THE RELATIONSHIP BETWEEN ADMISSIONS CREDENTIALS AND THE SUCCESS OF STUDENTS ADMITTED TO A PHYSICS DOCTORAL PROGRAM

by

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A dissertation submitted in partial fulfillment of the requirements
for the degree of Doctor of Education
in the Department of Educational Research, Technology, and Leadership
in the College of Education
at the University of Central Florida
Orlando, Florida

Spring Term
2007

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ABSTRACT

The researcher developed this study based on the Hardgrave, et al. (1993) statement that for a doctoral student, it was “more than just standardized scores, previous academic performance, and past work experience [that] ultimately affects whether the candidate will be successful in the program” (p. 261). This study examined both the subjective and quantifiable aspects of application materials to a physics doctoral program to explore potential relationships between the credentials presented in the application and the ultimate success of the admitted students. The researcher developed questions with the goals of addressing the problem of attrition in doctoral programs and gaining a better of understanding the information provided in students’ application packets. The researcher defined success as either enrolled four years after admission or attainment of the degree. This study examined the records of a population of students admitted to a physics doctoral program from the fall of 1997 to the fall of 2003 to determine their level of success as of August 2006. An exploratory analysis of the data provided answers to each of the research questions as well as an extensive understanding of the students admitted into the program during this time.

This study examined both admission credentials and constructs identified by past researchers. An evaluation of the data gathered in this research revealed no relationships between these and student success as previously defined. In 1974, Willingham stated simply, “the best way to improve selection of graduate students will be to develop

improved criteria for success" (p. 278). To this end, recommendations emerged regarding the decision-making process and suggestions for future research. This study was not developed to prove or disprove past research findings that predicted success from admissions information; rather, the researcher developed this study to explore each of the credentials that a student presents with his or her application packet, and to tell the story about the nuances of these credentials as they related to student success in a physics doctoral program.

ACKNOWLEDGMENTS

To consider whom to acknowledge is to consider all of the time and emotions that one experiences during the process of writing a dissertation and to reflect on who was by your side during those times. To the chair of my committee, Dr. Tubbs, thank you for your guidance and support, I could not have been as successful with this project had you not stood behind my vision for this research. To my committee members: Dr. Dziuban, Dr. Mucciolo, Dr. Pawlas, and Dr. Taylor, your feedback and support were priceless. Eduardo, I am glad to have worked with you as an advisor on my research, I am glad that you were willing to be a part of this and now know how lucky your students are to have you as an advisor. Dr. Pawlas, you have been a kind and extremely helpful mentor to me, the program benefits from your assistance. Dr. Taylor, your quick feedback was very calming and though provoking. And Chuck, jestem bardzo wdzięczny; I really enjoyed working with you.

In addition to my committee, I have to acknowledge Clark who was always by my side. Words on this page cannot express the gratitude I have for you. Your support was unconditional; your understanding was unlimited. To my mother and father, thank you for my life and how well you taught me to live; I hope I always make you proud. I have to acknowledge my friends, Cory, Courtney, Heidi, Joe, and everybody else who has had to put up with me for the last several years while I was off in dissertationland. To my colleagues at work: Mike, thanks for the inspiring story and the words of wisdom from your fellow graduate student: "Work harder! Work faster!" and thanks to Sabrina, who put up with my scatterbrained and overbooked days in the office.

Finally, I need to thank two very important people – my colleagues and my friends – Joanne Chive and Nancy Marshall. Our once-a-week "study sessions" were the most important part of this process. We held each other up, we laughed, we stressed, we did it. I really couldn't have done this without you.

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LIST OF ABBREVIATIONS AND ACRONYMS

AAU ....Association of American Universities

CGS ....Council of Graduate Schools

GPA..Grade Point Average

GRE..Graduate Records Examination

GRE-A ....Analytic Section of the GRE

GRE-V ....Verbal Reasoning Section of the GRE

GRE-Q ....Quantitative Reasoning Section of the GRE

NRC ....National Research Council

NSF ....National Science Foundation

Ph.D. ....Doctor of Philosophy

SEM ....Science, Engineering and Math

STEM..Science, Technology, Engineering and Math

TOEFL ....Test of English as a Foreign Language

CHAPTER ONE:
INTRODUCTION

With attrition rates currently averaging between 30% to 50% for students admitted into doctoral programs, retention of those students is an issue of concern within graduate education (Denecke, 2004; Golde, 2005). Of particular concern is the problem of doctoral non-completion among students who pursue the science, technology, engineering, and mathematics (STEM) disciplines (Council of Graduate Schools [CGS], 2006b; Denecke).

A question central to this issue was raised by Smallwood (2004), who asked,

> given the hundreds of millions of dollars poured into graduate study by institutions and the federal government, not to mention the years of the students' lives, should we accept a system in which half of the students don't make it? (para. 3)

Analyzing attrition studies, Smallwood determined that among doctoral programs, an evaluation and assessment of admission process could address this problem. The Council of Graduate Schools (2006b), in the *Ph.D. Completion Project*, identified the selection process as one of the six key factors "that can ultimately affect the likelihood that a particular student will complete a Ph.D. program" (Overview).

Determining which applicants are ultimately admitted into a graduate program requires a "conceptual approach to the selection process that accounts for the relationships among institution objectives, selection criteria, subjective ratings, admission decisions, student performance and faculty evaluations" (Vernon, 1996, p. 6) of the applicants. Committees primarily base their admission decisions on the information provided by the applicant. The Council of Graduate Schools recommended that this information include graduate records examination (GRE) scores, the undergraduate grade point average (GPA), letters of reference, and proof of English competency for non-native English speaking applicants (Diminnie, 1992; Walpole, Burton, Kanyi & Jackenthal, 2002). Other criteria evaluated as a part of an application and shown to relate to completion rates in graduate programs are a review of previous research experience (Diminnie), motivation toward completion of a degree (Ferrer de Valero, 2001), and commitment to completion of the degree (Tinto, 1975). Additionally, Tinto (1993) and Santiago and Einarson (1998) found that personal characteristics of the applicants, such as goal orientation (Tinto, 1993) and academic self-efficacy—or confidence toward completing the degree (Santiago & Einarson)—were predictive of a student's success in a doctoral program.

The application items provide the examination scores, past grades, cognitive indicators, and any other information that become the applicant's credentials that identify his or her unique and personal qualifications for graduate study. When tasked with conceptualizing the criteria upon which the final admission decision will be based, admission committees consider these application credentials along with other performance indicators, adopting "the underlying assumption … that knowledge can be inferred from representative examples of prior behaviors" (Hardgrave, Wilson & Walstrom, 1993, p. 661).

One anticipated result of a conscientious selection process is the admitted student will be successful. Willingham (1974) stated simply that "the best way to improve selection of graduate students will be to develop improved criteria for success" (p. 278). Adelman (1999), Bowen and Rudenstine (1992), and Hartnett and Willingham (1974) each identified degree completion, among other criteria, as a commonly accepted measure of success. Attiyeh (1999) conducted an extensive analysis of doctoral students' academic progress and identified a second measure of success. In a study of persistence, Attiyeh identified a criterion of success as students who continued to enroll, or persisted, in their fourth year of study. Bowen and Rudenstine provided additional support for a fourth year of enrollment as an indication of successful progress, noting that "some individuals in all time periods and all fields have completed their PhDs in three to four years" (p. 118). Synthesizing these findings, students who enrolled for at least four years had a greater chance of being successful in the program.

Purpose of Study

This study examined both the subjective and quantifiable aspects of application materials to a physics doctoral program to determine any relationships between the credentials presented in the application and the ultimate success of the admitted students. A number of additional factors characterize enrollment and management challenges when selecting students for admission into a doctoral research program. In the United States, these programs generally have a high number of international students (Brown, 2005; Lorden, 2003; Mulvey & Nicholson, 2005; Neuschatz & Mulvey, 2003); women and minorities are generally underrepresented (Association of American Universities [AAU], 1998; Brown; CGS, 2006b; Denecke, 2004); and they consume a large amount of funding from the academic institution (AAU; Golde, 2005). In addition to these characteristics, a program may also be under pressure from institutional goals to meet growth demands or from program needs to fill research and teaching positions; thereby depreciating an attempt to admit for success and focusing on admissions to meet demands. These characteristics serve only to complicate the selection process beyond the ideal of selecting for success.

Diminnie (1992) posited that understanding the characteristics presented by the applicant population, identifying the unique characteristics of the students admitted into a program, and identifying specific criteria that could enhance the selection process were necessary actions to determine if there were any relationships between the admission credentials and the success of admitted students. Analyzing the admission process may also provide a program with information for selecting applicants for success (Tinto, 1975). Evaluating admission credentials, and more specifically, reviewing the more subjective application items may provide insight into the student's intentions toward completing the degree. These ideas guided this study, which was to determine if any relationships existed between the information provided in the application packets of students admitted into a doctoral physics program and their level of success within that program.

Hardgrave, et al. (1993) stated that it was "more than just standardized scores, previous academic performance, and past work experience [that] ultimately affects whether the candidate will be successful in the program" (p. 261). Realizing this, this study attempted a more exploratory review of the graduate application credentials. This study reviewed a combination of the standard evaluative items (GRE test scores and past undergraduate GPAs) along with an application of recommendations provided by Adelman (1999). Adapting Adelman's conclusions about selection for undergraduate degree programs, this study theorized that a more thorough review of the academic resources the graduate applicants bring with them from their post-secondary education might provide important variables to consider as a part of the doctoral admission decision process. Further, the subjective criteria presented in the application may provide insights into the student's ultimate success (Baird, 1975; Diminnie, 1992; Hartnett & Willingham, 1980; Willingham, 1974).

Tinto (1993) stated that "…past research has, with few exceptions, failed to document how student experience come, over time, to shape the completion of the doctoral degree" (p. 235). However, the past experiences that students describe in their application to an advanced degree have been shown to relate to how successful they are with completing the degree (Diminnie, 1992; Geisinger, 2004; Tinto, 1975; Vernon, 1996). While several authors conducted research to determine how standardized admission information predicted success in a graduate program, this study focused on a single program's admission process to provide a more detailed analysis of application credentials and their relationship to the level of success that students were able to achieve in a physics doctoral degree program. For the purposes of this examination, this study defined success as both continued enrollment four years after admission and degree attainment.

Statement of Problem

Attrition in doctoral research programs is currently viewed as a national problem (Denecke, 2004; Golde, 2005), which is further complicated by the impact of lost time and resources of both the student and the institution into which he or she was admitted (AAU, 1998; Kerlin, 1995; Smallwood, 2004). In 2005, an initiative coordinated by the Council of Graduate Schools known as the *Ph.D. Completion Project* was created to "reduce rates of Ph.D. attrition and increase completion" (Denecke & Fraiser, 2005, p. 1). The Council of Graduate Schools (2006b) noted several challenges that face graduate education.

> [A]n increasing demand for workers with advanced training, particularly at the graduate level, an inadequate domestic talent pool, and a small representation of women and minorities graduating at all education levels are among some growing concerns over workforce issues that relate to the economic health and competitiveness of the United States. (CGS, Overview)

The debate about the size and strength of doctoral education has persisted for several decades. In 1991, Schapiro, O'Mally, and Litten, by way of a review of literature, found that the demand for academicians who received a doctorate level of education greatly outweighed the supply. The debate over an alleged shortage versus an oversupply of doctoral students in science and engineering continues with scholars and researchers acknowledging and disputing the claim (Butz, et al., 2003; Geiger, 1997; Nerad, 1997; Teitelbaum, 2003). Furthermore, past research appears to focus these debates primarily on the domestic talent pool. Regardless of an actual shortage or oversupply of doctoral students, admitting students who will be successful in the program may address the challenge of selecting students who fulfill specific needs of industry, of institutional goals, or of the program's goals. Admitting students who are not successful will only serve to complicate the issue further.

Attrition in doctoral programs occurs for a number of reasons. In one of the most comprehensive analyses of doctoral education published, Bowen and Rudenstine (1992) acknowledged that there were both voluntary and involuntary reasons for attrition. Students leave graduate school because either they made the decision to do such, or the program dismissed them for failure to meet requirements (Bowen & Rudenstine). The authors noted that identifying the specific reasons why a student no longer pursues a doctoral degree might encompass many and more complicated reasons that are not easily classified (Bowen & Rudenstine). Golde (1994, 2000) conducted in-depth interviews with students who left doctoral programs and found that a student's academic and social integration plays a significant part in the decision to leave. In a later study, Golde (2005) identified additional reasons for doctoral attrition that were based in a "mismatch between the student and the discipline…[, a] mismatch between the student and department" (p. 380), and a poor perception of the job market.

In addition to making better-informed admission decisions, understanding why students do not complete a program may also serve to reduce attrition rates in graduate programs, thus providing better justification for institutional investments. Discovering any relationships between the admission credentials presented in application items and the success of a student may provide information to develop better admission processes.

Research Questions

The researcher developed questions to provide a better understanding of the items that students submit in their application packets to a doctoral research program and how the information contained within those items may, or may not, reveal information that relates to the ultimate success of that student in the program. A selection committee bases admission decisions on the information found in the application packet. These packets include the details—the admission credentials—that are specific to and provide unique characteristics about the applicant. Specific credentials include items such as scores on the GRE verbal section, undergraduate and graduate GPAs, years of research in the field, the applicant’s description of his or her interest in the program, previous coursework completed, degrees earned from undergraduate or graduate institutions, and so forth. This study offered four research questions to explore the relationships between the credentials that applicants present and their ultimate level of success. These questions were the basis of an analysis of the admission credentials of students admitted into a physics doctoral program between the fall 1997 and the fall 2003 semesters.

1. What relationships, if any, can be found in admission credentials and students who are still enrolled in a physics doctoral program four years after admission?
2. What relationships, if any, can be found in admission credentials and a student's academic status in a physics doctoral program four years after admission?
3. What relationships, if any, can be found in admission credentials and students who complete a physics doctoral program?
4. What trends, if any, can be found in admission credentials and success in a physics doctoral program?

Significance of the Study

The Council of Graduate Schools (2004) pointed out "there is a dearth of data comparing alternative selection processes to completion outcomes" (p. 13). Past research has also shown that a thorough review of the items presented as a part of an application was the most useful tool in the admission process (Baird, 1975; Geisinger, 2004; Johnson, 2000; Vernon, 1996). At the institution studied, the results of this research may assist admission committees for doctoral programs with their evaluation of application credentials. More specifically, this study may also be used to aid graduate degree programs in the STEM disciplines with a process for deciding which admission credentials are most relevant to the discipline and how the decision-making process should take place. Information collected from the applications of students admitted into the physics doctoral degree program being studied, including student's research history, past work experience in the discipline, subjective characteristics about degree commitment, and scores on standardized tests, may also assist a physics program's selection committee in an evaluation of the criteria used to make future admission decisions. Furthermore, this study may reveal to admission committees a better method of reviewing materials and may provide support for consideration of more specific or different items to submit as a part of a doctoral application.

Definition of Terms

The following terms are included to provide clarification regarding their use in this study. The researcher developed those definitions not accompanied by a citation.

Academic Year: At the university studied, this consists of three semesters: summer, fall and spring, usually beginning in May with the start of the summer semester and ending in May of the next year at the end of the spring semester.

Admissions Credentials: The specific and unique information that an applicant provides about him or herself in the documents of the application packet.

Application Packet: The application packet consists of the set of items reviewed and evaluated by an admission committee for admission into a degree program. The graduate program, most often in combination with the graduate institution, determines which items are requested from the applicants. The admission committee selects these items to provide the them with the information they need to make a decision regarding the applicant. Most commonly used are the four application items recommended by the CGS

(Diminnie, 1992; Walpole et al., 2002), as well as the university application, a resume, and the statement of interest. These seven items are defined as follows:

Graduate Application: A graduate application is the standardized document completed by the applicant for admission into an institution of higher education. The application provides general biographic and demographic information as well as past academic information and other information required by the institution.

Graduate Records Examination (GRE): The Educational Testing Service (ETS) developed the GRE as a standardized test, used to assess a student's level of academic competence. Currently, the GRE consists of a general test that is comprised of two multiple-choice sections that test verbal and quantitative reasoning and a written analytic section, and a subject test that tests a student's level of competence in a specific discipline. Until 2003, the analytic reasoning section was multiple-choice. "The GRE General Test measures critical thinking, analytical writing, verbal reasoning, and quantitative reasoning skills that have been acquired over a long period of time…" (Educational Testing Service [ETS], 2006). The subject test of the GRE includes a multiple-choice examination in a specific discipline and is used "to determine the extent of the examinees' grasp of fundamental principles and their ability to apply these principles in the solution of problems" (ETS).

Letter of Reference: Individuals, including academicians, who know the applicant and can speak to his or her ability for success in a graduate program write letters of reference.

Resume: The resume provides a student generated summary of information about previous schools attended, the major field of study and degrees earned, previous work or research experience, and any other experiences or information that the applicant deems important for the admission committee (Vernon, 1996).

Statement of Interest: Also known as "statement of research" or "goal statement," the statement of interest is a letter written that accompanies the application to the program. This statement may include information about the applicant's intentions for pursuing the intended degree program, any experience with research or intended area of research, any plans or goals that the applicant has upon completion of the program, or how the degree is relevant to the applicant.

Transcripts: The transcript includes official information from an academic institution about courses completed, grades earned, and degrees earned.

Test of English as a Foreign Language (TOEFL): A standardized test often required of non-native English speakers as a part of the application process for institutions of higher education in the United States is the Test of English as a Foreign Language (TOEFL). This test is used to measure the "ability of non-native speakers of English to use and understand English as it is spoken, written, and heard in college and university settings" (ETS, 2006).

Attrition: Attrition is "the failure of a student who has been enrolled to continue her or his studies; that is, the student has dropped out of the program" (Issac, 1993, p. 15). The Council of Graduate Schools based on a National Science Foundation (NSF) definition, defines attrition as the proportion of an entering cohort that does not complete the program undertaken (CGS, 2006b).

Barron's *Profiles of American Colleges*: One type of ranking guide used to "derive data about college selectivity" (Zhang, 2005, p. 317) at the graduate and undergraduate level.

Carnegie Classifications: In 2005, the Carnegie Foundation determined the most current Carnegie Classifications. The Foundation based these classifications on degree conferral data that reported to the National Center for Education Statistics in 2004 and reported by the Integrated Postsecondary Education System.

Doctoral Applicant: An individual who is applying for admission into a doctoral degree-granting program is a doctoral applicant.

Degree Attainment: A student attains a degree when he or she completes of all the course, research, and examination requirements resulting in certification and a degree.

Doctoral Student: An individual who admitted into a doctoral degree-granting program.

Doctoral Candidate: A doctoral student who has completed the course requirements and has met any program-defined milestones that allows him or her to advance into the research stage of the doctoral program, also known as candidacy.

Grade Point Average (GPA): The calculation of grade points earned divided by the total grade points eligible. The institution examined in this study used a four-point grading scale.

Graduate Cohort: Students admitted into a doctoral program during an academic year are a part of a graduate cohort.

Graduate Student: A graduate student is a student who has gained admission into a post-secondary, graduate degree-seeking program after completion of at least a bachelor's level degree.

National Research Council (NRC): The NRC conducts an assessment of the "quality and characteristics of research-doctorate programs in the United States" (The National Academies, 2006, para. 2). The following direct these assessments:

> 1) the collection of quantitative data through questionnaires administered to institutions, programs, faculty, and admitted to candidacy students [sic] (in selected fields), 2) collection of program data on publications, citations, and dissertation keywords, and 3) the design and construction of program ratings using the collected data including quantitatively based estimates of program quality (The National Academies, para. 2).

National Science Foundation (NSF): "The National Science Foundation (NSF) is an independent federal agency created by Congress in 1950 'to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense'" (National Science Foundation, 2005).

Persistence: Persistence is described as enrollment "at the beginning of one academic year of study and also being enrolled at the beginning of the next academic year" (Attiyeh, 1999, p. 4). The Council of Graduate Schools, based on an NSF definition, defines persistence as progression through various stages at which attrition may occur (CGS, 2006b, Project Information).

Physics Doctoral Program: Hoffer, et al. (2005) in the *2004 Summary Report of the Doctorate Recipients from United States Universities* include the physics doctoral program in the category of "physical sciences" (p. 8). In this report, the physics sub-category included the following disciplines: "acoustics; chemical and atomic/molecular; elementary particle; biophysics; nuclear; optics; plasma and high-temperature; polymer; solid state and low-temperature; applied physics; physics, general; and physics, other" (p. 86).

Post-Secondary Institution: Any degree granting institution that includes a level of education beyond the K-12 or secondary (high school) level.

Retention: Based on the type of research conducted, conflicting definitions of retention exist in the literature. As defined by Adelman (1999), retention is students' ability to "complete degrees, no matter how many institutions they attend" (p. xi). The Council of Graduate Schools, based on an NSF definition, defines retention as "continued registration in the original doctoral program of choice" (CGS, 2006b, Project Information). The analysis of data in this study addressed retention from the latter definition.

Selection Criteria: The criteria by which an admission committee determines who it will admit into a graduate program. These criteria can include both objective and subjective measures.

Science, Technology, Engineering, and Mathematics (STEM) Programs: Physics doctoral programs are included in the STEM programs. This acronym is a way of classifying science, technology, engineering, and mathematics programs. The STEM programs are sometimes represented without the technology aspect and referred to as SEM.

Success: Success is defined as degree attainment (Hartnett & Willingham, 1980) or persistent enrollment four years after admission (Attiyeh, 1999).

Assumptions

For the purpose of this study, the following assumptions directed this analysis:

1. The application items submitted by the student include factual information.
2. The authors of the letters of reference will base these letters on actual knowledge of the applicants.
3. The statements made by the applicants in the statements of intent are thoughtful and factual.

Limitations and Delimitations

When reviewing the information in this study, the reader must also take the following limitations and delimitations into consideration:

1. This study includes a population of students admitted into one doctoral degree program at one institution and the findings cannot be generalized to a larger population.
2. The first students enrolled into this university in 1968, and the physics doctoral program started in 1989.
3. The students' records examined in this study included students who entered the physics doctoral program from both bachelors' and master's degrees.
4. The students whose records will be analyzed in this study were admitted in part based on high GRE scores or high bachelor's GPAs.
5. This study did not evaluate several factors that also influence admission decisions. These include the possibility that admission decisions are also made on the basis of a personal, undocumented recommendation, the impact of institutional pressures to meet enrollment or headcount growth goals, and the need for a program to admit students to fill teaching or research positions.

Organization of Remainder of the Study

This study will provide the following information: a review of literature, how researcher collected and analyzed the data, the results of these analyses, and any conclusions drawn from the analyses. Chapter Two serves as the review of literature and a guide to the study, explaining why this research was relevant and providing information and conclusions from previous studies that have been conducted on selection and admission, specifically focusing research on doctoral programs in the STEM disciplines. Chapter Three provides complete information about the methodology of data collection, including how the researcher gained access to the data, what was collected, and how the researcher conducted the statistical analyses. Chapter Four presents the results of the detailed data analyses, including a discussion of each of the research questions. The final chapter, Chapter Five, concludes this research, providing a discussion and interpretation of the results presented in the previous chapters. This final chapter also includes recommendations for future studies as well as implications for policy or practice related to the findings. This study also includes a complete list of references as well as several supplemental documents in the appendices, including requests and approvals for access to data and details regarding the coded data.

CHAPTER TWO:
LITERATURE REVIEW

Several researchers and organizations view the current attrition rate in doctoral research programs as a national problem (CGS, 2006b; Denecke, 2004; Golde, 2005; National Science Foundation (NSF), 1998). The study of graduate education and the study of attrition are important areas in need of further research (Baird, 1993; Denecke; NSF). Baird cited three reasons why the study of graduate education, including the impact of attrition, enrollment, and degree completion, was important. First, Baird found that there were a large number of students involved in graduate education. In the early 1990s, "more than one and a half million students enroll[ed] in graduate programs" (p. 3). The second reason was because graduate education "is the path to many critically important positions in our society since its programs form researchers, health professionals, teachers, managers, professors, and a great array of technical workers" (p. 3). Finally, Baird noted that the study of graduate education was important to gauge the impact of the financial costs on both the students and the institutions that enroll them.

> Graduate education is the most costly area of higher education. Because classes tend to be small and education often involves one-on-one interactions between professors and students and because the necessary equipment and facilities are often expensive, the cost per student is high. (Baird, p. 3)

Debra Stewart, current president of the Council of Graduate Schools, commented that "graduate education in the United States has been an enormously successful enterprise, serving the vital scientific, cultural, and economic needs of the nation and of the global community" (CGS, 2006a, para 1).

In 1998, the National Science Foundation (NSF) published the proceedings of a workshop on graduate student attrition. As a part of this workshop, researchers and moderators identified several reasons why graduate student attrition, especially in the STEM areas, was a national concern and identified three main reasons why research in the area of doctoral attrition was important (NSF, 1998). These reasons were: (a) the cost of higher education for the institution and the student, (b) the relevance of this sort of research to NSF's direct and indirect support of science-based fellowship, traineeships and research assistantships, and (c) NSF's "commitment to increase the participation and success rate of historically underrepresented groups in science and engineering education" (NSF, p. 1). In 2004, Denecke reiterated two of the reasons cited by NSF, explaining that there was a need to expand the domestic talent pool in these fields and echoing the fact that there was under-representation by women and minorities. Additionally, Denecke stated, "in the research workforce in general [graduate study in the STEM areas] are, and should be, priorities for universities, federal agencies, and corporate America" (p. 7).

According to several researchers, a primary concern with doctoral attrition was the lost return on investments of both time and resources supplied by the student, the program, and the institution into which the student was admitted (AAU, 1998; Kerlin, 1995; Smallwood, 2004). Kerlin stated that

> due to the tremendous costs of graduate education—to the students, their institutions, and the society—institutions and researchers have a profound obligation to improve understanding of the causes and consequences of high rates of doctoral student attrition…. (Doctoral attrition and degree progress section, para 2)

Universities make great investments for and by the students who pursue doctoral degrees. Each year, the federal government invests billions of dollars in the research and development contributions of doctoral students (AAU; Miyoshi, 2000). Students who decide to pursue a doctoral program also make a significant personal investment (Smallwood), and failure to complete the degree can result in economic and psychological impacts (NSF, 1998). Malone, Nelson, and Nelson (2004) noted that the expenses a doctoral program accumulates for the operation of the program and support of students, researchers, and faculty could become a burden to both the student and the institution. Malone et al. went further to state that attrition has very negative side effects "because the costs of program planning and administration, including student admission and advising, are not recoverable" (p. 37).

Given the costs associated with students attempting but not completing graduate degrees, several researchers conducted studies using graduate application information as a predictor of whether or not a student may be successful in the program (Abedi, 1991; Adelman, 1999; Baird, 1975, Hardgrave, Wilson, & Walstrom, 1993; House, 2000; Malone et al, 2004; Moore, 1997; Morrison & Morrison, 1995; Vernon, 1996; Walpole, Burton, Kanyi, & Jackenthal, 2002; Willingham, 1974). Malone et al. presented a common method of examining application criteria as predictors of success in graduate school. In their 2004 study, Malone et al. used both quantitative and qualitative factors to predict the success of students in a doctoral educational administration program. The independent variables of their study included the commonly recognized items of GRE and GPA as well as the Carnegie Classification of the preceding institution. In addition, the researchers conducted a follow-up survey of students who enrolled in the program to assess their perceptions about why they did or did not complete the program. The significant findings of this study showed that Carnegie Classification of the undergraduate institution, as well as master's degree grade point average (where available) were "useful in predicting doctoral degree completion" (Malone et al., p. 51). This study also provided support for the use of undergraduate GPA as an evaluative criterion to consider as a part of the admission process (Malone et al.). However, Malone et al. suggested that more research should include an analysis of non-quantitative factors to assess why students who meet the basic criteria for admission do not complete the program.

The remainder of this chapter presents a review of research and consists of three sections. The literature review pertains to the selection of successful students in graduate programs and the resulting impact that cultivating successful students has on enrollments and degree reports as well as institutional rankings. The first section presents an overview of the development of the doctoral graduate degree in physics, providing information about the growth of the program by way of enrollment numbers and degrees awarded as well as the program's current status within the U.S. The second section extensively addresses the selection of graduate students for success in a program. Several perspectives presented information about student success, including: (a) an evaluation of the items in a graduate application, (b) persistence and attrition, (c) degree attainment, and (d) academic motivation and self-efficacy. The final section of this review of literature reports on the impact that graduate student success has on national assessments, or as they are most commonly utilized, rankings, and how these assessments are linked to graduate student success.

Science-Based Doctoral Programs in the United States

A Doctor of Philosophy in physics was one of the first three doctorates awarded in the United States (Rosenberg, 1961). In 1859, Arthur Williams Wright enrolled into the Yale Scientific School, currently known as Yale University. Yale admitted this student based on his elite familial status and graduated in 1861 with the first doctorate in physics. One hundred years later, Bent (1962) commented that

> all basic research is directed by those who hold the Doctor's degree, and a large fraction of this research is performed in universities as a part of Ph.D. program. What a distinguished scholar could not possibly accomplish with his own hands becomes a program of great importance when supported by the efforts of many graduate students. (p. 17)

Specifically, Bent noted that the contributions of the physics doctorate were most important in research development and in the scientific discoveries and contributions following World War II. Physics doctoral students have contributed to "advances in applied physics [that] have produced technologies that have strengthened our nation economically and militarily, while improving quality of life through their tremendous contributions to areas such as healthcare and the internet" (Campbell, et al., p. 5, 2005).

Enrollment and Completion

In 2005, Mulvey and Nicholson reported that 185 institutions offered a doctorate of physics in the United States. Of these institutions, the total fall 2004 graduate student enrollment included 12,898 students. Of these students, half were international (6,468) and among all enrollments, 2,716 (21%) were completing their first year (Mulvey & Nicholson). In the U.S., the physics discipline is one of the areas that have realized an increase in the enrollment of international students. Neuschatz and Mulvey (2003) noted that since the 1970s, non-U.S. citizens enrolling in physics doctoral programs at U.S. institutions increased from about 20% of total enrollments in the 1970s to 55% in the 2000-2001 academic year. This particular increase signified the largest enrollment of non-U.S. citizens to date (Neuschatz & Mulvey). Since the World Trade Center and Pentagon attacks in September of 2001, institutional enrollments by international students into physics graduate programs has declined by about 10%, with the most frequently cited reason for this being the student's difficulties in obtaining an educational visa (Neuschatz & Mulvey). Yet even with this impact, a survey of physics graduate programs' Fall 2002 enrollments revealed that non-U.S. citizens still accounted for between 40 to 53% of first year enrollments (Neuschatz & Mulvey).

While international enrollments appear to have stabilized since 2001, doctoral programs in physics have seen an increase in the number of women and minorities that are receiving the degree. Across the U.S., in the academic year 2003-2004, international students accounted for 54% and females accounted for 22% of first-year enrollments into physics doctoral programs (Mulvey & Tesfaye, 2006). Of the 2003 national graduating class in physics doctoral programs, 18% were female (up from 13% in 2001) but the under-represented minorities of Hispanics and African Americans received only 2% of these degrees (Mulvey & Nicholson, 2005). Across all doctoral disciplines, the number of under-represented minorities was slightly higher (Mulvey & Nicholson). The most recent analysis of degrees earned by Hispanic and African Americans was in 2000, and compared to 1988, there has been a 1.5% increase in doctoral degrees award to Hispanics and a 2.4% increase in degrees awarded to African Americans (Barrera, 2003). While these increases do represent overall improvement in the diversity of students awarded doctoral degrees, when the information is taken into account with the national population growth, about 4 to 5% in the Hispanic population, these increases do not appear to be keeping up with the nation's demographics (Barrera).

Since 1958, the NSF has collected data on students who have completed doctoral programs in the U.S. These data group physics with astronomy and categorizes these disciplines in the general field of physical sciences. In the most recent NSF survey of earned doctorates, physics and astronomy doctoral programs reported a decline in the number of degrees awarded (Hoffer et al., 2005). In 1994, universities awarded 1,692 doctorates in the field of physics and astronomy, compared to only 1,351 in 2004 (Hoffer et. al).

Another statistic reported by the NSF was that the number of years to complete a doctorate degree has decreased (Hoffer et al., 2005). In 1994, the time to degree attainment since admission to a physics doctoral program was a median of 7.2 years, while in 2004, that time decreased by about six months to 6.7 years (Hoffer et. al). For the graduating class of 2000, a Task Force on Graduate Education in Physics (Campbell, et al., 2005) conducted a survey that found "63% of the students received their Ph.D.s in 6 or fewer years" (p. 8).

In a recent evaluation of doctoral time-to-degree and degree completion, Syverson (2004) noted "the shortened time to degree combined with the decrease in those still seeking the degree are consistent with an improving job situation for new Ph.D." (p. 3). Langer and Mulvey (2005) pointed out that for the 2003 graduating class, the job market was still difficult, citing that while the majority of students who graduated with a physics doctorate were able to find post-doctoral employment (69%), less than 30% were able to find a potentially permanent position.

In 1998, including all doctoral programs in science and engineering, 27,278 doctorates were awarded; however, in the eight years following, these numbers declined dramatically to the lowest point in 2002 with only 24,588 doctorates awarded (Hill, 2006). In 2004, Hill (2005) reported that the number of doctoral degrees in science and engineering increased to 26,275, but this was not an improving trend for all disciplines.

The physics doctoral program did not benefit from the 2002 increases experienced at the broader range. Since the academic year 1995-1996, the number of degrees awarded in physics decreased by about 20% from 1,480 in 1996 to 1,090 (Mulvey & Nicholson, 2005) or 1,186 (Hill, 2006) in 2004 depending on the source of information. A couple of sources provide promising news for growth in these programs. In a projective report for the National Center for Education Statistics, Hussar (2005) cited that continued overall growth in doctoral education in the U.S. is expected with a 19% increase in the number of doctoral degrees awarded in the 2013-2014 academic year from the 2002-2003 academic year. Additionally, Mulvey and Nicholson (2006) projected that in the physics discipline, "PhD production should start to register relatively steady increases for the next few years" (p. 12). This may be due in part to increasing graduate enrollments in physics that Hill (2005) noted have occurred since the fall of 2000.

Funding and Accountability

Federal and local agencies have provided support to doctoral research programs since the early 1900s and have continued to do such with a spike in funding during the 1960s (Kidd, 1973). At the start of the 1960s, states supported universities, providing them with about $900 million for research funding (Kidd). This support increased to about $3.0 billion by the end of that decade (Kidd). Over the last several years, doctoral research programs at public universities have received a substantial amount of federal funding by way of earmarked research dollars and "set-aside" (Payne, 2003, p. 17) program funding. The NSF initiated this set-aside funding as a reaction to the House

Committee on Science, Research, and Technology's concerns that only a few states were benefiting from NSF funding. As a result, in 1977 the NSF identified states that received low levels of funding and created a program whereby these states were given competitive research funding to stimulate research within the state's government, universities and/or private industry to "develop the infrastructure needed to be able to compete effectively" (p. 18) for federal funding.

In the 2003 fiscal year, the federal government provided over a billion dollars of funding to graduate students and post-doctorates (Pressl, 2003) accounting for over "60% of research funding received by research universities" (Payne, p. 13). These funds were largely provided by the National Institutes of Health (approximately 69%) followed by the National Science Foundation (approximately 15%) and the Department of Education (approximately 7%) (Pressl). Other funding sources that Pressl identified include the Department of Defense, the Environmental Protection Agency, the National Aeronautical and Space Agency, the Department of Agriculture, the Department of Energy, the State Department, and most recently, the Department of Homeland Security.

In the 1980s, governments and industry called the purpose of graduate education into question.

> …governments criticized the university for having neglected societal needs, and industry criticized the university for having trained their science and engineering doctorates too narrowly, and therefore producing researchers who were ineffective in the world outside academe. (Nerad, 1997. p. x)

These entities placed pressure on graduate institutions to produce more professionals in colleges and universities–labor markets anticipated "a severe shortage of doctorates"

(Nerad, p. ix)–and the purpose of graduate education was generally called into question. The 1983 Congressional Report, *A Nation at Risk* reflected the sentiments of this era and inspired a national accountability movement focused on clarifying the purpose of and improving the quality of graduate education. This accountability movement continued with universities required to account for their use of funds “in a way that responsibly reflects program quality, effectiveness, and efficiency” (Denecke, p. 1, 2003).

Selecting Successful Graduate Students

A report published by the Council of Graduate Schools in 2004 made the point that “better selection can result in higher completion rates” (p. 13). To these ends, research has shown that producing successful graduate students was dependent in part upon whom the program admitted (Hardgrave, et al., 1993; Moore, 1997; Shipman, Aloi, & Jones, 2003; Zhang, 2005).

To aid selection committees with the decision-making process, Geisinger (2004) formulated several questions that committees should ask themselves, and he based these questions on an institution’s understanding of the factors that affect admission decisions. Some of the factors Geisinger identified included the level of the “degree to be awarded, the nature of the discipline and the program, the maximum size of the program, and the funding for the program” (p. 1). In addition, the institution should keep in consideration the political and policy-related issues that influence and affect the purpose, mission, and goals of a graduate program (Geisinger). Geisinger developed seven general questions to ensure the success of a graduate student. The premises of these questions are as follows:

1. Are developed academic abilities important for success in the program?
2. What developed academic abilities are critical for success…?
3. Do applicants have the requisite skills and abilities to succeed?
4. How does the applicant compare to those who have succeeded in the past in the program and those who have not?
5. How do the applicants compare with those they are competing?
6. To what extent are external standards imposed on the program important?
7. How does the program define success in graduate study? (pp. 4-5)

For those making admission decisions, these questions provided a guide to assess and "develop indices deemed appropriate as part of the application process" (p. 5) and the information gathered can be used to "hypothesize the scores needed on those indices that parallel appropriate levels of skills" (p.5).

Vernon (1996) examined the processes used by those who make admission decisions and found that "decision makers need to choose performance measures with an understanding of how their choice affects the predictive value of various selection criteria and of their subjective ratings" (p. 18). In keeping with the CGS recommendations, Vernon found that the most commonly used performance measures were a student's GRE scores, undergraduate GPA, and letters of reference. Due to the limited predictive nature of these ratings and performance measures, Vernon found that they should not be treated as absolutes, because in doing so the reviewer "overlooks an important aspect of the issues involved in selection" (p. 12), namely the unique and personal characteristics of the applicant.

The process of deciding whom to admit entails the involvement and commitment of the admission committee members. Johnson (2000) conducted an extensive review of the admission criteria used by a selective and specialized graduate program and determined that a thorough evaluation of the application packet was important to gain a true assessment of a student's match with the program. This thorough evaluation would also provide insights to assess if the program could develop the student, benefit from the student's strengths, and provide the student with the greatest potential for success. Johnson found that the time spent conducting this review was "a wonderful innovation … as long as the program faculty are willing to review all of the applications" (p. 3). The review of application materials was a critical investment of time by the decision-makers, but with well-constructed admission criteria decided upon and implemented, "the time it takes to review the portfolios [was] well spent due to the insights gained regarding future students" (p. 3). To these ends, Johnson stated that the process of deciding whom to admit provided the committee and program faculty information about an applicant's strengths and accomplishments. The benefit of this thoughtful process included "retention …and insights that assist with guiding students toward meaningful graduate products and graduation" (p. 3).

Vernon (1996) examined the admission processes at the Rand Graduate School of Policy Studies for predictors of a variety of measures of student performance. Citing that admission committee members often "view the process as very time consuming and lack consensus about the appropriate criteria for admission" (p. iii), Vernon also supported the need for thoughtful evaluation of the specific admission criteria selected. Central to the research, Vernon explored the role that judgment plays in an admission committee's decision and extensively examined the difficulties with predicting success from different admission credentials. Vernon exemplified these difficulties by quoting Cronbach, who stated, "tests that predict one outcome will often not…predict another" (p. 34). A commonly used credential, GRE scores, may be of value in attempting to predict success in a graduate program, but researchers have found that these scores do not always have a significant predictive ability (Morrison & Morrison, 1995; Vernon). Vernon concluded that judgment does have value in the decision-making process; however, admission committees should work from clarified objectives, rational decision making processes, and enhanced evaluation policies to optimize the use of the committee's time.

To make admission decisions, Geisinger (2004) suggested an empirical approach to review "different kinds of developed academic abilities to determine which are most likely to yield successful students in the program" (p. 5). Geisinger explained that

> when an applicant presents a profile of developed academic abilities that is similar to students who have not succeeded in the past, a strong rationale is needed in terms of either why this applicant will succeed or why he or she should be accepted. (p.2)

An appropriate evaluation of past performance measures, such as standardized test scores and grade performance, was an important aspect of the decision-making process (Vernon, 1996). Adelman (1999) found that the most significant predictors of undergraduate degree attainment were not the predictive ability of the score on entrance exams or high school GPA or the quality of the institution the student attended. Instead, most significant was a combination of the intensity and quality of the preceding institution's curriculum—the most dominant predictor—the student's test scores, and the student's class ranking. At the undergraduate level, these "academic resources" (Adelman, p. 11) provided a stronger link to actual degree completion at the next level.

The Graduate Application

As the research discussed in this section has shown, good admission decisions are based in part on an understanding of effective us of the items in the graduate application. The items included in an application most often follow recommendations from the Council of Graduate Schools. These recommendations include scores on the graduate records examination (GRE), the undergraduate grade point average (GPA), letters of reference, and for non-native speakers, proof of English competency as most often found in TOEFL scores (Diminnie, 1992; Walpole, Burton, Kanyi & Jackenthal, 2002). Following the "the underlying assumption … that knowledge can be inferred from representative examples of prior behaviors" (Hardgrave et al., 1993, p. 661), the items that are included in a student's application packet should provide the information necessary to make an admission for success.

The first two items recommended—GRE scores and undergraduate GPA—provide quantitative information about the student's academic ability. However, Hardgrave et al. (1993) noted that when utilizing these sorts of evaluative criteria, the admission committee should be aware of the biases with respect to GRE scores and undergraduate GPAs actual ability to predict success in a graduate program. Reviewing past research, Hardgrave et al. identified several limitations with these scores' ability to predict success from admitted student's scores. These limitations are as follows:

1. That grade point averages are skewed, as they are generally averaged from between 2.0 and 3.5.
2. That the sample was normally biased, as students' scores analyzed in prediction studies were those who were accepted, enrolled and received grades.
3. That the sample was biased, as those who earned low test scores and had lower GPAs were generally not admitted.

Morrison and Morrison (1995) conducted a meta-analysis of research on the predictive validity of the GRE for student success. Using graduate grade point average as the criterion for success, the researchers concluded, "the quantitative and verbal components of the GRE possess minimal predictive validity" (p. 311). Using performance measures to predict success at the graduate level, Hardgrave et al. (1993), in an extensive study of the different predictive models, conducted an analysis of standardized test scores—in this particular case, the Graduate Management Admissions Test (GMAT) used for admission into graduate business programs—and the undergraduate GPA's ability to predict a student's first year average GPA. Using the traditional techniques found in continuous and categorical prediction models, as well as a neural networks approach, Hardgrave et al. found that "none of the methodologies, other than neural networks used as a continuous predictor model, could accurately predict" (p. 260) students whose first year GPA would be "high-risk," (p. 260) or students with a GPA below 3.0. Furthermore, they stated that even though the neural networks method could accurately predict the high-risk GPAs, it "did such a poor job in other categories, and overall, it probably is not the 'best' approach" (p. 260). The researchers found that using quantitative data such as standardized test scores and undergraduate GPAs do not provide a useful tool to predict how well or how poorly a student would perform at the graduate level (Hardgrave, et al.). Their conclusion was that it was

> more than just standardized scores, previous academic performance, and past work experience [that] ultimately affects whether the candidate will be successful in the program… [and that] a decision maker should work to expand the information included in the analysis above and beyond that which has been previously used." (p. 261)

These conclusions were supported in a later study by Hoffer and Gould (2000) who analyzed similar variables (GMAT scores and undergraduate GPAs) to predict a student academic performance via the student's "graduate quality points average" (Data and Method, para 2). Their findings produced a small difference between the predictive strength of the neural networks model over traditional models, but their conclusion was to suggest "that all institutions should seriously consider qualitative measures as well" (Conclusions, para 2); and further stated that future predictive models be built to incorporate more qualitative indicators (Hoffer & Gould).

In addition to test scores and GPAs, several researchers have also identified qualitative items such as an applicant's commitment, independence, and motivation as important criteria to consideration in the admission decision process (Ferrer de Valero, 2001; Girves & Wemmerus, 1988; Tinto, 1975). Hartnett and Willingham (1980) indicated that the letters of reference provide a type of rating scale that gives information about competencies of the applicant. These letters were generally "written by someone chosen by the student and therefore, presumably, by someone very familiar with the student's work and abilities" (Hartnett & Willingham, p. 287). Diminnie (1992) identified that "letters which can describe the applicant's background experiences, motivations, or capacity to succeed should be included" (p. 16) in an application packet. Walpole et al. (2002) also found that an admission committee can determine additional information about the applicant from letters of reference, including information pertaining to the applicant's capability for advanced graduate work, any indications about the quality of work previously attempted or of which the applicant was capable, the interpersonal skills of the applicant, and the applicant's initiative.

In addition to the CGS recommended application items detailed previously, research has found that other documents submitted as a part of an application packet also provide important insights into the academic ability and goal orientation of the applicant (Baird, 1975; Diminnie, 1992; Geisinger, 2004; Hartnett & Willingham, 1980; Johnson, 2000; Moore, 1997; Walpole, et al., 2002; Willingham, 1974). Hartnett and Willingham found "that self-reported accomplishments at one educational level…tend to predict similar accomplishments at a later educational level" (p. 286). Tinto (1993) noted, "events are continually shaped by past events and, to some degree, molded by the anticipation of future events" (p. 235). Information about "attitudes, values, motivation, determination, and creativity may play an important role in assessing an applicant's potential for success" (Diminnie, p. 23) and the applicant can provide all of this information within the content of the statement of interest (Diminnie). To these ends, a statement of interest, and in many cases a resume, provide additional information that an admission committee may find useful when evaluating a student's application packet. The statement of interest includes information about research orientation and academic and career goals and the resume outlines previous academic, research, and career accomplishments.

Diminnie (1992) pointed out that the statement of interest provides the applicant the opportunity to give details about a specific area of interest with respect to research. Gathering information from a number of graduate admission committees, Walpole et al. (2002) found useful indications of the applicant's fit between personal goals and the program offerings as well as his or her knowledge of the field and the program to which he or she applied in the statements of interest. Admission committees also used the statement of interest to identify if the applicant stated any definitive plans with respect to completion of the degree, namely any career goals.

An application packet that includes a resume provides specific details to the admission committee about past academic, research, and career accomplishments.

Vernon (1996) found that the resume provided relevant information about "schools attended by the applicant, his or her major field of study and previous work experience, as well as other experiences that the applicant deems important" (p. 17). Foremost, the resume provided information about how long the applicant has been involved with or gained experience with the stated employment. Admission committees can find additional information in the resume, including information about previous research in which the applicant has been involved and presentations or publications that the application may have authored or been apart (Geisinger, 2004; Hartnett & Willingham, 1980; Moore, 1997). Additionally, Baird (1975) found that students who were successful in graduate coursework received awards or recognitions for accomplishments in the field of science or held scientific assistantships.

Persistence and Attrition

Research often identifies those who persist to degree completion as successful graduate students. Defining and identifying doctoral persistence and attrition has been the foundation of several researchers' work (Attiyeh, 1999; Bowen & Rudenstine, 1992; Tinto, 1993). A given institution may describe attrition as the non-completion of a degree program and persistence as making satisfactory progress (Adelman, 1999). Complications in research about doctoral attrition have stemmed from what Adelman identified as the understanding that while it was the institution's responsibility to retain a student, it was the student who completed the degree regardless of the number of institutions attended; therefore when studying retention, information should be collected on the “student, not the institution” (p. xi). Within an institution, Decker (1973) indicated that because of the many purposes a doctoral program might serve, “some attrition will always be present due to the need to satisfy conflicting objectives and to imperfect admission screening procedures” (p. 136).

Attiyeh (1999) analyzed an extensive database of graduate student enrollment collected through the Association of American Universities/Association Graduate Schools Project for Research on Doctoral Education (*AGS Project*). The researcher used these data to determine the persistence of graduate students in doctoral programs during the first four years of graduate study as it related to a number of variables, including enrollment, academic aptitude, and academic achievement. Attiyeh defined persistence as enrollment from year to year. The *AGS Project* data collected information on a student until (a) the student dropped out, (b) the institution no longer provided data, or (c) the student reached the fourth year of study. The third of these criteria was used by the *AGS Project* because in analyzing fourth year’s data, “it is [sic] impossible to distinguish between students who drop out and those who graduate” (p. 4), and it was therefore assumed that “no students [would]…graduate with less than four years of study” (p. 4). Time-to-degree completion studies reinforced this assumption, finding that completion rates in the doctoral science disciplines were a result of 6.7 years of graduate coursework (Hoffer, et al., 2005). Further, Bowen & Rudenstine (1992) indicated that among all fields, some students complete the program by the fourth year.

Successful academic progress as identified by academic status was also essential for completion of a degree program. In a study attempting to provide validity to the GRE's ability to predict long-term success in graduate school, Burton and Wang (2005) noted that "degree attainment can be difficult to predict if it is essentially an oversimplified true/false question…since such a stark distinction poorly captures a complicated process" (p. 40). For this reason, researchers have used various stages in doctoral education to study academic progress (e.g. Tinto, 1993). Preceding Attiyeh's (1999) study of doctoral persistence, Bean (1985) cited continued enrollment as a sign of success and that grades earned indicated "a student's meeting the behavioral expectations of faculty members and usually academic achievements" (p. 38). As Bean found in a review of literature, the grades that a student earns are associated to attrition in that a student may choose to leave voluntarily or be removed as a result of grades. Further, Bean found that the grades made prior to admission were influential on the grades earned while in the program.

Examining other aspects of doctoral progression, or lack thereof, Bowen and Rudenstine (1992) identified three stages of attrition. The authors determined these by how many students entering a cohort were still enrolled "(1) before starting the second year of study… (2) after starting the second year but before completing all requirements for the PhD other than dissertation … [and] (3) after completing all requirements but the dissertation" (p. 111). Conversely, Girves and Wemmerus (1988) identified doctoral degree progression as three steps: "(1) courses beyond the master's are completed, (2) the general examination is completed admitting the student to doctoral candidacy, and (3) the doctoral degree is earned" (p. 166). In this research, admission into candidacy presented itself as an important stage of attrition or completion in a doctoral program.

Tinto (1993) postulated that persistence at the doctoral level would be related to the success of the student at later stages of career development, stating, "… a theory of doctoral persistence is but an early stage of a more general theory of professional career attainment, completing one's degree [is] but one step of many to success in those professions for which that degree applies" (p. 233). Synthesizing previous research on doctoral attrition, Tinto (1993) described three stages of persistence as transition, acquisition, and completion.

1. Transition: Occurring over the first year of study, this stage involved adjustment to graduate life and establishment of one's membership in the academic community. "Persistence at this early stage will also be influenced by the character of individual commitments to the goal of doctoral completion and by specific career goals" (Tinto, p. 236).
2. "Acquisition of knowledge and development of competencies deemed necessary for research" (p. 236): This stage results in candidacy, based in part on faculty judgment of the student's ability to complete the program. Further, the student's social and academic integration were "localized within the department" (p. 236).

3. Completion of the doctoral dissertation: In the previous stage, establishing relationships with many faculty was important and in this stage the relationship with the major advisor was the most critical and influential aspect of degree attainment.

To achieve the third stage, Tinto (1993) commented that social and academic aspects of academic study were very important to degree completion, stating "[t]he notion of social integration at the graduate level is more closely tied to that of academic integration than it is at the undergraduate level" (p. 232). Taking a closer look at academic integration, Smallwood (2004) cited C. M. Golde who provided the following insight in an article for the *Chronicle of Higher Education*:

> "One reason the sciences have lower attrition rates is that you are admitted to be in the Joe Schmoe lab," she says. You and Professor Schmoe "have spent some time getting to know each other and vet each other." That's quite different, she says, from a student who plans to study international labor economics but, after doing years of coursework, realizes that there is no one in the department for him to work with. (The selection factor, para. 6)

Golde (2000) identified that a student's integration into the academic program was key to his or her continued success in the program. The Task Force on Graduate Education in Physics (Campbell et al., 2005) conducted research that further supported this survey. As a part of their information collection, Campbell et al. found that graduate students concurred with the importance of building community with both fellow students and the faculty of the physics department.

Degree Attainment

In the 1980s, reduction in federal and state funding for graduate education resulted in educational institutions' wariness of increasing institutional funding to improve graduate production and as a result, required quantifiable output data (Nerad, 1997). "Time-to-degree and degree completion rates were obvious measures by which institutional effectiveness and efficiency could be evaluated" (Nerad, 1997, p. x) thus establishing these as important evaluative measures of a graduate program. With this in mind, degree completion was one anticipated result of a conscientious selection.

Hartnett and Willingham (1980) posited that degree completion resulting in graduation was "generally regarded as the single most important criterion of success" (p. 283). Decker (1973) also used the criteria of degree completion as a success measure, noting, "failure to achieve that objective represented a lack of success" (p. 130). Hartnett and Willingham went further to explain how other criteria for success, such as grades earned in coursework, time to complete the degree, completion of comprehensive examinations, and quality of the dissertation were also used by programs to measure how well a student performs (Hartnett & Willingham). For each criterion, they identified the corresponding limitations, and they cited two limitations with degree attainment. First, there were often multiple reasons why a student did not complete a degree program, "many of which have little or nothing to do with competence or academic ability" (p. 283) and were sometimes a result of a student's indecision about re-enrolling into courses. Second, the researchers cited that many institutions do not and are often unable to keep adequate records on who does not complete the program and why they do not complete the program (Hartnett & Willingham).

Examining the completion of the degree as it related to the entire process of degree attainment, Adelman (1999), in an extensive review of the literature, posited that degree attainment was not the only variable for success. He stated, "…there are very few national studies across the entire literature on persistence and attrition that hold the completion of a degree to be the sole and/or most prominent dependent variable." (p. 30) Adelman's point was that "completion transcends persistence" (p. 26). Basing his research on undergraduate degree attainment, Adelman noted the importance of degree completion as a final measure of success. His conclusion was that

> Without credit accumulation information, structural equations with 'persistence' as an outcome are very deceiving, and are apt to overstate the influence of affective factors as opposed to academic achievement….Unlike 'persistence,' the completion of a bachelor's degree is a censoring event, the culmination of years of preparation and effort. (p. 27)

Referring back to the academic resources that Adelman (1999) used to predict success at a later educational level, Zhang (2005) conducted an extensive analysis to determine if the quality of an undergraduate institution had any effect on a student's likelihood of completing a graduate degree. Zhang found that "graduating from high-quality undergraduate colleges was shown to increase the probability of graduate school enrollment and degree attainment" (p. 335). Adelman's work related to the graduate level, postulates that the intensity and quality of an undergraduate institution's curriculum "influences the educational outcomes of the following levels" (Zhang, p. 334).

Academic Motivation, Efficacy, and Concept

In a review of students' experiences with graduate school, Hartnett and Katz (1977) argued that the personal and social aspects of a graduate student are just as important as the research and training aspects, and that the selection of successful students should focus on the motivation and task-orientedness of the student as well as the other evaluative criteria. Santiago and Einarson (1998) surveyed new graduate students in engineering, chemistry, physics, and applied physics, asking about "previous education and work experience, entering enrollment information, expectations about their graduate programs and faculty interactions, anticipated outcomes, and demographic information" (p.168). This survey intended to explore the extent to which "student background characteristics are predictive of academic self-confidence and academic self-efficacy" (p. 167). Using Albert Bandura's research on self-efficacy and applying it to graduate students, Santiago and Einarson defined academic self-efficacy as "student confidence in the ability to complete program requirements" (Santiago & Einarson, p. 169). According to the authors, little research has focused "on the academic self-confidence of students in graduate science and engineering programs, and virtually none pertaining to academic self-efficacy" (p. 164).

In their study, Santiago and Einarson (1998) proposed that their findings might provide a method of early-identification of students who may be at risk for attrition. The concept that even among "intellectually homogeneous graduate students with records of successful prior academic performances" (p. 167) the outcomes of their academic performance may be very different provided a basis for their research. The researchers found that some of the most significant predictors of academic self-efficacy identified by students were undergraduate preparation and positive expectations about their interacting with graduate faculty (p. 178). One of the purposes of a study conducted by Bean (1985) was to "describe a conceptual model of student dropout that emphasizes student selection for … certain behaviors and attitudes that were expected to have a direct effect on attrition" (p. 36). Bean discovered that a student's commitment to an institution "seemed to be a function of a student's goal of completing college and the perceived utility … of attending the school" (p. 59), thus suggesting an important relationship between commitment and completion of the program.

The Santiago and Einarson (1998) study found a slight negative correlation between undergraduate GPA and academic self-efficacy. Considering that a high undergraduate GPA would not effect a student's perception that he or she would obtain the same in graduate course work, or vice versa, this negative correlation illustrated that it "matter[s] whether individuals believe they possess the abilities relevant to the new performance context" (p. 179). In addition to this conclusion, the researchers also found that gender was not a factor in academic self-efficacy.

Tinto (1993) noted that as the stages of doctoral persistence reflect academic progress, there was also significant social integration that occurred within the academic community. The doctoral student's "academic and social communities are localized within the department, [and] interactions within them tend to become intertwined" (p.

236). To these ends, the "individual commitments to the goal of doctoral completion and … specific career goals" (Zwick as cited in Tinto, p. 236) become a motivation of success. Having goals increases the possibility that a student will continue through the stages of persistence identified by Tinto (1993).

> …individuals whose educational and career goals are such as to require the completion of a doctorate–as is the case of a person wishing to become a university faculty member in the physical sciences–are more likely to finish than other persons whose goals are not so linked. (Tinto, 1993, p. 239)

Tinto (1993) found, however, that the "nature of external commitments (e.g. work and family responsibility) may also serve to decrease the rate of persistence" (p. 239).

Conducting an exploratory analysis of factors that affect student success in a graduate program, Ferrer de Valero (2001) noted that in interviews, admission officials cited that an applicant's commitment, motivation, and perseverance toward degree completion, as well as personal level of independence were factors that influenced a student's ability to be successful. Tinto (1993) found that "given the tie between graduate study at the doctoral level and the attainment of career goals," (p. 236) fit between a student's goals and the institutional offerings would influence his or her persistence in graduate school. He cited that there was a relationship between the student's specific goals and commitments and "the relevance of institutional programs to those goals" (p. 236). Referencing multiple sources, Tinto (1975) determined that the "higher the level of plans" that a student expressed with respect to educational or career goals the "more likely the individual [was] to remain in college" (p. 102).

Walpole et al. (2002) found several characteristics that admission personnel identified as related to a student's ultimate success in a graduate program. Based on this research, Burton and Wang (2005) identified the top five "qualities and skills of successful graduate students" (p. 7) as the following: (a) persistence, drive, motivation, enthusiasm, positive attitude; (b) amount and quality of research or work experience; (c) interpersonal skills/collegiality; (d) writing/communication; (e) personal and professional values, and (f) character, such as integrity, fairness, openness, honesty, trustworthiness, consistency. Reporting on admission committee's review of applicants' letters of reference and statements of interest, these were the most highly sought characteristics for a potential admission (Walpole et al., 2002). Additional factors leading to academic success were identified by Abedi (1991), whose review of literature found that critical thinking was "significantly correlated with a student's measure of success in graduate school" (p. 152). Additionally, Girves and Wemmerus (1988) found that "one's ability to do independent research may be [one of the] more important criteria for assessing academic success at the doctoral level than graded coursework" (p. 184).

Studying students' perceptions, House (2000) explored academic self-concept in an extensive survey of students enrolling into science, engineering, and mathematics undergraduate programs and found that "students with higher academic self-concept tended to earn higher first-year grades" (p. 213). House defined academic self-concept as the "sum of student's self-ratings of overall academic ability, drive to achieve, mathematical ability, writing ability, and self-confidence in intellectual ability" (p. 211).

In an earlier survey of students, Baird's (1975) research included an analysis of college senior's attitudes about graduate school. From this research, the author concluded that "consideration of graduate or professional school at an early age was most positively related to grades" (p. 943) in all areas researched, including biological and physical sciences. Additionally, Baird (1975) found that a student's expressed self-confidence about handling graduate academic work also related to the grades ultimately earned. Specifically related to the science-based field of study, the only achievement-based criteria that Baird (1975) found related to grades earned at the graduate level was earning an award in the field.

Graduate Rankings

Reviewing applicants for characteristics beyond the potential to complete the program will not only enhance the admission process, but, as Hardgrave et al. (1993) found, they may have an impact on a school's ranking. These researchers commented that "quality students may impact a school's reputation; admitting poor performing students could have an adverse effect" (pp. 249-50). Brooks (2005) also noted that indicators of program effectiveness often include the "proportion of students completing their intended degree program and the timeliness of completion" (p. 12). In the U.S., the two evaluation measures most often considered when discussing a graduate institutions reputation are the 1995 National Research Council (NRC) assessments of Research-Doctorate programs and the Carnegie Classifications (Ehrenberg & Hurst, 1996; Zhang, 2005).

Further scrutiny and increased qualifying of graduate education occurred in the 1980s with the establishment of the NRC reputational assessments. These assessments were, and are currently, based on scholars' perceptions of an institution's effectiveness for educating scholars and scientists at the doctoral level (Nerad, 1997; Toutkoushian, Dundar, & Becker, 1988) and have become an earmark for the success of a doctoral granting institution (Ehrenberg & Hurst, 1996). Brooks (2005) conducted an analysis of the present measures used to assess graduate program quality and identified the strengths and weaknesses of these measures. Regarding the 1995 NRC assessments, the researcher pointed out that this assessment and its perception as a "reputational survey" (p. 5), were used as a basis for rank-ordering graduate degree programs (Brooks).

The Carnegie Classifications were developed in 1971 by Clark Kerr to "support research in higher education by identifying categories of colleges and universities that would be 'homogeneous with respect to functions of the institutions and characteristics of students and faculty members'" (Carnegie Foundation for the Advancement of Teaching, 2001, p. vii). In part, these classifications were based on the number of degrees an institution awarded (Carnegie Foundation, 2001). The Carnegie Foundation did not intend these classifications to be used as rankings, but rather to provide research information that "institutions and individual doctoral programs [could] take…very seriously" (Nerad, 1997, p. xi) for funding and assessment purposes. The Carnegie Foundation (2005) insisted that numerous organizations and institutions still misuse these classifications by treating them strictly as methods of ranking a graduate institution's educational quality. Brooks (2005), however, cited research that found a significant relationship between the both NRC's reputational scores and the Carnegie Classifications of undergraduate institutions in an analysis of an institution's actual doctoral program success.

These measures of quality, and specifically the NRC rankings, are "used not only by potential graduate students making application and acceptance decisions, but by university administrators making resource allocation decisions" (Ehrenberg & Hurst, 1996, p. 1). Brooks further cited research that found the NRC assessments and the *U.S. News and World Report* rankings were also highly correlated. The use of these assessments as a sort of ranking were also found in the 2005 Task Force on Graduate Education in Physics survey, which used these assessments to qualify degree programs (Campbell et al., 2005). In this survey, graduate institutions were divided into the "top 30" (p. 17) and the "rest" (p. 17) based exclusively on "NRC rankings" (p. 17).

International rating systems have evolved over the years, but these ratings have their own criticisms, similar to the controversies that have evolved from U.S. ratings and classification systems (Bowden, 2000; Cohen, 1999; Liu & Cheng, 2005). The primary rating systems found among European, Asian, and Middle-Eastern countries were "league tables" (Bowden, p. 41) comprised of weighted combinations of performance indicators, including degree completion rates. These league tables are comparable to the university rankings published by the *U.S. News and World Report*, and like this report, university officials perceive these league tables as a source disagreement, primarily because of methodological issues (Bowden). Magazines, newspapers, or university guidebooks publish these tables (Bowden). Attempts at establishing an official league table in England began with the first set of performance indicators published by the Higher Education Funding Council for England (HEFCE) in 1999 (Bowden). The HEFC developed these performance indicators to review access, non-completion rates, outcomes, employment, and research output of students in higher education (HEFCE, n.d.). HEFCE specifically pointed out that the performance indicators are "not 'league tables', and do not attempt to compare all [higher education institutions] against a 'gold standard' or against each other" (HEFCE, n.d. para 1).

A variety of sources, including *Asiaweek* magazine, the *Daigaku Rankings*, and the *Academic Ranking of World Universities*, provide higher education rankings for institutions in the Eastern hemisphere (Cohen, 1999; Liu & Cheng, 2005; Yonezawa, Nakatsui, & Kobayashi, 2002). *Asiaweek* published its first rankings in 1997 and the most recent in 2000 (Cohen). The magazine compiled these rankings from completed surveys that asked about peer ratings, application and enrollment numbers, faculty profile, published research, and financial resources (Asiaweek, 2006). These rankings are not without controversy. Chinese universities refusing to participate (Plafker, 1999) presented methodological concerns, the breath of geography covered by the surveys made country and political comparisons difficult, the rankings were inconsistent from year to year, and the evaluative criteria were inconsistent across institutions (Cohen).

In Japan, published “selectivity scores” (Yonezawa et al., p. 374) are used by students and the public to find out the minimum entrance scores required by universities and have been widely used since the 1950s. In the 1990s, new types of university ranking were introduced, primarily the *Daigaku Rankings* to provide additional information to evaluate the quality of the institution as determined by number of publications, quotations of publications, amount of research funding provided by the Japanese government, and contributions to society (Yonezawa et al.). For the last of these criteria, another ranking, *Asahi Shimbun*, collected information primarily on article publication (Yonezawa et al.).

Shanghai Jiao Tong University developed an *Academic Ranking of World Universities* (ARWU) in 2001 based on “internationally comparable data” of academic and research performance (Liu & Cheng, 2005, p. 1). Several indicators provided the basis of information collected to produce these rankings. This included (a) if any member of the institution was awarded a Nobel Prize, a Fields Medal, or a Highly Cited Researcher recognition; (b) the number of articles published in *Nature* or *Science*; (c) the number of articles indexed by Science Citation Index-Expanded (SCIE) or Social Science Citation Index (SSCI); and (d) in the 2004 ranking the number of full-time equivalent academic staff (Liu & Cheng). Problems with the ARWU cited by the authors included criticisms similar to the NRC rankings or other classification systems in the U.S.; however, the ranking of international institutions also has difficulties caused by how an institution classifies itself—by name, type, or other criteria (Liu & Cheng). Furthermore, Sidel (1983) pointed out in an article describing the Chinese system of higher education that institutions in China have a number of strict entrance criteria for admission into graduate school and doctorate degrees are not comparable to those received at U.S. institutions. The current system of higher education in China is based on strict and very specific educational guidelines and is focused primarily on science and engineering as opposed to social sciences and humanities that prevailed during the Cultural Revolution and the pre-1976 era of higher education (Sidel).

The globalization of higher education presents a more competitive atmosphere among institutions for the potential applicant. As a tool used by applicants and stakeholders, rankings, rating systems, and classifications continue to present methodological and ideological controversy.

CHAPTER THREE:
METHODOLOGY

Selecting graduate students for admission into a program becomes an important process when it is intended to address the challenges faced by graduate education—not enough workers with advanced training, inadequate domestic talent pool, underrepresented women and minorities (CGS, 2006b; Denecke, 2004; Denecke & Fraiser, 2005; NSF, 1988). The time taken to complete the selection process becomes an important investment of time when attrition rates are so high in doctoral education (AAU, 1998; Baird, 1993; Johnson, 2000; Kerlin, 1995; Smallwood, 2004). Informed admission decisions and an understanding about those who do not complete a program may serve to reduce attrition rates. The application presents characteristics about the applicant analysis and relating these to the success of the student may reveal information useful in the development of better admission and retention processes, providing better success rates, and attracting quality applicants to the program.

Statement of Problem

The purpose of this study was to provide a contribution to the "dearth of data comparing alternative selection processes to completion outcomes" (CGS, 2004, p. 13) and to address the problem of attrition as it relates to the selection process in doctoral research programs. To explore the relationships between the credentials that an applicant presents and his or her ultimate level of success, the researcher developed the following questions:

1. What relationships, if any, can be found in admission credentials and students who are still enrolled in a physics doctoral program four years after admission?
2. What relationships, if any, can be found in admission credentials and a student's academic status in a physics doctoral program four years after admission?
3. What relationships, if any, can be found in admission credentials and students who complete a physics doctoral program?
4. What trends, if any, can be found in admission credentials and success in a physics doctoral program?

Setting and Study Population

A collection of information from the entering cohorts of students into one university's physics doctoral program from the fall of 1997 through the fall of 2003 provided the data analyzed in this study. The analysis included archived application items and archived academic records of students admitted and enrolled during this time at a large, public, metropolitan research institution in the southeastern United States. The collection of information was based in part on Bowen and Rudenstine's (1992) research, whereby information about student completion rates were tracked from the entering year so that the groups' successes could be determined as a "population" (p. 117). The application and academic records were obtained from the university's Division of Graduate Studies archived student records database (ViewStar), supplemented by archived documents held in the physics department's student files. Official scores and bachelor degree GPAs, upon which admission decisions were based, were obtained from the student records system (PeopleSoft) used by the university. The 2000 Carnegie Classification of this institution was Doctoral/Research Universities—Intensive and the 2005 Carnegie Classification of this institution was Comprehensive Doctoral (no medical/veterinary).

The researcher collected data from the fall 1997 to the fall 2003 for two reasons. First, the institution's Division of Graduate Studies reported that more complete archived information was available starting with the fall 1997 classes' admission. Second, the physics doctoral program admitted its first students in 1988, and the program was entering its tenth year with the start of data collection. The researcher assumed that after ten years of processing admissions, the program determined what application materials would be most useful for making admission decisions.

Data Collection

The researcher obtained permission to collect archived graduate student information from the vice provost and dean of the Division of Graduate Studies (Appendix A) and from the physics department's graduate program director (Appendix B). The researcher obtained formal approval and authorization to collect and analyze archived student application credentials and records information from the university's

Institutional Review Board (Appendix C). To protect the identities of the students and to comply with the federal confidentiality mandates of the state, a third party—a university official—initially collected all of the documents in this analysis and removed any personally identifiable information before the researcher received these items. The collection of data followed these steps:

1. The university official created packets containing the students' application items and academic records.
2. The university official redacted personally identifiable information from all of the items in the packets, including student names, identification numbers, names of individuals who wrote letters of reference, titles of presentations or publications, and any other information associated directly with the student.
3. The university official randomly coded the individual packets with a unique, non-personally identifying number.
4. The university official kept a spreadsheet of information that linking the code to the student so that if the physics department of the university graduate office found additional documents they could be associated with the correct student packet. The university official did not share this spreadsheet with the researcher.

No one under the age of 18 submitted an application to this program; therefore, this study included all of the applicant documents that met the criteria for analysis.

This study involved both quantitative and qualitative analyses. Transcripts and official score reports confirmed any scale data reported by the applicant. Additionally, the resume provided information about years of discipline-related employment and the number of awards or publications. For these, the number and where applicable the length of the occurrence were coded. An analysis of the nominal variables used the subjective, open-ended items of the application packet, which included the letters of reference, the statements of intent, and the subjective aspects of the resume. The researcher coded the types of constructs identified in the letters of reference and statement of interest. The following section explains this process in more detail and Appendix D provides details of the coding process.

University Application

The university's application provided demographic information regarding the applicant's age, gender, ethnicity, and citizenship. The researcher also used the application to confirm or cross-reference previous degree attainment. In many instances, the application included a personal statement and resume; however, the researcher considered these items separately.

Graduate Records Examination

Score reports from the Educational Testing Service or the university's student record system provided official Graduate Records Examination (GRE) scores. Information collected from the ETS score report included scores on the GRE general tests—verbal reasoning, quantitative reasoning, and analytic sections—as well as physics subject test scores, if available. In 2002, the analytic section of the GRE changed from a multiple-choice section (scored 200-800) to a written section (scored 0-6) (ETS, 2006). The GRE subject test in physics covered topics in the following areas, listed in declining order of the frequency of the topic: classical mechanics, electromagnetism, optics and wave phenomena, thermodynamics and statistical mechanics, quantum mechanics, atomic physics, special relativity, laboratory methods, and specialized topics (ETS, 2006). The scale on the subject test was from 200 to 990.

Test of English as a Foreign Language

The university's student record system or ETS provided official Test of English as a Foreign Language (TOEFL) scores. For the records included in this study, there were two versions of the TOEFL available to international applicants: computer-based and paper-based testing. The computer-based TOEFL measured English language proficiency in listening, structure, reading, and writing, and ETS scored this test on a scale of 0 to 300. The paper-based TOEFL measured listening comprehension, structure and written expression and reading comprehension and the scale on this test was from 310 to 677 (ETS, 2006). A score-comparison chart provided by ETS compared the two scores, and this analysis used the normalized computer-based scores.

Transcripts

This study used transcripts to provide information about past academic history and to determine where students attempted or earned degrees (Attiyeh, 1999; Walpole et al., 2002). The research collected information about the number of institutions attended and the number of degrees earned by the applicants. From the undergraduate transcripts, the researcher reported GPA for the first year of study and the final, institutional GPAs. Specific information collected about the month and year of entry into and exit from the institution, the name of the program pursued, the total number of hours completed at the institution, the type of degree sought and, if applicable, the month and year that the degree was earned provided additional information for analysis. For admission into a graduate program at the institution in question, the university calculated an admission GPA from the last 60 hours of a completed bachelor's degree. As a resource for international institutions, the *Wisconsin Directory of International Institutions* (Tackett, Onaga, & Niesen, 2006) provided supplemental information about international institutions' profiles and grading systems.

From any graduate transcripts, the researcher reported GPA for the first year of study and the final, institutional GPAs. The researcher collected specific information about the month and year of entry into and exit from the institution, the name of the program pursued, the total number of hours completed at the institution, the type of degree sought and, if applicable, the month and year that the degree was earned. When needed, the researcher also used the *Wisconsin Directory of International Institutions*

(Tackett, Onaga, & Niesen, 2006) as a resource for information about graduate institutions.

Decker (1973) stated that it was "reasonable to assume that a direct relationship exists between the quality of training a student receives as an undergraduate and his [sic] performance in a Ph.D. program" (p. 132). Attiyeh (1999) noted that collecting information about an institution's academic ranking is one way of assuming the institutions standard of "excellence and selectivity" (p. 15). To aid in this evaluation, Barron's *Profiles of American Colleges* provided rankings for undergraduate institutions in the United States and the 2005 Carnegie Classifications and the 1995 National Research Council (NRC) effectiveness and quality ratings provided information about graduate institutions. The NRC ratings were intended to represent the "scholarly quality of program faculty" (Goldberger, Maher, & Flattau, 1995, p. 124) and the "effectiveness of a program in education research scholars/scientists" (Goldberger, Maher, & Flattau, p. 124). International graduate institution rankings were more difficult to gather as the researcher found no reliable or validated institutional rankings. To provide some comparative information of international and domestic universities, the researcher compiled rating information from Shanghai Jiao Tong University's (2006) *2005 Academic Ranking of World Universities* for institutions included in this ranking. A group associated with the Institute of Higher Education at Shanghai Jiao Tong University in China (Shanghai Jiao Tong University, 2006) compiled these ranking and first published them in 2003.

Letters of Reference and Statement of Interest

Several criteria drawn from previous research provided the basis for the nominal information drawn from the letters of reference and statements of interest. Most application packets included three letters of reference, but ranged from between one and seven. The researcher reviewed any letter included in the application packet. Open-ended essays written in a format of the applicant's choosing primarily comprised the statement of interest.

The researcher conducted a review of the letters of reference and statement of interest to identify statements related to aspects of success identified in previous research. From the letters of reference and statements of interest, researchers identified comments related to commitment and motivation toward degree completion and/or stated fit between personal goals and academic offerings (Baird, 1975; Ferrer de Valero, 2001; Walpole et al., 2002); expressed career goals (Tinto, 1993); specified area of research interest (Diminnie, 1992); and previous research, awards, professional experience, or publications in the field (Baird; Girves & Wemmerus,1988). These researchers noted that the presence of these characteristics increased the likelihood of a student's success in a program. These characteristics provided the constructs identified in the letters of reference and statements of interest supplied by the students in this study. Table 1 identifies the specific constructs used in this study and documents that contains them. Appendix E provides an operational definition for each of these constructs.

Table 1:
Constructs Found in Letters of Reference and Statement of Interest

Item	Construct
Letters of reference	Background in Physics
	Commitment
	Critical thinking
	Independence
	Motivation
	Perseverance
	Self-confidence
Statement of interest	Fit between personal goals and institutional offerings
	Interest in teaching
	General research interest
	Goals (as a result of degree attainment)
	Specific research interest

Resume

A review of resume information was collected according to research conducted by Baird (1975), Hartnett and Willingham (1980) and Moore (1997) to identify relevant work experience and the number of years experience, past research, and the number of presentations or publications. Similar to the information gleaned from the statement of interest or letters of reference, the resume provided additional information about particular achievement-based criteria. Baird indicated that past achievements were related to grades earned in a graduate program. Furthermore, Hartnett and Willingham noted, "self-reported accomplishments at one educational level … tend to produce similar accomplishments at a later educational level" (p. 286). Finally, where Moore simply identified the presence or absence of prior work experience in research to predict academic performance from previous evaluative measures and information, this study attempted to account for the number of years of performance as well as the quantity of research published or awards earned. To these ends, the researcher coded the resume for the presence or absence of employment, research awards, or presentations or publications in physics or a related discipline.

Academic Records

The researcher collected information regarding degree progression and completion from the university's internal transcripts. To determine persistence as defined by Attiyeh (1999), the researcher reported the number of semesters completed and the cumulative GPA and academic status at the end of each academic year of enrollment. Following Abedi's (1991) findings, the researcher also reported the semester and year of degree attainment.

Data Analysis

To answer each of the research questions, the analyses conducted were exploratory in nature and examined the relationships between different application credentials that the student presented and the success of that student. This analysis did not carry any null hypotheses, as the researcher did not hypothesize any conclusions regarding outcomes. The evaluation of a student's success was determined in two ways. First, the researcher examined the academic records to determine if the admitted student continued enrollment in the program after four years. Second, the academic records provided information about attainment of the degree. These two success criteria (enrolled after 4 years or degree attainment) were the dependent variables. Binary logistic regressions provided initial analyses to determine the scale variables effects on the dependent variables. The researcher extrapolated these findings to include analyses related to the nominal constructs to determine any relationships between these constructs and the success variables. The Statistical Package for the Social Sciences (SPSS), Version 14.0 (SPSS, 2005) provided the platform for these analyses.

The application records examined included all students admitted during the fall 1997 semester through the fall 2003 semester. Of the 94 students offered admission, the researcher removed 30 (32%) students' records because they never enrolled into courses during the semester of admission, and removed 10 (11%) because they were data retrieval errors. (The records that were data errors consisted of students who either were not applicants to the physics doctorate program or they were not offered admission into the physics doctorate program between the fall 1997 and fall 2003 semesters.)

Of the original population, those analyzed included 54 applicants (57%) who enrolled in their semester of admission. This population consisted of seven cohort years, and of the total population, 40 (74%) were male and 14 (26%) were female. The domestic/international population consisted of 29 (54%) domestic and 25 (46%) international applicants. Applicant age at the time of admission ranged between 22 and 44 years of age, with a mean age of 28.24 and a median age of 27. Table 2 provides detailed information about the applicants for each of the seven cohorts analyzed.

Table 2:
Demographics of Students in Each Doctoral Cohort

	1997	1998	1999	2000	2001	2002	2003	N
Admitted and Enrolled	2	4	8	10	11	8	11	54
Male	2	2	7	6	9	5	9	40
Female	0	2	1	4	2	3	2	14
Dom	0	2	3	5	7	5	7	29
Int'l	2	2	5	5	4	3	4	25
Avg. Age	26	32	30	30	25	30	27	28
Ethnicity								
Asian	1	0	1	2	0	2	2	8
Black	0	0	0	0	2	1	1	4
Hispanic	0	0	0	0	1	0	0	1
White	1	3	4	6	8	5	6	33
Unknown	0	1	2	2	0	0	2	8

Summary

This chapter described the methods and procedures used to collect and analyze the data in this study. The population consisted of all students admitted and enrolled from the Fall 1997 to the Fall 2003 semester into a physics doctoral program at a large, public metropolitan research university in the southeastern United States (N = 54). The analyses conducted were exploratory in nature to examine any relationships between the application materials submitted by these applicants and their ultimate success as determined by status four years after admission or completion of the degree. The next chapter will provide details about the analyses conducted.

CHAPTER FOUR:
RESEARCH FINDINGS

Introduction

This chapter presents the findings from the data collected from the application documents and academic transcripts of students admitted and enrolled into a physics doctoral program. Initially, this chapter will describe the population, revealing information about the students in each cohort including identifying those who met the success criteria. Finally, the investigator presents an analysis of the completion rates, followed by a review of the findings for each research question. The Statistical Package for the Social Sciences, Version 14.0 (SPSS, 2005) provided the platform for data analysis.

Description of Population

Using the institutional database for the period of fall of 1997 to fall of 2003, the institution identified 94 students admitted into the physics doctoral program at a major metropolitan research university in the southeastern United States. Of this initial population, those 54 students that enrolled in the program served as the final cohort, providing data for the study though their applications and academic records. The student's application items and academic history provided 164 variables for consideration.

Table 3 provides a summary of information about the 54 students. This table shows the number of students who met the success criteria and information pertaining to degree progression or discontinuation. Of the 54 students who enrolled into a minimum of a first semester of coursework, 35 (65%) of these students admitted to candidacy. Regarding the success criterion, 22 (41%) students enrolled for at least four years and 18 (33%) students graduated with the doctorate. The physics program provided students the option of receiving a Master of Science (M.S.) degree in route to completing the doctorate program. Thirty (56%) of the 54 students received the M.S. in route, and nine (17%) of these students left the program after receiving this intermediate degree. At the institution in question, students not enrolled for three consecutive semesters changed to a discontinued status. Twenty-two (41%) of the students who admitted and enrolled were ultimately discontinued. Twenty of these students were previously in regular academic status, one student admitted to the program on a provisional basis, but the college dismissed this student after the first semester because of poor academic performance.

Table 3:
Success and Progress of Students in Each Doctoral Cohort

	1997	1998	1999	2000	2001	2002	2003	N	%
Admitted and enrolled	2	4	8	10	11	8	11	54	-
Success criteria									
Enrolled four years	1	2	6	3	9	1	0	22	41
Completed Ph.D.	2	2	5	3	2	4	0	18	33
Degree progression									
Obtained candidacy	2	3	6	5	9	6	3	35	65
Received M.S.	2	3	5	3	8	4	4	30	56
Discontinued	0	1	3	5	3	3	7	22	41

Success Criteria: Enrolled Four Years and Degree Attainment

The application documents contained 164 variables for analysis. Appendix D provides a list of all of the variables initially collected from the documents. A majority of the information derived from the application documents and academic transcripts was not present in every student's file or would not contribute to the results of this study. Therefore, this analysis isolated several variables as a core dataset. The researcher considered the remaining data separately to compliment findings or to provide more information about specific applicants. Table 4 presents the core dataset of the 22 nominal variables and 8 scale variables used to determine if there were any relationships between these items and the ultimate success of the student.

Table 4:
Nominal and Scale Variable Analyzed in this Study

Nominal variables	Scale variables
Demographics (age, race, gender, nationality)	Bachelor's first year GPA
Bachelor's degree discipline	Bachelor's final GPA
Attempted graduate coursework (prior to admission)	GRE-Verbal score
Attained graduate degree (prior to admission)	GRE-Quantitative score
Seven constructs from the letters of reference	GRE-Analytic score
Five constructs from the statement of interest	Admission GPA
Award or recognition in the discipline	Number of months to complete bachelor's
Publication or presentation in the discipline	GPA after first year of doctoral coursework
Employed in the discipline	

Several binary logistic regression analyses were conducted to identify any significant predictive relationships among the nominal and scale variables with the outcome measures. These models did not produce any significant predictive findings from either success criterion (enrolled four years or attained degree). After the researcher reviewed the information about degree progression, it was clear that the 2003 cohort—initially included because the researcher believed that some students might have graduated by the time of the study—presented a factor that limited the analyses. This cohort, with students who entered the program in the fall of 2003, has not had any students graduate nor any student enrolled for at least four years. The former of these success criteria was not surprising given the national average of 6.7 years to degree completion, and the latter of these success criteria was simply not possible because in August 2006, these students completed only three years. This being the case, the researcher conducted analyses to determine the success of the admitted students in the 1997 through 2002 cohorts, thus reducing the total number of cases in these analyses by 11 to 43 students. Although this decision did result in a smaller dataset, the detailed amount of information gathered from these applicants still provided a more valuable dataset for comparative analyses.

Reviewing graduation rates as a success measure, Bowen and Rudenstine (1992) recommended calculating minimum completion rates (MCR) and truncated completion rate (TCR) for the students who completed the degree. MCR refers to the "percentage of the entering cohort who have earned the doctorate *by a specified year*" (p. 106). Fortythree students who admitted an enrolled in 1997 to 2002 cohorts provided information for calculation of the MCR. By the August of 2006, 18 of these students attained the doctoral degrees, resulting in an MCR of 54%.

The “percentage of an entering cohort who earned the doctorate *within a specified number of years from entry to graduate study*” (Bowen & Rudenstine, 1992, p. 106) results in the TCR. According to Bowen and Rudenstine, “truncated completion rates are particularly useful when comparisons are being made between outcomes for recent cohorts … and outcomes for earlier cohorts” (pp. 106-107). The Task Force on Graduate Education in Physics (Campbell, et al., 2005) found that 63% of students completed the doctorate in physics in six or fewer years. These national data provided the specified number of years from entry into the graduate program. As of August 2006, the overall TCR was 50% for the cohorts evaluated (1997 through 2000). Both of the students admitted into the 1997 cohort completed the program and the 2000 cohort had a TCR of 30%. The data from the 2001 through 2003 cohorts were not included in the TCR computations as the students admitted in these cohorts have not had the opportunity enroll for 6 years. Table 5 provides details of the TCR rates for each cohort.

Table 5:
Admission, Completions, and Truncated Completion Rates for Each Doctoral Cohort

	1997	1998	1999	2000	2001	2002	2003
Admitted and enrolled	2	4	8	10	11	8	11
Attained degree	2	2	5	3	2	4	0
Number and percentage of truncated completion rates	2 (100%)	2 (50%)	4 (50%)	3 (30%)	-	-	-

Note. Students in the 2001 through 2003 cohorts were not included because degree completion as of August 2006 was the basis for TCR computations, and no students in these cohorts completed the degree by this date.

Completing several preliminary regression models without success, taking into account the small size of this population, and examining more closely the makeup of this student population, the researcher determined that reviewing the success criteria in combination, instead of separately, may provide a better opportunity for identifying important relationships. For these reasons, statistical analyses completed in the remainder of this study used a combined success criterion. This combined success criterion still provided information relevant to the purpose of the study that was to determine any relationships between admission credentials and success of physics doctoral students; therefore, the two success criteria (enrolled four years and degree attainment) were analyzed as a combined success criterion, “Enrolled Four Years or Attained Degree.”

Analysis of Research Questions

The research questions developed for this study provided the foundation for examining the admission credentials identified in the core dataset for any relationships to the combined success criterion. Because the success criterion was not applicable to the fall 2003 cohort, the researcher conducted statistical analyses on the fall 1997 to fall 2002 cohorts. Where relevant, the researcher included information about the fall 2003 cohort to provide more details about the analyses. Where information is presented in tables, most include information about the complete dataset (N = 54) followed by information about the fall 1997 to fall 2002 cohorts (N = 43). The analysis of each research question provided an understanding of the students admitted into the program through August of 2006. The remainder of this chapter follows a discussion of the research questions; however, with the decision to combine the success criteria, the researcher combined questions one and three resulting in the following questions:

1. What relationships, if any, can be found in admission credentials and enrollment in a physics doctoral program four years after admission or completion of the program?
2. What relationships, if any, can be found in admission credentials and a student's academic status in a physics doctoral program four years after admission?
3. What trends, if any, can be found in admission credentials and success in a physics doctoral program?

Admission Credentials and Enrollment after Four Years or Degree Attainment

Research Question #1: What relationships, if any, can be found in admission credentials and enrollment in a physics doctoral program four years after admission or completion of the program?

Using the combined success criterion and eliminating the 2003 cohort, the first statistical analysis conducted was an additional binary logistic regression using both the nominal and scale variables; however, as past regression models had not presented any significant results, so had this attempt. Furthermore, the small size of the dataset with the exclusion of the 2003 cohort would have produced an unstable model. As a result, the researcher gathered descriptive information to gain insights into the cohorts of physics doctoral applicants and conducted correlation analyses of the scale and nominal information available from their application materials.

Analysis of Scale Credentials

Adelman's (1999) findings implied that important variables relevant to the doctoral admission process were present in the academic resources that the applicant brought with them from their post-secondary education. The scale variables that included different undergraduate GPA, the separate GRE scores, the number of months to complete a bachelor's degree and the GPA after the first year of doctoral coursework were the first item reviewed for all of the cohorts.

The mean admission GPA was 3.25; however, the university assigned 19 of the 54 students a generic GPA of 3.00 because either the transcripts were from an international institution or they did not have a GPA calculated for admission. Including these generic 3.00 GPAs does not provide an accurate representation of bachelor's GPA earned by these cohorts. Therefore, the mean GPA was recalculated using the final bachelor's GPA, which resulted in $\bar{x} = 3.27$. For these cohorts, the mean scores on the GRE were as follows: verbal reasoning (GRE-V), $\bar{x} = 501.1$; quantitative reasoning (GRE-Q), $\bar{x} = 726.6$; and the analytic section (GRE-A), $\bar{x} = 579.2$. Table 6 provides a description of the GPAs that were calculated at different times during the bachelor's career and the separate GRE scores.

Table 6:
GRE Scores and Bachelor GPAs for Students Admitted and Enrolled in the Physics Doctoral Program

	First Year Bachelor's GPA	Final Bachelor's GPA	Admit GPA	GRE-V	GRE-Q	GRE-A
Mean	3.15	3.27	3.25	501.1	726.6	579.2
Median	3.30	3.29	3.00	520	740	620
Mode	3.00	3.10	3.00	600	750	720
Range	1.38-4.00	2.20-4.00	2.60-4.00	270-700	600-800	200-780

A comparison of the cohorts' undergraduate GPA to university data and GRE scores to the national data were completed. For admission into the graduate program, the required minimum GPA was a 3.00 in the last 60 hours of coursework completed for the bachelor's degree. Fifty-one of the 54 students had an admission GPA evaluated as a part of their application, and using 3.00 as the minimum, 44 students met this criterion.

To determine how the scores of the students analyzed in this study compared to the national data, data from the Educational Testing Service (ETS) (2006) identified scores that approach the 50th percentile. ETS recommends that programs examine and compare GRE scores based on the most recent percentile ranks. According to national data collected by the ETS between 2002 and 2005, 48% of test takers scored below a 460 on the GRE-V section and 47% scored below 600 on the GRE-Q section. Using these national percentile scores as a cut-off point, of the 53 students who submitted GRE verbal and quantitative scores as a part of their admission credentials; 36 students had a score at or above the national average for GRE-V (range = 270 to 700); and 53 students had scores at or above the national average for GRE-Q (range = 600 to 800).

For the GRE-A, according to data collected by ETS between 1999 and 2002[1], 50% of the test takers scored below 580. Using this national percentile score as a cutoff, of the 52 students who submitted analytic scores, 31 students had a score at or above the national average for GRE-A (range = 200 to 780). Three students took the test after the fall of 2002 and scored 4.5 or better proved competitive, and these student's scores were included in as above the national cutoff.

[1] In 2002, ETS revised the analytic reasoning section of the GRE from a multiple-choice test to an essay-based test. At that time, the scoring was also changed (see Appendix D).

Table 7 presents a summary of the score requirements achieved and the number of students who met the average GRE or minimum bachelor's GPA and the number and percentage of students who were successful in the program[2]. The total number represented in each category varies because not every student admitted had complete GRE records or had a bachelor's transcript evaluated for admission.

Table 7:
Number of Students Who Met the Average or Minimum Admission Criteria and the Success of Those Students Admitted Between Fall 1997 and Fall 2002

			Excluding 2003 cohort			
	All cohorts		1997 – 2002 cohorts		Successful	
	N	Met minimum	N	Met minimum	N	%*
Admit GPA (3.00)	51	44	40	33	24	73
GRE-V (460)	53	36	42	27	18	67
GRE-Q (600)	53	53	42	42	30	71
GRE-A (580)	52	31**	42	23	17	74

Note. Not every student provided GRE scores or had a transcript evaluated for admission
*Percentage was calculated from the number of students in the 1997-2002 cohorts who could meet the minimum and were successful.
**Three students completed the GRE-A in essay format, received a 4.5 or better, and were included.

[2] 2003 cohort excluded

Of those students who did not meet the GRE cut-off scores, calculations revealed the number of student who were below the cut-off and the number who were successful in the program. Seventeen students were below a 460 on the GRE-V, yet seven students who received this score attained the degree, and of the 21 students who scored below a 580 on the GRE-A, nine attained the degree.

In addition to the scores on the general GRE examination, 15 students also completed the GRE subject test in physics. According to data collected by ETS (2006), between 2002 and 2005, 12,427 took that test and 50% of these students scored a 680 or higher, with a range between 440 and 990. Using 680 as a cutoff, only four of the 15 students in the present study who sat for the physics subject test (range = 430 to 980) had a score better than this average. The program admitted these four students between the fall of 1997 and the fall of 2002, and among them, one enrolled for at least four years, three completed the degree and one discontinued for non-enrollment. Examining all of the cohorts, of the 15 students who completed the physics subject test, nine students either enrolled for four years or completed the degree (60%) and six students discontinued for non-enrollment.

Strong positive correlations were found between the GRE-A and GRE-V scores ($r = .577$, $p = .01$) and GRE-A and GRE-Q scores ($r = .544$, $p = .01$). These correlations account for 30% of the shared variance between the analytic and verbal score and 33% of the variance between the analytic and quantitative scores. The GPA obtained at the end of the bachelor's first year of study was significantly correlated with the final bachelor's

GPA (r = .826, p = .01) and with the admission GPA (r = .575, p = .01), and the final bachelor's GPA was significantly correlated with the admission GPA (r = .753, p = .01). These correlations show 67% of the shared variance between the first year's and final GPA from the bachelor's degree, 33% of the variance between the first year's GPA and admission GPA, and 57% of the variance between the final and admission GPA. The relationship between the number of months it took to complete a bachelor's degree was negatively correlated with the bachelor's first year GPA (r = -.393, p = .05). This significant, negative relationship presents a reliable indication that as the GPA at the completion of the first year of bachelor's coursework decreases the number of months it takes to complete the degree will increase. However, the correlation only accounts for 15% of the variance shared between these two variables. Another significant, negative correlation was found between the number of months to complete the bachelor's degree and the GPA at completion of the first year of doctoral coursework (r = -.310, p = .05), but only 9% of the variance between these two variables was shared between these two variables. Table 8 presents correlations of the scale variables from the information of students in cohorts 1997 through 2002.

Table 8:
Intercorrelations Among Scale Variables

	Correlation Coefficients							
	1	2	3	4	5	6	7	8
1 - GRE-Verbal	-							
2 - GRE-Quantitative	27	-						
3 - GRE-Analytic	58*	54*	-					
4 - Admit GPA	01	16	09	-				
5 - Bachelor's First Year (FY) GPA	22	-06	16	58*	-			
6 - Bachelor's Final GPA	-12	20	11	75*	83*	-		
7 - # Months to Complete Bachelor's	09	-06	-05	-32	-39*	-32	-	
8 - # Months Employed in Discipline	12	16	-08	-09	-32	-11	01	-
9 - FY GPA in Doctoral Program	-05	24	17	19	10	18	-31*	04

Note. Decimals are omitted.
* ($p \leq .05$)

Scatterplots presented in Figures 1 and 2 were included for the correlations between the number of months to complete the bachelor's degree as related to final bachelor's GPA and the GPA at the first year of doctoral coursework to provide a visual representation of these correlations. Analyses conducted on these correlations with the outliers removed resulted in these correlations not being significant. A discussion of these analyses follows.

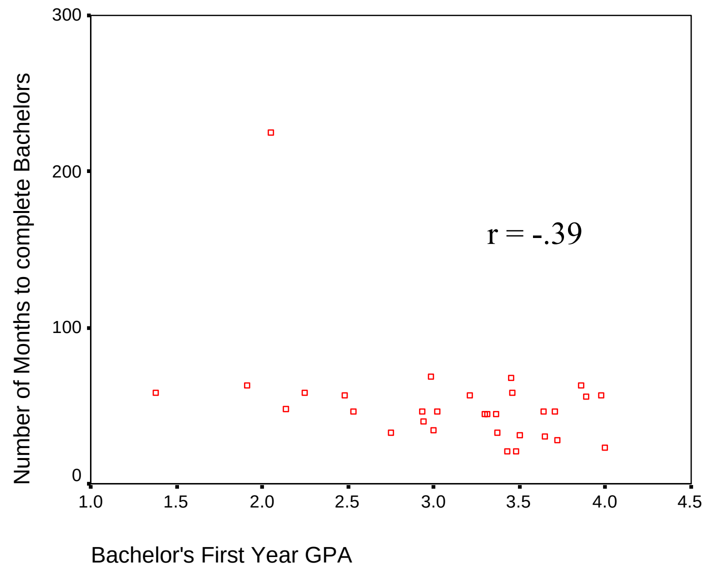


Figure 1:
Scatterplot of the Number of Months to Complete the Bachelor's Degree and Bachelor's First Year GPA

Figure 1 shows the 15% variation between the two scale variables indicated; however, the significant correlation (p = 05) may be misleading and an outlier appears to influence this correlation. When this correlation was recalculated excluding the outlier, this resulted in a non-significant correlation (r = -.312, p = .094).

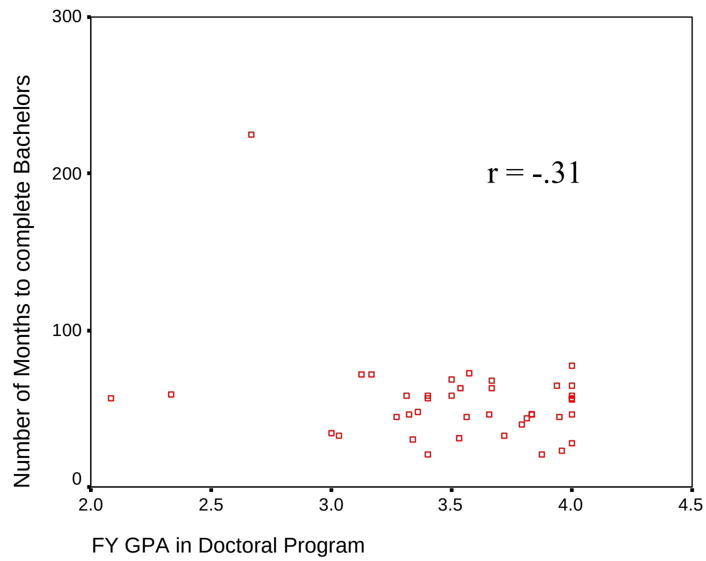


Figure 2:
Scatterplot of the Number of Months to Complete Bachelor's Degree and GPA after First Year of Doctoral Coursework

Figure 2 displays the 9% variation between the two scale variables indicated in the scatterplot. The presence of an outlier in this correlation may also be pulling the correlation to the negative results, and removing it may result in no significance relationship between these two variables. This significant correlation (p = .05) may be misleading and an outlier appears to influence this correlation. Recalculating these correlations with the outlier removed also resulted in a non-significant correlation (r = -.086, p = .598). This analysis also indicated that there was a 59% chance that this relationship was due to sampling error.

A test of significance in a one-way analysis of variance (ANOVA) determined the relationship of these scale variables to the combined success criterion. This resulted in only one significant finding, represented in Table 9. With a significance of p = .018, the ANOVA reported that the majority of those who were successful had a high GPA in their first year of graduate study (N = 30, $\bar{x}$ = 3.64), while those who were not successful had a lower first year GPA (N = 13, $\bar{x}$ = 3.30).

Table 9:
Analysis of Variance for Success Criterion and GPA for First Year of Doctoral Coursework

	$\bar{x}$	*SD*	*df*	*MS*	*F*	*p*
Success Criterion Not Met	3.30	0.580	1	1.048	6.097	0.018
Success Criterion Met	3.64	0.322	41	0.172		
Total	3.54	0.139	42			

Analysis of Nominal Credentials

Several correlation analyses determined if there were any relationships between the various qualitative information and credentials presented in the core dataset and the success criterion. Among the demographic information, no significant correlations with the success criterion were found with respect to the student's age (p = .77), sex (p = .32), ethnicity (p = .93), nationality (p = .82), or region of birth (p = .49). The majority of students admitted into this program earned a bachelor's degree in physics or a related field (N = 45, 83%), followed by a bachelor's degree in engineering or a related field (N = 5, 9%), chemistry or a related field (N = 3, 6%), and one student received a degree in psychology. The majority of students received their bachelor's degree as a result of coursework completed at only one institution (N = 35, 65%), and the remaining students attended two to four undergraduate institution (N = 19, 35.2%) to complete their coursework for a bachelor's degree. Where available, Barron's *Profiles of American Colleges* (2000) classified 30 of the 54 undergraduate institutions attended by the students in these cohorts. Of the 30 classifications, 16 (53%) institutions received very competitive or highly competitive rankings.

Chapter Three detailed information about several constructs that, if present among the application credentials, would provide information about students who had the highest likelihood of being successful in a graduate program. Of the 54 students' application and academic documents reviewed, 49 students included at least one letter of reference and 35 students included a statement of interest. Table 10 provides information about how many out of the total population exhibited each of the constructs as well as those who exhibited the constructs from the 1997 to 2002 cohorts and were successful.

Table 10:
Number of Students whose Letters of Reference or Statements of Interest Included Constructs and the Success of Those Students Admitted Between Fall 1997 and Fall 2002

		Excluding 2003 cohort		
	All cohorts	1997 – 2002 cohorts	Successful	
	N	N	N	%*
Letter of reference				
	49	41	28	68
Background	17	16	10	63
Commitment	30	27	20	74
Critical thinking	30	26	17	65
Independence	16	14	10	71
Motivation	26	23	13	57
Perseverance	30	25	15	60
Self confidence	15	13	7	54
Statement of interest				
	35	25	16	64
Fit	17	14	9	64
Goal	18	15	12	80
Research	12	8	6	75
Specific research	18	14	10	71
Teaching	7	5	2	40

Note. Not every student submitted letters of reference or statements of interest with the application; therefore, N will not equal the total number of applicants.
* Percentage was calculated from the number of students in the 1997-2002 cohorts whose documents included the construct and were successful.

Crosstabulation analyses determined if any of the constructs found in the letters of reference or personal statements bore any relationship to the combined success criterion. Of these constructs, the only one with any significant relationship to the success criterion was the motivation construct found in the letter of reference (p = .043). The model expected successful students to have higher indications of the motivation construct, yet the results found that students who were not successful actually had the higher incidence of the motivation construct. All of the remaining construct crosstabulations bore no significant relationship to the success criterion.

With the motivation variable, a test of significance in an ANOVA resulted in a significance of p = .044. This test also reported that the majority of those who exhibited the construct of motivation were not successful. This presented an inverse relationship between motivation and the ultimate success of the student, and analyses found that 77% of the students who were not successful had the motivation construct in their letters of reference. Table 11 displays this finding.

Table 11:
Analysis of Variance for Success Criterion and Motivation Construct

	$\bar{x}$	*SD*	*df*	*MS*	*F*	*p*
Success Criteria Not Met	0.77	0.439	1	1.023	4.44	.044
Success Criteria Met	0.43	0.504	41	0.236		
Total	0.53	0.505				

Several significant correlations presented from the correlation analyses between the constructs. From the letters of reference, the commitment construct and background were correlated at r = .303 (p = .05). Perseverance and teaching (r = .308, p = .05), fit and commitment (r = .330, p = .05), and research and self-confidence (r = .336, p = .05) all presented correlations between the constructs found in the letters of reference and the statements of interests. These correlations accounted for 9%, 10%, and 11% of the shared variance, respectively. From the statements of interest, the specific research construct was correlated with fit (r = .365, p = .05) and goal (r = .429, p = .01), and the goal construct was correlated with teaching (r = .343, p = .05). The specific research construct accounted for 13% of the variation in fit and 18% of the variation in the goal construct. Additionally, correlation between teaching and goal accounted for 11% of the variance shared between the two constructs. Table 12 presents a correlation matrix of these and the remaining correlations of the constructs.

Table 12:
Intercorrelations between Constructs

	Correlation coefficients										
	1	2	3	4	5	6	7	8	9	10	11
Letter constructs											
1 – Background	-										
2 – Commitment	-30*	-									
3 – Critical thinking	13	07	-								
4 – Independence	18	23	05	-							
5 – Motivation	-05	15	10	-05	-						
6 – Perseverance	-13	23	18	-01	15	-					
7 – Self confidence	-02	-02	01	-24	21	15	-				
Statement of interest constructs											
8 – Fit	08	33*	16	15	05	29	19	-			
9 – Goal	-06	16	-01	-09	19	03	05	22	-		
10 – Research	25	-13	-10	-21	-03	04	34*	18	03	-	
11 – Specific research	08	12	-15	-15	15	19	19	37*	43*	18	-
12 – Teaching	-13	-02	-00	-25	05	31*	08	-10	34*	20	06

Note. Decimals are omitted.
* ($p \leq .05$)

The letters of reference, resumes, or statements of interest provided information that Adelman (1999) referred to as academic resources. These academic resources include experiences that the applicant had prior to applying to the doctoral program. Adelman believed these resources presented important information an admission committee should consider when deciding whom to admit. Applying this to a doctoral research program, the resources taken into consideration would include the following: (a) any previous employment where the applicant utilized their knowledge of physics, (b) discipline-related awards or recognitions, and (c) presentations or publications associated with physics or a related disciplines research. Table 13 provides information about the academic resources identified in the cohort's application items and the number of successful students who presented each or a combination of these credentials[3].

[3] Excluding cohort 2003.

Table 13:
Number of Students With Previous Experience or Accomplishments and the Success of Those Students Admitted Between Fall 1997 and Fall 2002

		Excluding 2003 cohort		
	All cohorts	1997 – 2002 cohorts	Successful	
	(N = 54)	(N = 43)	N	%*
	Individual credential			
Employed	32	24	17	71
Award/recognition	20	15	8	53
Presentation/publication	17	16	10	63
	Multiple credentials			
Employed & award/recognition	14	10	6	60
Employed & presentation/publication	10	9	7	78
Award/recognition & presentation/publication	12	11	6	54
Employed, award/recognition & presentation/publication	7	6	4	9
	Any credential			
Employed, award/recognition, or presentation/publication	40	31	20	65

Note. *Percentage was calculated from the number of students in the 1997-2002 cohorts who exhibited the construct and were successful.

Of the 43 students admitted into the program between the fall of 1997 and the fall of 2002, 30 students either completed the program or enrolled for at least four years. Of these students, 17 had previous employment in the discipline, eight received some award or recognition in the discipline, and 10 students published or gave presentations in the discipline. Looking at the admission credentials in various combinations, no more than seven students who presented any given combination of discipline experience or accomplishments were successful; however, looking at the students who held any one of these credentials, 20 of the 30 students (67%) were successful in the doctoral program.

Twenty-seven (50%) of all the students in these cohorts completed some number of graduate hours prior to admission into the program and 23 (43%) earned a graduate degree prior to admission into the physics doctoral program. Calculations completed on the domestic/international distribution of these students tested the assumption that most students who earn an international degree also earn a graduate degree. These calculations revealed that 15 domestic students and 12 international students completed graduate coursework prior to admission into this doctoral program; and of these students 12 domestic and 11 international students earned a graduate degree prior to entering the physics doctoral program. These findings revealed that of the 27 students who attempted previous graduate coursework 23 (85%) completed a degree program prior to entry into the physics doctorate. National Research Council data on quality and effectiveness ratings of graduate programs were only available for eight graduate institutions that applicants attended. A program that has a faculty quality rating of 5 is considered “distinguished” (Goldberger, et al., 1995, p. 2) and a program with a effectiveness rating of 5 is considered “extremely effective” (Goldberger, et al., p. 3). None of the graduate institutions’ ratings exceeded 3.35 for faculty quality or 3.25 for program effectiveness ratings. Table 14 provides information about the number of students who completed graduate coursework or completed a graduate degree prior to admission into the physics doctorate in each cohort. Excluding the 11 students in the 2003 cohort (N = 43), of the 18 students who attained the physics doctorate, 11 (61%) earned a previous graduate degree.

Table 14:
Number of Students Who Completed Some Graduate Work or a Graduate Degree Prior to Admission and the Resulting Degree Attainment

	Cohorts							
	1997	1998	1999	2000	2001	2002	2003	N
Admitted and enrolled	2	4	8	10	11	8	11	54
Some graduate work prior to admission	1	1	5	6	3	6	5	27
Prior graduate degree	0	1	4	4	3	5	5	22
	Attained physics doctorate							
Some graduate work prior to admission	1	1	4	1	1	4	0	12
Prior graduate degree	0	1	3	2	1	4	0	11

Admission Credentials and Academic Status after Four Years

Research Question #2: What relationships, if any, can be found in admission credentials and a student's academic status in a physics doctoral program four years after admission?

The analyses found no significant relationships with respect to the academic status of admitted students after four years of enrollment. Twenty-two of the students in these cohorts enrolled for at least four years, and all were in good academic standing at their fourth year of enrollment. Only two of the 54 students were not in good academic standing, but neither of these students enrolled for four years and both discontinued from the program.

Reflecting on Hardgrave, Wilson and Walstrom's (1993) insight that knowledge about an applicant's performance can be "inferred from representative examples of prior behaviors" (p. 661) does not directly apply to this population. Of those students who could meet the success criteria (N = 43), 22 students were admitted based on GRE scores that were above the national percentile averages for GRE-V and GRE-Q, and these students had a GPA that was above the university minimum; however, 8 students were discontinued from the program for non-enrollment; one as a result of poor academic performance. Of all the applicants admitted and enrolled, 14 students discontinued, two for poor academic performance. The majority of those who discontinued (57%) exceeded all of the admission criteria. Taking a more in-depth look at the two students who were discontinued due to poor academic performance, student A, who was dismissed and discontinued, was admitted with a GRE-V of 560, a GRE-Q of 750 and a GRE-A of 700.

Each of this student's GRE scores was above the national percentile averages. Student A's application packet included letters of reference, a statement of interest, and a resume, and the student's letters of reference and statement of interest had evidence of several constructs, including a fit between the student's educational wants and the institutions offerings. This student also received an award in the physics discipline. The program admitted Student B under restrictions due to low admission scores (the GRE scores and admission GPA were below university minimums) and the student discontinued after the first semester. Student B admission GRE-V was 410, the GRE-Q was 600 (below and at the national percentile average, respectively), no GRE-A was available, and the admission GPA was a generic calculation. This student's application packet also lacked letters of reference, a statement of interest, and a resume.

In the program in question, students are usually admitted to candidacy in the second year of the program. Of those who were in good academic standing throughout their enrollment, 35 of the 54 students (65%) obtained candidacy. These students admitted into candidacy in a time that ranged from their first semester of enrollment to three and a half years (almost eleven semesters) after they enrolled in the program. It took these students an average of 1.79 years (five semesters) to achieve candidacy, with a mode of two years or six semesters. Eighteen (56%) of the 32 students who could meet the success criteria earned the degree after admission to candidacy.

Trends among Admissions Credentials and Success

Research Question #3: What trends, if any, can be found in admission credentials and success in a physics doctoral program?

The exploration of data resulted in several trends. The physics doctoral program increased the number of students admitted each year, with the exception of the 2002 cohort. Truncated completion rates revealed that this physics doctoral program had attrition rates and completion rates that slightly better than and comparable to the national averages. By August 2006, the calculations presented an attrition rate of 41% (22 of the 53 students discontinued from the program) and a truncated completion rate of 50% (according to Bowen & Rudenstine, 1992). Further, the 35 of the 54 students enrolled in the program achieved candidacy (65%). Of the students who could meet the success criterion, 32 of these 43 students (74%) admitted to candidacy; however, meeting this status did not result in completion of the degree as only 18 (42%) of those who reached candidacy completed the degree. Figure 3 shows the number of students admitted and enrolled into the program with each cohort, the number admitted to candidacy, and the completion rates as of August 2006.

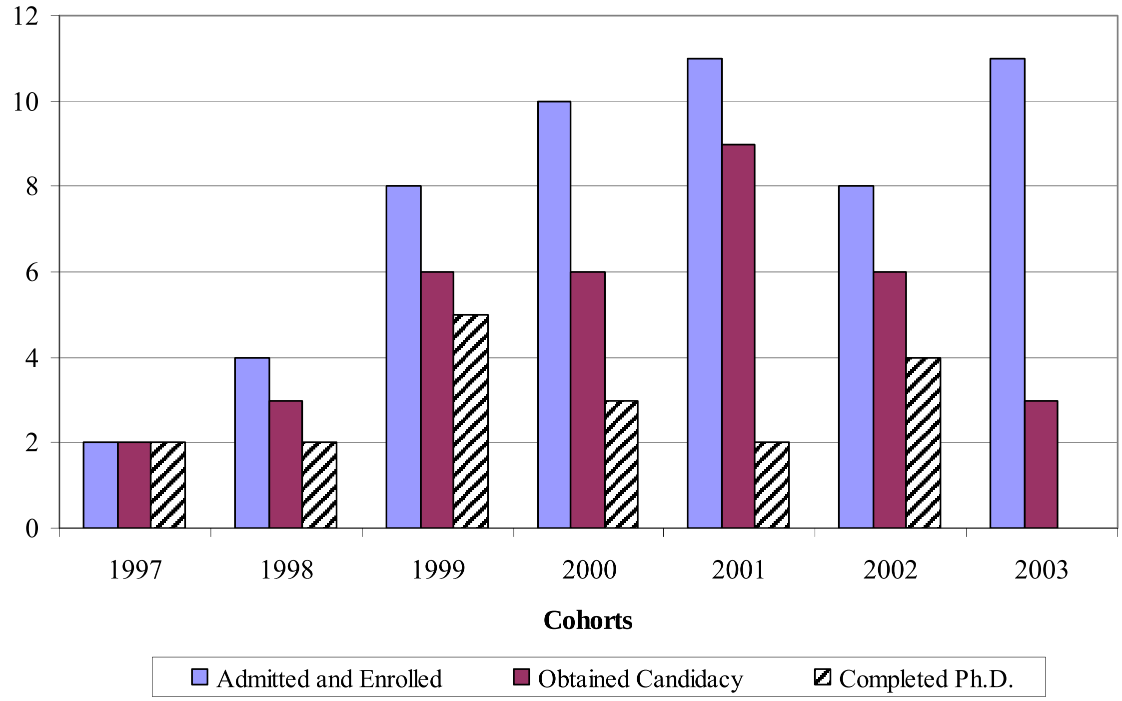
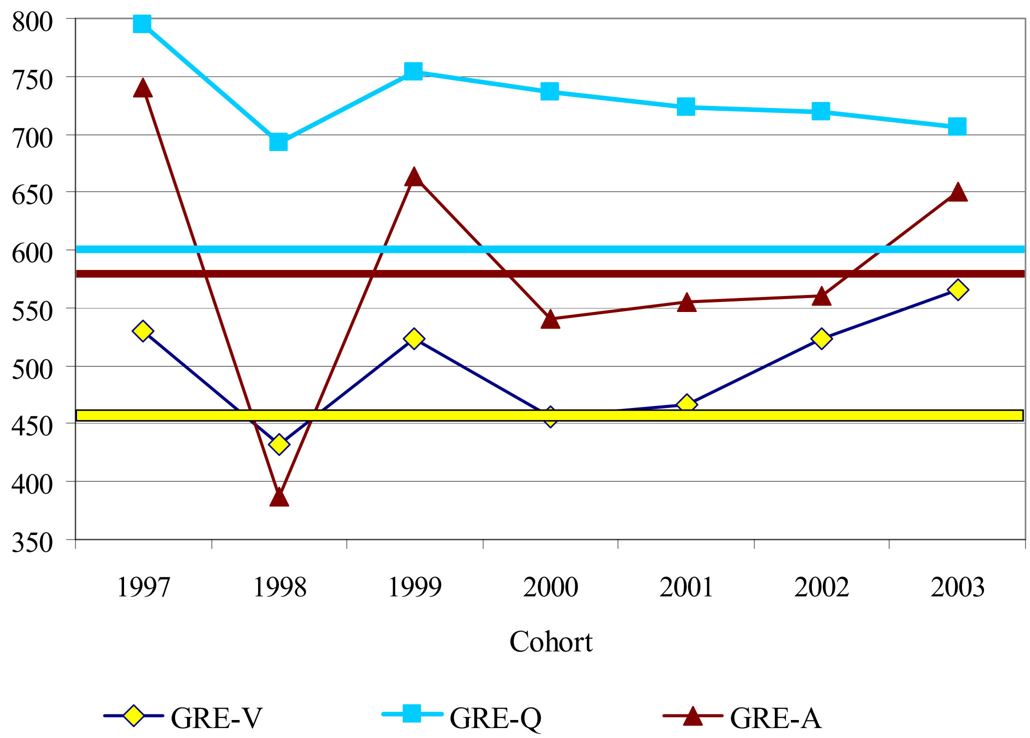


Figure 3:
Enrollment, Candidacy, and Degree Attainment as of August 2006

On average, it took these students 1.79 years (five semesters) to reach candidacy and 2.76 years (approximately eight semesters) to attain the degree after candidacy. Students who graduated with the physics doctoral degree did so in an average of 4.25 years (thirteen semesters), with a range of 2 to 6.41 years. The 1999 cohort had the highest graduation rate, with 63% of the enrolled students attaining the degree.

Compared to the ETS (2006) data for scores approaching the 50th percentile, the average GRE-V score for these cohorts was 460, the average GRE-Q score was 600, and the GRE-A score was 580. Figure 4 provides a chart showing the average GRE test scores for each cohort as they compare to the national percentile scores. Every student admitted into the program had GRE-Q and GRE-V scores above the 50th percentile; however, the 1998 cohort appeared to be the weakest.



Note. Solid lines depict the 50th percentile for the respective score.

Figure 4:
Average GRE Scores in Relation to National Averages for Doctoral Cohorts 1997 through 2003

In most instances, if a student's letters of reference and statements of interest included any one construct, that student met the success criterion 50% of the time. Similarly, in those cases where students letters or statements included any combination of these credentials more than half (65%) met the success criterion. Reviewing the students who had some experience with graduate level coursework or completed a prior graduate degree[4], 12 (28%) of the 43 who could meet the success criterion were successful in the program.

Summary

The application packets and academic histories provided an extensive and complex dataset of information for the students analyzed in this study. Several regressions provided conclusions that no significant relationships existed between the admission credentials of students admitted into a physics doctoral program between the fall 1997 and fall 2003 semesters. Two changes to the dataset resulted in the inclusion of two additional variables. First, in an attempt to conduct conclusive statistical analyses, the researcher created a variable excluding the fall 2003 cohort since students included in this cohort could not meet the enrollment criterion nor did they meet the degree attainment criterion. Reducing the dataset by 11 cases to include only the 1997 through 2002 cohorts of students resulted in statistical analyses completed on students who could meet the success criteria. A second variable added by the researcher was the combined success criterion, which still met with the intent of the study: to determine any relationships between admission credentials and success. While these changes to the data still resulted in no significant relationships, the information obtained from the extensive dataset revealed a great deal of information about the cohorts of students in this study.

[4] Excluding the 2003 cohort.

Analyses of the data provided answers to each of the research questions as well as an extensive understanding of the students admitted into the program during this time. The following chapter discusses the analyses.

CHAPTER FIVE:
CONCLUSIONS AND RECOMMENDATIONS

Statement of Problem

This study sought to determine if there were any informative relationships between the admissions credentials that an applicant presents to a physics doctoral program and the ultimate success of the student. The researcher defined success as a combined criterion of either enrolled in the program for a minimum of four years or attained the degree. The significance of this study was that improved selection processes may lead to reduced attrition rates and increased completion rates in doctoral programs. The selection of students for a doctoral program is one of the key factors evaluated by the Council of Graduate Schools that may “affect the likelihood that a particular student will complete a Ph.D. program” (CGS, 2006b, Overview). Following Diminnie’s (1992) recommendations, this research attempted not only understand the general characteristics of a population of applicants, but to gain an understanding of the unique credentials of the individual applicants. as well as identify any relationships these credentials had to the success of these students. The results of this examination presented recommendations that may enhance the selection process.

Population and Data Collection

Archived application documents and academic transcripts provided the basic information about students admitted and enrolled in the 1997 through 2003 cohorts of a physics doctoral program at a large, public, metropolitan research institution in the southeastern United States. The researcher obtained application items and academic records from the archived student records database (ViewStar) held by the university's Division of Graduate Studies. Archived documents held in the physics department's student files supplemented these records. Programs at the institution in question made admission decisions based on official test scores and a GPA calculated from the last 60 hours of a completed bachelor's degree. The researcher obtained this information from the student records system used by the university. The vice provost and dean of the Division of Graduate Studies (Appendix A) and the physics department's graduate program director (Appendix B) provided permission to collect archived graduate student information. The researcher obtained formal approval and authorization to collect and analyze archived student application and records information from the university's Institutional Review Board (Appendix C). To protect the identities of the students and to comply with the federal confidentiality mandates of the state, a third party collected all of the documents analyzed in this study and removed any personally identifiable information before the researcher received these items.

Summary and Discussion of the Findings

The research questions developed for this study guided the data collection and analyses. The following pages provide a summary of these findings with respect to each question. A preliminary analysis of the data revealed that a combined criterion provided a stronger success variable, resulting in the researcher combining the original questions one and three.

Admission Credentials and Enrollment after Four Years or Degree Attainment

Research Question #1: What relationships, if any, can be found in admission credentials and enrollment in a physics doctoral program four years after admission or completion of the program?

Initially, a binary logistic regression analyzed the combined success criterion as the dependent variable and both the nominal and scale data as the independent variables. This regression produced no significant predictive relationships between any of the items and the success of the students in these cohorts. As a result, the researcher conducted separate analyses on the nominal and scale data as they related to the combined success criterion to provide in-depth descriptive information about the cohorts.

Scale Credentials and Success

The cohorts of students in this study brought with them average GRE scores of 501.1 (GRE-V), 726.6 (GRE-Q), and 579.2 (GRE-A), a final bachelor's GPAs of 3.27, and admission GPAs of 3.25. Given the nation data on GRE scores that approach the 50th percentile (ETS, 2006), this population was above the national average for GRE-V and

GRE-Q but just below the average for GRE-A. The admission GPAs were usually above the university minimum for admission to a graduate program as 44 of the 51 students who had admission GPA calculated were above the 3.00 minimum.

The analyses revealed no direct relationships among the scale admission credentials and the combined success criterion; however, correlation analyses revealed several relationships between different admission credentials. Interpretations of these correlations provide a better description of the scale data used in this study. Strong and significant correlations found between the scores on the separate GRE general tests were expected, but the lack of correlations between GRE scores and GPA at completion of the first year of doctoral study was interesting because these findings do not replicate previous studies (see Burton & Wang, 2005). Analyses revealed an additional strong correlation between the admission GPA and the GPA upon completion of the bachelor's degree ($r = .753$, $p = .01$). The university calculates an admission GPA from the last 60 hours of the bachelor's degree; therefore, this correlation was expected. Correlations analyzed also showed that first and final bachelor's GPA were related ($r = .826$, $p = .01$). The first and final bachelor's GPA share 68% of the variance. This correlation provided information contrary to an adaptation of Adelman's (1999) conclusions. For the study of graduate admissions, one does not need to note whether the final GPA was higher than the first year of study's GPA, as Adelman suggested. The GPA at the completion of the first year is a subset of the final GPA and the admission GPA; therefore, one would expect that the two would be highly correlated. A correlation between the first year GPA and the GPA for the final year of study may provide results that are more interesting; however, the researcher did not collect data about the GPA for the final year of bachelor's study from the students' records.

Where this study found no relationships between admission credentials and success, it found that the GPA after the first year of enrollment in a doctoral program was a strong predictor of success. In a test of significance, an ANOVA found a significant relationship between GPA at the completion of the first year of doctoral coursework and the success criterion ($p = .018$). This finding provides an interesting insight regarding any admission credential's ability to accurately predict a student's success in a doctoral program.

Nominal Credentials and Success

An attempt to replicate Zhang's (2005) findings regarding the quality of the undergraduate program and the likelihood of degree attainment in a graduate program was unsuccessful. Barron's *Profiles of American Colleges* and Carnegie Classifications are exclusive to institutions in the U.S. Because students earned bachelor's degrees from international institutions and because students attended graduate institutions that did not have Carnegie Classifications, these classifications did not provide complete information for undergraduate and graduate program quality. Even accessing rankings and quality classifications conducted by non-U.S. entities proved difficult since limited and conflicting information was available on many of the international institutions. Therefore, the researcher drew no conclusions regarding the quality of the undergraduate institutions attended and degree attainment.

Among the nominal credentials, one construct had a significant status in crosstabulation analyses and in an ANOVA. The motivation construct had a significant negative correlation to the combined success criterion. The crosstabulation analysis revealed that students who exhibited the motivation construct were less likely to be successful ($p = .043$) and the ANOVA replicated these findings indicating that 77% of the students who were not successful were found to have the motivation construct. The motivation construct was not significantly correlated with any other construct, so the effects of this significant relationship can not be extended to any of the other constructs. This presents an interesting concept, which suggests that students who are identified as motivated by the writer of a letter of reference are less likely to be successful. The motivation construct was operationally defined as a qualified comment in the letter of reference where the writer "specifically stated that the applicant was motivated, was motivated toward accomplishing a goal, or had exhibited behaviors of or proven themselves as a capable student by way of dependability and ambition" (Appendix E). The implication of this may be that the letter writer was compensating for other academic deficiencies that would have provided information contrary to the student's success in a doctoral research program. Another interpretation would be that while a student may be described as highly motivated, that a student may have realistic expectations about completing the degree, but may not actually have a clear understanding of what he or she ultimately wants to do with a doctoral degree.

Correlations determined relationships that were useful for interpreting the constructs identified in the letters of reference and the statements of interest. Analysis of the data resulted in significant and in many cases strong correlations between several of the constructs. Interpreting the negative correlation between the background and commitment constructs ($r = -.303$, $p = .05$) may mean that the identification of academic or research history in physics is not enough to also identify a drive or commitment in the student to be successful in the discipline. Conversely, the correlation between commitment and fit ($r = .330$, $p = .05$) may mean that a letter writer's indication of a strong commitment to the discipline is reflected in a student's expression of a fit between their academic goals and program's offerings. The correlations between the teaching and goal constructs ($r = .344$, $p = .05$) found in the statement of interest as well as the correlation between the teaching and perseverance construct ($r = .308$, $p = .05$) described in a letter of reference, may result in an interpretation where those letters that described the student as enthusiastic or persistent in the discipline also describe students who express clear objectives about a future that involves teaching in the discipline or sharing their interest in the discipline with others. Further, these students will express this interest in the discipline as it relates to a specific goal for completing the doctoral degree. Another interpretation of the construct correlations can be made by the following statement: A self-confident student is one who pursues research ($r = .336$, $p = .05$). A correlation found a relationship between a letter of reference that describes a student as a self-starter or who was diligent and a student's indicating their interest in conducting research in the field. Students who determined their exact area of research interest (specific research) were able to indicate how their research interests can be met by the institution to which they are applying (fit), as well as provide well-defined goals upon completion of the degree (goals). This interpretation describes the correlations between specific research and fit ($r = .365$, $p = .05$) and specific research and goal ($r = .429$, $p = .01$).

The interpretations of the correlations in these ways helped to provide a better picture of the students who applied to this physics doctoral program. Many of the students who could be and were successful in the program used the statement of interest to express goals with respect to obtaining the degree and stated interest in either general or specific areas of research. For these students, the letters of reference provided varied items of insight, but the construct of commitment provided a common link to those who were successful.

Regarding the past experiences of applicants, Baird (1975) indicated that the presence of awards or employment in the discipline would increase the likelihood that a student would be successful in a doctoral program. While no significant relationships were found, it is noteworthy that of the cohorts that could meet the success criterion ($N = 43$), 24 (56%) students were employed in the discipline prior to admission, 17 (71%) of those previously employed met the success criterion and nine (37%) attained the degree.

Of the 15 (35%) students who received some award or recognition in the discipline prior to admission, eight (53%) of the students acknowledged in this way met the success criterion and six (40%) attained the degree.

Admission Credentials and Academic Status after Four Years

Research Question #2: What relationships, if any, can be found in admission credentials and a student's academic status in a physics doctoral program four years after admission?

As with the previous research question, the analyses conducted found no significant relationships between admission credentials and the academic status of the students after four years of enrollment in a physics doctoral program. Inferring successful status from past academic achievements, described as awards, recognitions, presentations or publications in the discipline, it appeared that while a student may have had notable achievements or recognitions in the past, these achievements are not significantly related to the status of the student after four years of enrollment in the doctoral program. Of the 43 students admitted and enrolled in the 1997 through 2002 cohorts, 15 students (35%) discontinued for non-enrollment by the fourth year. Of these students, the physics program removed two students because of poor academic progress.

While the analyses found no significant relationships between admission credentials and academic status after four years for the 1997 through 2002 cohorts, it was noteworthy that the majority of these students met the course requirements for degree completion, were doctoral candidates, and the majority was therefore approved in their doctoral research for continuation in the program. Of those who were in good academic standing throughout their enrollment, 32 of the 43 students (74%) obtained candidacy, taking an average of 1.86 years to attain this status. Of these students, only 18 (42%) students attained the degree. Even considering only those cohorts who met the truncated completion rate based on a six-year cut-off point, 17 of the 24 students admitted between 1997 and 2000 admitted to candidacy and only 12 of these students (70%) attained the degree by August of 2006. The cohorts' data provided information that eliminated the possibility that students simply followed the path of admission to candidacy, awarded a Master of Science in route to the doctorate, and discontinued. Of the 21 students who achieved candidacy and the program awarded an Master of Science., only one student discontinued after receiving this degree. These findings showed that even admission into candidacy was not a guarantee for degree completion.

Trends among Admissions Credentials and Success

Research Question #3: What trends, if any, can be found in admission credentials and success in a physics doctoral program?

The analyses presented trends in degree progression and attainment. From the admission of students into the fall 1997 class to August of 2006, the doctoral program studied had an attrition rate of 41% (22 of the 53 student enrolled in the program, discontinued from the program). Of the 1997 through 2002 cohorts, 32 students (74%) were admitted into candidacy; however, only 18 (42%) followed through to degree completion. On average, it took the students in these cohorts 1.79 years to reach candidacy and an additional 2.76 years to attain the degree after candidacy. Students who graduated with the physics doctoral degree did so in an average of 4.25 years, with a range of 2 to 6.41 years, and of the cohorts, the 1999 cohort had the highest graduation rate with 63% of the students completing the degree. As of August 2006, considering all of the cohorts, 14 students (26%) were still active in the program.

Classifications and rankings use enrollment and degree completion rates to report information about trends in graduate education. These rankings will continue to be an important evaluative tool to compare doctoral research programs, and attrition and completion rates are becoming more closely scrutinized as evidenced by changes to the NRC's assessments of doctoral research program. The 2007 NRC survey will include information about enrollment, attrition, and completion rates (Kuh & Ostriker, 2006). This program appears to have a lower than average attrition rate (41%) but an average completion rate (approximately 50%) based on minimal and truncated completion rates. The time-to-degree rate of the students was below the national average of 6.7 years; however, the range of time it took these students to complete the degree must also be taken into consideration.

Recommendations

This study explored Diminnie's (1992) first and second propositions and attempted to provide recommendations for the last. These recommendations focused first on the application packet itself and then on the selection process.

Graduate Application

From the fall of 1997 to the fall of 2003, the graduate application at the institution studied evolved through several iterations, from a document completed by hand through several versions of an application that a student completes online. While the information included in the application remained somewhat consistent, demographic information was not available on the hard-copy international application. Furthermore, prior to 2001, the international application requested only minimal information about the applicant's demographics and past academic history. A recommendation made with respect to the graduate application is that for internal reporting and comparison purposes, the information collected about student demographics should be the same for both domestic and international students. Furthermore, a program should consistently request information about the applicant's academic history.[1]

Letters of Reference

Standardization of the letter of reference resulting in letters based on and written along specific guidelines provides a more thoughtful evaluation of the applicant. Prompts could be included in the letter of reference that directs the author to address their thoughts about the applicant's commitment and motivations toward completing a degree. The questions currently asked on the letter of reference only request responses to assess the applicant's potential for graduate study, ability to work with others, adaptability, emotional sensibility, and leadership potential. While these may provide information

[1] Since the fall of 2004 the application is the same for both domestic and international students.

useful to a program, these ratings do not address several of the constructs related to an increased likelihood of success in a doctoral research program, nor does the current form letter of reference prompt for any further information, it only supplies an open-ended area for the author to provide a letter of their choosing. Figure 5 shows the ranking criteria used by the institution in this study, and one simple way to address this is to improve the Likert-style evaluation currently used. Questions that a letter writer may answer in this way and that are relevant to the research doctorate may include the following:

1. In your opinion, how well did the applicant work independently?

   (Rated very well to needed constant supervision)

2. The applicant often shared specific goals related to completion of a doctoral degree?

   (Rated strongly agree to completely disagree).

3. What is the likelihood that the applicant will complete a doctoral degree?

   (Rated very likely to not likely)

4. How committed was this applicant with the completion of the coursework or a project?

   (Rated very committed to not committed)

5. How strong would you rate the applicants background with [the specific discipline of] physics?

   (Rated very strong background to weak background)

The Educational Testing Service is also currently developing a standardized letter of reference (Kiernan, 2004) that may address the need to better develop the letter of reference; however, streamlining or standardizing the letter may still not meet the specific information needs that an admission committee may be most interested in evaluating.

Please rank the applicant in the following categories.

Potential for Graduate Study	Ability to Work with Others	Adaptability	Emotional Stability	Leadership Potential
☐ Recommend strongly	☐ Poor	☐ Poor	☐ Poor	☐ Poor
☐ Recommend	☐ Below average	☐ Below average	☐ Below average	☐ Below average
☐ Recommend with reservations	☐ Average	☐ Average	☐ Average	☐ Average
☐ Do not recommend	☐ Above average	☐ Above average	☐ Above average	☐ Above average
	☐ Excellent	☐ Excellent	☐ Excellent	☐ Excellent
	☐ Do not know	☐ Do not know	☐ Do not know	☐ Do not know

Figure 5:
Sample of Application Ranking Information from Institution's Form Letter of Reference

In this study, the authors of the letters of reference minimally addressed the prompt to discuss any "reservations you have or potential weaknesses you see in the applicant". Another indicator that would be useful to an admission committee includes information about difficulties the student had with his or her preceding academic experience or that they may have in a doctoral program. Additional information that a doctoral program could direct the writers of the letters of reference to provide would be to have the writer comment specifically on the student's academic strength in physics, level of independence in research and academics, as well as the writer's thoughts on the applicant's capacity for critical thinking or any other cognitive indicators that would be relevant to the doctoral program.

Statement of Interest

Statements of interest were missing from 19 of the 54 application files analyzed. Programs should specifically request this item from the applicant and conduct a thorough review of the statement of interest as a part of the decision process as a statement of this sort provides information directly from and about the applicant. Of those available, the statements of interest examined in this study comprised of open-ended essays that sometimes included general prompts for an academic goal statement, a research statement, an essay, or a personal statement, but little more. With the statement of interest, instead of assuming that the applicant will address why he or she wants to attend the institution for graduate research, a program should directly request the applicant supply this information. Additionally, to address the constructs, applicants should be prompted to clearly provide information about what they hope to attain with degree completion (what type of employment, become an instructor, specific job interest, etc.), what specific area of research interest they have, and how attending the institution will meet their degree attainment goals and interests. Additionally, the statement of interest can provide an assessment of students' knowledge of the program to which they are applying and the research offerings of the program as they relate to their interests.

Evaluation Criteria

Admission committees want the doctoral students they admit to exhibit a level of independence, be self-motivated to complete the program, have goals, show perseverance, and be a critical thinker. While the analyses in this study derived only minimally significant findings, one should not disregard the importance of these constructs. Past research has found that an increased likelihood of success in a program relates to the presence of these constructs and programs generally seek out applicants who have the cognitive indicators associated with these constructs. The correlations between certain constructs may result in a committee revising the way they analyze the letters of reference and statements of interest. The revised constructs include the following:

1. Retain the critical thinking, independence, and motivation constructs as operationally defined by this study (see Appendix E).
2. Expand the definition of the goal construct to include an indication of goals upon completion of the doctoral degree and details about those goals such as specific job placement or teaching position.
3. The construct of fit remains important for several reasons. Golde (2005) pointed out that one of the reasons for doctoral attrition was that there was "a mismatch between the student and the discipline" (p. 380). Fit would also include aspects of the commitment construct in that a statement of fit would show strong interest in the discipline and provide evidence of thoughtful degree consideration.
4. Expand the definition of the self-confidence construct to include expressions of research interest, whether generalized or specific.

Future Research

The following are suggestions for further research, recommended to validate the concepts found in this study and to contribute to the body of research on the topic of selection for doctoral research programs. Actual research focusing on the retention and success of students in doctoral research programs is only recently gaining interest and importance, as evidenced by the creation of the *Ph.D. Completion Project* in 2002. While the research conducted in this study did not reveal any significant relationship between the admission credentials examined and the ultimate success of students admitted into a doctoral research program, the analysis of data provided a unique description of the program's students and offered outlets for further examination of admission and retention processes.

The size of the population analyzed for this study presented a limitation; however, acknowledging this provided an outlet for identification of future research. Additionally, this study provided a number of possible research projects. The following recommendations for areas of further research examine these possibilities.

Expanded Data Collection

Increasing the population studied and the type of programs evaluated would serve to improve the likelihood that the results of this sort of analysis apply beyond this study and may provide significant results along the separate success criteria. A researcher may achieve these results by collecting data on students admitted into physics doctoral programs at several institutions or broadening the disciplines studied to include students admitted into doctoral programs in the science, technology, engineering and mathematics areas at several institutions.

Another way of expanding the data collected would be to conduct research on a doctoral program's application pool in its entirety. This research would include evaluating application materials of every student who applied to the program and conducting a follow-up study to compare the admission credentials and success of those admitted to those not admitted. Though challenging, this sort of evaluation would provide a more detailed look at an application pool to determine what type of student applies to doctoral research programs. An even more interesting analysis includes students admitted into one doctoral research program, following those students not admitted into the specified program but admitted into any other comparable program, and determining and comparing who was successful. This type of study may also provide additional insights into the selection processes of an admission committee as well as the culture of different doctoral research programs.

Enhanced Data Collection

The compilation of information collected from the application items and application histories of students admitted into doctoral research programs can be more useful adopting the information found in the correlated constructs. When thoroughly reviewed, the letters of reference and statements of interest provided cognitive indicators, identified as constructs in this research that were not otherwise available from the application. Using the previous recommendation that identified the more succinct constructs found in the letters of reference and statements of interest may provide a basis for a predictive model in a study conducted to replicate previous research (see Baird, 1975; Diminnie, 1992; Girves & Wemmerus, 1988; Walpole, et al., 2002).

Finally, a closer examination should be completed on the impact that graduate student funding has on degree completion rates. Funding impacts every aspect of the graduate process as students may accept an offer of admission based on funding support and may continue in the program based on continued funding support.

Redefining Success

This study developed two success indices, but these are not the only indicators that are relevant to success in a physics doctoral program. The following are additional definitions for success identified at the time of application, while enrolled in the program, and after completion of the program.

1. Research skills sought by a member of the faculty may serve as a criterion for success derived from application materials. This success criterion would address the program's contribution to the construct of fit, where the program selected an applicant to enhance the research objectives of the program.
2. Success defined as degree attainment within five years of admission.
3. Active involvement in research with a member of the program's faculty provides a success measure that points to the application of the skills the

applicant acquired and the absence of such may indicate either a lack of educational attainment or the student's lack of integration in the program.

4. As the application items identified publications at the time of application, the student's ability to continue to produce publishable research after admission could be a criterion for success.

5. Admission to candidacy provides an interim success criterion.

6. Finally, the placement of the student into a teaching or research position after degree attainment would be a success measure that would provide feedback about the effectiveness of training provided to the student, how well students applied the skills acquired, and may address the students' ability to network. This analysis may also provide information to determine how and to what extent industry pursues the students who graduate from the program.

Examine the Decision Making Process

This study did not evaluate several additional factors that influence the decision making process. These include the possibility that (a) committees make admission decisions based on a personal, undocumented recommendation, (b) there are institutional pressures to meet enrollment or headcount growth goals, and (c) committees make decisions to fill need created by teaching and research positions. This research study assumed but did not explore each of these factors.

Institutional and programmatic missions and goals influence a program's admission processes and an examination of this may ensure that the program has clearly defined guidelines for the admission committee to begin the applicant evaluation process. The practice of admitting to meet enrollment needs may result in less discriminating decisions so that a program meets numeric requirements as opposed to admitting students who may be most successful in the program. Examining how admission committees make these types of decisions and the resulting impact of each type of decision would provide a basis for discussion about these sorts of admission practices.

Evaluation of Non-Completers

To expand on the present study, additional areas of research include an examination of those students who did not complete the program to determine their reasons for leaving the program, and an examination of those students who admitted but never enrolled into the program. This sort of study would include an exploration of the personal variables that a student brings with them upon admission to the program, an exploration of the different influences that faculty have on a students success or failure, and an exploration of programmatic variables that influence or assist as student toward success or failure. Conducting this sort of research, one must first acknowledge the obvious difficulty with collecting information on students when they are not a part of the program.

Replicating Golde's (2000, 2005) research, this sort of study could be in the form of in-depth interviews or surveys applied specifically to research doctoral programs to explore the unique and personal characteristics of the students in these programs. The researcher should pay special attention to the level of academic and social integration that occurs in these programs, as anecdotal information indicates that research based doctoral programs lack this integration.

In the academic community, one may also come across a discussion regarding the necessity of a certain level of attrition in a doctoral research program. This may be associated with a Darwinian mentality that results in only the most worthy and qualified students actually receiving the degree. Whether or not this is the case presents a direction for further research.

In addition, the following questions provide outlets for additional research on those students who discontinued for non-enrollment:

1. Did the student complete at the same doctoral program at another institution? If so, would this student be considered a success?
2. Did the student re-enroll into and complete the program at a later date?
3. Were any simple explanations available for why the student left the program? The student may have discussed family or personal reasons with advisors or mentors prior to a student discontinuing. A student who leaves because of a lack of integration within the program may be less obvious but if identifying the reasons may provide information about the personality of the student or the culture of the program.

Faculty and Alumni Perceptions

Assessing the perceptions of the doctoral research faculty about why students left or why students complete may also provide personal insights into the type of student that the faculty believes would be successful in the program. This sort of survey may also be used to provide general faculty input to the selection process. Additionally, alumni of the program can provide their perceptions about how effectively the program prepared them for post-doctoral employment. At the institution in question, the Office of Research conducts a survey of graduating students, and this office gives programs the opportunity to supplement this survey with their own questionnaire. A review and analysis of the institutional exit survey along with any program specific information may provide more information about how the students who completed the program achieved their success. These sorts of perception surveys may also provide insights about the culture of the program.

Retention Programs

Research to determine the types of mentoring or academic follow-up that is most useful toward the outcome of degree attainment with students in doctoral research programs provides another outlet for additional research. Previous research has shown that increasing academic integration effectively increases retention rates (Golde, 1994, 2000; Tinto, 1993).

Theory in Application

Since this study determined that there were no significant relationships between admission credentials and the success of students admitted into a doctoral research program, a provocative application of these findings would be to develop a longitudinal case study of a program that conducted blind, random admissions and then follow those admitted students to discover how they perform. The basis of admissions would be that an applicant presents commitment toward completing the degree simply by applying to the program. This type of study would provide a wealth of interesting information, but may be ethically questionable.

The theories about application characteristics and degree attainment presented in the Santiago and Einarson (1998) study provide another area for additional research. When admitted into a graduate program, would a survey student's perceptions about their success result in a self-fulfilling prophecy? Could additional research replicate the Santiago and Einarson's findings?

Theoretically, goals or missions of an institution and program set the foundation for admission processes, program offerings, and research foci. A reexamination of the philosophy and rationale behind these guidelines and their application to the program's admission criteria would serve to validate the goals and missions. Furthermore, this examination would provide an outlet for further discussion about how the program goals relate to their desire for successful graduate students.

Finally, an area where this study may transcend academia would be to apply the application credential concept to applications for employment. What credentials or constructs are transferable to industry? Which employment application credentials relate to a successful hire? How would research operationally define a successful hire? These questions would guide research that may provide industry applications.

Implications and Conclusions

This study determined that there were no significant relationships between admission credentials and the success of students admitted into a physics doctoral program. The researcher classified these admission credentials as both nominal and scale variables identified in an extensive dataset that is outlined in Appendix D. With these variables identified, specific variables created a core dataset that contained the most useful information and provided for several statistical analyses. While the data analyzed presented much ambiguity for significant predictive models to be completed, the information presented in this study provided many details about the students whom the physics doctoral program admitted and the resulting successes of some of the students.

The data also provided information that resulted in a discussion of stories describing the cohorts in this study. This research shows that a specific evaluation of the admission credentials and the identification of constructs that were previously believed to be related to the likelihood of success bore no relationships to whether or not a student was still be enrolled after four years or attained the degree. Interestingly, the only credential analyzed that did have a relationship to the success criterion was the inverse relationship of the motivation construct found in the letter of reference. That no significant relationships were found among the various application credentials and the student's success does not discredit the use of these credentials in the decision making process, as graduate admission committees will continue to use these credentials as representative examples of past performance. What any researcher needs to acknowledge are the many intrinsic, extrinsic, and un-documented reasons why students are selected for admission into a graduate program and how these other indicators may be related to a student's success in the program. Doctoral research programs need criteria upon which to base admission decisions, and this study implies that singling out any of these credentials and concluding that the absence of such a credential (or a below-average credential) is a debatable reason to deny a student.

This study was not developed to prove or disprove past research findings that predicted success from admissions information; rather, the researcher developed this study to explore each of the most prevalent credentials that a student presents with his or her application packet, and tell the story about the nuances of these credentials as they related to a student's progress in a doctoral research program. The significance of this study lies in the descriptive information provided about the students in this doctoral program. With increasing scrutiny of attrition and completion rates, one way for a program to address this microscopic view of program success rates is to take an introspective view of whom the program admitted to evaluate if past practices yielded results with which the program is satisfied and provide a means to discuss possibilities of improvement to current practices.

APPENDIX A:
COPY OF MEMORANDUM APPROVING ACCESS TO
STUDENT RECORDS HELD IN THE DIVISION OF GRADUATE STUDIES

c: P. Panousis
M. Johnson
T. Wilkerson

University of Central Florida

Office of the Dean
College of Sciences
Graduate Services Office

Memorandum

To: Patricia Bishop
From: Peter Panousis, Dean
Date: April 13, 2006
~~**Re**~~**:** cc: Michael Johnson, Associate Dean

Attachments

I am writing this memo to request that the Division of Graduate Studies allow Teresa Wilkerson access to student records for use in research that is being conducted that will benefit graduate programs within our college and that will be analyzed as a part of her dissertation research. It is understood that this information will be analyzed and reported following the appropriate procedures protecting against the release of any specifically identifiable information regarding student's records and that approval from the institutional review board will be pursued when appropriate.

Peter Panousis

Patricia J Bishop
Approved: April 14, 2006

Teresa - needs to get IRB approvals, and adhere to the Ferpa guidelines in using the information. pb

P.O. Box 161997 Orlando, FL 32816-1997 (407) 823-1997 FAX (407) 823-1998

APPENDIX B
COPY OF E-MAIL APPROVING ACCESS TO STUDENT RECORDS HELD IN THE PHYSICS DEPARTMENT

From: Eduardo Mucciolo <mucciolo@physics.ucf.edu>
To: "Teresa Wilkerson" <twilkers@mail.ucf.edu>
Date: Tuesday, July 11, 2006 11:33 PM
Subject: Re: Physics PhD Applicant Documents

Dear Teresa,

we will certainly help you. I'm forwarding this message to Angie Roman, so that she can provide you with the copies you need. I'm out of town till July 24th.

Regards,

Eduardo

On Jul 11, 2006, at 2:02 PM, Teresa Wilkerson wrote:

> Dr. Mucciolo,
>
> As a part of my dissertation research, I want to ensure that I have the
> most complete files available for my analysis; therefore, I am writing
> to you to ask for a copy of any application materials you may have in
> your files for the student in the attached list.
>
> Included in this spreadsheet are applicants who Graduate Studies has
> identified as admitted into the Physic PhD program from the fall of
> 1997
> to the fall of 2003. I am specifically interested in any application
> items you may have for the student who actually enrolled (were
> matriculated) in their first semester. If you notice any obvious
> omissions (students who were admitted into the PhD program, but aren't
> on the list) plese forward their documentation as well.
>
> Note: In Column F, "no matric" means they were admitted, but did not
> enroll in their semester of admission; "y" means they were enrolled in
> the semester they were admitted.
>
> Can you please forward a copy of these items to Dr. Johnson's
> attention?
>
> Thank you in advance.
>
> Teresa
> <PhysPhDFA97-FA03.xls>

--
Eduardo Mucciolo
Department of Physics e-mail: mucciolo@physics.ucf.edu
University of Central Florida phone: 407-823-1882
P.O. Box 162385 fax: 407-823-5112
Orlando, FL 32816-2385

CC: Angie Roman <iroman@mail.ucf.edu>, Mike Jimenez <mjimenez@physics.ucf.edu>

APPENDIX C:
INSTITUTIONAL REVIEW BOARD APPROVAL

University of Central Florida

Office of Research & Commercialization

June 27, 2006

Ms. Teresa Wilkerson
P.O. Box 4112
Winter Park, FL 32826-3246

Dear Ms. Wilkerson:

With reference to your protocol #06-3554 entitled, **"The Relationship Between Admissions Credentials and the Success of Physics Doctoral Students,"** I am enclosing for your records the approved, expedited document of the UCFIRB Form you had submitted to our office. **This study was approved on 6/21/06. The expiration date will be 6/20/07.** Should there be a need to extend this study, a Continuing Review form must be submitted to the IRB Office for review by the Chairman or full IRB at least one month prior to the expiration date. This is the responsibility of the investigator. **Please notify the IRB office when you have completed this research study.**

Please be advised that this approval is given for one year. Should there be any addendums or administrative changes to the already approved protocol, they must also be submitted to the Board through use of the Addendum/Modification Request form. Changes should not be initiated until written IRB approval is received. Adverse events should be reported to the IRB as they occur.

Should you have any questions, please do not hesitate to call me at 407-823-2901.

Please accept our best wishes for the success of your endeavors.

Cordially,

Barbara Ward

Barbara Ward
UCF IRB Coordinator
(FWA00000351 Exp. 5/13/07, IRB00001138)

Copies: IRB File

BW:jt

12201 Research Parkway • Suite 501 • Orlando, FL 32826-3246 • 407-823-3778 • Fax 407-823-3299

APPENDIX D:
DETAILS OF DATA CODING FOR SPSS

Application

app	Packet of information pertaining to one applicant		
adm	Semester of Admission		
cohort	Code for year pertaining to one cohort		
	1	FA97 – SU98	
	2	FA98 – SU99	
	3	FA99 – SU00	
	4	FA00 – SU01	
	5	FA01 – SU02	
	6	FA02 – SU03	
	7	FA03	
apptype	Type of application submitted		
	1	handwritten, domestic, including ethnicity information	
	2	handwritten, international, not including ethnicity information	
	3	handwritten, international, including ethnicity information	
	4	online	
bdate	Date of birth		
appage	Age at time of application		
sex	1	M	Male
	2	F	Female
	3	U	Unspecified
eth	Ethnicity		
	1	A	Asian
	2	B	African American
	3	H	Hispanic
	4	U	Other
	5	W	Caucasian
domintl	Domestic or International		

birnat	Birth nation or Specific country of origin		
	1	A	United States
	2	B	Bulgaria
	3	C	China
	4	E	Egypt
	5	G	Germany
	6	I	India
	7	J	Japan
	8	K	Kenya
	9	N	Ukraine
	10	O	Romania
	11	P	Poland
	12	Q	Iraq
	13	R	Russia
	14	T	Turkey
	15	U	Cuba

region	Country/Region of Origin	
	1	Africa
	2	Asia
	3	Central America
	4	Middle East
	5	Russia/Eastern Europe
	6	United States

Graduate Records Examination (GRE)

Code	Range	Description
grev	200-800 (10 pt scale)	Verbal score
greq	200-800 (10 pt scale)	Quantitative score
gream	200-800 (10 pt scale)	Analytic multiple-choice score (until 10/02)
greaw	0-6 (.5 pt scale)	Analytic written score (10/02 - present)
gres	200-990 (10 pt scale)	Physics subject score

Test of English as a Foreign Language (TOEFL)

Code	Range	Description
toeflc	0-300	Computer-based test score
toeflp	310-677	Paper-based test score
toefl	0-300	TOEFL Score (paper-based score scaled to computer-based score)

Transcripts

admitgpa — Last 60 hours of bachelor's degree GPA calculated for admission into PhD program at the institution studied.

gpatype/gpacode

How GPA was calculated for admission

1	Generic	Inaccurate GPA, only used to indicate bachelors is equivalent to U.S. degree
2	None	No GPA was calculated
3	UCF calc	Calculated by university
4	WES calc	Calculated by WES or Silny

Information from bachelor's institution where degree was earned

bac1	Bachelor's institution upon which admission GPA was based and the institution where the bachelor's degree was earned
ba1ent	Month/Year of first attendance
ba1ext	Month/Year of last attendance
bac1type/ba1typcd	Degree program attempted 1 Physics (or related) 2 Engineering (or related) 3 Chemistry (or related) 4 Other
ba1fygpa	First year GPA
ba1fingp	Final, cumulative GPA

ba1cum	Final, cumulative hours completed
ba1dg/ba1dgcd	Degree type attempted
1	Bachelor of Arts
2	Bachelor of Engineering
3	Bachelor of Electrical Engineering
4	Bachelor of Science
5	Int'l Advanced (MS/Specialist)
6	No bachelor's reported
ba1date	Month/Year degree earned
ba1month	Month to degree
numbaatt	Number of institutions attended to obtain degree
1prvba	Information about a second institution where coursework was completed prior to degree or concurrent with degree. Total of two institution's data coded.

Information from master's or doctoral transcripts where an advanced degree was attempted or earned.

gradwork	Was graduate work attempted
grad1	Graduate institution attended after completion of the bachelor's degree but prior to entry to Physics PhD at institution studied
grad1ent	Month/Year of first attendance
grad1ext	Month/Year of last attendance
gr1type	Degree program attempted
	1 Physics (or related)
	2 Engineering (or related)
	3 Other
	4 Nondegree
gr1fygpa	First year GPA
gr1fngpa	Final, cumulative GPA
gr1tohrs	Final, cumulative hours completed
gr1deg/gr1degcd	Degree type attempted
	1 Master of Science
	2 Doctor of Philosophy
gr1ermdg	Degree attainment (y/n)
gr1degdt	Month/Year degree earned
gr1mths	Month to degree or last enrollment
gr1atten	Number graduate institutions attended prior to admission to doctoral program
grad2	Second institution's data (total of two) coded for above information

Classification/Rankings/Descriptions

bac1bar/bac1barc	Barron's *Profiles of American Colleges 2001* selector description for the undergraduate institution attended 1 vc very competitive 2 hc highly competitive 3 mc mostly competitive 4 co competitive 5 lc less competitive
bac1arwu/gr1arwu	2005 Academic Ranking of World Universities (ARWU) ranking of international institution. Ranges were averaged to a mid-point ranking.
bac1arwuc/gr1arwuc	2005 ARWU ranking of institution among other institutions within the same country. Ranges were averaged to a mid-point ranking.
gr1carne	2005 Carnegie Classification for the graduate institution attended 1 CompDoc/MedVet 2 CompDoc/NMedVet 3 Doc/Prof 4 Doc/STEM 5 Postbac-A&S/Bus 6 Postbac-Prof/Other 7 S-Doc/Ed
gr1nrcq	1995 National Research Council (NRC) quality rating for program at graduate institution attended (range 0 to 5; 0 = "not sufficient for doctoral education", 5 = "distinguished")
gr1nrcef	1995 NRC effectiveness rating for program at graduate institution attended (range 0 to 5; 0 = "not effective", 5 = "extremely effective"

Letters of Reference

totalltr	Total number of letters submitted
ltr1, ltr2, ltr3	Minimum three letters of reference available (coded individually) (y/n)

Constructs identified in letters of reference (y/n)

ltrbkg	Background in Physics
ltrcom	Commitment
ltrcrit	Critical Thinking
ltrind	Independence
ltrmot	Motivation
ltrper	Perseverance
ltrslfcon	Self Confidence

Statement of Interest

perstmt Statement of interest available (y/n)

Constructs identified in statement of interest (y/n)

psfit	Applicant goals match program offerings
psgoal	Described plans with respect to degree completion (unspecified)
psres	Interest in research
psspecres	Specificed research area of interest
pstch	Interest in teaching

Resume

resume Resume available (y/n)

Information about employment, awards/recognitions (discipline related), and presentations/publications (discipline related)

employed	Employment information available (y/n)
empl1	Most recent employment in the discipline
empl1st	Month/Year employment started
empl1end	Month/Year employment ended
empl1mo	Number of months employed
empl2-x	Information about previous employment

award	Award information available (y/n)
awdtotal	Total number of awards or recognitions

awd1	Type/title of award or recognition
awd2-x	Information about additional awards
publicat	Publication information available (y/n)
pubtotal	Total number of presentations or publications
pub1	Presentation venue (i.e. conference) or publication name (i.e. journal title)
pub2-x	Information about additional presentations/publications

Internal Transcripts

txgpaay1	GPA at the completion of the first academic year
txstat1	Academic status at the completion of the first academic year 1 Dis Discontinued 2 Prv Provisional 3 Reg Regular
txenrly2-x?	Student enrolled in second and subsequent years
txgpaay2-x	GPA at the completion of the second and subsequent years
txstat2-x	Academic status at the completion of the second and subsequent years
admitcan	Admission into candidacy (y/n)
semcan	Semester admitted into candidacy
candxsem	Number of semesters enrolled from admission to candidacy
candmoyr	Month/Year admitted into candidacy
candXMo	Number of months enrolled from admission to candidacy
eligible	Enrolled prior to SU03 and could be enrolled 4 years.
enrl4yrs?	Enrolled minimum four years (y/n)
txstsem	Last semester of enrollment (not to be reported past summer 2006 if still enrolled)
txlstmy	Month/Year of last enrollment
txtotalm	Total months enrolled (from admission to last semester)
txlstgpa	GPA for last semester of enrollment
txlststa	Status for in last semester of enrollment
txttlsem	Number of semesters enrolled
graduate	Degree attainment (y/n)
gradoenrl	Attained degree or was enrolled for four years (y/n)
txdegdat	Month/Year degree earned

msnroute	Master's in route to completion of PhD awarded (y/n)
datems	Month/Year MS degree awarded
semms	Semester MS awarded
endwms	End program with MS (y/n)
disc	Discontinued from program (y/n)
fa06acti	Student still in active status; eligible to enroll in the fall 2006 semester (y/n)
Notes	Any relevant or useful information to be noted about the student that was not coded

APPENDIX E:
OPERATIONAL DEFINITIONS OF CONSTRUCTS

Indicated below are the operational definitions that guided the review and identification of the indicated constructs in the letters of reference and statements of interest.

Letter of Reference

Construct	Operational Definition
Background	Letter provided a qualified comment where the writer specifically stated that the applicant had a history in academics or research.
Commitment	Letter provided a qualified comment where the writer specifically stated that the applicant had a strong interest in the discipline, was driven for success, and followed-through and completed tasks/assignments/projects.
Critical Thinking	Letter provided a qualified comment where the writer specifically stated that the applicant was intelligent, analytical, meticulous, curious, creative, logical, investigative, or had successfully been involved in a project or research.
Independence	Letter provided a qualified comment where the writer specifically stated that the applicant worked well by him or herself, or the applicant presented original ideas.
Motivation	Letter provided a qualified comment where the writer specifically stated that the applicant was motivated, motivated toward accomplishing a goals, or had exhibited behaviors of or proven themselves as a capable student by way of dependability or ambition.
Perseverance	Letter provided a qualified comment where the writer specifically stated that the applicant was perseverant, reliable, and enthusiastic about their academics, exhibited qualities of a tenacious and persistent student/researcher.
Self-Confidence	Letter provided a qualified comment where the writer specifically stated that the applicant was a self-confident individual, who exhibited characteristics of self-confidence (diligent, self-starting, responsible individual).

Statement of Interest

Construct	Operational Definition
Fit	Statement included a direct comment regarding how the applicant's interest fit with the program's offerings.
Goal	Statement included a comment regarding applicant’s generalized goal or goals upon completion of the doctoral degree.
Research	Statement included a comment regarding the general area of research interest that the applicant intends to pursue in the doctoral program.
Specific Research	Statement included a comment regarding a specific area of research interest that the applicant intends to pursue in the doctoral program.
Teach	Statement included a comment that he/she is pursuing a doctoral degree because of an interest in teaching.

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