Are Professional Science Master's (PSM) Programs Beneficial for Graduates? An Evaluation of PSM Programs

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Abstract

Since the early 2000s, we have seen an increase in the need for graduates in various STEM fields. The Professional Science Master's (PSM) program was created in 2001 to address this increased demand. While research has shown the benefits these programs may provide, there is limited research examining the current state of PSM programs. The current research evaluates the perspective of students, alumni, faculty and program directors concerning the benefits from the PSM. Results suggest these programs still create competitive graduate students with concepts from the PSM being implemented in non-PSM programs.

Keywords: Professional Science Master's, Academic Quality, Graduate Programs, Graduate Skills.

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). These programs prepare students to enter into a career in the STEM field. They are not intended to replace traditional degree programs but instead they focus on helping students acquire a deeper and broader level of scientific knowledge beyond a Bachelor's degree and apply those skills (National Research Council, 2008).

Prior to the creation of the PSM, a master's degree in many STEM fields was often seen as a stepping stone to a 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 was designed to intercept those students that may not be interested in a doctorate, but those who are more interested in the practical and current research with immediate application in the workforce.

Among the fields included in PSM, there are few evolving faster than the area of computer science / information systems / information technology. This has made traditional curriculum development models difficult to follow. 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 other programs such as 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, jumping from 25 thousand degrees awarded in 2014 to 32 thousand in 2015 (National Science Board, 2018).

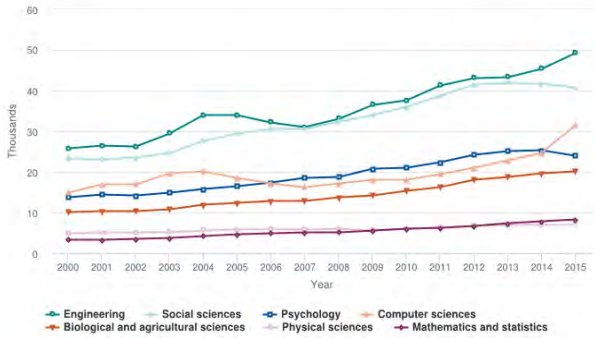

Figure 1. Science and Engineering Master's degrees awarded by field (National Science Board, 2018).

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:

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?

The focus of the current research is in the PSM category of Computer Science / Analytics / Big Data / Statistics. This includes many programs that are a collaboration between computer science departments and information systems departments. 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.

2. BACKGROUND

Backed by the Albert P. Sloan Foundation, the PSM initiative originated in 1997 as a number of universities focused on the integration of science and mathematics in new programs that crossed into management, law and other professional areas (Council of Graduate Schools, 2008). It wasn't until 2001 when a partnership between the Council of Graduate Schools (CGS) and Sloan began promoting the PSM initiative to various institutions offering master's degrees. In 2006, the CGS assumed full responsibility from the Sloan foundation and set the goal of making PSM a regular feature of graduate programs in the US (Council of Graduate Schools, 2008). As of 2018, there were 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 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", help 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. This is approached in a variety of ways, though most commonly through internships, externships, 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 university engage more with industry through employer representatives, experts and alumni (Denecke et al., 2017). This is emphasized in many of the marketing materials for the PSM which 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. Table 1 below provides a comparison of traditional master's programs to PSMs.

Traditional **master's**	Professional **Science Master's**
Often stepping stone to PhD	Considered an alternative to PhD, a "terminal" degree
Thesis	Capstone
Theory-based	Application-based
Developed by university	University & Employer Developed
May or may not directly benefit local business economy	Designed to directly benefit local business through internships and direct hires

Table 1. Comparison of master's programs (from http://www.ncsl.org/portals/1/documents/Educ/09FallForumLynch.pdf)

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." (from the National Professional Science Master's Association, https://www.npsma.org/). While there is variation in how this is interpreted and implemented among institutions and programs, applied learning is a staple of the PSM programs.

Much of the research conducted on PSM has been through the Council of Graduate Schools (CGS) who were involved in the creation of this program. While they have shown a high employability rate of PSM graduates (Council of Graduate Schools, 2008), this was a pilot study conducted over 10 years ago. There has been limited research examining the benefits of PSM programs in recent years. Early criticism of PSM programs questioned the benefit of these degrees specifically around employability when compared to the cost of such programs (Russo, 2008).

The following study has several objectives achieved through the examination of 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.

3. METHODOLOGY

The universities chosen for this study offer an official PSM and are endorsed on the Professional Science Master's website. The programs chosen all come from the Computer Science/Analytics/Big Data/Statistics category. Programs within this category include PSMs in the Information Systems, Computer Science and interdisciplinary.—The initial sample size of invited participants consisted of 15 universities.

Procedure

Initial contact with the universities began 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. 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). Thus, the final participants included two different universities.

The survey (via email) was distributed by the Program Coordinator to the students, alumni and faculty within the PSM. In addition to the surveys distributed, interviews were conducted with program directors. This was due to the limited number of universities participating. These qualitative results will be discussed later in subsequent sections.

Survey Development

The target populations of these surveys include program faculty, current students, and alumni. Items on the surveys ask the subject to indicate their level of agreement with a statement on a 4-point Likert scale. Additionally, open-ended questions were included in each survey.

The survey was designed using Kirkpatrick's four levels of evaluating training programs (Kirkpatrick & Kirkpatrick, 2006). In this framework, Kirkpatrick aims to guide program evaluation and subsequently instrument development by examining four levels:

Level		Description
1	Reaction	individual perceptions
2	Learning	knowledge, skills, abilities gained as a result of program
3	Behavior	ability to apply those newfound skills
4	Results	organizational change as a result of students applying those skills

Table 2. Kirkpatrick's Four Levels

The Kirkpatrick framework was chosen because of the wide application across academia and industry. 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. These 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. For a list of survey questions used and how they align with the various Kirkpatrick levels, see Appendix A.

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.

4. RESULTS

The final survey was distributed across 2 universities for a total of 51 participants including students, faculty and alumni. The PSM at these two universities focused on computational science and data science/business analytics. The results are described in the subsequent sections separated by the quantitative and qualitative responses from participants.

4.1 Quantitative Results

Current PSM students and alumni were asked about reasons why students choose to pursue a PSM over the traditional master's program. The results can be found in Table 3.

	Students *(n=27)*	Alumni *(n=17)*
To develop highly-valued business skills	55.6%	52.9%
To increase opportunity for promotion, advancement and/or salary increase	51.9%	41.2%
"Real world" practical experiences	44.4%	35.3%
Advanced training to excel in science or math without a Ph.D.	40.7%	41.2%
Internship opportunity while in the program	33.3%	29.4%
Other	7.4%	17.6%

Table 3. Reasons for pursing a degree in a PSM program

Both current students and alumni agree on the top reason to enroll in a PSM program: to develop highly-valued business skills. In addition to developing valued skills, both students and alumni rated promotion, practical experience and advanced training without a PhD as being important. These results are similar to prior studies which alumni indicated 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). Other comments for pursuing a degree in a PSM program included networking, career change and gain additional/current skills.

Employability was another research question posed in the current study. 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. Finally, faculty were asked to report overall, how soon they observed graduates securing employment. Table 4 shows the employment expectations for current students and faculty. Also included is a column for alumni that reports the actual time it took to secure employment after graduation.

	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	3.3%	33.3%	17.6%
Within 1 year	3.3%	0%	5.9%
Longer than 1 year	0%	0%	11.8%

Table 4. Employment Expectations (Students & Faculty) and Actuals (Alumni)

There is agreement from all constituents that a majority of PSM graduates will have work lined up prior to graduation which is in agreement with how soon alumni were employed. Across all three groups of participants, over 80% of those surveyed agree that employment is expected (and actually occurred) within 6 months.

Additional questions were also posed to all participations concerning program satisfaction, workforce preparedness, and employer involvement (see Table 5 for results). Most alumni agree (either strongly agree or somewhat agree) with the statements that address program satisfaction and workforce preparedness. 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.

	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)			

Table 5. Satisfaction, Preparedness and Employer Involvement.

Faculty were also asked to rate their level of agreement with three statements regarding students as change agents, collaboration with employers, and programmatic change. All 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. This suggests that PSM programs need to work on involving more industry professionals within the program.

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. 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. For alumni, once out of the program and into the workforce, the belief remains the same.

4.1 Qualitative Results

The surveys contained several open-ended items to allow for qualitative responses from 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 (the number for each category refers to number of responses, not number of people):

Current Students

- 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

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

Faculty

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

There is agreement across all populations that technical skills including programming 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

- 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

- 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.

4.3 Program Coordinator Interviews

Because of the limited response to the survey, additional 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 four large, public universities. 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 3 to 15 years of experience in leading a PSM program.

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 with 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.

4.4 PSM Affiliated Universities vs. Non-PSM

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 2 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, the 21st Century National Defense Education Act (NDEA-21), discussed earlier. Growth in the latter years begins to taper off. While an upward trend is evident, it appears to be growing at a lesser rate.

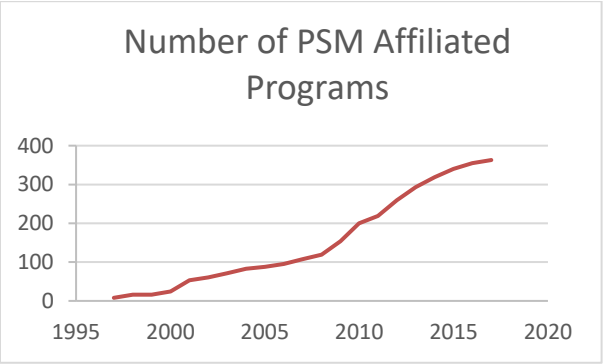

Figure 2. The number of PSM affiliated programs from 1997-2017.

A closer look at this data in comparison with the number of master's degrees conferred (in all content areas) is depicted in Figure 3. 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 3 also displays the PSM programs available nationwide, increasing but slowing growth and dipping under the trend line (not shown). Over the ten-year period shown, the number of master's degrees conferred continues to rise at historical rates, while the number of new PSM programs rate of increase may be decreasing. Future research could show whether or not this trend will continue or if the number of PSM programs will decrease over time.

Finally, to understand how these types of programs compare to traditional master's, a detailed comparison within a state system (i.e., the North Carolina System) was undertaken to examine the importance of these programs in a more detailed analysis. Of the 16 universities in the North Carolina system, 609 degrees were considered to be from traditional master's program while only 21 (or less than 4%) were affiliated with a PSM program. 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. Further analysis at a sample of universities suggest some master's programs follow the philosophy surrounding PSM but are not officially affiliated with the program. More discussion about these findings are included in the subsequent, discussion section.

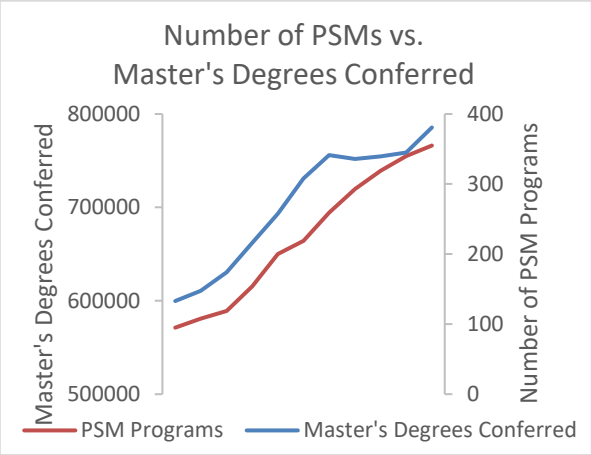

Figure 3. The number of PSM programs vs. master's degrees conferred 2006-2016.

5. DISCUSSION

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 another significant factor for becoming a PSM program. This research question was addressed through the survey as well as interviews with program directors. Survey results supported employability with over 80% of alumni stating they either had

employment by graduation or within 6 months. During the interviews, 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.

As previously mentioned, the 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. However, none of these programs described are official PSMs, but they are all implementing core PSM characteristics.

5.1 Limitations

This study has potential limitations. Determination of the sample size of universities ensured that computer science, information science, and other multidisciplinary PSMs were part of the study. However, with a limited number of universities agreeing to participate, the breadth of programs represented is limited.

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.

The employment results may be skewed as most are in the area of tech which is experiencing an all-time high in hiring 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.

5.2 Future Work

Future research needs to be conducted to include a larger sample of participants. While the initial sample size of 15 universities seemed sufficient, future studies will be expanded to include all universities within a specific category to increase response rate.

While the focus of the current research is the examination of PSM programs, future research will expand on the comparison of these programs to more traditional master's programs. Academic research in master's programs has included curriculum development (Shah, Kumar & Smart, 2018) and comparisons of requirements/curriculum (Karsten, H., Topi, H., Brown, S. A., Carvalho, J., Donnellan, B., Shen, J., Tan, B. C. Y. & Thouin, M., 2015). There is still a need to understand how a PSM program may offer benefits (e.g., employability) compared to a traditional master's program.

Additionally, given the conclusion that many new programs have adopted the PSM model without affiliating with the PSM organization, further investigation into newly created graduate programs may be warranted. This could bring into question the benefits of programs officially affiliated with PSM compared to those that follow PSM methodologies.

6. CONCLUSION

PSM programs appear to be beneficial for all parties involved including the employers, university, department and students/alumni. 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.

7. REFERENCES

Council of Graduate Schools. (2008). The Professional Science Master's Degree: Results of a Pilot Survey of Programs. Washington, D.C.

Denecke, D., Feaster, K., & Stone, K. (2017). Professional development: Shaping effective programs for STEM graduate students. Washington, DC: *Council of Graduate Schools*.

Karsten, H., Topi, H., Brown, S. A., Carvalho, J., Donnellan, B., Shen, J., Tan, B. C. Y. & Thouin, M. (2015). Master's degree programs in information systems: a global view. *Proceedings of the AIS SIG-ED IAIM Conference*, 1-9.

Kirkpatrick, D., & Kirkpatrick, J. (2006). *Evaluating Training Programs: The Four Levels.* Berrett-Koehler Publishers, San Francisco.

Komura, K. (2017). Evaluation Report: Outcomes for PSM Alumni: 2015/16 (Rep.). Claremont, CA: PSM National Office.

National Research Council. (2008). Science Professionals: Master's Education for a Competitive World. Washington, DC: *The National Academies Press*. Retrieved from https://doi.org/10.17226/12064.

National Science Board. (2018). *Science and Engineering Indicators 2018*. NSB-2018-1. Alexandria, VA: *National Science Foundation*. Retrieved from https://www.nsf.gov/statistics/2018/nsb20181/.

Russo, G. (2008). National Academies panel endorses professional master's degree. *Nature 454 (547).*

Shah, V., Kumar, A., & Smart, K. (2018). Moving Forward by Looking Backward: Embracing Pedagogical Principles to Develop an Innovative MSIS Program. *Journal of Information Systems Education,* 29(3), 139-156.

Appendix A. Survey Questions

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?				