low High - Middle Low - Middle
Cumulative AFIT	327.466	0.0	High - Unsuccessful Middle - Unsuccessful High - Low High - Middle Low - Middle

Table 18

Chi-Squared Test Between
Achievement Levels

Variable	Chi-squared Value	Significance
Marital Status	1.96179	.5804
Rank	6.65983	.3535
Source of Commission	6.11546	.4104
Rated Officer	1.87825	.5981
Previous Grad. Work	.09034	.9930
Type of Undergraduate Degree	27.33672	.0069
Advisor Advised In Past 3 Years	17.04707	.0007
Advisor's Acad. Background	.34144	.9521
Where Advisor Works	17.07164	.0007
Type of Thesis	1.93632	.9255
USAFA/Other Colleges	7.24041	.0646

Table 17 presents the analysis of variance results. A Scheffe posteriori contrast test was also performed, and Table 17 shows which (if any) achievement levels were significantly different. For example, there was a significant difference between high successful and unsuccessful students for the years in the military characteristic.

The chi-squared test was used to test the categorical characteristics for differences among achievement levels. Table 18 presents the results of the chi-squared analysis. The three categories (Lt. Colonel, Major, and Engineering School) eliminated in the successful/unsuccessful analysis were also eliminated in this analysis. Also, the people with industrial engineering degrees had to be placed into the "other" engineering degree category.

Predictor Characteristics

Factor analysis and discriminant analysis were used to determine which student characteristics available to the AFIT Director of Admission would best predict success among applicants for the GEM program. Factor analysis was used to reduce the predictor characteristics to a smaller number of uncorrelated factors. These factors were then used in a discriminant analysis to determine which of the factors were most important in discriminating between the successful and

unsuccessful students. The factors most important in discriminating between the successful and unsuccessful students are the best factors for the AFIT Director of Admission to use to predict success among the applicants for the GEM program. Several sets of factor and discriminant analyses were performed, and in each case the discriminant functions only correctly classified approximately 60% of the students. In an attempt to obtain better discriminating functions, the individual characteristics were used in the discriminant analysis. These discriminant functions correctly classified approximately 80% of the students.

Discriminant analysis requires a data base to be complete (no blanks in the data) for each variable used in the analysis. Since all of the GEM students did not take both the GRE and the GMAT, it was impossible to perform just one discriminant analysis and still consider both the GRE and the GMAT characteristics. Therefore, two discriminant analyses were accomplished: one with the students who took the GRE and the other with the students who took the GMAT. Also, each category of the categorical predictor characteristics was treated as an individual variable in discriminant analysis.

The seven students who did not have calculus in their undergraduate programs were eliminated from these two discriminant analyses because they were missing the data

about mathematical background. Also, the 25 students who did not take either test were excluded from these two analyses. These exclusions left 135 students in the GRE discriminant analysis and 47 in the GMAT discriminant analysis. The results of the GRE and GMAT discriminant analyses were inconclusive because the GMAT and GRE characteristic did not enter the discriminant functions.

Since GMAT and GRE scores did not appear to be important variables for predicting success, a discriminant analysis was performed without these two characteristics. All of the students except the seven who did not have calculus were included in this analysis. Table 19 presents the standardized discriminant function coefficients for the characteristics that entered the function. These coefficients are presented as absolute values. The predictor characteristics with the largest coefficients are the most important variables in discriminating between the successful and unsuccessful students.

This discriminant function classified 87.17% of the students into the correct group (successful/unsuccessful). The classification table obtained from this analysis is presented in Table 20. This table shows in what group the function would have classified each student.

Table 19

Standardized Discriminant Function Coefficients

Characteristic	Discriminant Function Coefficients
Age	.81346
Years In Military	.75368
Source of Commission (Aviation Cadet)	.40578
Architectural Degree	.68048
"Other" Engineering Degree	.32249
Undergraduate GPA	.27484
Months Since Undergraduate Degree	.74616
Math Undergraduate GPA	.49904
Months Since Math	.59115

Table 20

Discriminant Analysis Classification

Actual Group		No. of Cases	Predictor Group Membership 1	2
Unsuccessful	1	11	8 72.7%	3 27.3%
Successful	2	176	21 11.9%	155 88.1%

Percent of Grouped Cases Correctly Classified = 87.17

For example, eight of the unsuccessful students were correctly classified into the unsuccessful group; in the other, three were incorrectly classified into the successful group.

This chapter presented the results of the various statistical tests used in this study. The next chapter will discuss these results in detail.

CHAPTER V

DISCUSSION OF RESULTS

This chapter provides a discussion of the results presented in Chapter IV. The discussion is presented in three parts: the student profiles, the differences between profiles, and the predictor characteristics.

Student Profiles

The six profiles (population, all successful, high successful, middle successful, low successful, and unsuccessful) developed by means and standard deviations, and frequencies provide useful information about the students who attended the GEM program. When looked at individually, these profiles are self-explanatory.

The correlation coefficients in the correlation profile show the strength of a linear relationship between the student characteristics and the achievement levels. The significant correlations are presented in Table 21.

The correlation coefficients for age and years in the military are negative, which means as the variable or student characteristic increases, the academic achievement level decreases.

Table 21

Significant Correlations Between Student Characteristics and the Four Achievement Levels

Variable	Correlation Coefficient	Significance
Age	-.1968	.006
Years In Military	-.2366	.001
GRE-Q	.2080	.014
GRE-Total	.2060	.015
Math Credit Hours	.2118	.004

For example, an older student would be expected to achieve a lower degree of success at AFIT then a younger student. Undergraduate math credit hours, GRE-Q, and GRE-Total had positive correlation coeffi. ents; therefore, as these characteristics increase, so does the degree of success at AFIT.

It is important to remember that these five student characteristics are the only significant "linear" related characteristics. The other characteristics could be significantly related to the achievement levels for some non-linear relationship.

Differences Between Profiles

Three statistical techniques (t-test, analysis of variance, and chi-squared test) were used to test for differences between profiles. To test for differences, the appropriate statistical technique had to be performed on each student characteristic in the profiles. For each characteristic tested, there was a five percent probability of a Type I error. The repeated use of a statistical technique in an experiment increases the experiment-wide probability of rejecting a true hypothesis. For example, the t-test was used to test the 16 continuous scale characteristics for significant differences between the successful and unsuccessful profiles. Sixteen t-tests were performed, each having a five percent probability of a Type I error; therefore, the experiment-wide error was equal to 0.56: P(reject Ho/ Ho true) = 1 - P(fail to reject Ho/ Ho true) = 1 - $(1 - 0.05)^{16}$ = 0.56. Since the experiment errors could not be controlled, it is important for the reader to realized there was a greater than five percent chance of rejecting at least one true hypothesis in the tests for differences between profiles.

Differences Between Successful/Unsuccessful Profiles

The t-test analysis found there were significant differences between the successful and unsuccessful students

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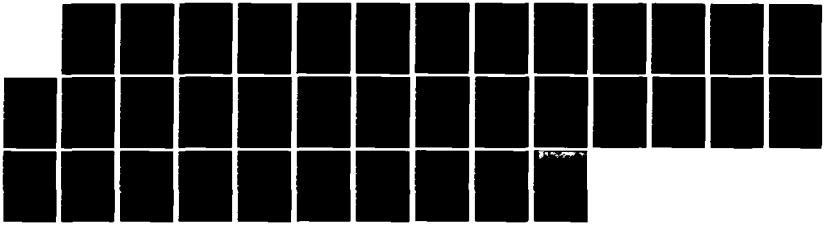

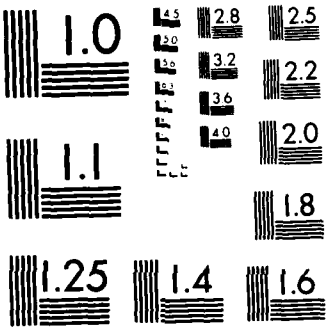

for five of the continuous scale student characteristics. The significant t-tests are presented in Table 22.

Table 22

Significant t-Tests Between Successful And Unsuccessful AFIT GEM Students

Variable	F-Value	2-Tailed Prob.	t-Value	2-Tailed Prob.
Years In Military	1.46	.297	-2.56	.011
Engineering GPA	1.01	1.00	4.84	.000
Socio-Humanistic GPA	1.64	.391	3.49	.001
Analytical GPA	1.02	.862	4.09	.000
Cumulative AFIT GPA	1.54	.457	5.08	.000

The four characteristics dealing with AFIT GPAs were highly significant, a finding which would be expected since cumulative AFIT GPA was used in defining success. All four AFIT GPAs for the successful students were significantly larger then those of the unsuccessful students. Also, unsuccessful students had significantly more years in the military then did the successful students. The unsuccessful students averaged 10.25 years in the military while the successful students averaged only 6.80 years. The years in the military characteristic is a puzzling result because the age

and time since undergraduate degree characteristics were not significant (although age was close, with a significance of 0.055). If both of these characteristics had been significant, then this result could have been attributed to academic staleness. Since no obvious reason exists for this result, further research would be required to determine why the time in the military characteristic is significant.

The chi-squared analysis showed that two of the thesis advisor characteristics were significantly different. These two significant categorical characteristics are presented in Table 23. The successful students had a larger percentage of advisors who had advised in the past three years than did the unsuccessful students. Also, the thesis advisors for the successful students were predominantly from the School of Systems and Logistics, while a majority of the unsuccessful students had advisors from outside the School of Systems and Logistics.

Possible reasons for these characteristics being significant are provided below. If an advisor has advised in the past 3 years, he should be knowledgeable about the current thesis procedures and thus be in a better position to insure a student completes his thesis on time.

Table 23

Significant Chi-Squared Tests Between
Successful And Unsuccessful AFIT GEM Students

Variable	Chi-squared Value	Significance
Advisor Advised In Past 3 Years	6.40218	.0114
Where Advisor Works	10.09622	.0015

The school an advisor works in is important because if an advisor works in the School of Systems and Logistics he should be more aware of how an advisee is progressing on his thesis with respect to the other students than would an advisor who works outside of the School of Systems and Logistics. Since the majority of the students who did not complete their thesis (unsuccessful students) had advisors outside the School of Systems and Logistics, it is possible these advisors were not aware that their advisees were behind schedule and would not finish a thesis on time.

Differences Among Achievement Levels

An analysis of variance established that six continuous scale characteristics were significantly different among the four academic achievement levels. Table 24 shows the six significant characteristics obtained from the analysis of variance.

Table 24

Significant Analysis of the Variance
Tests For Achievement Levels

Variable	F-Value	F-Sign.	Achievement Levels Between Which Differences Existed
Years In Military	3.904	.0098	High - Unsuccessful
Math Credit Hours	3.350	.0202	High - Low
Engineering GPA	53.385	0.0	High - Unsuccessful Middle - Unsuccessful High - Low High - Middle Low - Middle
Socio-Humanistic GPA	96.475	0.0	High - Unsuccessful Middle - Unsuccessful High - Low High - Middle Low - Middle
Analytical GPA	145.492	0.0	High - Unsuccessful Middle - Unsuccessful High - Low High - Middle Low - Middle
Cumulative AFIT GPA	327.466	0.0	High - Unsuccessful Middle - Unsuccessful High - Low High - Middle Low - Middle

The Scheffé posteriori contrast test shows which of the achievement levels are significantly different from each other. This analysis established a significant difference between the high successful and the unsuccessful students for years in the military. The high successful students had an average of 6.08 years in the military, while the unsuccessful students averaged 10.25 years. As discussed earlier, there is no obvious reason for this result.

A significant difference existed for the mathematical credit hour characteristic between the low and high successful students. The high successful students averaged 13.36 hours of mathematics while the low successful students averaged only 10.79 hours. One possible conclusion about this result is mathematical background (measured by mathematical credit hours) has a positive effect on performance at AFIT. Therefore, the more math a student had in his undergraduate program, the better he would do in the GEM program.

The four characteristics pertaining to AFIT GPA were significantly different among all of the achievement levels except for the low successful and unsuccessful levels. This result would be expected since cumulative AFIT GPAs were used to divide the students into the academic achievement levels.

Three categorical characteristics were found

significantly different. These three characteristics are presented in Table 25.

Table 25

Significant Chi-Squared Tests
Between Achievement Levels

Variable	Chi-squared Value	Significance
Type of Undergraduate Degree	27.33672	.0069
Advisor Advised In Past 3 Year	17.04707	.0007
Where Advisor Works	17.07164	.0007

The chi-squared analysis determines if there is a significant difference among the achievement levels and the categorical characteristics; however, it does not tell which of the categories is causing the significant difference. Further research beyond the scope of this study would be required to determine which of the categories are not independent of the achievement levels. The following is a subjective observation about which undergraduate degree might be causing the significant differences between achievement levels. The percentage of the total population of architects in the unsuccessful and low successful achievement levels is much higher (by at least 15%) then for

any of the other types of degrees. Therefore, one possible reason for the significant differences between the types of undergraduate degrees and the achievement levels is that the architects do not perform as well in the GEM program as do the other types of engineers.

The two explanations provided in the section for differences between successful and unsuccessful students with respect to the advisor characteristics (advisor advised in past 3 years, and where the advisor works) are also valid here for the differences among the achievement levels. Those two possible explanations were (1) that an advisor who had advised in the past 3 years is more knowledgeable of current thesis procedures and (2) that an advisor who works in the School of Systems and Logistics is more likely to be aware of an advisee's progress on his thesis then an advisor who works outside of the School of Systems and Logistics.

Predictor Characteristics

The discriminant analysis which used all of the individual characteristics except GRE and GMAT established that nine characteristics were important in discriminating between the successful and unsuccessful students. These characteristics are the best characteristics (based on historical data) for predicting success among the applicants

for the GEM program. The function created from these nine characteristics correctly classified 87.17% of the students. Table 26 presents the nine predictor characteristics in order of importance.

The standardized coefficients represent the relative contribution of the associated characteristic to the function. Therefore, the characteristics with the largest coefficients are the most useful in predicting success at AFIT. The sign of each coefficient designates whether the characteristic is making a positive or negative contribution to the function. Since the discriminant function coefficients are based on standardized data, the interpretation of the signs is beyond the scope of this study.

The aviation cadet (source of commission) characteristic is not a very useful characteristic since the population examined only had one student with this characteristic. Also, this source of commission has not been available for a long time, so the Director of Admission will probably not be seeing any more students with this source of commission.

The purpose of this study was to provide the AFIT Director of Admission and applicants for the GEM program with the best predictors for success at AFIT, not to set or recommend a policy for admission.

Table 26

Standardized Discriminant Function Coefficients

Characteristic	Discriminant Function Coefficients
Age	.81346
Years In Military	.75368
Months Since Undergraduate Degree	.74616
Architectural Degree	.68048
Months Since Math	.59115
Math Undergraduate GPA	.49904
Source of Commission (Aviation Cadet)	.40578
"Other" Engineering Degree	.32249
Undergraduate GPA	.27484

These nine student characteristics are the best predictors of success at AFIT based on the historical data used in this study. Both the AFIT Director of Admission and applicants for the GEM program should use these nine characteristics only as they feel appropriate to determine a person's chance of being successful at AFIT.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

This chapter states the conclusions that can be drawn from the results of this research and makes recommendations for future research. Conclusions about the three research objectives of this study will be presented first, followed by some general conclusions about GRE and GMAT scores. Recommendations for future research will be presented in the final section of this chapter.

Conclusions

Research Objective One

To identify the characteristics present in successful Graduate Engineering Management students which are not present or are present to a different degree in the unsuccessful students.

Seven student characteristics were found statistically different between the successful and unsuccessful students. These seven characteristics were years in the military, AFIT engineering GPA, AFIT socio-humanistic GPA, AFIT analytical GPA, cumulative AFIT GPA, advisor advised in past three years, and where the advisor worked. Of the seven significant characteristics, only the years in the military charac-

teristic is available to the AFIT Director of Admission to be used as a predictor characteristic. Therefore, based on the characteristics examined in this study, it can be concluded that no statistically significant difference (except for years in military) existed between the successful and unsuccessful students when they enter AFIT.

Thesis advisor characteristics appeared to be important in determining whether a student was successful or unsuccessful. Two of the three advisor characteristics examined in this study (advisor advised in past three years and where the advisor worked) were significantly different between the successful and unsuccessful students. Successful students had both a larger percentage of advisors from the School of Systems and Logistics, and a larger percentage of advisors who had advised in the past three years then did the unsuccessful students. This result could cause new students in the GEM program to pick only advisors who met these two criteria; however, that would be a mistake for the following three reasons. First, several of the successful students had advisors that did not meet this criteria. Therefore, some professors who would make very good advisors might not have been considered just because they did not meet these two criteria. Secondly, a few students had advisors who met the criteria but the students were still unsuccessful. Having an advisor who meets the criteria does not guarantee

that a student will be successful. Finally, the new (1982) School of Systems and Logistics policy regarding thesis advisors might eliminate these significant differences with respect to thesis advisors. The new policy requires a student who has an advisor that has not advised in the past three years to also have a reader. The reader must be a qualified advisor. Therefore, under this new thesis advisor policy, a student would always have someone working with him or her who has advised in the past three years.

As expected, a significant difference exists between the successful and unsuccessful students with respect to the four AFIT GPA characteristics (engineering GPA, socio-humanistic GPA, analytical GPA, and cumulative AFIT GPA); however, this result can be misleading. Cumulative AFIT GPAs were not the reason for students being unsuccessful, instead it was the fact that they did not complete a thesis which made them unsuccessful.

Research Objective Two

To identify the student characteristics for each of the academic achievement levels and determine whether or not there are differences among these levels.

This research project found statistically significant differences among the academic achievement levels for nine of the student characteristics. The nine significant

characteristics were years in military, undergraduate math credit hours, AFIT engineering GPA, AFIT socio-humanistic GPA, AFIT analytical GPA, cumulative AFIT GPA, type of undergraduate degree, advisor advised in past three years, and where the advisor worked.

Significant differences existed between the high successful and unsuccessful students for years in the military. The high successful students had an average of 6.08 years in the military while the unsuccessful students averaged 10.25 years. No obvious reason was found for this result. A significant difference was also found between the low and high successful students for mathematical credit hours. The high successful students had more mathematical credit hours then the low successful students; therefore, it is possible that mathematical background (measured by mathematical credit hours) has a positive effect on performance at AFIT.

Although, a significant difference was found among the achievement levels for undergraduate degree, further research beyond the scope of this study would be required to determine which of the degrees were not independent of the achievement levels. The conclusions presented earlier in this chapter about the thesis advisor characteristics are also valid for this research objective.

Research Objective Three

To identify which characteristic available to the AFIT Director of Admission best predict success among applicants for the GEM program.

Nine student characteristics were found to be good predictors of success at AFIT. The nine characteristics, in order of importance, were age, years in the military, months since undergraduate degree, architectural degree, months since math, math undergraduate GPA, source of commission (aviation cadet), "other" engineering degree, and undergraduate GPA. These predictor characteristics are the best predictors of success in the GEM program based on historical data; therefore, further research into which characteristics best predict success in AFIT graduate programs should be conducted before making any changes to current AFIT admission requirements.

GRE And GMAT

In this study, GRE and GMAT scores did not appear to be important in predicting success in the GEM program. Neither GRE nor GMAT scores entered into the discriminant analysis function; therefore, they were not important in discriminating between the successful and unsuccessful students. This result is contradictory to the findings in the literature review. Most of the studies in the literature review found

at least one of the GRE scores (GRE-V or GRE-Q) to be important variables for predicting success in graduate programs. The GRE and GMAT scores were also not significantly different among the academic achievement levels (although GRE-Q and GRE-Total were close with significances of 0.0552 and 0.0956, respectively). However, the correlation profile did show that GRE-Q and GRE-Total scores were significantly linearly related to the academic achievement levels. This result conflicts with the discriminant analysis and the results from the tests for differences between achievement levels. A possible cause of this conflict might be the manipulation of the database into the four academic achievement levels.

Recommendations For Future Research

The following is a list of recommendations for future research.

1. If this study proves to be of value to the AFIT Director of Admission and/or applications for the GEM program, then similar studies for each of the other graduate programs should be conducted to determine the best predictors of success and to determine the differences between the successful and unsuccessful students in each program.

2. A further study on the GEM students should be conducted in order to determine:

(a) Why the time in the military characteristic was significant in this study.

(b) Which of the undergraduate degrees examined in this study caused the significant differences among the achievement levels.

3. Unlike civilian graduate students, Air Force students do not necessarily have to apply for AFIT in order to be considered for an AFIT graduate program. An Air Force officer may be asked by Military Personnel Center if he or she desires to attend AFIT; therefore, the desire to attend AFIT (motivation) could be an important factor in a student's being successful at AFIT. A research study should be conducted to determine if a relationship exists between the desire to attend AFIT and success at AFIT.

4. A study looking at several AFIT graduate programs should be accomplished to determine the value of GRE and GMAT scores in predicting success at AFIT.

Summary

This research project concluded that statistically sig-

nificant differences did exist between successful and unsuccessful students in the GEM program. Nine student characteristics were also determined to be good predictors of success. This study provides the AFIT Director of Admission and applicants for the GEM program with information about the performance of previous GEM students, so they can better evaluate a future student's chance of being successful.

APPENDICES

APPENDIX A

DATA COLLECTION SHEET

DATA COLLECTION SHEET

_____ Data set number _____ AFIT CLASS
_____ Age _____ DOB _____ Date Entered AFIT
_____ Married (1- yes,0- no) _____ Date Suppose to Grad.
_____ Years in Military _____ TAFMSD
_____ Rank (0- civilian, 1- 2Lt, 2- 1Lt, 3- Capt, 4- Maj, 5- Lt. Col. 6- Foreign student)
_____ Source of Commission (1-USSA, 2-ROTC, 3-OTS, 4-Other)
_____ SOS (0- no, 1- residence, 2- correspondence)
_____ Rated Officer (1- yes, 0- no)
_____ GRE-V
_____ GRE-Q
_____ GMAT
_____ Undergraduate GPA
_____ Months Since UGD _____ UG Graduation Date
_____ Months Since Last Calculus Course _____ Date
_____ Math Credit Hours
_____ Math UG GPA
_____ UG College Name _____
_____ Previous Graduate Work (1- yes, 0- no)
_____ Type of UGD (1-Elect,2-Mech,3-Arch,4-Civil,5-Indust, 6-Other)
_____ Number of Courses Transferred In
Thesis Advisor _____
_____ Advised Thesis In Past 3 Years (1- yes, 0- no)
_____ Academic Background (2- PhD, 1- Masters, 0- BS)
_____ Field of Expertise _____
_____ Where Advisor Works (1- Eng, 2- Log, 3- CE, 4- Other)
_____ Type of Thesis (1- Pure CE, 2- Partial CE, 0- Non-CE)
Thesis # _____
_____ Finished Thesis (1- On time, 2- Late, 3- Never)
Date _____
_____ Graduated (1- On time, 2- Late, 3- Never)
Date _____
_____ Deficiency (1- None, 2- GPA, 3- Class(s), 4- Thesis, 5- 2&3, 6- 2,3,&4, 7- 3&4, 8- 2&4)
_____ AFIT GPA
_____ GPA for Applied Engineering Courses
_____ GPA for Socio-Humanistic Courses
_____ GPA for Analytical Courses

APPLIED ENG.			SOCIO-HUM.			ANALYTICAL		
Course	HG	QPT	Course	HG	QPT	Course	HG	QP

Course - Course Number
HG - Credit Hours and Letter Grade
QPT - Quality Points

APPENDIX B

DATABASE OF AFIT GEM STUDENTS

KEY TO DATABASE

Column (s)	Characteristic
1 - 2	Age of Student
3	Married (0-no, 1-yes)
4 - 5	Years In Military
6	Rank (1-2Lt, 2-1Lt, 3-Capt, 4-Maj, 5-Lt Col)
7	Source of Commission (1-USSA, 2-ROTC, 3-OTS, 4-Other)
8	SOS (0-no, 1-resid., 2-corresp., 9-unknown)
9	Rated Officer (0-no, 1-yes)
10 - 12	GRE-V Score
13 - 15	GRE-Q Score
16 - 18	GMAT Score
19 - 22	Undergraduate GPA
23 - 25	Months Since Undergraduate Degree
26 - 28	Months Since Math
29 - 30	Mathematical Credit Hours
31 - 34	Mathematical Undergraduate GPA
35 - 36	Undergraduate College Attended
37	Previous Graduate Work (0-no, 1-yes)
38	Undergraduate Degree (1-Elect, 2-Mech, 3-Arch, 4-Civil, 5-Ind, 6-Other)

Column (s)	Characteristic
39	Number of Courses Transferred In
40	Advised in Past 3 Years (0-no, 1-yes)
41	Advisor's Academic Background (2-Phd, 1-Masters, 0-BS)
42	Where Advisor Works (1-Eng, 2-Log, 3-CE, 4-Other)
43	Type of Thesis (1-Pure CE, 2-Partial CE, 3-Non CE)
44	Finished Thesis (1-On time, 2-Late, 3-Never)
45	Graduated (1-On time, 2-Late, 3-Never)
46	Deficiencies (1-None, 2-GPA, 3-Class(s), 4-Thesis)
47 - 50	AFIT Cumulative GPA
51 - 54	Applied Engineering GPA
55 - 58	Socio-Humanistic GPA
59 - 62	Analytical GPA

361173320500620 3.03071096092.000815113111113.463.603.603.00
220001200 3.09001042084.000304006201113.213.203.332.80
270043210540720 3.47060090123.283204001311113.693.603.504.00
230001200 3.23003025154.000904001311113.383.203.503.20
250001200 2.03001018153.143302001311113.433.403.333.40
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321113191 5712.33132156153.184006011211113.614.003.713.32
3310832905007205832.25096132182.447604011211113.814.003.833.68
261042190550660 2.18048078102.000106011211113.614.003.673.40
401175291 6542.30216234052.005202011211113.444.003.523.24
341113191550590 2.54132156122.300106011211113.584.003.523.44
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321123300490680 2.58115133061.502602011211113.744.003.723.60
271053191580690 2.63066097162.000104001221113.894.003.834.00
301073210 4892.40099116161.750204011211113.814.004.003.56
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311063391760760 2.57110128122.757202013221113.894.003.674.00
341124291460630 2.61151176122.250801011221113.774.003.503.84
391165191 6222.71194224092.334006011221113.254.003.003.12
381144210400570 1.96182182082.500302011211113.234.003.172.84
30106320170065068 33.12073116202.007305016221114.004.004.004.00
301073211 2.56086122133.002005016221113.934.004.003.86
27105310690810647 2.99062110093.330101013221113.603.503.223.79
291053290 4752.30086104161.500214011211113.814.003.623.88
371163390490670 2.48110134112.002612011211113.514.003.223.50
37113439151062052 12.37194203122.443212011211113.374.003.333.14
261053191540570 2.58062080163.000104016221113.614.003.563.50
29108312056077061 22.76096128162.000106011211113.814.003.723.76
291063310 4912.38086122103.327402011211113.894.003.833.89
311083200 5642.28102138072.502404012211113.694.003.523.60
301063201560620 2.52072078102.001501016211113.494.003.613.33
381205411 6503.40036084124.000702011221113.463.503.673.24
27105329048065048 92.35066085161.880204016211113.403.503.293.36
301063391 2.79089137204.007502016211113.554.003.393.54
321093210 4792.41110146101.503504012211113.614.003.673.40
291053390570710 3.13074116153.335502016211113.453.503.393.42
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23101220051066056 73.18026050083.505301001211113.894.003.674.00
37113429045057048 32.94164188093.670804001211113.343.503.173.04
361124290620640 2.48146173073.001104001221113.574.003.673.39
371103300720680 2.58134166121.837704001211113.804.003.673.84

APPENDIX C

UNDERGRADUATE COLLEGES

UNDERGRADUATE COLLEGES ATTENDED

BY GEM STUDENTS

College	Number of Students
Air Force Academy	31
Arizona State University	9
Arlington State College	1
Auburn University	3
Bradley University	2
California State University	3
Case Western University	3
Catholic University of America	1
Clarkson College of Technology	1
Clemson University	1
Colorado State University	1
Duke University	1
Fenn College	1
Florida Technological	1
Fresno State College	1
General Motors Institute	1
Geneva College	1
Georgia Tech.	1
Grove City College	2
Iowa State University	1
Kansas State University	5
Lafayette College	1
Leigh University	1
Louisiana Technological University	4
Lowell Technological College	1
Michigan Technological University	4
New Mexico State University	3
Newark College of Engineering	3
North Carolina State University	3
Northwestern University	1
Ohio State University	6
Oklahoma State University	4
Oregon State University	1
Penn Morton College	1
Penn State University	2
Purdue	1
Rutgers	1
San Jose State College	1
State University of New York	1
Sunny College	1
Texas A&M University	10
Texas Technological College	1
Texas Technological University	1

College	Number of Students
The Citadel	3
Tuffs University	2
Tulane University	1
Tuskegee Institute	2
University of Arkansas	2
University of California	1
University of Chattanooga	2
University of Detroit	1
University of Hawaii	1
University of Illinois	4
University of Kansas	1
University of Kentucky	1
University of Massachusetts	2
University of Miami	1
University of Missouri	4
University of Nebraska	1
University of New Hampshire	4
University of Pittsburg	1
University of Portland	1
University of Puerto Rico	1
University of South Alabama	1
University of South-West Louisiana	1
University of Tennessee	1
University of Texas	1
University of Virginia	1
University of Washington	2
University of Wisconsin	3
University of Wyoming	4
Utah State University	5
Virginia Military Institute	9
Virginia Polytechnical Institute	2
West Point	3
West Virginia University	2

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