The Role and Status of the Master's Degree in STEM

Council of Graduate Schools

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COUNCIL OF GRADUATE SCHOOLS

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Master's Completion Project Staff:

Robert Sowell, Vice President, Programs and Operations
Nathan Bell, Director, Research and Policy Analysis
Sally Francis, Senior Scholar in Residence
Leontyne Goodwin, Program Manager, Best Practices

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TABLE OF CONTENTS

Foreword

By Debra W. Stewart, President, Council of Graduate Schools

In 2004, the Council of Graduate Schools (CGS) launched the Ph.D. Completion Project, a national initiative to examine and document doctoral completion and attrition rates and to study institutional factors and interventions designed to improve completion and reduce attrition. During this ongoing project, we developed a solid empirical understanding of doctoral completion and attrition, and fostered a national dialogue among key stakeholders, particularly the deans of graduate schools, about the issue. That dialogue, and the success of our efforts to examine doctoral completion and attrition, convinced us that the time was right to begin an examination of completion and attrition in master's programs. Master's education is the largest and fastest growing part of the graduate education enterprise, and it is the component where women and minorities are in the majority. Master's education, particularly in science, technology, engineering, and mathematics (STEM) fields, is critical to preparing the workforce we need, yet we lack key information regarding master's completion and attrition rates and factors that contribute to student success. A more thorough analysis of the role and status of the master's degree, particularly in STEM fields, is necessary to address graduate degree production in the U.S. comprehensively and to begin to fill this gap that has long existed in master's education research.

As a first step and with funding from the Alfred P. Sloan Foundation, CGS began work on the Master's Completion Project in January 2009. The goal of this exploratory project was to clarify the current state of knowledge about completion and attrition in master's programs in STEM fields, to draw on current research to develop a better understanding about why students fail to complete, and to identify factors that contribute to successful completion. To accomplish this goal, CGS conducted a review of the literature on master's completion and attrition, collected and analyzed data on completion and attrition at the master's level, conducted research on the characteristics of master's programs, and facilitated a Dean Dialogue and a focus group on master's completion and attrition at the 2009 CGS Summer Workshop. The findings of this research formed the basis of a white paper, "Completion and Attrition in Master's Programs in STEM," which served as a backdrop for an invitational workshop in May 2010 that was funded by the National Science Foundation. The enthusiastic responses to the white paper and workshop confirmed that there is interest and value in further pursuing this important area of research.

The Role and Status of the Master's Degree in STEM presents the current state of knowledge about master's education, with a focus on completion and attrition in STEM. This publication illustrates the rapid growth and important role of master's education in the graduate education enterprise, and shows the responsiveness of master's degrees to current workforce needs that emphasize globalism, creativity, adaptability, and diversity as we transition into a knowledge economy. It also points to future research directions for fostering innovation and ensuring our competitiveness as a nation.

Acknowledgments

By Debra W. Stewart, President, Council of Graduate Schools

This publication is the result of the support and commitment demonstrated by many individuals and organizations throughout the Master's Completion Project. I want to extend a very special thank you to the Alfred P. Sloan Foundation for its financial support for this project and for recognizing the importance of examining completion and attrition in master's programs in science, technology, engineering, and mathematics (STEM). Deep thanks also go to the National Science Foundation for providing funding to conduct a workshop to explore the role and status of the master's degree in STEM and to undertake additional research on the impact of the master's degree on Ph.D. completion.

The generosity of the institutions and their graduate deans who provided data and participated in the workshop and focus groups deserve special mention and gratitude. You have greatly enhanced our knowledge of completion and attrition in STEM master's programs.

For their careful reviews of this publication, I extend a sincere thank you to Robert Augustine, Dean of the Graduate School, Eastern Illinois University; Allan Headley, Dean of Graduate Studies and Research, Texas A&M University-Commerce; Jacqueline Huntoon, Dean of the Graduate School, Michigan Technological University; and John Keller, Associate Provost for Graduate Education and Dean of the Graduate College, University of Iowa.

It is also fitting that I recognize the contributions of the CGS staff—Robert Sowell, Nathan Bell, Sally Francis, and Leontyne Goodwin—for their devoted efforts to the Master's Completion Project and the production of this publication.

CHAPTER 1

Introduction

Background

Master's education in science, technology, engineering, and mathematics (STEM) fields plays an important role in meeting the needs of the U.S. workforce (National Research Council, 2008). Currently, about 120,000 individuals earn a STEM master's degree each year (National Science Foundation, 2010b). For some of these individuals the acquisition of the master's degree is the end goal while for some it provides a pathway to the doctorate. The academic experiences of STEM master's degree recipients exhibit great diversity—some complete a thesis while others complete capstones or other requirements, some attend full-time and others part-time, and some take courses online and others in traditional classroom settings. Over 5 million scientists and engineers with a master's degree as their highest degree currently work in the U.S. (National Science Foundation, 2010a). They can be found in every sector of the U.S. economy, some working as teachers, some as researchers, and others in management or professional services.

In recognition of the importance of master's degrees in STEM we need key information regarding master's completion and attrition rates and factors contributing to student success that is currently lacking in the literature. Recent research from the Council of Graduate Schools (CGS) shows that in major research universities about 57% of students who start Ph.D. programs complete their degrees within ten years (Council of Graduate Schools, 2008). Data from the National Center for Education Statistics (NCES) show that about 57% of first-time, full-time bachelor's degree-seeking students earn a baccalaureate within six years (Knapp et al., 2010). Very little is known, however, about completion rates for master's-level students.

Project Overview

In 2009, CGS launched a project with funding from the Alfred P. Sloan Foundation to draw on current research to clarify the state of knowledge about master's completion and attrition in STEM fields. The project also sought to identify factors that contribute to successful master's degree completion and to better understand why students fail to complete master's programs in STEM. Before examining completion and attrition, however, CGS recognized that it was important to develop a better sense of the range of master's programs offered in U.S. universities, in order to develop a typology of the characteristics of master's programs in STEM. Using an organizational typology will also lay the foundation for systematic future studies of master's degrees in STEM fields.

Building on the Sloan-funded project, CGS received funding from the National Science Foundation (NSF) to explore the role and status of the master's degree and the topic of master's completion and attrition in more depth. The NSF project included two components. First, a workshop held on May 18, 2010 explored the master's degree from three broad perspectives: 1) the role and status of the master's degree in STEM, 2) completion of STEM master's degrees and the impact of the master's degree on Ph.D. completion, and 3) career outcomes for master's degree recipients in STEM. In addition, the workshop provided an update on the Professional Science Master's (PSM) Initiative and NSF's Science Master's program. For the second component of the project, CGS conducted additional research on master's completion and its relationship to Ph.D. completion.

Organization of the Monograph

This monograph is composed of six chapters that are intended to shed light on the scope, purpose, and performance of master's degrees in STEM. Chapter 2 examines the status of the master's degree in the United States. Chapter 3 presents an examination of the categories and characteristics of STEM master's degree programs. Chapter 4 examines what is currently known about completion and attrition in master's programs in STEM and presents factors that contribute to master's completion and attrition. Chapter 5 summarizes the workshop that explored the role and status of the master's degree in STEM. The final chapter includes a summary, conclusions, and next steps.

The data presented in this monograph come from multiple sources. Depending on the level of detail available from the original data source, data are sometimes presented for all fields of master's education and in other cases just for STEM fields. References to "all fields" or "overall" indicate that the data being presented cover all fields of master's education, while the term "STEM" is used for data being presented for just those fields. The definition of STEM used in this monograph includes agricultural sciences; biological sciences; mathematics; computer sciences; physical sciences; earth, atmospheric and ocean sciences; engineering; social sciences; and psychology.

CHAPTER 2

The Status of the Master's Degree in the United States

Master's education is the fastest growing and largest part of the graduate education enterprise in the United States (Sims, 2006). The popularity of the master's degree reflects its flexibility and responsiveness to a wide range of individual and societal needs. Students pursue master's degrees to prepare for further advanced study; for teaching careers in public schools, community colleges, and universities; for careers in business and industry; to improve and upgrade their professional skills; to change professional fields; and to explore their own personal intellectual development.

Master's-Level Data and Trends

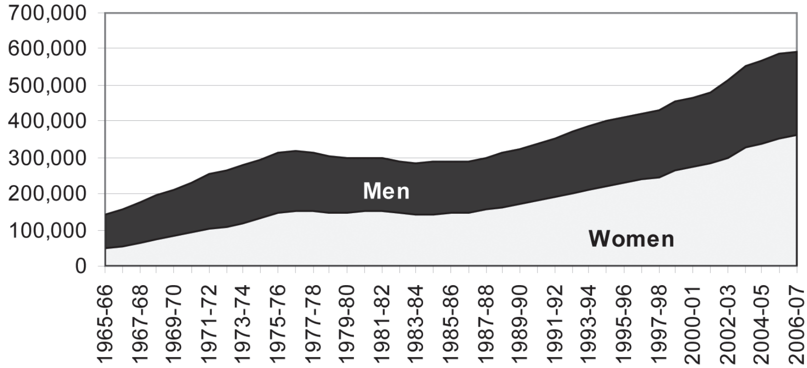
Master's degrees are awarded by a wide variety of U.S. institutions. In 2007-08, 48% of all master's degrees were awarded by public institutions, 43% were awarded by private, not-for-profit institutions, and 9% were awarded by private, for-profit institutions (Knapp et al., 2009). By basic Carnegie classification, master's colleges and universities awarded 38% of all master's degrees in 2007-08; research universities with very high research activity awarded 29%; research universities with high research activity awarded 19%; doctoral/research universities awarded 11%; and institutions with other Carnegie classifications (including baccalaureate and specialized) awarded 3% (Bell, 2009).

Across all fields, degree production at the master's level in the United States increased 104% between 1986-87 and 2006-07, from 290,532 to 593,350 (National Science Foundation, 2010b). In contrast, doctoral degree production increased 76% in this time period, and bachelor's degree production increased by just 50%. There are a number of reasons for the growth in master's education, including the fact that the master's degree is becoming the entry degree for employment in many fields. The result is that master's education occupies the largest portion of the graduate education enterprise, currently representing 75% of all graduate students and 90% of all graduate degrees awarded (Bell, 2009).

Master's degree production increased 3.9% annually on average between 1997-98 and 2007-08 (Bell, 2009). Much of this gain has been the result of the growth in the number of women earning master's degrees, with a 4.8% average annual rate of increase for women compared with a 3.0% average growth rate for men over the past decade.

Over the past 40 years, the rate of increase for women has been even more dramatic (Figure 1). In 1965-66, women earned about 47,600 master's degrees; by 2006-07, they earned over 360,000 master's degrees, more than seven times the number awarded forty years earlier (a 658% increase). In contrast, the number of master's degrees earned by men increased by 150% over the same time period (National Science Foundation, 2010b). Thus, the share of all master's degrees earned by women increased from 34% in 1965-66 to 61% in 2006-07.

Figure 1. Master's Degrees Awarded in the U.S. by Gender, 1965-66 to 2006-07



Note: Data for 1998-99 were not available.
Source: National Science Foundation, 2010

Across all fields, minorities have also driven much of the increase in master's degree production in the United States. In 1986-87, U.S. minorities earned about 30,000 master's degrees; in 2006-07, they earned nearly 122,000 (National Science Foundation, 2010b). Among U.S. racial/ethnic groups, the increase in master's degrees was greatest for Hispanics (356%), followed by African Americans (296%), Asian/Pacific Islanders (284%), and Native Americans (191%). In contrast, the rate of increase for temporary residents was 138%, and the growth rate for non-Hispanic whites was just 60%.

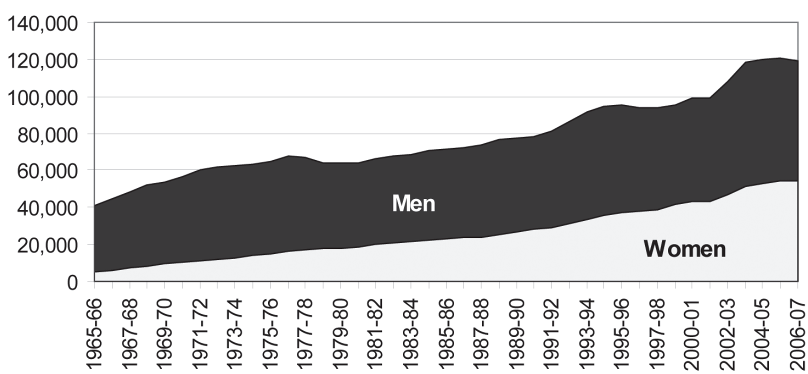
1 "STEM" includes agricultural sciences; biological sciences; mathematics; computer sciences; physical sciences; earth, atmospheric and ocean sciences; engineering; social sciences; and psychology.

Master's-Level Trends in STEM

In STEM fields,[1] degree production at the master's level in the United States increased 64% between 1986-87 and 2006-07, from 72,603 to 118,995 (National Science Foundation, 2010b). This rate of increase was slower than the rate of growth for all master's programs over the same time period (104% as noted above).

The majority of the growth in STEM master's degree production was driven by a large increase in the number of women earning degrees (Figure 2). Between 1986-87 and 2006-07, there was a 127% increase in the number of STEM master's degrees earned by women compared with a 33% increase for men (National Science Foundation, 2010b). Between 1965-66 and 2006-07, the share of STEM master's degrees earned by women changed significantly. In 1965-66, women earned about 13% of all STEM master's degrees; by 2006-07, they earned 45% of all STEM master's degrees (National Science Foundation, 2010b).

Figure 2. Master's Degrees Awarded in STEM Fields in the U.S. by Gender, 1965-66 to 2006-07



Note: Data for 1998-99 were not available.
Source: National Science Foundation, 2010

Large increases occurred in the past two decades in the numbers of U.S. minorities earning STEM master's degrees. In 1986-87, U.S. minorities earned about 7,000 STEM master's degrees; in 2006-07, they earned nearly 24,000 (National Science Foundation, 2010b). Among U.S. racial/ethnic groups, the increase in STEM master's degrees was greatest for African Americans (359%), followed by Hispanics (277%), Native Americans (267%), and Asian/Pacific Islanders (161%). In contrast, the rate of increase for temporary residents was 119%, and the growth rate for non-Hispanic whites was just 33%. Gains made by minorities in STEM master's degree attainment are important; however, their share of degrees remains low in comparison to minority representation in the general population. While U.S. minority groups comprise about 34% of the U.S. population (U.S. Census Bureau, 2010) they earned just 20% of all STEM master's degrees awarded in 2006-07. This figure, however, is twice the 10% share they earned in 1986-87.

Strong growth in the number of degrees awarded occurred across all broad STEM fields over the past decade. Master's degree production in social and behavioral sciences increased 3.5% annually on average between 1997-98 and 2007-08 (Bell, 2009). Growth was also strong in physical sciences (2.8% average annual growth), engineering (2.5%), and biological and agricultural sciences (2.1%).

Financial Support for Master's-Level Students

Nearly three-quarters (73.5%) of all master's-level students received some type of financial support in academic year 2007-08 (Wei, et al., 2009). The types of financial support received included loans, assistantships, fellowships, tuition waivers, and employer support, among others. For those students who received some type of financial aid in 2007-08, the average amount received was $14,386.

Student loans were the most common type of financial aid received by master's-level students in academic year 2007-08, with 43.6% receiving this type of aid (National Center for Education Statistics, 2009). Among students who received loans, the average amount received was $15,644. Stafford loans were the most common form of loan for master's-level students, with 39.4% of students receiving them, followed by private commercial or alternative loans (11.5%), graduate PLUS loans (3.1%), and Perkins loans (1.9%). Across all fields, master's-level students in architecture (74%) were most likely to have student loans in academic year 2007-08, followed by students in psychology (69%) and communication and journalism (56%). Students in engineering (14%) were least likely to have loans at the master's level, followed by those in computer and information sciences, foreign languages and literatures, and physical sciences (all 25%).

One-quarter (25.9%) of all master's-level students received financial support from their employers in 2007-08, either in the form of reimbursements or waivers of tuition/fees including those granted to university employees. The average amount of employer aid received was $5,245.

Among master's-level students in academic year 2007-08, 8.8% of master's-level students received fellowships, 7.0% received tuition and fee waivers from their institution, 5.4% received teaching assistantships, 3.8% received research assistantships, and 3.5% received other graduate assistantships. In addition, small percentages of students received financial support from their institution in the form of loans or work study.

Outcomes for Master's Degree Recipients

Overall, the potential income gain from earning a master's degree is substantial. Data from the U.S. Census Bureau show that over their working lifetimes, those whose highest degree is a master's can expect to earn an average of $2.5 million, while those with only a bachelor's degree can expect to earn $2.1 million (U.S. Census Bureau, 2002). The income advantage for those with a master's degree varies by field, with individuals in fields such as business experiencing more of an income advantage than those in fields such as education. In 2008, the median annual earnings of individuals with a master's degree were nearly $11,500 higher than the median for those with only a bachelor's degree: $64,116 compared to $52,624 (Bureau of Labor Statistics, 2010).

A master's degree also increases the likelihood of current employment, according to the Bureau of Labor Statistics (BLS). In 2008, among individuals 25 years of age and older, the unemployment rate for those with a master's degree as their highest degree was 2.4%, compared with 2.8% for those with only a bachelor's degree, and 5.7% for high school graduates (Bureau of Labor Statistics, 2010).

According to data from NSF, about 5.4 million employed scientists and engineers have a master's degree as their highest degree (National Science Foundation, 2010a). Individuals with a master's degree as their highest degree comprised 30% of all scientists and engineers employed in STEM occupations in 2006 (Kannankutty, 2008). Their share varied significantly by field, with master's-level scientists and engineers comprising nearly 43% of all individuals employed in the social sciences, but 23% of those in biological and agricultural occupations.

The majority of scientists and engineers with a master's degree as their highest degree (60%) were employed in business/industry in 2006, and another 20% were employed by 2-year colleges or pre-college institutions (National Science Foundation, 2010a). Twelve percent of master's-level scientists and engineers were employed in government, and just 8% worked in 4-year colleges and universities, medical schools or university research institutions.

Master's-level scientists and engineers most often report working in management, professional services, or teaching. In 2006, 20% of all scientists and engineers with a master's degree as their highest degree reported that their primary work activity was managing or supervising people or projects (National Science Foundation, 2010a). Another 19% reported professional services (healthcare, financial services, legal services, etc.) as their primary work activity, and 17% reported that their primary work activity was teaching. Among those in the latter category, the majority of these individuals (79%) were employed in 2-year colleges or Pre-K through 12 schools.

Among recent science, engineering and health master's degree recipients in academic years 2002-03 to 2004-05, 90% were working in April 2006. Among those with employment, 85% were working full-time (Proudfoot, 2008). The majority of employed recent STEM master's degree recipients were working in business/industry (57%), compared with 31% in educational institutions, and 12% in government. Computer and information sciences master's degree recipients were most likely to be employed in business/industry (76%).

The majority of STEM master's degree recipients secure initial employment in the state in which they receive their degree. According to data from NSF, among STEM master's degree recipients in 1997 to 2000, 65% of those who were employed were working in the same state as their master's institution one to three years after receiving their degree (Parsad and Gray, 2005). Earlier research from NSF found that only 41% of science and engineering doctorate recipients in 1999 secured initial employment in the state in which they received their degree (Sanderson and Dugoni, 2002), suggesting the importance of the master's degree to state and local economies.

Master's-Level Projections

Interest in master's education is expected to continue to increase in coming years. Across all fields between 2006-07 and 2018-19, the National Center for Education Statistics (NCES) projects that the number of master's degrees awarded will increase by 28% (23% for men versus 31% for women). This compares with projected growth of 49% for doctoral degrees, 24% for first-professional degrees, 19% for bachelor's degrees, and 25% for associate's degrees (Hussar and Bailey, 2009).

Students also continue to express a growing interest in earning a master's degree. For over 40 years, the Cooperative Institutional Research Program (CIRP) at the Higher Education Research Institute at UCLA has conducted a nationwide survey of American college freshmen, and the percentage of respondents indicating plans to obtain a master's degree as their highest degree has increased steadily over time. In fall 1974, 30% of the respondents to the CIRP survey indicated that they planned to earn a master's degree at some point; by fall 2009, that figure had increased by about one-third to 42% (Pryor et al., 2009).

Data from BLS indicate that employment in occupations that typically require a master's degree will increase 18% between 2008 and 2018 (Lacey and Wright, 2009). This compares with a 10% rate of growth expected for all occupations and a 17% increase for occupations typically requiring a bachelor's degree.

CHAPTER 3

Characteristics of STEM Master's Programs

Models of master's degree programs offered by U.S. institutions of higher learning vary in systematic ways that can be organized around a set of characteristics. Within general degree models, these characteristics include but are not limited to academic requirements for the award of the degree, administrative rules governing the program, and program delivery approaches. To provide a picture of common patterns of STEM master's degree offerings in the United States, exploratory analysis of all STEM master's degrees offered by a stratified random sample of thirty institutions was conducted. The strata were 1) the focus of the institution (i.e. doctoral or master's) and 2) the source of institutional control (i.e. public and private). The sample was drawn from the survey population for the CGS/GRE Survey of Graduate Enrollment and Degrees. The number of institutions selected in each of the resulting four categories is proportional to the total number of U.S. institutions in each category in the survey population. The survey population includes both CGS members and nonmembers, and includes a greater proportion of master's-focused institutions than does the CGS membership. Further, the sampling frame is the institutional level and, therefore, the sample institutions are not necessarily proportionate to the number of master's degrees awarded by all institutions, nor to the number of students enrolled in the master's programs offered by the sampled institutions. Two institutions are Historically Black Colleges and Universities. Four institutions are land-grant institutions. The thirty institutions studied are presented below in Table 1. A total of about 378 master's programs were analyzed.[2]

STEM master's program data were collected from the publicly accessible web sites of the thirty selected institutions. In several cases, clarification was sought through electronic or telephone contact with a representative of the institution. Weaknesses of this data collection approach are the availability, clarity, and accuracy of data via the web and the ease of navigability of the web pages visited. Programs included all science and engineering programs,

2 The number of individual, discrete programs was difficult to ascertain with precision because of differences in institutional practice in discriminating between majors, options, tracks, and so forth. Data in Table 1 include *all* program *offerings* (e.g. thesis, non-thesis, BS/MS, etc.) bearing the same field/discipline name; therefore, the number of programs enumerated in Table 1 is greater than the number of individual, discrete programs.

Table 1. Number of STEM Master's Degree Programs by Institution Focus and Control			
DOCTORAL INSTITUTIONS			
PUBLIC		**PRIVATE**	
Institution	**N**	**Institution**	**N**
College of William and Mary	11	Stanford University	33
University of California Berkeley	55	Clark University	9
University of Missouri Columbia	55	Massachusetts Institute of Technology	17
University of Massachusetts Boston	22	Brandeis University	13
The Ohio State University	63		
North Dakota State University	49		
MASTER'S-FOCUSED INSTITUTIONS			
PUBLIC		**PRIVATE**	
Institution	**N**	**Institution**	**N**
Ferris State University	3	Drury University	2
Buffalo State College	8	Bethel University	2
Clarion University of Pennsylvania	7	College of Mount Saint Joseph	1
Southern Illinois University Edwardsville	22	Oakland City University	0
Armstrong Atlantic State University	10	Argosy University	0
Indiana University – Purdue University Fort Wayne	19	Hampton University	10
North Georgia College and State University	3	Marian University	2
Bowie State University	4	Elon University	0
South Dakota School of Mines and Technology	13	Benedictine University	5
Florida Gulf Coast University	9	Newman University	2

social science programs, master of science programs associated with professional fields (e.g. vision science, nursing), and professional programs such as public health and public administration. The *2006 Crosswalk Between NSF Discipline Codes and the 1990 NCES Classification of Instructional Programs* was used to guide program inclusion/exclusion. Expert judgment was applied in determining which programs to include. The research goal was to identify models of STEM master's programs with illuminating data sufficient to inform the development of future scientifically designed studies. For both doctoral and master's-focused institutions included in this study, public institutions offered, on average, a higher number of STEM master's degree programs than did the private institutions, but considerable variability was observed within categories.

This study focused on providing an analysis of the types of master's programs and did not consider the distribution of students enrolled within the defined program. It could be the case that the distribution of students enrolled is markedly different from the distribution of the various types of programs that were observed. It is posited, for example, that a much smaller proportion of students is enrolled in thesis-required programs than the proportion of such programs compared to all master's programs.

Master's Program Models

Four broad categories of master's program models were identified: stand-alone, en route to Ph.D., dual degree, and accelerated degree. These four models are described briefly here and in greater detail throughout the discussion of specific program characteristics.

Stand-alone programs are master's programs into which students are directly admitted. Stand-alone programs may be offered alongside doctoral programs in the same field or may be the highest degree offered in a particular field at a given institution. Stand-alone programs differ in terms of various programmatic characteristics discussed in the following pages and also may be a partner program in a dual degree model or an accelerated degree model. In addition, stand-alone programs may be research-oriented or professionally/career-oriented.

Master's programs en route to the Ph.D. are programs that may or may not admit students directly into the master's program. However, for students in these programs their stated goal is the Ph.D. In en route programs, Ph.D. degree seeking students may be awarded the master's degree along the way to the Ph.D., whether or not that ultimate destination is actually reached. En route programs vary in admission restrictions, and they vary in the mechanism by which students provide evidence to merit the award of the master's degree.

Dual degree programs are those that are closely coordinated with another master's program. Dual degrees culminate in the award of two master's degrees upon completion of all of the requirements of both master's degree programs. Characteristics of master's programs that are partners in dual degree arrangements show considerable variability in terms of academic requirements for the award of the degree, administrative rules governing the program, and program delivery approaches. In some cases the number of credits required are shared between the programs, resulting in the total number of credits required being less than would be necessary for two stand-alone degrees.

Accelerated degrees are those that have been closely coordinated with a bachelor's degree program in the same or closely related field of study. Accelerated degrees culminate in the award of both the bachelor's degree and the master's degree upon completion of all of the requirements of both degree programs. Again, across accelerated degree programs characteristics vary considerably. In some accelerated degree programs a set of credits are shared between the two degrees and may reduce the number of required credits.

Although *order* can be found in the four master's program categories identified, there exists a great deal of variation *within* each of the four categories. For example, accelerated programs vary in characteristics such as time limits, student funding, delivery mode and so forth. Similarly, stand-alone programs vary in multiple characteristics such as whether or not a thesis is required, time limits, delivery mode and so forth.

The program data gathered from the thirty institutions in this study illustrate the variation within each of the four master's program categories. The University of California, Berkeley and The Ohio State University are highlighted in particular because the large numbers of STEM master's programs at these institutions help to demonstrate the variations within program categories. Appendix A, Selected Examples of Characteristics of Master's Degree Programs, presents examples of the characteristics discussed below by institution.

Dual degree. At the institutions included in this study, the dual degree model was fairly common (Appendix A, part a). Common dual degree combinations included the MBA, JD, or MPH as one of the two programs. Typically, students must be admitted to both programs simultaneously and must earn both degrees in order to benefit from the advantages of program coordination such as double counting of course credits. Examples of dual degree programs occurred at very different types of institutions reflecting curricular innovation in response to the complexity of modern challenges. Numerous occurrences of various program combinations were observed.

Accelerated. A model similar in construction to the dual degree model is the accelerated bachelor's/master's or co-terminal degree (i.e. BS/MS or BA/MA— Appendix A, part b). Many such programs were non-thesis programs but accelerated bachelor's/master's programs also were observed that did require a thesis. Only one accelerated program was observed at a master's-focused institution. Degree acceleration may be dependent on leveraging prerequisite experiences. Accelerated degrees are sometimes open only to undergraduate students currently enrolled at the same institution, frequently in specified programs. Accelerated degrees also may be coordinated with an undergraduate honors program (Appendix A, part c). Brandeis University offered the largest number of accelerated degrees including three programs designed to be completed in a total of four years.

En route to Ph.D. Award of the master's degree en route to the Ph.D. or as a degree awarded as an exit strategy from the Ph.D. appeared as a fairly standard model at the larger research, doctoral institutions. Various restrictions apply to master's degrees awarded en route to the Ph.D. such as the requirement that students apply for the master's degree prior to taking the doctoral preliminary or qualifying examination. At the University of California, Berkeley and at The Ohio State University, a substantial number of master's programs were offered only as a degree en route to the Ph.D.

At The Ohio State University, programs that offer both a master's and a doctoral degree "…and where the master's degree is considered a stepping stone to the doctoral degree (The Ohio State University, 2007)…" are listed as MS/PH.D. to signify the intended relationship between the two programs. About 75% of The Ohio State University's master's programs analyzed for this study are offered as "slash" programs; the remaining programs are not designed to lead to doctoral study. Generally, the stated goal of slash or en route programs is to prepare students for doctoral study. Students may be offered admission into the master's program, sometimes only by petition, or may be offered admission into the doctoral program but, in either case, may choose to end their study at the master's level or complete the Ph.D. Some programs impose strict time limits on termination at the master's level which has the practical effect of making the master's program an exit strategy from the Ph.D. When students are enrolled as doctoral students, annual reviews and/or preliminary examinations typically are oriented toward assessing the student's probability of success in the Ph.D. program even though the master's degree may be awarded at this stage of study. Importantly, programs such as Biostatistics, Chemistry, Microbiology, Molecular Genetics, Physics, and Psychology focus entirely on the Ph.D. degree. In these programs, students may be required to complete a master's degree as the first stage of the doctoral degree program or they may be admitted only directly into the doctoral program and receive a master's degree only as an exit strategy from doctoral study. Some programs such as Neuroscience, offer only the Ph.D. degree.

The same strong focus on research and doctoral study exists at the University of California, Berkeley. Many graduate programs at the

University of California, Berkeley admit new students to the fall term only, expect all students to study full time, and only award the master's degree en route to the Ph.D. or to students enrolled in other graduate programs at the University of California, Berkeley. This model[3] is prevalent among STEM graduate programs and a number of graduate programs offer *only* the Ph.D. degree. For example the University of California, Berkeley's Physics program admits new students for fall term only and does not admit students whose goal is to earn the master's degree. Doctoral students who have completed 35 units of coursework and who pass a comprehensive examination may choose to file for the master's degree en route to the Ph.D. Passing the Ph.D. preliminary examination constitutes passing the master's comprehensive examination (University of California, Berkeley, 2010).

The University of California, Berkeley does offer master's degree programs in Computer Science and in Mathematics but only for students who do not express a goal of earning the Ph.D. degree. Students whose goal is to earn the Ph.D. degree are admitted directly to the Ph.D. programs and may be awarded a master's degree en route to the Ph.D. Departmental financial support is generally offered only to Ph.D. students.

Exit strategy. Most doctoral programs provide an opportunity for students who leave a Ph.D. program to earn a master's degree upon exit. An example of the master's degree as Ph.D. exit strategy is the Biophysics program at The Ohio State University. Students are *not* admitted directly into the MS in Biophysics unless they are financially self-supporting; also students who are no longer eligible Ph.D. students may be classified as master's students. The MS may be earned by passing the Ph.D. qualifying examination, completing an experimental thesis, or by passing a modified preliminary examination and submitting a modified thesis. These are typical mechanisms for earning a master's degree as an exit strategy.

Intra Category Characteristics

In general, the programs studied exhibited great variability in terms of requirements, rules, and delivery mode.

Academic requirements. Individual programs may set additional academic requirements that are consistent with institutional requirements established centrally.

3 The "slash" model at UC Berkeley indicates that the master's degree is awarded only en route to the Ph.D. Students are not admitted directly to a master's degree program.

Thesis requirements. Just over half (about 51%) of the master's degree programs offered by the institutions studied included *both* a thesis and a non-thesis option. An additional one-quarter of the programs offered *only* a thesis-required option. The typical thesis program required 30 semester credits including 6 thesis credits and any core requirements. About one-fourth of the total programs were offered *only* as a non-thesis option.

Many non-thesis programs included specific requirements in lieu of thesis. Such requirements included capstone courses, practicums, internships, research papers, extra courses, or a written examination in addition to an oral examination (Appendix A, parts d & f).

Non-thesis programs tended to be professionally oriented such as programs in criminal justice, nursing, applied mathematics, occupational therapy, the master of public health, the master of public policy/affairs/administration, speech pathology, and the master of social work. But, even programs such as criminal justice and nursing occurred in the thesis-required format at some institutions. It should also be noted that thesis nursing programs often awarded few credits for thesis research and sometimes none suggesting that such theses may be more comparable to projects or papers that are often required in non-thesis programs in fields such as engineering.

Also, dual degree, accelerated bachelor's/master's (i.e. BS/MS, BA/MA), and master's/Ph.D. (i.e. MS/PH.D., MA/PH.D.) programs often were non-thesis programs (Appendix A, part a). Such dual degree programs predominantly were professionally oriented. However, at large research institutions such as The Ohio State University, University of Missouri, and University of California, Berkeley, even these types of dual degree programs often required a thesis. Also of note, at the large research universities included in the study, most non-thesis programs in reality were master's degrees awarded *en route* to the Ph.D. degree. That is, these programs did not admit students whose stated goal was to earn a master's degree and not a Ph.D. In such programs, students are admitted *only* to the Ph.D. program and Ph.D. students may be awarded the master's degree by several mechanisms most commonly by passing the Ph.D. qualifying or comprehensive examination, *not* by writing a thesis.

A variety of approaches were observed for non-thesis programs that were offered *alongside* thesis-required programs (Appendix A, part d). In some instances, coursework credits simply replaced thesis research credits resulting in the same number of total credits as required for the thesis program. Some coursework only programs prohibit students from changing from the thesis-required program to the coursework only program. In other non-thesis programs, additional coursework is required in lieu of thesis research resulting in a greater number of total credits required for the award of the degree. That is, instead of the typical 6 credits of thesis research, 8 or 9 or more credits of coursework are required. This was the model most commonly observed. Additional approaches included a research project plus seminar-format final examination and a written examination in addition to an oral examination.

Often, when both a thesis-required and a non-thesis form of a given program were offered *alongside* one another by the same institution, a degree title *different* than the MA or MS was awarded for a non-thesis program (Appendix A, part e). Although not currently the case, widespread and consistent use of this practice would signal that the degree recipient had completed a non-thesis master's degree program.

Generally, non-thesis *only* programs (i.e. programs for which there is no thesis-required program offered by the same institution alongside the non-thesis program) were observed less frequently compared to non-thesis programs offered *alongside* thesis-required programs and were predominantly offered in professionally oriented fields such as nursing, public affairs, occupational therapy, and social work (Appendix A, part f). Requirements in lieu of thesis included practicums, internships, research papers, extra courses projects, or a written examination along with an oral examination. In addition to stand-alone non-thesis programs in public administration/affairs, nursing non-thesis stand-alone programs nearly always required an internship. Another frequently observed non-thesis requirement was a research project or paper.

Several unusual examples of non-thesis requirements were noted. The program in Clinical Exercise Physiology offered by Benedictine University requires two internships and an academic and skills competency examination. The Software Engineering program offered by the University of Massachusetts, Boston, requires a software development project. It is probable that numerous other unusual or unique non-thesis requirements exist reflecting the great diversity of the master's degree and its responsiveness to workforce and societal needs.

Professional science master's. Although the number of Professional Science Master's (PSM) programs is growing dramatically across the country, the PSM model appeared on the websites of only four of the institutions studied (Appendix A, part g). Among the five total programs observed are two programs offered at the same university and one program that has not yet been officially recognized as a PSM program by the Council of Graduate Schools.

Required credits. Most institutions in this study required a minimum of 30 semester credits for the award of the degree but variance was observed. Frequently, as noted previously, non-thesis programs required credits in addition to the minimum number required by the institution as did professionally oriented programs. For example, the Medical Physics program at Hampton University requires 59 credits. The Speech Language Pathology program at Clarion University and the Health Services Administration program at Armstrong Atlantic State University require 53 credits. The Criminal Justice program at Drury University sets its credit requirement for the capstone experience according to the level of professional experience previously attained by the student.

Foreign language. Few foreign language requirements were noted with the exception of most area studies programs. For example, African American Studies, Latin American Studies, Near Eastern Studies, and Italian Studies at the University of California, Berkeley all include a foreign language requirement as does Classical Archeology. At The Ohio State University, Slavic and East European Studies, African American Studies and Eastern Asian Studies include a foreign language requirement as do the programs in Art History and Archeology at the University of Missouri and the Paleontology program at the South Dakota School of Mines and Technology.

Portfolio. A portfolio was specified as a requirement only rarely. The program in Economics and Finance at Southern Illinois University, Edwardsville required a portfolio in addition to completion of a thesis. The MA/PH.D. program in Italian studies at the University of California, Berkeley included a portfolio along with a language requirement, a translation examination, and the MA examination. A business plan is required for the non-thesis Computer Science and IT Entrepreneurship program at Brandeis.

Teaching experience. Several programs indicated that a teaching experience is required of all students (Appendix A, part h). This requirement could be satisfied in various ways; a graduate teaching appointment was the most common approach.

Multi-institution programs. Instances of multi-departmental and multi-institutional degree programs were observed. Fields that are highly regional or geographic in interest, are dependent on access to natural resources, or are highly dependent on advanced and costly infrastructure appear to utilize complex organizational structures to take advantage of the resources and capabilities of several organizational units. The Marine Sciences and Technology program offered by the University of Massachusetts Intercampus Graduate School of Marine Sciences and Technology is an intercampus degree involving the campuses at Amherst, Boston, Dartmouth, and Lowell (http://www.umassmarine.net/degrees/). Students choose a "home" campus but have access to instruction and research infrastructure at the other campuses. Some courses are offered via distance delivery to students regardless of home campus. Similarly, the College of William and Mary offers a program in Marine Science via the Virginia Institute of Marine Science.

The University of California, San Francisco, a health and medical focused campus, and the University of California, Berkeley jointly offer a thesis-required Health and Medical Science (JMP) program. The program is a 5-year MS/MD program; students spend the first 3 years at the University of California, Berkeley. According to the JMP website (http://jmp.berkeley.edu/about/master.htm) a major advantage of the JMP is the opportunity for medical students to work with faculty members at the University of California, Berkeley while in medical school.

Administrative rules. Administrative rules with which all programs must comply are established centrally. These institutional rules and regulations include matters such as admissions standards, the manner by which students may establish in-state residency for purposes of billing tuition, enrollment residency, and time limits for degree completion.

Admissions. En route master's programs often are not open for direct admission; instead, students are admitted into the Ph.D. program and then earn the master's degree along the way to the Ph.D. Such programs may be open for admission to external applicants who do not intend to pursue doctoral study but this approach is infrequent and may require a formal petition. Accelerated master's programs were open for admission only to undergraduate students currently enrolled at the same institution. Accelerated master's programs may operate in parallel to a Ph.D. program in the same field that is an en route program that would not ordinarily offer master's admission. Another model is that of programs that are open only to students currently enrolled in graduate programs in other fields at the same institution. See Appendix A, part i, for several examples of various approaches.

Time limits. Most programs analyzed in this study did not deviate from the institutional limit on time to degree completion which was typically 6 or 7 years. Examples of shorter time limits included 2, 3, 4, and 5 years set by individual programs (Appendix A, part j). In regard to time limits, it is of particular note that the Graduate Division at the University of California, Berkeley requires all doctoral programs to set a normative time to degree; some master's programs appear to elect to do so as well. Normative time is used as an incentive for timely degree completion through a Dean's fellowship vehicle (see http://www.grad.berkeley.edu/policies/dntf.shtml).

An approach observed in use by research doctoral focused programs was to limit the time available to complete the master's degree to only 2 or 3 years for both thesis-required and non-thesis programs. For example at North Dakota State University, the programs in Agricultural and Biosystems Engineering, Plant Pathology, and Plant Sciences all warn that student *funding* may be terminated after 2 years in the program although there is no specific time limit for completing degree requirements.

Full-time/part-time enrollment. The vast majority of programs analyzed in this study were offered both on a full-time and part-time basis. Programs that were specified as full-time only tended to be offered by large research universities or were professionally oriented programs with highly specified curricula. In fact, the policy of the Graduate Division at the University of California, Berkeley is that all graduate programs are full-time except for an evening/weekend MBA program and the Master's in Financial Engineering. Among all programs analyzed in this study, several were offered on only a part-time basis (Appendix A, part k).

Single start date. Some programs admit students to begin graduate study at only one point in time during the academic year, usually fall term (Appendix A, part l). Many professionally oriented programs (e.g. nursing) begin at only one point in time. Such programs generally have very structured curricula that include learning experiences that are highly sequential in nature. Thus, a single start date is practical from a management perspective when repeated course offerings in multiple terms throughout the year are not financially feasible. Several programs that begin only in summer were also observed.

Cohort model. The cohort model (Appendix A, part m) was occasionally observed, sometimes in combination with a single start term date. Generally, the cohort model does not permit students to pursue graduate study on a part-time basis because the curriculum is structured in a linear fashion such that all students experience the program as a cohort. Community building is viewed as an extremely valuable benefit of this approach.

Funding restrictions. Financial support is sometimes available only to doctoral students or is restricted to a specified period of time for master's students. For example, as mentioned previously, at The Ohio State University, students are not admitted directly into the Biophysics degree program unless they are self-funded or no longer eligible for the Ph.D. degree program. Students in the Rural Sociology program at the University of Missouri are limited to 3 years of funding or a maximum of 6 semesters of fee waivers. Beginning in the sixth semester of enrollment and forward, stipends of students enrolled in the Chemical Engineering and the Computer Science programs at the University of California, Berkeley are reduced on an increasing percentage basis. Funding is limited to 8 terms by the program in Plant Cellular and Molecular Biology at The Ohio State University.

Alternate delivery modes. Most programs analyzed in this study were delivered in a traditional, on campus mode although a substantial number of interesting delivery approaches was observed (Appendix A, part n). Online delivery was offered more often only for some courses within degree programs and infrequently for entire programs. Professionally oriented programs and those that were designed specifically to target working adults were more likely to offer a non traditional delivery mode than were traditional science master's programs.

The master's in International Affairs (international security focus) at North Georgia College and State University is entirely online and operates on a two-year cycle. The interdisciplinary Creative Studies program at Buffalo State College is offered as a combination of short summer courses and distance courses. The Science in a Changing World PSM degree at the University of Massachusetts, Boston, offers some courses online. The Information Systems Management program at Ferris State University is offered half online and half on weekends in a 7-week, year-round format. A number of examples of programs delivered during evening hours were observed.

Unusual program offerings. Several unusual, possibly unique, programs were observed such as the Paleontology program at North Dakota

State University which indicates on its website that it is the only such program in the U.S. Benedictine University offers an MSSCP in Science Content and Process targeted to K-9 teachers. This program is a cohort model and is delivered evenings and Saturdays. The University of Missouri offers a program in Natural Resources designed for practicing professionals that requires a technical report. Similarly, North Dakota State University offers a program in Emergency Management and a Master of Managerial Logistics degree targeted to career military officers and other professionals. Brandeis University offers a program in Computer Science and IT Entrepreneurship.

Summary of Characteristics of STEM Master's Programs

Four broad categories of master's program models were identified: en route to Ph.D., dual degree, accelerated degree, and stand-alone. While *order* can be found in the four categories, there exists a great deal of variation *within* each of the four categories.

In 1944 Irwin Buell put forward the following observations about the master's degree:

> The master's degree cannot be defined in any exact terms that will include all kinds and varieties that are awarded by all kinds of educational institutions…. The qualifications that need to be met by the candidate vary from nothing definite to stern unyielding standards. The degree is awarded lavishly at this institution and reluctantly at that one. If one attempts to survey and classify the procedures in vogue, he is lost in a maze of varying requirements. There are no exceptions because there is no rule; a point midway between extremes is not an average; and a college at that point in one respect may be extreme in another (p. 400).

Buell's observation, made more than one-half century ago, holds true today for the array of STEM programs analyzed in this study. Although today's master's programs can be categorized into four broad degree models, the permutations and combinations of characteristics associated with specific programs within each category are quite numerous even within the same institution. For example, although master's programs can be classified as either thesis-required or non-thesis, many program models exist within each of these two categories. Thesis-required programs include both full-time and part-time, different numbers of credits awarded for thesis research, different admission restrictions, and so forth. Similarly, non-thesis programs include full-time and part-time, face-to-face and distance, coursework only and internship, and so forth. As Buell observed, it is quite difficult to effectively and fully organize the master's degree even within very broad categories. However, the master's degree is universally defined as graduate level study beyond the bachelor's degree and designed at the program level in accordance with differing academic philosophies to meet various student goals. It is in this regard—the ability of programs to be responsive and flexible—that the strength and power of master's education is understood.

CHAPTER 4

Master's Completion and Attrition

Previous Research on Master's Completion and Attrition

When CGS began to examine the issue of completion and attrition in doctoral programs prior to the launch of the Ph.D. Completion Project (see www.phdcompletion.org), a considerable body of existing research was uncovered. Several studies from the 1950s to present have documented completion and/or attrition rates among various populations and fields at the doctoral level. Ph.D. completion rates from those studies ranged from a low of 33% in the humanities and social sciences in one study to a high of 76% among doctoral students in biomedical and behavioral sciences in another study of students supported by NIH National Research Service Award training grants (Council of Graduate Schools, 2008). CGS' Ph.D. Completion Project found that among students entering doctoral programs between 1992-93 and 1994-95, the ten-year completion rate was 57%. Considerable research has also been conducted on the factors that contribute to completion and attrition at the doctoral level, including the student/advisor relationship, financial support, cohort size, and student quality, among other factors (Council of Graduate Schools, 2004).

In contrast to research at the doctoral level, a review of the literature on master's completion and attrition reveals a limited amount of data and/or research. Only two cross-university and cross-discipline comparative studies were found on the topic, and both were from outside the United States. In addition, very little research has been conducted on the factors that contribute to completion and attrition at the master's level.

One of the two cross-university and cross-discipline comparative studies is a 2004 report from the Canadian Association of Graduate Studies (CAGS). The report presented completion data for master's students who entered a number of Canadian universities in 1992, although the exact number and names of the institutions included in the study were protected. The study found that median ten-year completion rates ranged from 73% in social sciences to 83% in physical and applied sciences. The study determined that the median time to completion of the master's degree was six semesters in the humanities, seven in the social and physical sciences, and eight in the life sciences. The median time to attrition was five semesters in the humanities, social sciences and life sciences, and four semesters in the physical sciences. Relying on factors identified in other previously published research at the doctoral level, the CAGS report included several recommendations for improving completion in graduate programs, including collecting better data on retention and funding, providing adequate funding to graduate students, tracking student progress, encouraging academic and social integration, regular reviews of programs, improving procedures for supervisor selection, educating faculty and staff about factors associated with completion, providing better information to students about what to expect in graduate school, conducting student exit surveys, and evaluating educational support to graduate students.

The second cross-university and cross-discipline comparative study was conducted by the Higher Education Division of the Department of Education, Training and Youth Affairs in Australia (Martin, et al., 2001). It presented completion data for 2,905 students who began master's programs between January and March of 1992. At the end of 1999, 43% of these students had either completed their master's degrees or a master's equivalent or higher degree. The study found that male students were less likely to complete than female students (41% vs. 46%), and that full-time students were more likely to complete than part-time students (47% vs. 39%). Completion rates were generally higher in the sciences; students in agriculture (53%), health (50%), and veterinary science (50%) had the highest completion rates at the master's level, and those in architecture (32%), arts, humanities and social sciences (37%), and business and economics (38%) had the lowest completion rates. Younger students generally had higher completion rates than did older students. Among those under the age of 24, the completion rate was 47%, compared with 41% for students 25 to 29 years of age, 42% for students 30 to 39 years of age, 38% for students ages 40 to 49, and 44% for those 50 and over.

Several studies have examined master's completion and attrition in individual programs and universities or in certain population groups or fields:

A 1988 study examined attrition among 4,325 students entering graduate programs at New Mexico State University in the fall semesters in 1979, 1980 and 1981 (Matchett,1988). Of those 4,325 students, 28% had not received a graduate degree by July 1986. Attrition rates were nearly identical for men and women – 28% vs. 29%. The attrition rate for minority students was 34%, compared with 27% for white students. The study found a somewhat higher level of attrition in engineering disciplines, while agricultural disciplines had the lowest attrition rates.

A survey of all master's-level nurse anesthesia programs in 1990 found that only 8% of 1,696 students who entered these programs between 1985 and 1990 failed to complete them (Mathis, 1993). Attrition rates for individual programs ranged from 0% to 25%, and the average attrition rate for all programs rose slowly from 6% in 1986 to 10% in 1990. Nearly half of all respondents (46%) indicated that personal reasons were the most common cause of students leaving master's-level nurse anesthesia programs, followed by academic reasons (21%), clinical reasons (17%), and a combination of those three reasons (16%).

A 2004 study of completion and attrition rates of master's-level international students at an unnamed American university found that among 866 entering students from 1987 to 2002, 622 (72%) had graduated at the time of the study, 92 (11%) had dropped out of the program, and 152 (18%) were still active (Nelson, et al., 2004). The study found that TOEFL scores were not a predictor of future master's degree completion.

A 2008 study of completion in the Criminology/Criminal Justice (CCJ) program at Florida State University tracked 287 master's students who entered the CCJ program between 1991-92 and 2000-01 (Lightfoot and Doerner, 2008). About half (47%) of the entering students were female, and the majority (79%) were white. Nearly all (96%) were U.S. citizens or permanent residents. Of the 287 entering master's students, 107, or 37%, failed to complete. The study found a correlation between completion of the master's program and age of the student upon entry to the program, with younger students more likely to complete. There was also a correlation between higher GRE scores and successful completion.

An exploratory study at Western Washington University examined data for four cohorts of master's students matriculating in 2000, 2001, 2002 and 2003 (Ghali and Mor, 2010). About sixty percent of the entering students were female, and more than four out of five were white. Twenty-four master's programs were included in the study, including eight programs in science and mathematics and three in social sciences. Overall completion rates ranged from a low of 74% for the 2000 cohort to a high of 87% for the 2001 cohort. In science and mathematics, completion rates for the four cohorts ranged from 67% to 83%, and in social sciences, completion rates ranged from 66% to 83%. The study found a relationship between completion and the inverse of the cohort size, with higher completion rates in smaller cohorts. The demographic characteristics of students had no impact on completion rates.

Completion rates in the U.S. studies ranged from a low of 63% in the Lightfoot and Doerner study of a master's program in Criminology/Criminal Justice to a high of 92% in the Mathis study of master's-level nurse anesthesia programs. Completion rates in the Canadian study ranged from 73% in social sciences to 83% in physical and applied sciences, while the overall completion rate in the Australian study was just 43%. Differing methodologies and study populations preclude meaningful comparisons between studies of completion and attrition rates among demographic groups.

Master's Completion and Attrition Data

Through contacts with CGS member institutions and Internet searches, CGS secured access to master's completion data from five U.S. universities. Four are research institutions and one is a master's-focused institution. The data from these five institutions are not directly comparable for a number of reasons. First, the numbers of years of data are not the same. Second, students in the datasets entered the master's programs over different time periods. Third, some institutions submitted 6-year completion rates, some 4-year rates, and some 3-year rates. And finally, there was no standard definition of entering cohort or degrees awarded by year. For example some institutions could have reported master's degrees awarded to Ph.D. students who received the master's along the way to the Ph.D. even though they were not included with any class of entering master's students. Despite these known and unknown inconsistencies across the five institutions, we do believe the data give some insight to master's completion rates over a range of programs.

Findings from the data are presented below. The identities of the institutions are not revealed. They will be referred to as Institutions A, B, C, D and E. The data are presented first for all master's programs at the institution and then for STEM programs, when available. The STEM programs are grouped into the following broad fields: computer and information sciences, engineering, life sciences, mathematics, physical sciences, and social sciences.

<u>Institution A:</u>

Institution A, a public research university, reported six-year completion rates for 7,516 students who enrolled in all master's programs between 1998 and 2004 (Table 2). Seventy-five percent of the students completed their degrees within six years. Of the 3,473 students enrolled in STEM disciplines, 76% completed within six years. The STEM completion rates ranged from a low of 67% in mathematics to a high of 81% in computer and information sciences. Overall, women completed at a higher rate (79%) in STEM fields than men (74%). Women completed at higher rates than men in engineering, life sciences, and physical sciences, while men completed at higher rates in computer and information sciences and social sciences. The rate of completion in mathematics was the same for men and women at 67%.

Table 2. Six-year Completion Rates for Students Entering Master's Programs in Academic Years 1998-2002 at Institution A, a Public Research University					
	Entering Students		**Completion Rates**		
Gender	**Female**	**Male**	**Female**	**Male**	**All**
All	4,229	3,287	78%	71%	75%
STEM	1,616	1,857	79%	74%	76%
Computer/Info Science	114	322	81%	82%	81%
Engineering	210	804	75%	71%	72%
Life Sciences	788	295	81%	74%	79%
Mathematics	9	18	67%	67%	67%
Physical Sciences	156	210	79%	75%	77%
Social Sciences	339	208	74%	76%	75%

Institution B:

More detailed data were available from Institution B, which is also a public research university (Table 3). In addition to enrollment and completion data by program, data were also available by gender, citizenship, race and ethnicity, enrollment status (full-time vs. part-time), and graduate credits earned prior to enrollment in the master's program.

The six-year completion rate for 7,188 students matriculating into all master's programs at the institution between June 1, 1998 and January 1, 2004 was 68% (Table 3). Also, 68% of the 4,365 students enrolled in STEM fields completed the master's degree within six years. The highest rate was in engineering (71%) and the lowest was in physical sciences (58%). Women and men completed at the same rate overall in STEM (68%), but women completed at higher rates in engineering, mathematics, physical sciences and social sciences, while men completed at a higher rate in life sciences. Men and women completed at the same rate in computer and information sciences.

Full-time students in STEM programs completed at a rate of 73%, 19 percentage points higher than part-time students. Full-time students completed at a higher rate in all broad fields except social sciences. The differences were particularly pronounced, 25 or more percentage points, in all other fields except for life sciences.

Table 3. Six-year Completion Rates for Students Entering Master's Programs from June 1998 through January 2004 at Institution B, a Public Research University					
	Entering Students		**Completion Rates**		
Gender	**Female**	**Male**	**Female**	**Male**	**All**
All	3,229	3,959	68%	67%	68%
STEM	1,496	2,869	68%	68%	68%
Computer/Info Science	189	482	67%	67%	67%
Engineering	367	1,515	75%	70%	71%
Life Sciences	397	347	65%	71%	68%
Mathematics	153	146	68%	67%	68%
Physical Sciences	129	191	60%	57%	58%
Social Sciences	261	188	69%	60%	65%
Enrollment Status	**Full-time**	**Part-time**	**Full-time**	**Part-time**	
All	4,272	2,491	74%	54%	
STEM	3,328	1,037	73%	54%	
Computer/Info Science	462	209	76%	47%	
Engineering	1,375	507	78%	52%	
Life Sciences	641	103	68%	65%	
Mathematics	280	19	70%	32%	
Physical Sciences	286	34	62%	29%	
Social Sciences	284	165	64%	66%	
Citizenship	**U.S. & PR**	**Int'l**	**U.S. & PR**	**Int'l**	
All	5,874	1,314	66%	72%	
STEM	3,137	1,228	66%	72%	
Computer/Info Science	363	308	56%	80%	
Engineering	1,262	620	71%	71%	
Life Sciences	659	85	69%	61%	
Mathematics	214	85	68%	67%	
Physical Sciences	239	81	54%	69%	
Social Sciences	400	49	63%	78%	
Race/Ethnicity	**Afr. Am.**	**As./PI**	**Afr. Am.**	**As./PI**	
All	552	372	59%	66%	
STEM	224	284	50%	67%	
Race/Ethnicity	**Hispanic**	**White**	**Hispanic**	**White**	
All	118	4805	67%	67%	
STEM	83	2531	65%	68%	
Graduate Hours Completed Prior to Admission to the Master's Program	**<3**	**>=3**	**<3**	**>=3**	
All	3,553	3,635	51%	84%	
STEM	2,289	2,076	51%	87%	
Computer/Info Science	574	97	65%	80%	
Engineering	763	1,119	47%	88%	
Life Sciences	341	403	44%	88%	
Mathematics	133	166	47%	84%	
Physical Sciences	185	135	36%	89%	
Social Sciences	293	156	56%	81%	

International students (72%) completed at a six percentage point higher rate than U.S. citizens and permanent residents (66%). The positive differences are particularly pronounced in computer and information sciences, physical sciences and social sciences. However, U.S. citizens and permanent residents completed at a higher rate than international students in life sciences, and completion rates were identical in engineering and very similar mathematics. Among U.S. racial/ethnic groups, African American students completed at the lowest rate in STEM fields at 50%, compared to 68% for White students, 67% for Asians/Pacific Islanders, and 65% for Hispanics.

Students who completed the equivalent of one or more three-credit graduate courses before admission to the master's program had considerably higher completion rates than students with minimal or no graduate credits prior to admission. Overall, students with no prior graduate credits and with 1- 2 credits completed at a 51% rate, while 84% of the students with 3 or more credits upon admission to the master's program completed the master's degree. For students in STEM programs the completion rate was even higher (87%) for students with 3 or more graduate credits. Completion rates in all six of the STEM broad fields for students who had 3 or more graduate credits prior to admission to the master's program were substantially higher than were completion rates of those who had no credits. The most pronounced differences were in engineering, life sciences and physical sciences at more than 40 percentage points.

<u>Institution C:</u>

Institution C is a master's-focused institution that provided completion data for 939 students enrolling in master's programs in the years 2000-2003 (Table 4). Eighty percent of these students completed their master's degrees within four years. Seventy-four percent of the 308 students who enrolled in STEM fields graduated in four years or less. Completion rates for STEM students varied by broad field from a low of 59% in computer and information sciences to a high of 82% in mathematics. The four-year completion rate for life sciences students was 79% followed by physical sciences and social sciences at 72%. Institution C did not have engineering programs.

Table 4. Four-year Completion Rates for Students Entering Master's Programs in Academic Years 2000-2003 at Institution C, a Public Master's-Focused University		
	Entering Students	**Completion Rates**
All	939	80%
STEM	308	74%
Computer/Info Science	32	59%
Life Sciences	73	79%
Mathematics	38	82%
Physical Sciences	50	72%
Social Sciences	115	72%

Institution D:

Data for Institution D were obtained from the university's website. This institution posted three-year completion data for 1,978 students who entered master's programs in fall 2003 through fall 2005 (Table 5). Overall 77% of these students completed their master's degrees within three years. Also, 77% of the 816 students who enrolled in STEM completed the master's degree within three years. Eighty percent of the social sciences students completed, followed by 76% of the engineering students. The other STEM fields were aggregated into the natural sciences for which 74% of the students completed in three years.

Table 5. Three-year Completion Rates for Students Entering Master's Programs in Academic Years 2000-2003 at Institution D, a Public Research University		
	Entering Students	**Completion Rates**
All	1,978	77%
STEM	816	77%
Engineering	489	76%
Natural Sciences	146	74%
Social Sciences	181	80%

Institution E:

Institution E is a public research university. The six-year completion rate for 5,406 students entering master's programs in academic years 1998-2003 was 77% (Table 6). Eighty percent of the women and 73% of the men completed in six years.

Table 6. Six-year Completion Rates for Students Entering Master's Programs in Academic Years 1998-2003 at Institution E, a Public Research University					
	Entering Students		Completion Rates		
Gender	Female	Male	Female	Male	All
All	2,933	2,473	80%	73%	77%

The Impact of Master's Degrees on Ph.D. Completion

One of the outcomes for master's degree recipients is pursuit of a Ph.D. Findings from the CGS Ph.D. Completion Project suggest that completion of a master's degree prior to admission to the Ph.D. program could have an impact on Ph.D. completion. Moreover, research conducted by Sheila Edwards Lange (2010) shows that women and students from underrepresented minority groups (African Americans, Hispanics, and Native Americans) are more likely to earn the bachelor's, master's, and doctoral degrees at three different institutions than their male and majority counterparts. These findings are critical to understanding pathways to and through doctoral education, identifying the roles of master's degrees on doctoral completion, and exploring broader definitions of attrition in the STEM education pipeline.

As part of this project on the role and status of the master's degree, four of the Ph.D. Completion Project Research Partners were engaged to provide more detailed information about the status of entering Ph.D. students with regard to the master's degree. All are research universities with very high research activity, three public and one private. Specifically, the four institutions provided ten-year Ph.D. completion data for seven cohorts of students who entered doctoral programs from 1992-93 through 1998-99 and seven-year completion data for students entering from 1999-2000 through 2001-02. In both cases the students were grouped into one of the following three categories describing their status with respect to the master's degree upon entry to the Ph.D. program:

1. Direct admission to the Ph.D. program from the bachelor's degree.
2. Completion of a master's degree at the same institution before admission to the Ph.D.
3. Completion of a master's degree at a different institution before admission to the Ph.D.

As was the case for the Ph.D. Completion Project, the data were provided for six broad fields and by gender, citizenship and race/ethnicity. The six broad fields are as follows: engineering, life sciences, mathematics, physical sciences, social sciences and humanities. There were 6,702 students in the seven cohorts for which ten-year completion rates were determined and 3,194 in the three cohorts analyzed for seven-year completion rates. The ten-year group was 70% male vs. 30% female and 62% U.S. citizen and permanent resident vs. 38% international. Among the U.S. citizens and permanent residents 4.7% were African American, 6.8% were Asian American, 3.0% were Hispanic, and 83.3% were White.

More than 60% (4,174) of the 6,702 students in the ten-year completion group were admitted to the Ph.D. program directly from the bachelor's degree (Table 7). Twenty-nine percent (1,955) had a master's degree from a different institution upon admission to the Ph.D., and 8% (573) had a master's degree from the same institution.[4]

Overall, 59% of the 6,702 students completed the Ph.D. in ten years (Table 7). However, the percent of completers among the students who had a master's degree from a different institution (70%) was considerably higher than that for students who entered the Ph.D. program directly from the bachelor's degree (55%) or with a master's degree from the same institution (56%). Students with master's degrees from a different institution completed at higher rates than the other two categories in all broad fields. In all broad fields except the life sciences, where the numbers of students who entered the Ph.D. with a master's from the same institution were quite small, the differences were more than 10 percentage points between having a master's from a different institution and the other two categories.

The same pattern existed for gender and citizenship. Male and female students, U.S. citizens and permanent residents and international students who had a master's degree from a different institution all completed at higher rates than their peers entering with a master's degree from the same institution or entering the Ph.D. directly from the bachelor's degree (Table 7). Again, in all four cases the differences were 10 percentage points or more. While the numbers are small for some of the racial/ethnic groups, Asian American, White, and Hispanic students completed at a higher rate if they had a master's degree from a different institution prior to admission to the doctoral program. African American students completed at a slightly higher rate if they had a master's

4 It should be noted that it was not possible for one institution to provide data on the number of students that completed a master's degree at that institution before enrolling in the Ph.D. because upon completion of the master's degree the student's permanent record was changed to Ph.D. and previous graduate enrollment history was lost.

degree from the same institution. African Americans who were admitted to the Ph.D. directly from the bachelor's degree completed at a lower rate than African Americans in the other two categories by nine and seven percentage points.

Table 7. Ten-year Completion Rates for Students Entering Ph.D. Programs from 1992-93 through 1998-99 as a Function of their Status with Respect to the Master's Degree Upon Initial Enrollment in Ph.D. Programs

			Status of Student upon Admission to the Ph.D. Program					
	All Students Entering Ph.D. Programs		**Admitted Directly from the Bachelor's**		**Admitted with Master's from Same Institution**		**Admitted with Master's from Different Institution**	
	Enrolled	% Completed	Enrolled	% Completed	Enrolled	% Completed	Enrolled	% Completed
All	6,702	59%	4,174	55%	573	56%	1,955	70%
Broad Field								
Engineering	1,724	70%	873	64%	250	66%	601	79%
Life Sci.	634	63%	442	58%	52	67%	140	76%
Mathematics	643	47%	459	43%	23	39%	161	57%
Phys. Sci.	2,118	58%	1,579	56%	75	45%	464	67%
Social Sci.	907	53%	557	49%	58	47%	292	62%
Humanities	676	55%	264	47%	115	45%	297	67%
Gender								
Female	2,031	57%	1,315	53%	163	52%	553	69%
Male	4,671	61%	2,859	56%	410	58%	1402	70%
Citizenship								
US Cit./PR	8,285	54%	2,925	52%	380	53%	872	63%
International	2,526	68%	1,252	62%	192	62%	1,082	76%
Race/Ethnicity								
African Amer.	198	46%	134	44%	19	53%	45	51%
Asian Amer.	285	50%	190	51%	30	37%	64	55%
Hispanic	127	46%	90	43%	15	53%	23	57%
White	3,480	55%	2,454	53%	311	54%	715	64%

In the second dataset the four institutions provided seven-year completion data for 3,194 students who started their Ph.D. programs in 1999-2000 through 2001-02 (Table 8). The completion patterns were very similar to those for the students starting programs between 1992-93 and 1998-99. Overall students who had completed a master's degree at a different university prior to matriculation in the Ph.D. program completed the Ph.D. at a higher rate (63%) than students who were admitted to the Ph.D. directly from the bachelor's degree (49%) and those who completed a master's at the same institution (37%). This order of completion rates held for all six broad fields, men, women, U.S. citizens and permanent residents, and international students. The order was mixed among the four racial/ethnic groups. White and Hispanic students who had master's degrees from a different institution completed the Ph.D. at higher rates that those who had a master's from the same institution, or who were admitted to the Ph.D. directly from the bachelor's degree. African Americans and Asian Americans who started the Ph.D. directly from their bachelor's program completed at higher rates than those in the other two categories. In all four racial/ethnic groups students who had a master's degree from the same institution completed at lower rates than students who had a master's from a different institution, or were admitted to the Ph.D. directly from the bachelor's degree.

Table 8. Seven-year Completion Rates for Students Entering Ph.D. Programs from 1999-2000 through 2001-02 as a Function of Their Status with Respect to the Master's Degree Upon Initial Enrollment in Ph.D. Programs

			Status of Student upon Admission to the Ph.D. Program					
	All Students Entering Ph.D. Programs		**Admitted Directly from the Bachelor's**		**Admitted with Master's from Same Institution**		**Admitted with Master's from Different Institution**	
	Enrolled	% Completed	Enrolled	% Completed	Enrolled	% Completed	Enrolled	% Completed
All	3,194	53%	1,780	49%	342	37%	1,072	63%
Broad Field								
Engineering	993	63%	374	59%	203	44%	416	76%
Life Sci.	234	52%	154	51%	19	47%	61	54%
Mathematics	299	36%	209	35%	9	0%	81	41%
Phys. Sci.	1,051	56%	737	54%	57	39%	257	67%
Social Sci.	346	43%	200	42%	18	11%	128	49%
Humanities	271	33%	106	20%	36	17%	129	48%
Gender								
Female	996	47%	590	47%	76	25%	330	54%
Male	2,198	55%	1,190	50%	266	41%	742	67%
Citizenship								
US Cit./PR	1,558	45%	1,053	44%	175	34%	330	50%
International	1,636	60%	723	55%	164	40%	749	69%
Race/Ethnicity								
African Amer.	91	30%	65	35%	5	0%	21	19%
Asian Amer.	127	37%	76	41%	33	27%	18	39%
Hispanic	60	43%	41	41%	6	17%	13	62%
White	1,245	46%	847	46%	130	38%	268	52%

Factors Contributing to Master's Completion and Attrition

As previously stated, there are very little data on master's completion and attrition rates and the factors that contribute to attrition and completion in master's programs. In an effort to begin a dialogue on this topic among the representatives from CGS member institutions, two sessions were held at the 2009 CGS Summer Workshop that focused on this topic: a Dean Dialogue attended by approximately 82 graduate deans and an invitation-only focus group in which 14 graduate deans participated. The outcomes from these two sessions are integrated in the following discussion.

In the Dean Dialogue, three graduate deans made introductory comments about master's completion. Following these comments, participants were asked to form small groups to discuss factors that, based on their experience as leaders in graduate education, contributed to the success, or lack thereof, of master's students in completing their degrees.

In the focus group the participants were asked to address the four following questions:

1. How do you define attrition in master's programs?
2. What are the factors affecting master's attrition?
3. How might the following affect master's attrition? Enrollment status of the student (part-time vs. full-time), delivery mode of the program or courses in the program (face-to-face vs. online), and the degree requirements (coursework only, thesis, internships, culminating project, etc.)
4. What interventions are effective in reducing attrition?

The discussion of the definition of attrition in master's programs centered on the time limits institutions allow for completion of the degree. The time limit ranged from 5 to 10 years for the institutions represented by the focus group participants (Table 9). At one institution the time limit was 5 or 7 years depending on the number of credit hours required by the program. Most of the participants reported that exceptions could be made with sufficient justification by the student and the program. About half of the participants reported that their institution had a continuous registration policy for master's students. Most also indicated that they had systems for tracking students' progress toward the degree – some were electronic systems and some were done on an informal basis by the student's department or program. There was agreement among the focus group participants that tracking student progress was more difficult in the absence of a continuous registration policy.

While not a question posed to the focus group, in the discussion of the definition of attrition several participants talked about non-enrollment before a student was removed from the program. At one institution with a six-year time limit for completion, the student was dropped from the program in the first semester of non-enrollment (Table 9). In another it was five years. Most reported that 1-3 semesters of non-enrollment would lead to termination of the student from the master's program. In most cases students who were terminated because of failure to meet the enrollment requirement would be allowed to apply for re-admission to the program.

Table 9. Respondents' Definitions of Attrition and Related Policies and Practices

Respondent	Time Limits	Continuous Enrollment Policy	Exceptions Allowed	Students Tracked	Period of Non-enrollment to Attrition	Stop-out Policy
Institution A	6-year limit		yes	yes	3 semesters	
Institution B	6-year policy		yes		none	3 semesters
Institution C	6 years to complete			yes	1 year	
Institution D	5-year time limit				3 semesters	
Institution E	5-year limit		yes	yes		
Institution F	10-year limit	yes	yes			
Institution G	7-year limit	yes			none	
Institution H	5- or 7- year limit, depending upon # credits required				12 months	
Institution I	7-year limit	yes		informal	1 year	
Institution J	8-year limit		yes		1 year	
Institution K	5 to 7 years	yes		yes	5 years	
Institution L	6-year limit	yes				
Institution M	6-year window	yes				

Participants in both the Dean Dialogue and the focus group identified a wide range of factors they believe contribute to attrition among master's students. For discussion purposes in this document the factors are grouped into the following categories:

1. Financial support
2. Personal/family/job issues
3. Faculty mentoring and teaching
4. Motivation and understanding of commitment and opportunities
5. Program rules, policies and procedures
6. Other

Financial support. Participants indicated that financial support is a critical factor that affects completion and attrition in master's education. In particular, a lack of assistantship or fellowship support, tuition waivers for students, and financial support from employers were identified as having an impact upon the completion of graduate education at the master's level. The participants specifically noted insufficient funding for students in professional master's programs. Some mentioned that while assistantships were available, the stipends were very low. In addition, accrual of student debt and the high cost of tuition were also pertinent factors.

Personal/family/job issues. The challenges of balancing personal life responsibilities can affect students' completion of master's programs. Participants noted that other noteworthy factors include presence of children, the need to work, relationship status, and veteran status.

Faculty mentoring and teaching. Faculty advising and mentoring were also believed to be critical factors in the success of master's students. Several participants in the two sessions stressed the need for qualified faculty who are available to provide strong, high quality mentoring in which mentors clearly define expectations for students and provide students with well-defined milestones they are expected to meet in order to complete the degree. Participants emphasized the importance of handbooks that clearly outline the requirements of programs and of the faculty's awareness of general rules and regulations. Some participants expressed a belief that mentoring of students in professional master's programs was not as readily available and sometimes of a lower quality compared to mentoring in arts and sciences programs. They also reported that mentoring is particularly important in STEM fields and that the issue of acculturation should be included in the mentoring experience.

Motivation and understanding of commitment and opportunities. A lack of students' understanding of the commitment and/or opportunities associated with the master's degree was believed to be a contributing factor to master's attrition. Participants in the Dean Dialogue and the focus group expressed the view that some students do not completely understand the commitment that is needed to be successful. Some students lack motivation, necessary maturity, and understanding of what a graduate program entails or its relevance to career goals. There are also occasions when students enroll in master's programs for the wrong reasons, question the value of the degree, and/or are not capable of meeting the expectations of graduate studies.

Program rules, policies, and procedures. Concern was also expressed that graduate school and/or program rules, requirements, policies and procedures could contribute to failure to complete the master's degree. Limited course offerings, continuous enrollment policies, and the treatment of a master's degree as a "throw-away" degree were believed to sometimes be a factor. The thesis was also cited as an impediment for some students insofar as issues of efficiency are concerned (i.e. defining topics, managing expectations and data collection). Other factors identified were ineffective systems for tracking student progress and inflexible time-out policies.

Other. Campus environment, culture and student services were cited by some participants as factors that can impact attrition and completion. Specific examples include lack of accessibility to campus and unavailability of student services, in general, for evening, part-time and distance education students. These students also sometimes have limited opportunities to feel connected to the university community and to have face-to-face interactions with faculty and other students.

Many students leave master's programs to pursue other opportunities. This was particularly true of students in disciplines like computer science and electrical engineering. In the 1990s and early years of the 21st century, industry jobs were plentiful for students with some graduate training in information technologies. Master's students also sometimes leave their programs before completion to pursue Ph.D. programs. One participant in the focus group talked about international students with MD degrees who are admitted to master's programs even though their real goal is to find an internship at a medical school in the U.S.

Focus group participants also were asked to comment on the effect of three specific factors on completion: enrollment status (part-time vs. full-time), delivery mode (face-to-face vs. online), and degree requirements. In the case of full-time versus part-time status, the consensus of the group was that the same factors affecting completion and attrition apply equally to both full-time and part-time students. It is a question of how full-time status is defined and participants agreed that the definition varies from institution to institution. Another complication is that some students attend on a full-time basis during summers but do not attend during the remainder of the academic year. Therefore, they are not counted in official fall enrollment statistics. Also, participants pointed out that it cannot be assumed that a full-time student is not employed part-time or full-time while simultaneously pursuing the degree.

A similar argument about lack of consistency in definition and the risk of overgeneralization in regard to enrollment status was made in the case of delivery mode. The delivery mode for specific programs cannot necessarily be classified into a single category because there are hybrid programs as well as hybrid courses (e.g., a portion on-line and a portion face-to-face). In addition, off-site delivery is being used, sometimes in combination with online or on campus delivery. Further, physical sites are being created by some programs where students in online programs can access student services.

Participants emphasized the importance of establishing a community culture unique to the program, regardless of delivery mode, and that more structure contributes to higher completion rates. In this regard, access for on-line students to student services was viewed as important for degree completion. Examples of community building included online peer mentoring, groups organized by students for academic as well as social purposes, virtual student lounges, and online alumni associations. Programs that employ a cohort model were believed to be conducive to higher completion rates owing to the high level of structure. Often another benefit of cohort approaches is the strong sense of community and peer support that develops among students. Generally, participants agreed that engagement can occur online as well as in on campus programs.

The use of new technologies appears to positively affect completion. Participants mentioned course management systems, availability of electronic class notes, and virtual engagement strategies as aiding in retention. Technologies such as these are available for use in both online and on campus programs.

The third factor the focus group was asked to discuss was degree requirements. Internship requirements were believed to have a positive impact on master's completion. Also, internships often lead to jobs upon completion of the degree. Participants in the focus group pointed out the need for master's programs to include some form of relevant practical training such as a teaching experience, internship or research experience, and a culminating event that requires students to make a presentation on their work. It was pointed out that there may be differences among states and institutions in requirements for a culminating event such as a thesis, examination, or capstone experience. Participants also discussed whether or not a professional versus a research oriented master's program has an effect on completion. In this context, the PSM model and non-thesis programs were discussed.

The last question posed to the focus group related to interventions to reduce attrition and improve completion (Table 11). Participants agreed that the first step was to have admissions processes that could effectively identify students with a high potential to succeed. This should be followed by effective orientations either online, face-to-face, or both where possible. It was suggested by one participant that the orientations for students who are scheduled to start the program in the fall should begin in June. Early, continuous and effective mentoring was identified as essential to the success of students, particularly in the case of minorities and women. In the area of campus environment and culture the focus group identified high engagement of the students, support for students with families, and support for women and minorities as priority interventions. Other effective interventions identified by the focus group include clear and solid policies, such as continuous registration, and practices for identifying and helping students who are not making normal progress to the degree.

Table 11. Promising Strategies for Reducing Attrition and Improving Completion

Financial Support	Admissions/ Orientation/ Mentoring	Environment/ Culture	Rules/Policies/etc.
provide assistantships	have smart admissions, pick students who can succeed	support for students with families, culture centers, resource fair at orientation	have solid policies, e.g., continuous registration, credit requirements, etc.
employer support	peer mentoring for URMs and women	support for women and minorities	
provide higher assistantships for humanities students - often lower than STEM	provide thorough orientation, email and face-to-face	high engagement of students, like in NSF funded programs	
don’t always pull support after 2 years	have extended orientation in June	send emails to non-registered students	
some disciplines self-supported	online orientation	letter from dean after 3 years of enrollment	

CHAPTER 5

CGS/NSF Workshop: The Role and Status of the Master's Degree in STEM

CGS and NSF held a day-long workshop, "The Role and Status of the Master's Degree in STEM," on May 18, 2010. The CGS/NSF workshop brought together nearly 90 experts in graduate education and representatives of funding institutions, federal agencies, and disciplinary societies to explore the role and status of master's education in STEM; factors impacting completion and attrition at the master's level; and career outcomes for individuals with master's degrees in STEM.

Tony Carnevale (2010), Director of the Center on Education and the Workforce at Georgetown University and keynote speaker, discussed the demand for STEM and graduate education through 2018 and presented trends relative to workforce needs and master's degrees in STEM. According to Dr. Carnevale's projections, there will be 7.9 million jobs in STEM in 2018, 24% of which will require a graduate degree. In addition, master's-level employment opportunities in STEM are projected to increase by 17% between 2005 and 2018, a larger increase than the overall economy (10%), with computer science and mathematics fields driving the growth. In 2018, master's-level jobs in STEM are expected to be concentrated in manufacturing, professional, and scientific industries, as well as public administration. Jobs in the life sciences are more likely to be broadly dispersed across industries than any of the other STEM occupations.

The workshop included four panels, the first of which offered a broad overview of master's education in STEM, outlined burgeoning efforts to promote and sustain professionalization of master's degrees, and delineated ranges of diversity inherent in STEM master's programs and among STEM master's degree recipients. Eleanor Babco (2010), Associate Program Director of CGS' Professional Master's Initiative, presented some of the types of master's degrees in STEM, roles and functions of these degrees in academia and the workforce at-large, and demographic data relative to STEM master's degree recipients. She noted that master's programs represent approximately 75% of total graduate enrollment in the U.S. and that women represent 60% of total enrollment in master's programs. Between 1998 and 2007, the largest increase in STEM master's degrees was in computer science and the smallest increase was in the physical sciences. Despite overall growth in STEM master's enrollment, underrepresented minority groups, which included over 30% of 18-24 year olds in 2007, earned only 18% of all master's degrees, 16% of master's degrees in STEM, and 12% of natural science and engineering master's degrees.

In a similar vein, Sheila Edwards Lange (2010), Vice President for Minority Affairs and Vice Provost for Diversity at the University of Washington, explored the role of the master's degree on pathways to and through doctoral education. She presented her research findings that build a framework for understanding the growth in master's degrees awarded in STEM, pose critical questions about the role and impacts of master's education on the doctoral education recruitment and training pipeline, and may have appreciable implications for better understanding key factors and intervention points in the STEM educational pipeline. Some salient findings of Dr. Edward Lange's research point to the fact that women and students from underrepresented minority groups are more likely to earn the bachelor's, master's and doctoral degrees at three different institutions than their male and majority counterparts. Subsequently, Vice Provost and Dean of the Graduate School of Marquette University, William Wiener (2010), rounded out the first panel with a report of trends in master's education in STEM at Marquette University. He underscored the integral role that master's education plays in the preparation of well-trained professionals for the business and industry workforce.

The second workshop panel addressed the issue of completion and attrition in master's education in STEM, broadly, from three institutional perspectives. Moheb Ghali (2010), Vice Provost for Research and Graduate Dean at Western Washington University, considered the feasibility of improving data collection methods that are used in gathering attrition, completion, and time-to-degree data. He shared his use of the Banner Student Information System to examine completion rates and average time-to-degree data for four cohorts of students across 24 master's programs. Dr. Ghali noted that the same process may be applied to gain greater understanding of individual attrition, completion, and time-to-degree rates. He provided a written methodology to workshop participants for replication with their institutional data.[5]

Brenda Brouwer (2010), Associate Vice-Principal and Dean of the Graduate School at Queen's University in Ontario, shared master's and doctoral

5 Moheb Ghali's and Denise Mor's methodology for use of the Banner Information System to examine completion rates and time-to-degree data can be located online at http://www.cgsnet.org/portals/0/pdf/CGSNSF2010_Ghali.pdf.

enrollment and completion data from a Canadian context. Queen's University currently offers 27 master's programs in STEM, with approximately 47% of master's-level students at Queen's University pursuing studies in STEM. Dr. Brouwer's presentation accentuated the role of the master's degree at Queen's University and in Canada in general as a prerequisite for most doctoral programs.

Purdue University's Dean of the Graduate School, Mark J.T. Smith (2010), provided an analysis of 10-year completion data showing completion trends for doctoral students with bachelor's and master's degrees upon admission to doctoral programs across five broad fields. Dr. Smith stated that regardless of gender or discipline, completion rates were higher for those who had earned master's degrees prior to admission to the doctoral program than for those who entered the doctoral program immediately after earning the bachelor's degree. Some factors that were cited as being influential and, thus, impact the completion process are major professors/mentors, preparation for and engagement in the research process, personal/family-related stressors, financial stressors, and departmental or broader academic climate, to name a few.

The third panel updated workshop participants on the NSF Science Master's Programs and the CGS PSM Initiative. In 2010, NSF's Science Master's Program considered 214 proposals and granted 21 awards to programs throughout the United States including Puerto Rico. Myles Boylan (2010), Program Director in the Division of Undergraduate Education and Division of Graduate Education at NSF, discussed numerous benefits of the Science Master's Program to industry leaders and members of the educational community. The Science Master's Program increases opportunities for employers to actively engage in the development of graduate education and training that meet the targeted needs of the workforce. In similar fashion, CGS' PSM Initiative continues to demonstrate the demand for professionals who possess a master's-level education in STEM coupled with professional skills components that are developed in consultation with employers. Since its inception in 1997, the PSM Initiative has seen a dramatic increase from less than 10 programs to more than 200 programs at over 100 institutions in 2010. PSM programs are offered at institutions at various levels of the Carnegie Classification System, but are particularly concentrated at Master's Colleges and Universities (larger programs), Research Universities (very high research activity), and Research Universities (high research activity). Carol Lynch (2010), Senior Scholar in Residence and Program Director of the CGS Professional Master's Initiative, discussed ongoing efforts to encourage states to endorse PSMs, promote PSM sustainability, and ensure that the PSM becomes a regular feature of graduate education in STEM.

In his presentation in the fourth panel on career outcomes for STEM master's degree recipients, B. Lindsay Lowell (2010), Director of Policy Studies at Georgetown University's Institute for the Study of International Migration, stated that the *Science and Engineering Indicators 2010* report points to increases in the availability of qualified individuals who may contribute to the STEM workforce. Although the career outlook for STEM master's degree recipients is positive in the main, there is a need for continual cultivation of talent at all levels of the STEM educational pipeline to ensure the availability of human capital and competitiveness at national levels. Wayne Stevenson (2010), Director of Science Education Programs at Oak Ridge Associated Universities, described efforts to identify and shape the early career goals of STEM trainees. He informed the workshop participants about partnerships at Oak Ridge Associated Universities that advance research and education in STEM through fellowships, scholarships, K-12 teacher development, and other training opportunities. Lilian Wu (2010), Program Executive at IBM Global University Programs, discussed the complexities and interconnections of building and sustaining a strong and efficient workforce and emphasized the need for individuals who not only come to the workforce with core strengths of a given discipline but who are also dynamic, adaptable, creative, and able to reach across disciplines to shape and innovate in ever-changing global contexts.

Two small group discussion sessions at the CGS/NSF workshop offered participants opportunities to provide feedback regarding the ways in which presented data comport with the direction of the STEM master's degree at their institutions and ways that the attrition and completion data may support improvement of student outcomes. Workshop participants expressed strong interest in understanding more about the role and status of the master's degree, in general, but particularly in STEM fields. Some additional topics of interest included the purpose and goals of master's programs; early intervention strategies in the STEM education pipeline; career outcomes for master's recipients, particularly recipients of PSM degrees; and more systematic tracking of master's students to enable more empirical data relative to completion and attrition at the master's level. Some identified areas of need were comprehensive, standardized completion and attrition data for master's-level programs, increased information about available funding opportunities at the master's level, and outcomes for graduates of PSM programs.

CHAPTER 6

Summary, Conclusions, and Next Steps

Summary and Conclusions

Master's education is the fastest growing and largest part of the graduate education enterprise in the United States currently representing 75% of all graduate students and 90% of all graduate degrees awarded. Across all fields, degree production at the master's level in the United States increased 104% between 1986-87 and 2006-07, and in STEM fields, degree production increased 64% over the same time period. The majority of the growth in STEM master's degree production over the past two decades was driven by large increases in the number of women and minorities earning degrees.

An examination of the characteristics of master's degree programs at a random sample of 30 U.S. institutions shows that today's master's programs can be categorized into four broad degree models: en route to Ph.D., dual degree, accelerated degree, and stand-alone. While *order* can be found in the four categories, there exists a great deal of variation *within* each of the four categories. The permutations and combinations of characteristics associated with specific programs within each category—such as academic requirements for the award of the degree, administrative rules governing the program, and program delivery approaches—are numerous even within the same institutions. These primary features make it quite difficult to effectively and fully organize the master's degree within the four broad categories. A critical feature, however, is that the master's degree is universally defined as graduate level study beyond the bachelor's degree and designed at the program level in accordance with differing academic philosophies to meet various student goals. It is in this regard—the ability of programs to be responsive and flexible—that the strength and power of master's education is understood.

A review of the literature on master's completion and attrition reveals a limited amount of data and/or research. Only two cross-university and cross-discipline comparative studies were found on the topic, and both were from outside the United States. Completion rates in a 2004 Canadian study ranged from 73% in social sciences to 83% in physical and applied sciences, and the overall completion rate in a 2001 Australian study was just 43%. Completion rates in five relevant U.S. studies ranged from a low of 63% to a high of 92%.

CGS examined master's completion data from five U.S. universities (see Chapter 4). Although the data from these institutions are not directly comparable due to differing methodologies, they do provide insight to master's completion rates over a range of programs. At institution A, the overall six-year completion rate in all master's programs was 75%. In STEM master's programs, the six-year completion rate was 76%, with a higher completion rate for women (79%) than for men (74%). In institution B, the six-year completion rate was 68% for all master's programs and 68% for STEM master's programs as well. Full-time students completed at a higher rate than part-time students, and students who completed one or more three-credit graduate courses before admission to the master's program had a considerably higher completion rate than students with minimal or no graduate credits prior to admission. At institution C, the four-year completion rate was 80% overall and 74% in STEM master's programs. The three-year master's completion rate was 77% overall at institution D and 77% in STEM master's programs as well. Institution E reported a 77% six-year completion rate for students in master's programs. Women had a higher completion rate (80%) than did men (73%).

As part of the NSF-funded project, CGS engaged four Ph.D. Completion Project Research Partners to provide more detailed information about the status of entering Ph.D. students with regard to the master's degree. Institutions were asked to group completers and non-completers into three categories with respect to the master's degree upon entry to the Ph.D. program: direct admission to the Ph.D. program from the bachelor's degree, completion of a master's degree at the same institution before admission to the Ph.D., and completion of a master's degree at a different institution before admission to the Ph.D. Overall, 59% of the students at these four institutions completed the Ph.D. within ten years, but the percentage of completers among students who had a master's degree from a different institution (70%) was considerably higher than that for students who entered the Ph.D. program directly from the bachelor's degree (55%) or with a master's degree at the same institution (56%). Men, women, U.S. citizens and permanent residents, and international students who had a master's degree from a different institution all completed at higher rates than their peers entering with a master's degree from the same institution or entering the Ph.D. program directly from the bachelor's degree.

Very little research has been conducted on the factors that contribute to completion and attrition at the master's level. In an effort to begin a dialogue on this topic, two sessions were held at the 2009 CGS Summer

Workshop that focused on this topic: a Dean Dialogue and an invitation-only focus group. Participants in these two sessions identified numerous factors that might affect attrition and completion, including financial support, an appropriate understanding of the commitment associated with pursuing a master's degree, balancing work/life responsibilities, the critical role of faculty mentoring, continuous enrollment policies, thesis/non-thesis requirements, delivery mode, and enrollment status, among other factors. When asked to suggest interventions to reduce attrition and improve completion, focus group participants agreed that the first step was to have admissions processes that could effectively identify students with a high potential to succeed. This should be followed by effective orientations either online, face-to-face, or both where possible. Early, continuous and effective mentoring was identified as essential to the success of students, particularly in the case of minorities and women. Other effective interventions identified by the focus group included high engagement of the students, support for students with families, support for women and minorities, clear and solid policies such as continuous registration, and practices for identifying and helping students who are not making normal progress to the degree.

While this monograph has not addressed and answered all of the research questions surrounding completion and attrition in STEM master's programs, for the first time, the scant extant literature about master's completion and attrition, master's completion data, and detailed descriptions of current master's program models have been synthesized and integrated into a single document. Given the dominance of the master's degree within the graduate enterprise, its upward growth trajectory, and the critical role of master's education in addressing the nation's innovation and competitiveness agenda, the foundational knowledge assembled in this monograph is an essential first step to inform future work.

Next Steps

This monograph is a first step in the exploration of the role and status of the master's degree in STEM and it points to logical next steps to developing a deeper understanding of STEM master's education. Further study is needed on the characteristics of STEM master's programs, completion and attrition patterns across STEM fields and student populations, and factors that affect students' success in master's programs.

A more comprehensive taxonomy of STEM master's programs is needed, along with standard definitions of terms associated with various stages of master’s study. This monograph also points to the need for a comprehensive study of master’s attrition and completion. Comparable completion and attrition data need to be collected in a standard format from a range of colleges and universities representative of all institutions that award STEM master’s degrees. These data should be disaggregated by field, student demographic characteristics, and other program characteristics as identified in the taxonomy study. Input from students, faculty, graduate program administrators, and graduate deans is needed to identify factors that are perceived to affect students’ success in or failure to complete STEM master’s programs.

A study that includes the above components is essential to determine the extent to which attrition from STEM master’s programs is an issue that merits further attention and would guide the design of a more in-depth study, if warranted, to identify best practice interventions to increase completion and reduce attrition in STEM master’s programs.

APPENDIX A

Selected Examples of Characteristics of Master's Degree Programs

INSTITUTION	PROGRAM	COMMENTS
a. *Dual Degree Model*		
Benedictine University	Public Health and Information Systems	MPH and MSMIS
Clark University	Community Development and Planning and Business Administration	MA and MBA
MIT	Leaders in Global Operations	MBA and engineering degree
The Ohio State University	Public Administration and Natural Resources	MA (Public Admin) and MS or MA (Natural Resources)
b. *Accelerated Bachelor's/Master's Degree*		
Brandeis University	Chemistry	BA/MA; 4-year
Brandeis University	Mathematics	BA/MA; 4-year
Brandeis University	Physics	BA/MS; 4-year
Brandeis University	Neuroscience	BS/MS; thesis-required
Brandeis University	Computer Science	BA/MA
Brandeis University	Computational Linguistics	Thesis-required
Clark University	Biology	BA/MA; thesis-required
Clark University	Chemistry	BS/MS
Clark University	Geographical Information Science	BS/MS
College of William and Mary	Chemistry	BS/MS
Southern Illinois University, Edwardsville	Biological Sciences	3+2
Stanford University	Sociology	BA/MA

Stanford University	Biology	BS/MS
Stanford University	African Studies	BA/MA
The Ohio State University	Biochemistry	BS/MS
University of California, Berkeley	Computer Science	
University of California, Berkeley	Electrical Engineering	BS/MS
University of Massachusetts, Boston	Chemistry	BS/MS
University of Massachusetts, Boston	Applied Sociology	BA to MA
c. *Coordinated with Honors Program*		
Clark University	Geographical Information Science	Coordinated with honors undergraduate program
Stanford University	Biology	Coordinated with honors undergraduate program
d. *Non-thesis Requirements—Non-thesis Alongside Thesis*		
College of William and Mary	Applied Science	Additional coursework that results in a total of 32 total credits compared to 30 total credits for the thesis program
Hampton University	Applied Mathematics	3 additional credits (i.e. 27 coursework credits compared to 24 credits in the thesis program)
North Dakota State University	Electrical Engineering	3 additional credits (i.e. 27 coursework credits compared to 24 credits in the thesis program)
South Dakota School of Mines and Technology	Civil Engineering	2 additional credits along with a research project or paper
South Dakota School of Mines and Technology	Mechanical Engineering	2 additional credits along with a research project or paper
South Dakota School of Mines and Technology	Technology Management	2 additional credits along with a research project or paper
Southern Illinois University, Edwardsville	Environmental Science	5 additional credits (i.e. 38 total credits) and a research paper
Southern Illinois University, Edwardsville	Physics	Research project and seminar format final examination

The Ohio State University	All	4-hour written examination in addition to 2-hour oral examination
University of Missouri	Computer Engineering and Computer Science	Prohibits students from changing from the thesis-required program to the coursework-only program.
e. *Thesis and Non-thesis offered alongside one another by the same institution--different degree titles*		
Benedictine University	Clinical Psychology	MS and MSCP
North Dakota State University	Transportation and Urban Systems	MS and MSTS
Stanford University	Computer Science	MS and MSCS
University of California, Berkeley	Mechanical Engineering	MS and MENG
University of Missouri	Computer Science	MS and ME
f. *Non-thesis Requirements—Non-thesis Only Program*		
Armstrong Atlantic State University	Criminal Justice	Field practicum or 2 additional courses
Benedictine University	Clinical Exercise Physiology	2 internships and academic and skills competency examination
Brandeis University	Anthropology	Research project or paper
Brandeis University	Computational Linguistics	Internship
Clarion University of Pennsylvania	Biology-Environmental Sciences	Internship or independent study
Clark University	Public Administration	Practicum or internship
College of William and Mary	Criminal Justice	Research project or paper
Indiana University-Purdue University, Fort Wayne	Public Affairs	Practicum or internship
MIT	Leaders in Global Operations	Internship
North Georgia College and State University	Public Affairs	Internship if the student has no prior experience in public affairs
University of Massachusetts, Boston	Public Affairs	Case study seminar
University of Massachusetts, Boston	Software Engineering	Software development project

University of Missouri	Public Health	Internship
g. *Professional Science Master's Degrees (PSM™)*		
Brandeis University	Biotechnology	
Southern Illinois University, Edwardsville	Biotechnology Management	
Southern Illinois University, Edwardsville	Environmental Science Management	
Stanford University	Biomedical Informatics	
h. *Teaching Experience Required*		
Clark University	Physics	
The Ohio State University	Horticulture	
The Ohio State University	Chemical Engineering	
University of Missouri	Biochemistry	
i. *Open Only to Selected Students*		
Stanford University	Chemical Engineering	MS open only to current undergraduates, students in other doctoral programs, or external MS-seeking students
University of California, Berkeley	Economics	MA open only to Law students or students in other doctoral programs
j. *Limit on Time to Degree Completion*		
Drury University	Criminology	2 years
North Dakota State University	Mathematics	3 years
The Ohio State University	Anthropology Biomedical Engineering (5 yrs	2 years
The Ohio State University	Atmospheric Sciences	3 years
The Ohio State University	Geography	4 years
The Ohio State University	Entomology	4 years

The Ohio State University	Biomedical Engineering	5 years
University of California, Berkeley	Global Health and Environment	6 semesters
k. *Part-Time Only*		
Buffalo State College	Industrial Technology	
Stanford University	Biomedical Informatics	
l. *Single Start Date*		
MIT	Leaders in Global Operations	Summer
North Georgia College and State University	Family Nurse Practitioner	Summer
Southern Illinois University, Edwardsville	Sociology	Fall term
The Ohio State University	Evolution, Ecology, & organismal Biology	Fall term
University of California, Berkeley	Physics	Fall term
University of Missouri	Physiology	Fall term
University of Missouri	Medical Pharmacology	Fall term
m. *Cohort Model*		
Bethel University	Nursing	
North Dakota State University	Managerial Logistics	
North Georgia College and State University	Nurse Practitioner	
Southern Illinois University, Edwardsville	Psychology	
The Ohio State University	Geography	
University of California, Berkeley	Demography	
University of Massachusetts, Boston	Applied Linguistics	

n. *Alternate Delivery Modes*		
Buffalo State College	Creative Studies	Online and short summer courses
Ferris State University	Information Systems Management	Half online and half on weekends in 7-week, year-round format
Indiana University-Purdue University, Fort Wayne	Most engineering	Evenings
North Georgia College and State University	International Affairs	Online
North Georgia College and State University	Public Administration	Evenings
University of Massachusetts, Boston	Science in a Changing World	Partially online
University of Massachusetts, Boston	Public Affairs	Evenings
Southern Illinois University, Edwardsville	Physics	Evenings
Southern Illinois University, Edwardsville	Social Work	Evenings
Southern Illinois University, Edwardsville	Civil Engineering	Evenings

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Council of Graduate Schools
One Dupont Circle, NW
Suite 230
Washington, DC 20036-1173
Phone (202) 223-3791
Fax (202) 331-7157
www.cgsnet.org