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ARE UNIVERSITIES PROVIDING A COMPETITIVE AND RELEVANT GRADUATE EDUCATION? AN EVALUATION OF PROFESSIONAL SCIENCE MASTER'S PROGRAMS

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ABSTRACT

Are universities providing a competitive and relevant graduate education? An evaluation of Professional Science Master's programs. Rivenbark, Jessica Bowen, 2019. Capstone Paper, University of North Carolina Wilmington.

The purpose of this paper is to evaluate Professional Science Master's (PSM) programs across the United States by examining the internal processes followed which gather employer input, develop and revise curriculum, and matriculate students into the scientific workforce. What are universities doing to promote and sustain these programs? Are students leaving the programs feeling marketable and confident? Are universities collaborating with employers for the purposes of program improvement? The research indicates that PSM programs are needed nationwide to sustain our scientific economy and compete globally. Since implementation, data shows that these PSM programs are effective and boosting the skills of the workforce. It is becoming more common practice for institutions of higher education to utilize advisory boards, which include employers and industry experts in decision making and ensure the employability of their students.

CHAPTER 1: INTRODUCTION

The Professional Science Master's (PSM) is a relatively new type of graduate degree which is "designed for students who are seeking a graduate degree in science or mathematics and understand the need for developing workplace skills valued by top employers." (2018, September 22 Retrieved from https://www.professionalsciencemasters.org/about). The PSM distinction spans five fields:

- Agricultural Science/Food Science/Nutrition
- Biotechnology/Biomedical/Pharmaceutical
- Computer Science/Analytics/Big Data/Statistics
- Environmental Science/Ocean Science/Sustainability/GIS
- Physical/Chemical Sciences

For this research, the focus is solely on the Computer Science/Analytics/Big Data/Statistics category and the PSM programs that reside within it.

These degrees are not intended to replace traditional degree programs but instead "they aim to engage students with professional goals and help them become scientists uniquely suited to the 21st-century workplace, equipped with a deeper and broader scientific knowledge than that acquired with a Bachelor of Science degree and the skills to apply it." (Colwell, 2009) Prior to the creation of the PSM, the master's degree was often seen as a stepping stone to the doctorate. In some cases, the master's degree is an undesirable path for doctoral science students who "master out" due to not being able to advance to doctoral candidacy. The PSM is designed to intercept those students that may

not be interested in the doctorate, but more interested in practical and current research with immediate application in the workforce.

There is no other industry that is evolving faster than computer science, and so traditional curriculum development models simply do not work. A unique challenge for these programs is having a structure in place that allows for continual collaboration with industry experts and modification of curriculum to seamlessly move students through the program and into the workforce with the skills that the industry demands at that time. This is very different than curriculum development and maintenance for psychology or philosophy because of the innovative nature of technologies. By the time textbooks can become published they are irrelevant and out of date.

According to the National Science Foundation (NSF), enrollment in science and engineering graduate programs are the highest they have ever been. As depicted in Figure 1, there has been gradual incline across all science and engineering degrees over the years, but none have made a gain like computer science has, jumping from 25 thousand degrees awarded in 2014 to 32 thousand in 2015. ("2018 Indicators Report", 2018)

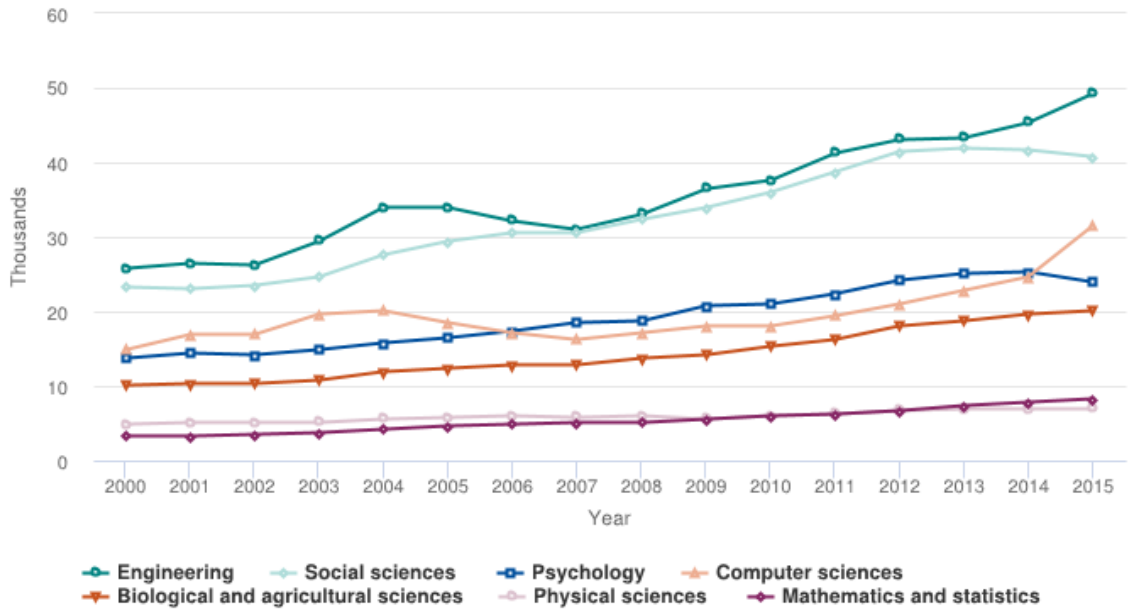

Figure 1. Science and Engineering Master's degrees awarded by field 2000-2015.

As demand continues to grow for graduates and the popularity increases in PSM programs, questions remain around the success of these types of programs. The research presented here aims to answer four questions:

- Are PSMs offering a competitive and relevant education?
- Are graduates of these programs immediately employable?
- What is the role that employers play in curriculum design and ongoing modification?
- Are graduates satisfied with the skills gained from the PSM?

By answering these questions, the research closely examines the processes surrounding program design of PSMs to ensure quality education for students, employability of graduates, and satisfaction of employers resulting in a more qualified workforce.

Background

The PSM initiative originated in 1997, "when a select number of research universities developed programs integrating science and mathematics studies with knowledge and training in management, law, or other professional arenas." (Lynch, Babco, McAllister, Vincent, & Mahler, 2008) This effort was backed by the Albert P. Sloan Foundation. In 2001, the Council of Graduate Schools (CGS) partnered with Sloan and began promotion of the PSM initiative to various institutions offering master's degrees. In 2006, the CGS "assumed primary responsibility from the Alfred P. Sloan Foundation for supporting and promoting the Professional Science Master's Initiative, with the goal of making the PSM degree a regular feature of U.S. graduate education." (Lynch, Babco, McAllister, Vincent, & Mahler, 2008) In 2007, President George W. Bush signed the America COMPETES Act (P.L. 110-69), also known as The America **C**reating **O**pportunities to **M**eaningfully **P**romote **E**xcellence in **T**echnology, **E**ducation, and **S**cience Act, which garnered support for PSMs at the NSF. As of 2018, there are 345 PSM programs, at 157 institutions, in 35 states, and 4 countries endorsed on the PSM website. (2018, September 22)

The National Professional Science Master's Association (NPSMA) is the membership association for the PSM initiative and was designed to further along the PSM agenda of new programs and workforce alliances for PSM students and alumni. PSMs are unique combinations of rigorous study in science or math coupled with coursework in management, policy, or law. NPSMA delineates PSM programs as being designed collaboratively with industry experts, to provide a *science plus* curricula, which encompasses science content knowledge as well as the highly desirable business skills.

These industry experts, also referred to in this research as “employers”, develop the curricula, serve on advisory boards, and foster internships.

Another core characteristic of the PSM is the application of the skills learned during the program in the areas of science, technology, and business. Programs approach this in a variety of ways, though most commonly through internship, externship, coursework, and capstone projects. In a 2017 report published by the CGS, several recommendations were made to improve professional development (including graduate education) for science, technology, engineering and mathematics students including suggesting the university “should engage employer representatives, content experts and alumni, and should employ established and/or research best practices.” (Denecke, D., Feaster, K., & Stone, K., 2017) One of today’s best practices in education is applied learning. The PSM flyer shown in Figure 2 informs employers that students experience applied learning opportunities and enter the workforce better prepared than traditional master’s graduates. Students leave the program with STEM-specific skills as well as the professional skills needed to contribute to the scientific workforce upon hire.

Figure 2. PSM flyer for employers.

For universities that are considering whether or not to start a PSM, there are guiding principles from the CGS which describe a feasibility determination as well as the core curricular elements which must include, "an experiential component that must include at least one capstone project, supervised collaboratively by faculty and employers, evaluated or graded by faculty and typically developed with an employer(s),

which integrates the practical application of scientific and professional knowledge, behavior, and skills." (NPSMA, 2018) While there is variation in how this is interpreted and implemented among institutions and programs, applied learning is a staple of the PSM programs.

The research has several objectives achieved through the examination of multiple has several objectives across multiple parties involved in these programs. PSM program faculty are surveyed to gain a better understanding of their role in curriculum design/modification. Survey questions seek to measure level of involvement with industry experts (employers) as well as level of satisfaction with the skills addressed in the program. Current PSM students are surveyed to measure how effectively the program is delivering the science and business skillset. Level of satisfaction is measured with current students. PSM alumni are surveyed and asked to evaluate how their skills gained as a result of the PSM, measure up in the workforce.

CHAPTER 2: REVIEW OF LITERATURE REVIEW AND ANALYSIS

The available research on PSMs seems to mimic that of the timeline presented Chapter 1. The bulk of the available research occurs between 2004 – 2009, with the most recent research in the last few years coming from the CGS or the PSM itself. In fact, in examining a Google Trend of the search for the term "professional science masters" shows a visible decline in the frequency of web inquiries from 2004 - today. (2018, September 29) Retrieved from https://trends.google.com/trends/explore?cat=958&date=all&geo=US&q=professional%20science%20masters

Figure 3. The decline in frequency of Google searches for the term "professional science masters" since 2004.

Despite the lack of research on PSMs in recent years there are several publications which focus on curriculum development with employers, employability in STEM fields, and

employer satisfaction with graduate skills. In the following paragraphs, these journal articles and publications across time and sources were examined comprehensively to make justification for this new research and how it fits in with the current knowledge landscape on this topic.

In June 2004, the President's Council of Advisors on Science and Technology (PCAST) released a report to the President titled, "Sustaining the Nation's Innovation Ecosystems: Maintaining the Strength of Our Science and Engineering Capabilities", in which a glim picture was painted of the nation's talent pool and level of competitiveness compared with other nations. A clarion call was made to improve STEM training and retention via improved collaboration between government agencies (employers) and universities. The recommendation of PSMs was specifically mentioned and the report added, "The Administration should strongly advocate these programs." (Marburger & Kvamme, 2004) The report concluded that adoption of the recommendations would "result in significate progress toward maintaining our innovation ecosystem and preserving our Nation's industrial and economic strength."

In February 2006, the 21st Century National Defense Education Act (NDEA-21) introduced a bill to the House of Representatives which would, in part, require the NSF Director to establish PSM programs for "national security and economic competitiveness" (Reyes & Silvestre, 2006). The bill has since been referred to the Subcommittee on Research, the Subcommittee on 21st Century Competitiveness, and the Subcommittee on Education Reform.

The Space Race

Multiple articles make comparison to the Soviet Union launching Sputnik 60 years ago, and the "space race" that ensued. One article describes how 2005 was this same poignant moment where a call to action was needed or else cautioning of, "a slow withering, a gradual decline, a widening gap between a complacent America and countries with the drive, commitment and vision to take our place." ("Tapping America's Potential", 2005) Among the recommendations for our nation to avert this crisis is one to motivate students to study STEM fields and contribute to the STEM workforce, by way of a PSM program which can "encourage college students to pursue fields outside of academic that combine science and/or math with industry needs." ("Tapping America's Potential", 2005)

National Crisis

The two previously mentioned papers reflect the nation's economic dire state, which is when PSMs really took off. Universities acted and an increase in program offerings appeared across the nation. In 2008, the CGS published the results of a pilot survey of programs, of which University of North Carolina Wilmington participated. As a result, the National Professional Science Master's Association was formed, an advocacy group for PSMs. Job placement data presented in this paper demonstrates that "the PSM mission is being fulfilled: more than seven out of ten PSM graduates are finding work in the business, government and nonprofit sectors." (Lynch, Babco, McAllister, Vincent, & Mahler, 2008)

In 2008, the Board on Higher Education and Workforce Policy and Global Affairs published a report which recommended "concerted action to accelerate the development

nationally of professional science master's education." (Colwell, et al., 2008) The report detailed how creation, promotion, and abundance of these programs would be one step toward fulfilling workforce needs as well as ensuring global competitiveness and relevancy. This one step is part of a series of steps needed to secure our nation's intellectual currency and economic development. The remaining steps describe actions that should be taken by institutions of higher education, federal and state government, philanthropic organizations, professional societies, employers and students.

Employment Projections

Each year, the Department of Labor's Bureau of Labor Statistics analyzes employment data and makes projections for the next decade. Tables 1-3 contain data surrounding employment trends and predictions. Table 1 shows the projected growth for all occupation areas. The computer and mathematical occupations are expected to grow 13.7% by the year 2026 ("Occupational Projections Data 2016-26", 2017). Table 2 names computer and mathematical jobs are also among the fastest growing occupations. Table 3 indicates that across the computer science professions, a bachelor's degree is the norm, but those with master's degrees are a close second. Apart from Computer and Research Scientists, employees in the computer science area with a doctoral degree make up less than 5% of each job category.

Table 1. Employment by major occupational group, 2016 and projected 2026.

National Employment Matrix	Employment		Change, 2016-26		Median annual wage, 2017
	2016	2026	Number	Percent	
Total, all occupations	156,063.8	167,582.3	11,518.6	7.4	$37,690
Management occupations	9,533.1	10,340.4	807.3	8.5	$102,590
Business and financial operations occupations	8,066.8	8,840.7	773.8	9.6	$67,710
Computer and mathematical occupations	4,419.0	5,026.5	607.5	13.7	$84,560
Architecture and engineering occupations	2,601.0	2,795.4	194.3	7.5	$79,180

Life, physical, and social science occupations	1,299.5	1,424.3	124.8	9.6	$64,510
Community and social service occupations	2,570.7	2,942.6	371.9	14.5	$43,840
Legal occupations	1,283.3	1,399.5	116.2	9.1	$80,080
Education, training, and library occupations	9,426.5	10,315.4	888.9	9.4	$48,740
Arts, design, entertainment, sports, and media occupations	2,772.9	2,941.0	168.1	6.1	$48,230
Healthcare practitioners and technical occupations	8,751.5	10,088.1	1,336.6	15.3	$64,770
Healthcare support occupations	4,315.6	5,335.2	1,019.6	23.6	$28,710
Protective service occupations	3,505.6	3,663.8	158.2	4.5	$39,550
Food preparation and serving related occupations	13,206.1	14,438.1	1,232.0	9.3	$21,910
Building and grounds cleaning and maintenance occupations	5,654.1	6,177.9	523.8	9.3	$25,620
Personal care and service occupations	6,419.7	7,647.4	1,227.6	19.1	$23,610
Sales and related occupations	15,747.8	16,206.5	458.7	2.9	$27,020
Office and administrative support occupations	23,081.2	23,230.8	149.6	0.6	$34,740
Farming, fishing, and forestry occupations	1,060.1	1,056.7	-3.5	-0.3	$24,390
Construction and extraction occupations	6,812.5	7,560.0	747.6	11.0	$44,730
Installation, maintenance, and repair occupations	5,905.4	6,293.6	388.2	6.6	$44,520
Production occupations	9,356.9	8,950.0	-406.9	-4.3	$33,990
Transportation and material moving occupations	10,274.2	10,908.4	634.3	6.2	$31,600

Table 2. Fastest growing occupations, 2016 and projected 2026.

National Employment Matrix	Employment		Change, 2016-26		Median annual wage, 2017
	2016	2026	Number	Percent	
Total, all occupations	156,063.8	167,582.3	11,518.6	7.4	$37,690
Solar photovoltaic installers	11.3	23.1	11.8	104.9	$39,490
Wind turbine service technicians	5.8	11.3	5.6	96.3	$53,880
Home health aides	911.5	1,342.7	431.2	47.3	$23,210
Personal care aides	2,016.1	2,793.8	777.6	38.6	$23,100
Physician assistants	106.2	145.9	39.6	37.3	$104,860
Nurse practitioners	155.5	211.6	56.1	36.1	$103,880
Statisticians	37.2	49.8	12.6	33.8	$84,060
Physical therapist assistants	88.3	115.8	27.4	31.0	$57,430
Software developers, applications	831.3	1,086.6	255.4	30.7	$101,790
Mathematicians	3.1	4.0	0.9	29.7	$103,010
Physical therapist aides	52.0	67.2	15.3	29.4	$25,730
Bicycle repairers	12.4	16.1	3.6	29.3	$28,390
Medical assistants	634.4	818.4	183.9	29.0	$32,480
Genetic counselors	3.1	4.0	0.9	29.0	$77,480
Occupational therapy assistants	39.3	50.7	11.4	28.9	$59,310
Information security analysts	100.0	128.5	28.5	28.5	$95,510

Physical therapists	239.8	306.9	67.1	28.0	$86,850
Operations research analysts	114.0	145.3	31.3	27.4	$81,390
Forest fire inspectors and prevention specialists	1.7	2.2	0.5	26.6	$37,380
Massage therapists	160.3	202.4	42.1	26.3	$39,990
Health specialties teachers, postsecondary	233.5	294.0	60.6	25.9	$97,870
Derrick operators, oil and gas	11.1	13.9	2.8	25.7	$46,140
Roustabouts, oil and gas	50.0	62.4	12.4	24.8	$36,960
Occupational therapy aides	7.5	9.3	1.8	24.7	$29,200
Phlebotomists	122.7	152.8	30.1	24.5	$33,670
Nonfarm animal caretakers	241.5	300.0	58.5	24.2	$22,950
Rotary drill operators, oil and gas	16.7	20.8	4.0	24.2	$53,980
Nursing instructors and teachers, postsecondary	67.9	84.2	16.3	24.0	$71,260
Occupational therapists	130.4	161.4	31.0	23.8	$83,200
Service unit operators, oil, gas, and mining	41.4	51.1	9.7	23.4	$48,290

**Numbers shown are in thousands*

Table 3. Educational attainment for workers 25 years and older by detailed occupation, 2015-16.

	Less than H.S. diploma	**H.S. diploma or equivalent**	**Some college, no degree**	**Assoc. degree**	**Bach. degree**	**Mast. degree**	**Doc. or prof. degree**
Total, all occupations	8.6	23.9	21.0	9.4	22.8	9.9	4.2
Computer and information research scientists	0.4	4.9	2.5	0.3	**34.8**	**33.0**	24.0
Computer systems analysts	0.5	4.6	13.4	7.8	**47.4**	**23.4**	2.9
Information security analysts	0.7	4.5	16.8	10.4	**42.9**	**22.4**	2.3
Computer programmers	0.6	4.6	12.9	8.7	**50.9**	**19.7**	2.8
Software developers, applications	0.4	2.1	8.2	4.8	**50.3**	**30.3**	3.9
Software developers, systems software	0.4	2.1	8.2	4.8	**50.3**	**30.3**	3.9
Web developers	0.6	4.8	15.5	9.7	**54.0**	**13.8**	1.6
Database administrators	0.7	5.7	12.5	8.8	**45.1**	**24.2**	3.0
Network and computer systems administrators	0.4	7.2	23.3	15.1	**40.7**	**12.0**	1.2
Computer network architects	0.5	5.8	22.3	12.7	**40.0**	**16.9**	1.8
Computer user support specialists	0.6	8.9	25.3	16.0	**37.4**	**10.5**	1.2
Computer network support specialists	0.6	8.9	25.3	16.0	**37.4**	**10.5**	1.2
Computer occupations, all other	0.8	7.5	20.6	14.7	**39.2**	**15.7**	1.4

**numbers shown are percentages*

There is clear evidence of a need and opportunity for highly skilled individuals to meet the demands of the modern economy. The goal of the current research is to evaluate how these programs are meeting these demands. Similar research questions posed in this paper have been asked by other researchers and included in different studies. However, this unique group of research questions has not been evaluated in depth before and the goal of this research is to provide new insights into the implementation and outcomes of PSM programs.

CHAPTER 3: METHODOLOGY

The universities chosen for this study all have one thing in common- they all offer an official PSM and are endorsed on the Professional Science Masters website. As mentioned in Chapter 1, the programs chosen all come from the Computer Science/Analytics/Big Data/Statistics category. This capstone is written for a multidisciplinary Computer Science and Information Science (CSIS) degree program, so the first university added to the sample was the University of North Carolina Wilmington. The only other university that offers a CSIS degree as advertised on the PSM program listings is the second added to the sample, Rutgers, the State University of New Jersey. Other universities were chosen based on offering a PSM in a single discipline, either Information Systems (Elmhurst College, New Jersey Institute of Technology, Baker College and Montclair State University) or Computer Science (North Carolina State University, Utah State University, University of Massachusetts Lowell and College of Saint Rose). The last universities were interdisciplinary PSMs and included Sonoma State University (Computer Hardware and Software Systems), Minnesota State University Mankato (Information Security and Risk Management), Austin Peay State University (Data Management and Analysis), Austin Peay State University (Information Security and Assurance), and University of North Carolina Charlotte (Data Science and Business Analytics). The initial sample size of invited participants consisted of 15 universities.

Procedure

Initial contact with the universities began in December 2018 with the Program Coordinator listed on the Professional Science Masters website. Program Coordinators were sent an email describing the study and asking for their willingness to participate. A copy of this letter is in Appendix A. As responses filtered in, some universities agreed

while others were unable to participate. Of the 15 universities invited, eight did not respond, three were unable or unwilling, one was willing but was too new of a program it did not have alumni or enough students far enough into the program to provide feedback, and three agreed to participate in the study.

Follow up with the Program Coordinators resumed in January 2019. Those that responded in December agreeing to participate were sent a follow up email with the link to the survey, along with suggested text to accompany with it. A copy of this letter is in Appendix B.

One survey (via email) was to be distributed by the Program Coordinator. This seemed to be a favorable approach as to minimize time required from Program Coordinators and keep participants anonymous. Also, the survey link was received by students, alumni, and faculty from a familiar source (the program coordinator), which can positively influence the return rate. Copies of the surveys are in Appendices C, D, E, and F.

Survey Development

The target populations of these surveys are: program faculty, current students, and alumni. With the assistance of the Program Coordinator, this data can be analyzed in aggregate form (across institutions) as well as disaggregated by institution. Further disaggregation may include other subsets such as program type or student type. Analysis of this data was primarily quantitative. Many of the items on the surveys ask the subject to indicate their level of agreement with a statement on a Likert scale. The Likert scale only has 4 scale ratings so that there is no neutral level of agreement. Each survey also contains open-ended items requiring qualitative analysis to be conducted to extract

commonalities in the data. Responses are coded numerically along with a code for missing responses, so the n-size of the data adjusts accordingly, and statistics remain proportionate across questions.

The stakeholder survey was designed using Kirkpatrick's four levels of evaluating training programs (Kirkpatrick, D., 1998). In this framework, Kirkpatrick aims to guide program evaluation and subsequently instrument development by examining four levels:

- Level One: **Reaction** (individual perceptions)
- Level Two: **Learning** (knowledge, skills, abilities gained as a result of program)
- Level Three: **Behavior** (ability to apply those newfound skills)
- Level Four: **Results** (organizational change as a result of students applying those skills)

The Kirkpatrick framework was chosen because of the wide application across academia and industry, the exact intersection where this study resides. The first level is focused on satisfaction, while the second level takes it a step further to assess whether actual knowledge, skills, and abilities (KSA) were gained as a result of the program. The first two levels concentrate on individual impact. The third level aims to measure the ability to apply the KSA acquired in the program and the fourth level examines performance changes made as a result of those applied skills. These last two levels concentrate on organizational impact.

In the current research, the four levels of the Kirkpatrick framework are evaluated across three populations: students, alumni, and program faculty (see Table 4). The first statement is a measure of a Kirkpatrick Level 1: Reaction. This level measures the individual perceptions of the stakeholders. The second statement is a measure of a Kirkpatrick Level 2: Learning. This level measures learning in the form of knowledge, skills, and abilities, as a result of the program.

Table 4. Survey alignment with Kirkpatrick's four levels of evaluating training programs.

Kirkpatrick Level	Students	Alumni	Faculty
Level 1: Reaction	I am satisfied with the degree to which my program addresses industry needs.	I am satisfied with the degree to which my program addressed industry needs.	I am satisfied with the degree to which my program addresses industry needs.
Level 2: Learning	I possess the knowledge, skills, and abilities desired by employers as a direct result of being in this program.	I possess the knowledge, skills, and abilities desired by employers as a result of completing this program.	I teach the knowledge, skills, and abilities desired by employers as a result of teaching in this program.

The survey was also developed with the research questions in mind. Table 5 uses the same two questions from Table 4 as an example, but instead aligns them with Capstone Research Questions. The question posed in Chapter 1, "Are graduates satisfied with the skills gained from the PSM?", is referred to in the chart below as "RQ4".

Table 5. Survey alignment with Capstone Research Questions.

Research Question	Students	Alumni	Faculty
RQ4	I am satisfied with the degree to which my program addresses industry needs.	I am satisfied with the degree to which my program addressed industry needs.	I am satisfied with the degree to which my program addresses industry needs.

Table 4 and Table 5 are small examples of survey alignment with various components of the research. A more detailed and comprehensive alignment is shown in Table 6. Each of the research questions is listed (by code) and aligned with the research question (if applicable) and Kirkpatrick level. Topics appearing in the Student Question Block also

appear in the Alumni and Faculty Question Blocks. This design is intentional to elicit multiple perspectives on the same topic.

Table 6. Full survey alignment with Research Questions and Kirkpatrick Levels.

Survey Question		**Topic Measured**	**Research Question**	**Kirkpatrick Level**
Student Question Block	S1A	Program satisfaction	RQ4	KL1
	S1B	Skills possessed	RQ4	KL2
	S1C	Workforce preparedness	RQ1	KL3
	S1D	Student/employer interaction	RQ3	
	S1E	Faculty/employer collaboration	RQ3	
	S2	Skills possessed	RQ1	KL2
	S3	Skills missing	RQ4	KL2
	S4	Reasons for PSM		
	S5	Doctoral intentions		
	S6	Time to employment	RQ2	
Alumni Question Block	A1A	Program satisfaction	RQ4	KL1
	A1B	Skills possessed	RQ4	KL2
	A1C	Workforce preparedness	RQ1	KL3
	A2	Skills possessed	RQ1	KL2
	A3	Skills missing	RQ4	KL2
	A4	Reasons for PSM		
	A5	Doctoral intentions		
	A6	Time to employment	RQ2	
Faculty Question Block	F1A	Program satisfaction	RQ4	KL1
	F1B	Skills taught	RQ4	KL2
	F1C	Workforce preparedness	RQ1	KL3
	F1D	Students ability to enact change in workforce		KL4
	F1E	Faculty/employer collaboration	RQ3	
	F1F	Programmatic change as a result	RQ3	KL4
	F2	Skills taught	RQ1	KL2
	F3	Skills missing	RQ4	KL2
	F4	Likelihood for new PSM		
	F5	New PSM name (if applicable)		
	F6	Collaboration done well	RQ1, RQ3	
	F7	Collaboration improvement	RQ1, RQ3	
	F8	Time to employment	RQ2	
Research Questions				
RQ1 - Are PSMs offering a competitive and relevant education? RQ2 - Are graduates of these programs immediately employable?				

RQ3 - What is the role that employers play in curriculum design and ongoing modification?
RQ4 - Are graduates satisfied with the skills gained from the PSM?

Pilot Study

Prior to data collection, the surveys were piloted with a small group of students, faculty, and staff. The pilot group was asked to read through the survey to ensure the questions were worded clearly, the instructions were thorough, and the functionality of the survey was intact. Members of the pilot group posed as stakeholders and completed the survey multiple times. Feedback was provided, and the survey was modified to increase readability and clarity.

CHAPTER 4: RESULTS

Despite the 15 invitations sent and the three universities that agreed to participate, the survey was only distributed by two Program Coordinators. The Program Coordinator at University of Utah and the Program Coordinator at University of North Carolina Charlotte. The breakdown by survey participants by University is as follows:

University Breakdown (n=51):

- University of Utah (5)
- University of North Carolina Charlotte (46)

These universities also offer very different PSM programs with University of Utah focusing on Computational Science and University of North Carolina Charlotte focusing on Data Science and Business Analytics. For these reasons, the results are overwhelmingly geared toward one university over the other, and one program over the other. This is discussed in further detail in the Limitations section of Chapter 5. Quantitative analysis was carried out in IBM's Statistical Package for the Social Sciences (SPSS) Software. Qualitative analysis of the open-ended survey items was conducted manually.

Chapter 1 outlined many reasons why students choose to pursue a PSM over a traditional master's program. Current PSM students and PSM alumni were asked this question and the responses are shown in Table 7. Both current students and alumni agree on the top reason to enroll in a PSM program: to develop highly-valued business skills. These top choices triangulate with PSM alumni surveyed by the PSM National Office in 2017. PSM alumni indicated on that survey that their top three reasons for enrolling were: "(1) to acquire specific skills and knowledge, (2) to learn more about something in which

I am particularly interested, and (3) to increase opportunities for promotion, advancement and/or pay increases" (Komura, 2017).

Table 7. Student reasons for enrolling in a PSM program.

(check all that apply)	Students *(n=27)*		Alumni *(n=17)*	
	n-size	% of students	n-size	% of students
To develop highly-valued business skills	15	**55.6%**	9	**52.9%**
To increase opportunity for promotion, advancement and/or salary increase	14	51.9%	7	41.2%
"Real world" practical experiences	12	44.4%	6	35.3%
Advanced training to excel in science or math without a Ph.D.	11	40.7%	7	41.2%
Internship opportunity while in the program	9	33.3%	5	29.4%
Other (please specify): -Good network -Career change -Wanted to take graduate level courses and learn a lot of analytical techniques in a short amount of time -Make my skills current -Offered at a time of day that did not interfere with my job	2	7.4%	3	17.6%

Employability is one the core characteristics of a PSM graduate. Current students were asked to predict how soon after graduation they would be able to find work. Alumni were asked to report how long it took them to secure employment after graduation. Faculty were also asked to report overall, how soon they observed graduates securing employment. Table 8 shows the employment expectations for current students and faculty. Also included in Table 8 is a column for alumni to report the actual time it took to secure employment after graduation. There is agreement from all constituents that PSM graduates have work lined up prior to graduation.

Table 8. Employment Expectations (Students/Faculty) and Actuals (Alumni)

	Student *(n=30)*	Faculty *(n=3)*	Alumni *(n=17)*
Prior to graduation	**63.3%**	**66.7%**	**52.9%**
Immediately after graduation	30.0%	0%	11.8%
Within 6 months after graduation	3.3%	33.3%	17.6%
Within 1 year after graduation	3.3%	0%	5.9%
Longer than 1 year	0%	0%	11.8%

A series of statements was posed to current students, alumni, and faculty whereby the survey participant was asked to rate their level of agreement with the statements. Table 9 shows that most current students agree (either strongly agree or somewhat agree) with the statements which address satisfaction, workforce preparedness, and employer involvement. Most alumni agree (either strongly agree or somewhat agree) with the statements that address program satisfaction and workforce preparedness. When faculty were asked these same three questions as students and alumni, there was a different result. The majority of faculty agree (either strongly agree or somewhat agree) with the statements surrounding workforce preparedness. However, there was slight disagreement with the statement that the program addresses industry needs.

Table 9. Levels of student, alumni, and faculty agreement.

	Student *(n=30)*	Alumni *(n=18)*	Faculty *(n=3)*
I am satisfied with the degree to which this program addresses industry needs.	3.13	3.33	3
I possess the knowledge, skills, and abilities desired by employers as a direct result of being in this program.	3.10	3.28	3.33
I feel prepared to enter the workforce and apply the knowledge, skills, and abilities that I've gained in this program.	3.20	3.35	3.66
This program affords me opportunities to interact with industry experts (potential employers).	3.03	N/A	N/A
The faculty in my program frequently communicate and collaborate with industry experts.	3.31	N/A	N/A

Likert Scale (4=Strongly Agree, 3=Agree, 2=Disagree, 1=Strongly Disagree)

Faculty were also asked to rate their level of agreement with three statements regarding students as change agents, collaboration with employers, and programmatic change. Table 10 shows that faculty agree (either strongly agree or somewhat agree) with the statements about students as change agents and programmatic change because of interactions with employers. However, there was slight disagreement with the statement about opportunities to collaborate with industry professionals.

Table 10. Question block for faculty to rate level of agreement.

	Faculty *(n=3)*
I feel confident that my students can go into the workforce and enact change as a result of being in this program.	3.33
Teaching in this program affords me opportunities to collaborate with industry professionals.	3
We have made programmatic change as a result of interactions with industry professionals.	3.66
Likert Scale (4=Strongly Agree, 3=Agree, 2=Disagree, 1=Strongly Disagree)	

The PSM is touted as a terminal degree and an alternate way to remain in science without a Ph.D. Both current PSM students and PSM alumni were asked about intentions to pursue a doctoral degree. Table 11 shows the responses for current students and alumni. In both audiences, the majority do not intend to pursue doctoral studies. This data also shows the longevity of this viewpoint. Current students, given their experiences within the program and interaction with industry, do not feel as though they will pursue doctoral studies after graduation. Then, once out of the program and into the workforce, the belief remains the same. It is possible that the alumni are settling into their new careers and do not feel advanced studies are required.

Table 11. Student and alumni intentions for doctoral degree.

Do you intend to pursue a doctoral degree?	*Students (n=30)*	*Alumni (n=18)*
Yes	6.7% (2)	16.7% (3)
No	**53.3%** (16)	**61.1%** (11)
Unsure at this time	40.0% (12)	22.2% (4)

The surveys contained several open-ended items to allow for qualitative responses from the survey participants. Current students, alumni, and faculty were all asked to list 2-3 skills that are highly sought after by employers that are currently part of the program. Responses fell into the categories below. Responses that could not be categorized (i.e., were not similar to at least one other response) are not included. The number for each category refers to number of responses, not number of people.

Current Students (n = 30)

- Data Analytics/Visualization/Storytelling (10)
- R (7)
- Machine Learning (5)
- Python (5)
- Business-Related Skills (4)
- SAS (4)
- SQL (4)
- Applied Mathematics/Statistics (2)
- Programming (2)

Alumni (n = 18)

- SQL (6)
- Data Analysis/Visualization (4)
- Python (4)
- R (4)
- Tableau (4)
- SAS (3)
- Statistical Modeling (2)

Faculty (n = 3)

- Technical Skills (2)
- Communication Skills (2)
- Collaboration Skills (2)

There is agreement across all populations that technical skills such as SQL, SAS, R, and Python be present in the PSM and are highly desired by employers. Data analytics and visualization were specifically mentioned by students and alumni, but not by faculty; although by listing "technical skills", this could easily encapsulate data analytics and visualization.

Current students, alumni, and faculty were also asked to list 2-3 skills that are missing from the program which they would like to see taught in future classes. Responses fell into the categories below. Responses that could not be categorized (i.e., were not similar to at least one other response) are not included. The number for each category refers to number of responses, not number of people.

Current Students (n = 30)

- Python (4)
- More Computer Science Courses (3)
- More Introductory Programming Courses (3)
- Big Data Technologies (2)
- Deep Learning (2)
- Statistics (2)
- Taking Project Through Entire Life Cycle (2)

Alumni (n = 18)

- Specific Language/Tool (10)
    - C++
    - D3
    - Java
    - Node.js
    - Non-SQL Solutions
    - Python
    - R

    - SQL
    - Tableau
    - VBA
- More Programming Courses (4)
- Communication/Presentation Skills (2)

Both current students and alumni agree that the PSM should include more programming courses. This is a fair request since all PSM students do not enter the program with an undergraduate computer science background. However, PSM programs in the Computer Science/Analytics/Big Data/Statistics category must teach some programming to teach the subsequent skills on which programming knowledge is based.

Interviews with Program Coordinators

Because of the small number of program coordinator responses, additional research was required to supplement the two survey responses. Interviews were conducted with past and current program coordinators to get a deeper understanding of their perspective surrounding the PSM. Five interviews were conducted representing the University of North Carolina Wilmington, the University of North Carolina at Charlotte, University of Utah, and Rutgers the State University of New Jersey. The sampling of interviewees consisted of a former department chair, directors (past and present), program coordinators, and a dean of the graduate school; all with experience in leading a PSM program for between 3 and 15 years. The first question asked was, “During your time as the director, have you made any major changes to the program?” The responses were as follows:

- Update curriculum
- Make changes based on labor market analysis
- Staffing changes made for additional support with leadership and advising

- Adding online courses to the curriculum for remediation purposes
- No major changes, program was new and still in implementation phase

As program coordinators were discussing previous changes, pending or upcoming changes were mentioned. These include:

- Develop a stackable core of courses. Then students can branch off into various tracks of data science: criminal justice, public policy…etc.
- Develop one group to oversee all changes. This is a separate, and larger, group from the advisory board but one that all curriculum and process changes can hopefully move more easily through with representation from both departments
- Add a project management component to the coursework

Next, they were prompted to describe some of the successes found in collaborating industry experts (employers) and any changes made to the program as a result of that collaboration. The responses varied yet all PSMs interviewed mentioned their advisory board and how it has helped stay in touch with industry. Some of the responses received are listed below:

- The advisory board pushes the university to grow
- The nature of the program draws students that have 3-5 years of business experience which brings a different set of questions and insights
- Connecting with thought leaders from energy, healthcare, entrepreneurial endeavors, and motorsports

However, some shared concerns in collaborating with employers such as employer requests for a specific tool or software to be taught in classes. Knowledge and

experience with this tool or software would mean the ability to "hit the ground running" when entering the workforce with little to no training. While this feedback is important in the broader sense, faculty do not want to design a course around what one particular employer has requested. One program coordinator gave the example, "I can teach a class on Amazon Web Services if it is a special topics class. But if I wanted to teach about cloud computing, I would only mention Amazon Web Services in addition to other solutions." Faculty want to ensure that students have a variety of skills and are aware of the principals behind them. Students should leave the program equipped with enough skills to appeal to the broader job market as a whole.

Another question asked, "What types of challenges have you encountered in facilitating an interdisciplinary PSM?", was often met with a thoughtful pause, and then deep explanation of several challenges. These include, but are not limited to:

- Silos within the university
- Trying to put forth any change. Too many separate groups of approvals, two deans, two sets of faculty (for those sharing a PSM across different departments/schools)
- Identity. Faculty positions have a "home" in one department, physical location of classes gives a geography division, not a "center" for the program if housed in two colleges
- Operational pieces are challenging
- Degree-specific course enrollments are often registration roadblocks and priority is awarded to students in those majors, not ours

Finally, program coordinators were asked, "What types of trends, in research or practice, have you seen in the PSM organization? Where do you see PSMs going moving forward?" The responses are as follows:

- New programs are broadening the PSM model to other science-based curricula such as biotechnology or earth resource management. I don't think these would have fit with the early definition of PSM.
- There is an issue of sustainability. At first, there was national support for PSMs but now that universities are on board, it doesn't seem worth the trouble of getting the affiliation at the national level when we can just do it on our own.
- Instead of the all-or-nothing model of either you affiliate with the PSM or you do not, there should be tiered levels of affiliation. This may allow for more to affiliate that would have otherwise not.
- The PSMs went from Sloan Foundation to Council of Graduate Schools to Keck Graduate Institute. There was a lot of initial growth but then stagnant for last 8 years or so. There needs to be more visibility on the national level.

These interviews prompted a tangential research question to emerge, "Are universities conducting PSM-like graduate programs on their own without the national affiliation?" First, an examination of the number of PSM programs worldwide needed examining. Figure 4 illustrates the number of PSM affiliated programs (from all content areas) from inception to 2017. From an overall perspective, there *is* growth over time. The most dramatic growth occurred between 2008-2010 where the membership nearly doubled. This is likely a direct result of the 2006 legislation, NDEA-21, discussed in Chapter 2. Growth in the latter years begins

to taper off. While an upward trend is evident, it appears to be reaching a plateau and growing at a less significant rate.

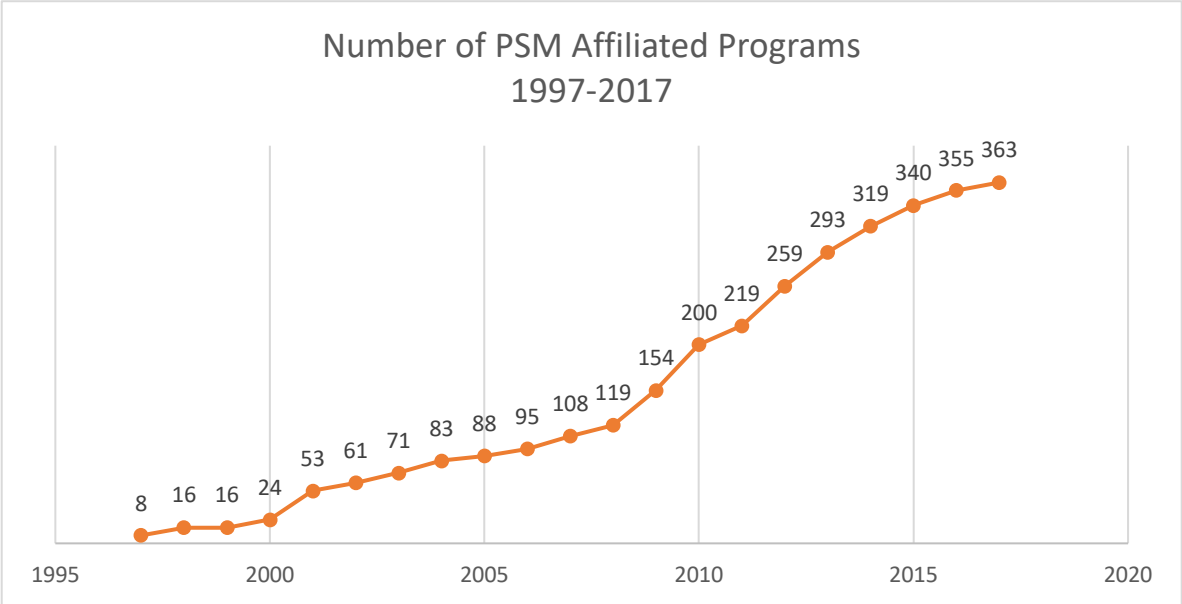

Figure 4. The number of PSM affiliated programs from 1997-2017.

A closer look at this data in comparison with the number of Master's degrees conferred (in all content areas) is depicted in Figure 5. The National Center of Education Statistics aggregates and publishes the number of Master's degrees conferred. The number of degrees awarded is steadily increasing. Figure 5 also displays the PSM programs available nationwide, increasing but slowing to a plateau and dipping under the trend line (not shown). Over the ten-year period shown in Figure 5, the gap between the number of Master's degrees conferred and the number of PSM programs has certainly begun to close. Future research could show whether or not this trend will continue or if the number of PSM programs will decrease over time.

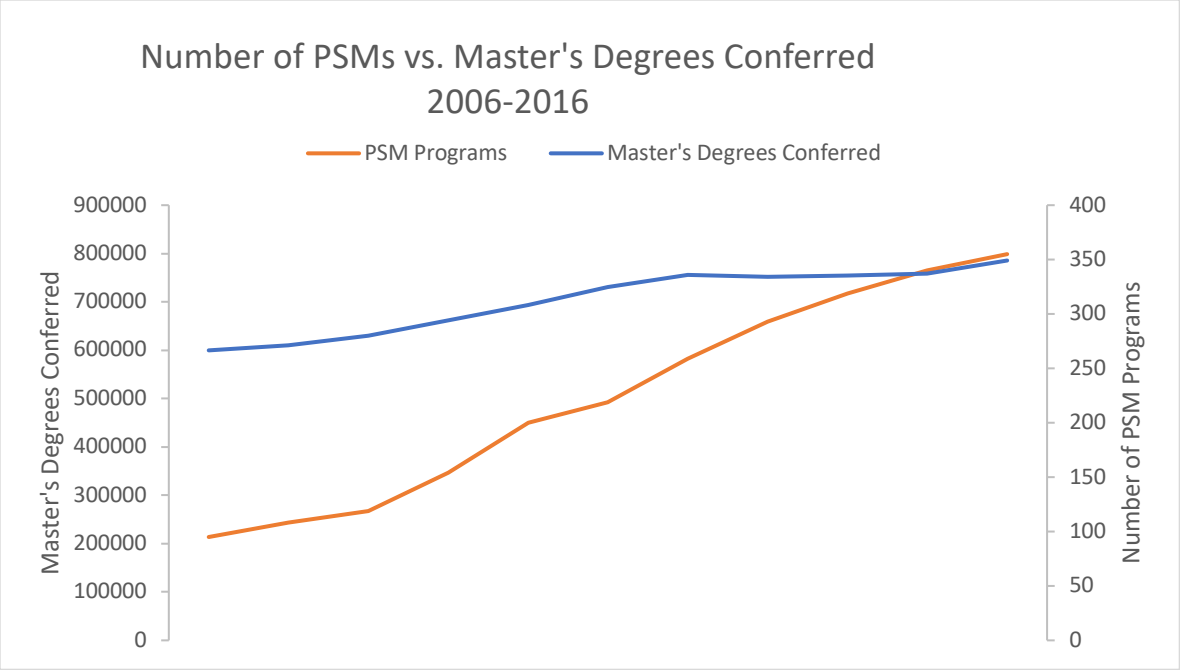

Figure 5. The number of PSM programs vs. master's degrees conferred 2006-2016.

To continue with an overall perspective across content areas, a detailed comparison within the North Carolina System will uncover how many PSMs there are in relation to traditional Master's programs. Figure 6 displays each of the sixteen universities and how many of the traditional master's degree programs there are in comparison with those that are officially recognized and affiliated with the PSM organization. The university with the most PSM programs is North Carolina State University with 8 PSMs available, roughly 8% of their programs. Only half of the universities in the North Carolina state system have a PSM available to students.

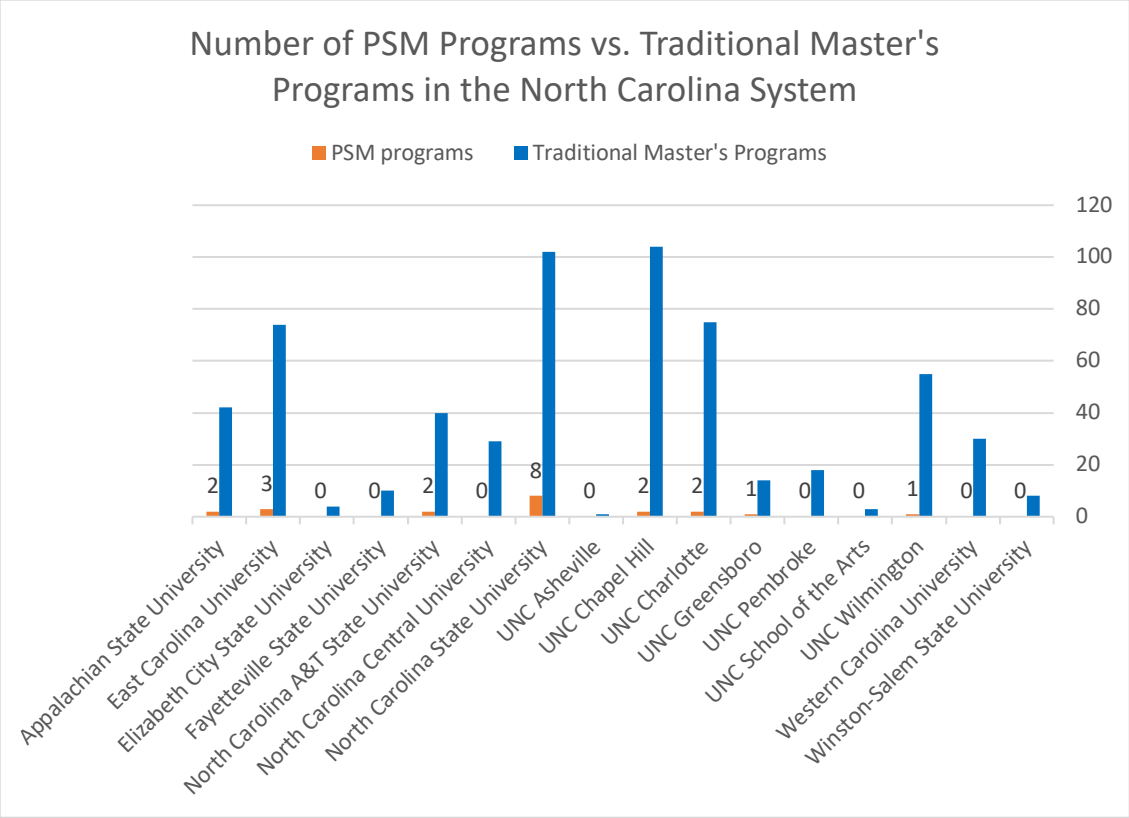

Figure 6. The number of PSM programs vs. traditional Master's programs in NC System.

CHAPTER 5: DISCUSSION AND CONCLUSION

PSM programs work strategically with industry professionals to collaborate, develop and revise curriculum, and matriculate students into the scientific workforce. The research question, “Are PSMs offering a competitive and relevant education?” can be answered with a resounding “Yes”. Each program coordinator interviewed spoke highly of the advisory boards and processes in place which ensured the curriculum is continually being evaluated with industry experts. This research has shown that PSM graduates leave the program feeling marketable and employable with their skillsets. This research has revealed that PSM alumni reflect on the skills learned in the program and feel prepared to enter the workforce.

Employability is assumed with PSM graduates. This research question, “Are graduates of these programs immediately employable?” was addressed when asking students, faculty, and alumni about the time it took to secure employment. During the interviews explained in Chapter 4, one program coordinator explained that anyone with decent tech skills is easily employable and can find work in a variety of industries. Another program coordinator was explaining the 100% placement rate advertised on the program website and went on to say, that there is no issue with students finding employment- in fact they have the opposite problem- students often find employment and struggle to finish out the program. This is due to the high level of interaction between employers and students. Events where students can have poster sessions explaining their research often puts them in a positive light to employers and makes for an informal job interview.

While each institution adopts the PSM model in their own way, the advisory board is a staple of the PSM. Through interviews, this research question, "What is the role that employers play in curriculum design and ongoing modification?", was answered. program coordinators described annual or bi-annual meetings with an advisory council, advisory board, or executive board whereby input from thought leaders in the industry helped to shape the program moving forward.

Finally, the satisfaction questions on the surveys sent to students and alumni directly addressed the research question, "Are graduates satisfied with the skills gained from the PSM?". Students and alumni alike were overwhelmingly positive about their experiences in the PSM programs. Students specifically mentioned skills acquired during the program that they felt would benefit them in the workforce. Alumni reflected on the skills gained during the PSM that gave them an advantage over their colleagues.

Interviews with program coordinators prompted a deeper dive into the number of PSM programs vs. traditional master's programs being offered in the North Carolina system. A close analysis of the university websites to determine how these non-PSM programs are operating illustrated that the PSM model has been widely adapted. Appalachian State University's Technology Master of Science website defines its industry and community involvement to potential students as, "All departments are highly involved with their industry counterparts and seek opportunities to work with community partners. In addition, each department has an advisory board of industry professionals that assist in program development, internships, job placement and fundraising." (Appalachian State University, 2019). The University of North Carolina at Greensboro describes in a flyer for the Master of Science Information Technology and

Management program how, "…faculty sponsors industry groups which enables them to maintain close linkages with the IT industry and local businesses" (Department of Information Systems and Supply Chain Management, 2019). The Master of Science in Computer Science and Information Technology at Winston-Salem State University has a curriculum that, "provides students who seek a master's degree in a technical field the benefit of completing a program designed with a unique pedagogic composition—the combination of a traditional computer science core with applied courses in information technology. This combination develops a skill set for the application of computer technology resources to solve a variety of information need problems. Additionally, this program develops communication and leadership skills required in the corporate/government sector" (Winston-Salem State University, 2019). All of these are quintessential PSM features; advisory boards, applied learning, science + business curricula. None of these three programs described are official PSMs, but they are all implementing core PSM characteristics.

Limitations

This study has potential limitations. Determination of the sample size of 15 universities ensured that computer science, information science, and other multidisciplinary PSMs were part of the study. However, with only two universities receiving the survey, this significantly limits the breadth of programs represented. One of those universities with a much larger response rate and so 90% of participants are in a Data Science and Analytics program, and from the University of North Carolina Charlotte.

Another limitation is the population of "current student" and that it could include someone in their first semester in the program, or someone preparing to graduate. During qualitative analysis, some participants mentioned being new in the program and listed skills they would like to see taught; despite not knowing if the skills could possibly be taught in later courses. Similarly, veteran students listing skills they possess because of being in the program could have been taught directly in coursework or picked up through extracurricular clubs or passion projects completed concurrently with coursework.

The employment calculations are focused on the area of tech for the purposes of this paper, however this presents a limitation because hiring in tech is at an all-time high with the digitization of more processes and workflows. Future research could parse this factor out to examine the employability of non-tech PSM fields.

Finally, exogenous factors are not considered in this research. These factors include, but are not limited to: trends in higher education, government funding, state of the economy, or PSM affiliation costs.

Future Work

Continuing this research would allow for additional universities to be added to the sample size. While 15 agreed to participate, only 4 were a part of an interview, and only 2 distributed the survey to their faculty, students, and alumni. This narrowing effect, a participation funnel if you will, narrows down those that actually participate and then the research is really only representing a portion of the whole.

Additionally, given the conclusion that many new programs have adopted the PSM model even without possibly affiliating with the PSM organization, further investigation into newly created graduate programs could may be warranted. This theory

could potentially be supported by these new programs and their collaboration with employers to ensure employable and relevant graduates.

Conclusion

PSM programs are a win-win-win. Students receive a real-world application of science and business curricula, and universities are providing relevant graduate education, and employers can influence a funnel that will drive future employees through the door. Research indicates that PSM programs are necessary to sustain our scientific economy and compete globally. The PSM model is now widely adapted as programs become more interdisciplinary, applied learning opportunities increase, and active advisory boards collaborate.

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APPENDICES

APPENDIX A

Letter to Program Coordinators

Appendix A: Letter to Program Coordinators

Dear <program coordinator>,

I am a graduate student at the University of North Carolina Wilmington in the Master of Science in Computer Science and Information Systems program with an anticipated graduation date of May 2019. For my capstone project, I have chosen to research ten other Professional Science Masters programs in the country to explore the continuum and relationship between providing a competitive and relevant education, the employability of graduates, and the satisfaction of employers.

With your assistance I will survey four populations at your school (1) the faculty teaching in the <program>; (2) the current students; (3) recent alumni (graduated less than 3 years ago); and (4) employers of graduates to better understand the successes your school has found in the delivering this type of unique interdisciplinary program. I feel it is important to clarify here that I will not ask for any email addresses, but instead provide you with the link (along with a brief explanation of the research for each audience) then you can distribute via email the survey to the program faculty, students, and employers of your choosing. I am asking you to send four emails on my behalf.

In return for your participation, I can provide you with the raw and analyzed data for your school (as well as the aggregate nationwide data). I am also happy to provide you with a copy of the finished research paper as I hope to submit it a portion of the research for publication. You will have this completed data and paper back from me by April 2019, at the very latest. This comes at a perfect time in the academic cycle as we wrap up the spring semester, reflect over the summer and make data-driven programmatic changes for fall.

On a personal note, this type of program appealed to me for a variety of reasons. UNCW offers an interdisciplinary approach from the School of Business in conjunction with the College of Arts and Sciences. I loved the idea of being a part of two colleges. This program also boasts a 96% placement rate and I knew it would equip me with the skills employers are seeking. The steady pool of local employers is frequently on campus recruiting graduates, speaking to classes, or sitting on the MSCSIS Advisory Board. This whole process is fascinating and one I want to explore at other institutions as well. What can we do better? What is the most effective way to engage with employers? How is curriculum modified based on employer demand for specific skills? And how often? Beginning fall 2019, I will enroll in the Ed.D program in Educational Leadership and hope to continue this research and either design a curriculum path or formulate an ongoing process for engaging with employers that directly transfers into curriculum, maximizing employability and relevance of education.

Please do not hesitate to reach out via email or phone if you have any questions or concerns. I look forward to conducting this analysis and hope that data from <university> can be included in the research. Please let me know by _____, if you are willing to participate.

Respectfully,

Jessica Bowen Rivenbark
Graduate Student
M.S. Computer Science and Information Systems
University of North Carolina Wilmington

APPENDIX B

Survey Distribution to Program Coordinators

Appendix B: Survey Distribution to Program Coordinators

Dear <program coordinator>,

I hope this email finds you at the start of a productive spring semester! You may recall, we exchanged emails at the end of the fall semester about my capstone project for the University of North Carolina Wilmington, specifically in the Master of Science in Computer Science and Information Systems program. I have chosen to research Professional Science Master's programs to explore the processes and principles behind providing a competitive and relevant education. **Thank you for agreeing to distribute the survey link!**

After the proposal of this research to my committee, I have narrowed down the focus of the research and will no longer need employers to be surveyed. Now, the focus will remain on three populations at your school (1) the current students, (2) recent alumni; and (3) the faculty teaching in the <program> to better understand the successes you have faced in delivering this program. The good news, I'm only asking you to **send one email** on my behalf and to enter all the addresses in the bcc: field.

Here is the survey link along with suggested email context for distribution:

> Dear students/alumni/faculty,
> A graduate student from the University of North Carolina Wilmington, Jessica Bowen Rivenbark, is conducting research and wants to survey stakeholders (students, alumni, and faculty) of Professional Science Master's programs like ours. Would you take a few minutes to complete the survey and contribute to this research? Our program will greatly benefit from seeing the research results as universities across the nation will be included. **Please complete this survey within the next 5 days.** Thank you.
> https://uncw.az1.qualtrics.com/jfe/form/SV_02raxT9yi3gt4Pj

The survey itself will initially ask for the completer to identify themselves as a "student", "alumni", or "faculty" and direct them to the appropriate question block. For that reason, **the same link can be sent to all audiences as soon as possible**.

Just a reminder, that in return for your participation, I can provide you with the raw and analyzed data for your school (as well as the aggregate nationwide data). I am also happy to provide you with a copy of the finished research paper as I hope to submit it a portion of the research for publication. **You will have this completed data and paper back from me by April 2019**, at the very latest.

Please do not hesitate to reach out via email or phone if you have any questions or concerns. I look forward to conducting this analysis and appreciate that data from <university> will be included in the research.

Respectfully,
Jessica Bowen Rivenbark
Graduate Student

M.S. Computer Science and Information Systems
University of North Carolina Wilmington

APPENDIX C

Survey Introduction and Initial Questions

Appendix C: Survey Introduction and Initial Questions

Thank you for taking the time to complete this survey. It should take approximately 5-7 minutes to complete. This research aims to capture stakeholder (students, alumni, and faculty) perceptions surrounding Professional Science Master's programs. Individual results will be kept confidential and anonymous. Responses will be aggregated with others for overall analyses. If you have any questions related to the survey, please contact Jessica Bowen Rivenbark (rivenbarkj@uncw.edu).

Q1. Which of the following best describes your role in a PSM program?*

(PSM = Professional Science Master's)

-current student in a PSM program

-alumni of a PSM program

-program faculty or program coordinator of a PSM program

Q2. Please choose your University's PSM from the list:**

(respondent chooses from dropdown menu containing all schools)

**There is display logic behind this survey that maps respondents' responses in Q1 to the appropriate question block. For example, if the respondent identifies with "faculty" in Q1, they are directed toward the Faculty Block of questions. Each of the corresponding survey blocks are included in Appendices D-F.*

***There is embedded piped text that maps respondents' responses in Q2 to the text of the question in subsequent questions. These are indicated as "**<university chosen in Q2>**" in Appendixes D-F.*

APPENDIX D

Student Block of Questions

Appendix D: Student Block of Questions

Student block:

S1. Please rate your level of agreement with each of the following statements.

	Strongly agree	Somewhat agree	Somewhat disagree	Strongly disagree
S1A. I am satisfied with the degree to which the program at **<university chosen in Q2>** addresses industry needs.	○	○	○	○
S1B. I possess the knowledge, skills, and abilities desired by employers as a direct result of being in this program.	○	○	○	○
S1C. I feel prepared to enter the workforce and apply the knowledge, skills, and abilities that I've gained in this program.	○	○	○	○
S1D. This program affords me opportunities to interact with industry experts (potential employers).	○	○	○	○
S1E. The faculty in my program frequently communicate and collaborate with industry experts.	○	○	○	○

S2. Please list 2-3 skills that are highly sought after by employers that you possess as a direct result of being in the program at **<university chosen in Q2>**

S3. Please list 2-3 skills that are missing from **<university chosen in Q2>** program, but that you would like to see taught in future classes.

S4. Why did you choose to enroll in a PSM program? (check all that apply)

- ☐ advanced training to excel in science or math without a Ph.D.
- ☐ internship opportunity while in the program
- ☐ to develop highly-valued business skills

- [ ] to increase opportunity for promotion, advancement and/or salary increase
- [ ] "real world" practical experiences
- [ ] Other (please explain):

S5. Do you intend to pursue a doctoral degree?

- ○ Yes
- ○ No
- ○ Unsure at this time

S6. How soon do you expect to find work after graduation?

- ○ I hope to have a job lined up prior to graduation.
- ○ Immediately after graduation
- ○ Within 6 months after graduation
- ○ Within 1 year after graduation

APPENDIX E

Alumni Block of Questions

Appendix E: Alumni Block of Questions

Alumni block:

A1. Please rate your level of agreement with each of the following statements.

	Strongly agree	Somewhat agree	Somewhat disagree	Strongly disagree
A1A. I am satisfied with the degree to which the program at **<university chosen in Q2>** addressed industry needs.	○	○	○	○
A1B. I possess the knowledge, skills, and abilities desired by employers as a result of completing this program.	○	○	○	○
A1C. I have entered the workforce and applied the knowledge, skills, and abilities that I gained from this program.	○	○	○	○

A2. Please list 2-3 skills that are highly sought after by employers that you possess as a direct result of completing the program at **<university chosen in Q2>.**

A3. Please list 2-3 skills that were missing from **<university chosen in Q2>** program, but that you would like to see taught to future students.

A4. Why did you choose to enroll in a PSM program? (check all that apply)

- ☐ advanced training to excel in science or math without a Ph.D.
- ☐ internship opportunity while in the program
- ☐ to develop highly-valued business skills
- ☐ to increase opportunity for promotion, advancement and/or salary increase
- ☐ "real world" practical experiences
- ☐ Other (please explain):

A5. Do you intend to pursue a doctoral degree?

- Yes
- No
- Unsure at this time

A6. How soon did you find work after graduation?

- I had a job lined up prior to graduation.
- Immediately after graduation
- Within 6 months after graduation
- Within 1 year after graduation
- Longer than one year

APPENDIX F

Faculty Block of Questions

Appendix F: Faculty Block of Questions

Faculty block:

F1. Please rate your level of agreement with each of the following statements.

	Strongly agree	Somewhat agree	Somewhat disagree	Strongly disagree
F1A. I am satisfied with the degree to which the program at **<university chosen in Q2>** addresses industry needs.				
F1B. I teach the knowledge, skills, and abilities desired by employers to the students enrolled in this program.				
F1C. I feel confident that my students can go into the workforce and apply the knowledge, skills, and abilities gained in the program.				
F1D. I feel confident that my students can go into the workforce and enact change as a result of being in this program.				
F1E. Teaching in this program affords me opportunities to collaborate with industry professionals.				
F1F. We have made programmatic change as a result of interactions with industry professionals.				

F2. Please list 2-3 skills that are highly sought after by employers that you teach in the program at **<university chosen in Q2>.**

F3. Please list 2-3 skills that are missing from **<university chosen in Q2>** program, but that you would like to see added to future classes.

F4. How likely is your university to affiliate its next new program with the PSM?

(PSM = Professional Science Master's)

- Extremely likely
- Likely
- Unlikely
- Extremely unlikely

F5. If your university is considering starting a new PSM, please list the program name/area.

F6. List 2-3 ways in which **<university chosen in Q2>** is successful at collaborating with industry experts (employers) to ensure the curriculum is relevant:

F7. List 2-3 ways in which **<university chosen in Q2>** could improve communication with industry experts (employers) and make programmatic changes to ensure relevant skills are taught:

F8. How soon do your students typically find work after graduation?

- Most have jobs lined up prior to graduation
- Most find jobs immediately after graduation
- Most find jobs within 6 months after graduation
- Most find jobs within 1 year after graduation
- Most find jobs 1 year after graduation

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