

The INNOVATOR

The Voice of the PSM

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FEATURE ARTICLE

The PSM is an Ideal Master's Degree:
It Embodies the Council of Graduate Schools' and
National Academies of Sciences, Engineering and
Medicine's recommendations for core elements

Linda D. Strausbaugh

RECENTLY A COLLEAGUE WHO DIRECTS A SUCCESSFUL PSM PROGRAM REPORTED EXPERIENCING challenges in recruiting prospective students who sometimes say something like “it’s only a PSM”, implying that the degree was somehow less than a more traditional master’s degree. This is but one example of the sometimes-difficult task faced in describing the PSM during meetings with students, faculty, administrators, and employers. A powerful counter to this perception is the message that the PSM is a model degree that embodies the core competency elements for a master’s degree recommended by the Council of Graduate Schools (CGS) and the National Academies of Sciences, Engineering and Medicine (NASEM). This article’s purpose is to introduce the core elements, describe how the PSM aligns perfectly with them, and provide a few examples of implementation.

An alignment framework for the master’s degree was created as part of the Council of Graduate Schools’ Project on the Master’s Degree (Augustine, 2017). This framework further informed chapter four on master’s degrees in the National Academies of Sciences, Engineering and Medicine’s Graduate Stem Education for the 21st Century (Leshner and Scherer, 2018). Both provide information and recommendations that are roadmaps for how we can effectively promote the PSM degree. This article considers the four common elements from the framework’s competency alignment: disciplinary and interdisciplinary knowledge; professional competencies; foundational and transferable skills; research. The discussion of each core element begins with a brief italicized extraction or summary from the NASEM report followed by ideas on how the PSM meets that criterion.



Message from the Editor

Welcome to the third issue of The INNOVATOR, NPSMA’s peer-reviewed publication that shares best practices and other relevant information with the PSM community. This issue will be especially valuable as we address the renewed interest in promoting the degree following its 20th anniversary. The issue draws attention to three strengths of the PSM: alignment with new national criteria (Strausbaugh); reasonable costs (Hoobler); and positive reviews by stakeholders (Rivenbark et al.). We believe program directors will find useful the practical advice on promoting the degree to government (McAllister), to GenZ (Hadelman), to employers (Strausbaugh et al.) and to regional partners (Grunwald). In addition to articles by NPSMA members, this issue introduces a new facet – invited relevant pieces from appropriate authors identified by our members.

The Common Core Competency Elements for a Master's Degree

1. Disciplinary and Interdisciplinary Knowledge: *Master's students should develop core disciplinary knowledge as well as the ability to work between disciplines.*

PSM degrees are required to have strong science content with a majority of courses in STEM. The PSM curriculum is appropriate to its discipline and of equivalent academic rigor to that in more traditional master's degrees. In addition, curricula of many PSM programs draw upon courses from more than one department or discipline, providing interdisciplinary perspectives.

When compared to a more traditional master's, the singular strength of the PSM degree is its commitment to graduating professionals who are workforce-ready without compromising scientific expertise. This commitment is encompassed by the CGS/NASEM recommended core elements of professional and foundational competencies. In the PSM world, there is already synergy between core elements, so the same skill or ability may be facilitated by more than one of them.

2. Professional Competencies: *Master's students should develop abilities defined by a given profession.*

Professional competencies are defined as those skills or abilities delineated by a specific profession. A PSM program primarily identifies these through programmatic interactions with its workforce advisory board (WAB). The PSM program's active engagement with representatives of the employment sector ensures that awareness of career-specific abilities is part of the program. Depending on the employment sector, career-specific skills may include business practices/finance, ethics/responsible conduct of research, regulatory affairs, or legal issues (e.g. entrepreneurship, intellectual property, etc.). The WAB also provides non-binding, strategic advice on employment needs and trends and identifies the professional and transferable skills employers value. Partners from business, industry, government agencies and non-profits also offer students an opportunity for career exploration, another recommendation in the NASEM report. WAB members can educate human resources divisions about the value

of the PSM degree and provide testimonials to others. Program directors will likely find a message of outreach to employers written by NPSMA national Workforce Advisory Council members Todd Arnold and Michael Moskal (2018) useful in recruiting industry partners. Additional information on the best practices for the establishment, roles and effective utilization of the WAB are provided elsewhere in this issue (Strausbaugh, Kalafatas and Friedman, 2019).

We can now showcase the PSM degree in the light of nationally endorsed elements for a master's degree and as an ideal graduate experience that features career preparation and exploration.

Some PSM programs create informal opportunities for interactions between students and industry personnel. Rutgers University PSM students interview three industry leaders in their fields of interest. Rice University programs hold "Lunch and Learn" events with PSM students and industry leaders. Many programs arrange for students to visit employment sites. University of Connecticut PSM students have visited pharmaceutical companies and the state forensic sciences laboratory; Rutgers University PSM students have visited the US Patent and Trademark Office. WAB members and employers appreciate an invitation to attend student poster or oral presentations on internships and capstone projects. Additional ideas for student exposure to industry and exploration of career options may be found in the PSM program in Microbial Biotechnology at North Carolina State University (Nappo and Hamilton, 2017).

Professional competencies also include licensing, certifications and other credentials. Graduate schools are increasingly taking advantage of these kinds of alternative and innovative approaches to education. Graduate level certificates are gaining traction as add-ons to degree programs and as stand-alone credentials. Joubert (2019) provides a brief summary of the kinds and values of graduate certificates.

Program directors might identify appropriate credentialing options and share them with students as value-added enhancements to their PSM degrees. PSM degrees directed toward careers that require formal licensure or certification (e.g., actuary, genetic counselor, some engineers) can provide preparation for completing formal approval processes. For example, students in Michigan State's PSM in Industrial Mathematics may be well-prepared to undertake actuarial exams. Certification content may also be built into the curriculum. As an example, PSM students in Middle Tennessee State's M.S. in Professional Sciences: Engineering Management Program take courses in Project Management, Six Sigma, and Lean Management; most students graduate with certification in all three.

Even for career trajectories that do not have absolute requirements for licensure or certification, there are practices that can enable PSM students to take advantage of certifications to enhance professional outcomes. A few sample credentialing options and examples relevant to the PSM world follow.

- Many institutions offer graduate-level certificates that can complement or expand the expertise of PSM students, often in an interdisciplinary manner. As one example, University of Utah students in the Professional Masters of Science and Technology program can take a Graduate Certificate in Sustainability.
- A large number of universities subscribe to the Collaborative Institutional Training Initiative (CITI). If your university is a CITI member free web-based training is likely available to students. For example, some University of Connecticut PSM students interested in biomedical or pharmaceutical careers have acquired CITI certifications in Human Subject Protection or Animal Care and Use. Even if your university does not subscribe to CITI, it is possible for learners to independently enroll in CITI training. CITI courses span a wide range of diverse topics from statistical analysis to ethics and responsible conduct of research (<https://about.citiprogram.org/en/courses/>).

- Some companies offer opportunities for training and certification. SAS, a leading analytics company, offers free introductory level academic training around its software suite and more advanced certifications for a fee (https://www.sas.com/en_us/training/offers/free-training.html). Google offers free digital skills training for adult learners and G suite certification for a fee (<https://applieddigitalskills.withgoogle.com/en/digital-training>).

3. Foundational and Transferable Skills: *Master's students should develop skills that transcend disciplines and are applicable in any context such as communications, leadership, and working in teams.*

This competency framework aligns strongly with the previously named "plus" requirements of the PSM, one of the original unique features of the degree. As a result, programs already offer preparation in foundational skills (e.g., communication, teamwork and team management, problem-solving and critical thinking, leadership and project management, statistics and data analysis). PSM programs deliver foundational and transferable skills content in a variety of ways: dedicated courses/seminars; guest lectures; integration into disciplinary courses; online. In a summary of the most desired skills across employment sectors and a survey of how PSM programs align with them, Harkins and Strausbaugh (2017) confirmed that PSM programs have been responsive to employer-identified skill sets for the workplace. Communication skills are the most frequently taught transferable skill, with 87% of responses listing it as specifically taught in their PSM programs. From the survey, PSM program coverage of leadership skills occurs within several topics: management of teams, projects or laboratories; leadership; strategic/critical thinking and decision-making. Conceptual elements of successful teamwork may be taught to students in courses and seminars. In practice, students are immersed in teamwork during experiential learning in the workplace environment. In the survey of PSM programs, internship/industry projects were tied with communication skills for the most frequent content.

In addition to the three foundational skills of communication, leadership, and teamwork men-

tioned as examples in the NASEM report, the PSM world has long considered some STEM career trajectories to include additional transferable skills that cross disciplines. As mentioned in the preceding section, some of these areas have options for certification or other credentialing.

4. Research: *As described by CGS and NASEM, research is broadly interpreted to mean creation, application and dissemination of knowledge appropriate to the master's level.*

Although most PSM programs do not require original research and a thesis, we should be mindful to not equate non-thesis degrees with non-research degrees. While research has not been part of the historical criteria for a PSM degree, its inclusion as a nationally recommended core element for the master's degree calls us to consider how the PSM degree can meet it. The NASEM report description of research specifically includes engagement in “work-based learning and research in a systematic manner”. Since its inception, a requirement for experiential learning has been a hallmark of the PSM. The NASEM report further characterizes the core element of research as experience in conducting research and other field studies, the application of the scientific method, and statistical analysis. One or more of these are very often components of PSM experiential learning. To summarize, the core element of research includes a variety of research-related activities that have been part of the PSM experiential learning concept from its inception: internships, co-ops, capstone projects, and other industry-based undertakings. In addition, some PSM students also participate in more traditional academic research projects.

There is evidence to support the assertion that PSM programs have a research component. As mentioned previously, a survey of PSM programs

revealed nearly universal requirements for work-based learning and research through internships and capstone projects. Moreover, descriptions of 39 students' activities in project presentations at the NPSMA National Conference and in alumni profiles provide clear examples of the kinds of diverse research-related experiences that PSM students routinely undertake (“The PSM Alumni and Graduation Chronicle”, 2018, 2019).

PSM research-related experiences reinforce foundational skills. Especially in work-based research, students must learn to be an effective member of a team with diverse disciplinary representation. Students often gain experience in analyzing and summarizing results in written formats like capstone or final reports and theses. Many students will design and present posters and/or talks to a public audience. The NPSMA provides an opportunity for students to present experiential learning projects to a national and

diverse audience in its student presentation session at the annual National Conference. The NASEM research description also recommends that students “learn about and understand the importance of research responsibility and integrity.” Many graduate schools offer compliance training in the Responsible Conduct of Research to meet requirements of federal funding agencies. As mentioned in an earlier section of this article, there are also online options that may include certification.

RECOMMENDATIONS

PSM program directors should map specific elements of their own degree onto the competency core elements of the alignment framework advanced by the Council of Graduate Schools and National Academies of Sciences, Engineering and Medicine. This serves three purposes: 1) an assessment of how well the program meets nationally recommended

Although most PSM programs do not require original research and a thesis, we should be mindful to not equate non-thesis degrees with non-research degrees.

core requirements, 2) a guide for future program development and 3) creation of talking points and a promotional document. In introducing and promoting the PSM to students and their families, faculty and administrators, employers and workplace leaders, we have often been in the position of explaining and validating a type of degree that was not well known or understood. We can now showcase the PSM degree in the light of nationally endorsed elements for a master's degree and as an ideal graduate experience that features career preparation and exploration.

For students, their families, and their undergraduate advisers, a roadmap for the program informs them of the existence of national recommendations for a master's degree. This invites a favorable comparison of the PSM with more traditional master's degrees (Table 1). It provides an opportunity for program directors to emphasize the decades-long position of the PSM program as the gold standard in delivery of the professional and foundational elements recently advanced by the national groups. Unlike more traditional coursework or thesis master's degrees that may have work to do to meet the core elements of the ideal master's, the PSM implemented these long ago and its community is experienced in career preparation and exploration.

For faculty and university administrators, programmatic alignment with the Council of Graduate Schools and the National Academies of Sciences, Engineering and Medicine confers immediate academic credibility. Endorsement of traditional PSM elements by esteemed national groups provides sound push-back on any tendency to portray the PSM as something "lesser" than traditional coursework or thesis masters. It reinforces the PSM community's position that it has been and continues to be an innovative degree. PSM degree programs can serve as an important resource for helping other master's programs in the institution understand and meet core elements around professional preparation and career exploration. Given the experience of PSM programs in delivering professional competency and transferable skills, directors might develop certificates or microcredentials that could be useful to all graduate students.

For employers and workplace leadership, alignment with national criteria provide an additional incentive to associate with PSM programs. The elevation of profession-linked competencies to a core element reinforces the necessity of meaningful engagement of employers with programs and students. Some employers and workplace leaders have asked about the basis for PSM program recognition and have indicated the importance of an independent and nationally endorsed set of criteria.

The Board of Directors of the National Professional Science Master's Association voted in September 2019 to approve a simpler, less expensive, and more inclusive process for PSM program recognition. The new elements for program affiliation align with the CGS and NASEM core competency elements. The historical PSM requirements have been rebranded with new wording and options for implementation to parallel the national report recommendations. Alignment with national recommendations for common core elements that the PSM already meets will confer program recognition with a level of authority beyond our PSM community.

Conclusion and Summary

In the framework of the recently published CGS and NASEM core competency elements, the PSM is an ideal degree. The PSM was ahead of its time at its inception over 20 years ago when its founders recognized the importance of adding career-related and foundational skills to STEM disciplinary knowledge. In addition, the required PSM experiential learning in a workplace context often shared many features with a traditional graduate research experience; this has been explicitly acknowledged in the recent national reports. The PSM is not a replacement for the traditional M.S. degree, rather it is a fundamentally different option tailored to the student who is more career-oriented and seeks knowledge of, and acclimatization to, the workforce environment (Table 1).

<u>CORE COMPETENCY ELEMENTS</u>	PROFESSIONAL SCIENCE MASTER'S	TRADITIONAL STEM RESEARCH M.S.
Approach to core elements	Immersion in the workplace setting for elements 2, 3, 4 and in the academic environment for elements 1 and 4.	Immersion in the academic setting for all elements.
Disciplinary and Interdisciplinary Knowledge	Majority of courses in one or more STEM disciplines; designed to accommodate interdisciplinary or multi-disciplinary degrees.	Majority or all courses in single STEM discipline; occasional coursework outside of the discipline.
Professional Competencies	Program and students are required to regularly interact with employers. Required workforce advisory boards inform programs on necessary career-specific business knowledge (e.g., financial practices, ethics, regulatory affairs, etc.). Opportunities for licensing and certification.	Programs and students are not required to interact with employers; there may be sporadic exposure to non-academic scientific professionals. Opportunities for licensing and certification.
Foundational and Transferable Skills	“Plus” training is a major component of PSM curriculum requirements; skills like communication, leadership, and teamwork have a workforce perspective toward abilities to interact with non-STEM co-workers; additional skill development encouraged and taught in most programs.	Communication, writing and teamwork skills have an academic perspective toward interacting with scientific peers from the same discipline; broader professional skills unlikely to be required; additional skill development mostly left to the student.
Research	Required internship, co-op, capstone, or workplace-based projects with guidance of workplace mentor and/or academic advisor; most require final report and/or public presentations.	Required original research project and MS thesis under guidance of faculty member; expected to publish results and present at conferences.

Table 1. Approaches to Core Competency Elements in the Professional Master's Degree and the Traditional STEM Research Master's Degree.

Resources and Examples

Citation of a particular institution, PSM program or company in this article does not imply endorsement or that this is the only such resource; rather they are provided as sample sources for additional information and examples.

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IN PRACTICE ARTICLE

Promoting the PSM: Context and Strategies for State and Federal Advocacy

Patricia McAllister

ACCORDING TO THE NATIONAL SCIENCE BOARD, THE NUMBER OF JOBS IN THE UNITED STATES (U.S.) requiring substantial science, technology, engineering, and mathematics (STEM) expertise has grown nearly 34% over the past decade (National Science Foundation, 2018). The situation is similar in other countries, and many of them are investing in STEM education and are challenging U.S. leadership in science and technology. Between 2000 and 2014, the number of Americans with a four-year degree in S&E grew by 53%; in China, this number was 360%. China's investments in higher education and research and development have driven the rapid growth of its technology in-

...it is more important than ever for leaders of the PSM community to make the case for the value of the PSM as a cornerstone of a national strategy to develop a highly skilled STEM workforce to ensure America's continued leadership in innovation and competitiveness.

dustry.

As the transformative impact of science and technology continues, it is imperative that the U.S. increase its investment in STEM education to ensure our economic competitiveness in the future. The American public places a high value on STEM education and career paths. In a recent survey of global job market trends, 72% of Americans agree that stu-

dents today should focus on STEM career paths and 60% believe their employers have trouble finding the right workers for STEM roles today (Randstad Survey, 2019).

Indeed, investing in higher education and creating policies to reduce student loan debt is a central issue in on-going policy debates among U.S. presidential candidates, especially on the Democratic side. Student debt totaled \$1.5 trillion last year, exceeding all other forms of debt except mortgages (Wall Street Journal, 2019). Most of the policy discussion to date, however, is focused on reducing debt associated with undergraduate education. Unfortunately, decisions made by Congress in the past concerning student loans have made graduate and professional education more expensive for students. These decisions include eliminating the in-school interest subsidy for graduate students, making graduate students pay higher interest rates than undergraduates, and establishing higher interest rates on Federal Direct PLUS loans. These actions are not consistent with developing the highly skilled workforce that the country needs.

Promoting the value of the Professional Science Master's (PSM) degree program has been important since the first program was started in 1997. Since that time, the number of PSM programs has grown steadily at institutions of higher education across the U.S. and internationally. In the current environment of competition for limited resources and ongoing scrutiny of higher education in general, it is more important than ever for leaders of the PSM community to make the case for the value of the PSM as a cornerstone of a national strategy to develop a highly skilled STEM workforce to ensure America's continued leadership in innovation and competitiveness.

The upcoming 2020 elections as well as specific policy proposals under consideration in Congress provide an opportunity to advocate for support for

PSM programs in developing a highly skilled STEM workforce. Congress is in the process of reauthorizing the Higher Education Act (HEA) which includes the Graduate Assistance in Areas of National Needs (GAANN) program. Last year, the GAANN program included a priority to support PSM programs. Members of the PSM community should urge Congress to retain strong support for the Graduate Assistance in Areas of National Needs (GAANN) program.

When preparing to advocate on behalf of the PSM as a critical component of STEM education and career pathways, it is essential to be in contact with your university's federal and state relation(s) officers. Many universities have one or more government relations officers on staff whose job is to represent the university's interests with policy makers.

Because workforce development and STEM education are major concerns for federal and state policy makers, it is important for directors of PSM programs to make sure their government relations officers are familiar with the PSM and can share information about PSM programs as part of their ongoing work.

Below are suggested steps to help you engage with your university's government relations officials.

Getting Started:

1. Schedule a 30-minute meeting with the Director of Government Relations or other appropriate individual at your institution for the purpose of providing an overview of the PSM program and its role in preparing a highly skilled STEM workforce.
2. Begin with providing an overview of what the PSM is, current statistics on the number of programs in the country and citations from national organizations that are supportive of the PSM movement.
3. Provide specific information about the PSM program at your institution including the number of programs, number of students enrolled, number of PSM graduates and information on local businesses and organizations where your PSM stu-

dents are interning or employed.

4. Any anecdotal or written feedback on PSM students or graduates from employers would also be of interest to your audience.
5. Make sure to provide a folder of information as part of your discussion and as a leave behind. The folder could include general information about the national PSM program, a list of national PSM programs, and any materials specific to your program(s).
6. Ask how the importance of STEM education and workforce development are being addressed by your government relations office and how the PSM program can contribute.

Follow-up:

1. Send a short note or email after the visit thanking your government relations officer for his/her time.
2. Develop a plan to share some information about the PSM program at least twice a year as a means of staying connected and in touch.
3. Inform NPSMA about interesting insights you learned from your visit that may be of interest to the whole NPSMA community at npsma@npsma.org.

Please contact the NPSMA with any questions, comments or feedback on your advocacy efforts to promote the value of the PSM.

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OPINION ARTICLE

Marketing Tactics to Help Reach Generation Z Students

Spencer Hadelman

REPRESENTING ROUGHLY 75 MILLION AMERICANS, GENERATION Z ARE QUICKLY RESHAPING HIGHER EDUCATION. Higher education branding must start to embrace new media and reshape the telling of brand stories to engage

with these entrepreneurially-minded students. While enrollment marketers have primarily focused their energy on Millennials, it is time to rethink strategies to reach prospective Generation Z students. Some important considerations:

Gen Z Students take 7 seconds for them to make a judgement on a university brand

Mobile moves enrollment - 81% of online students researched schools on a mobile device

Video and Storytelling are key. In fact, 50% of all mobile data traffic today is used to watch video. We are moving from a culture of written words to one of expressed ideas

For every day that you do not respond to a student inquiry, conversion rate goes down 10%

While statistics show Generation Z passing Millennials in numbers, this does not directly correlate to more students to market to. With search engines and virtual libraries right at our fingertips, Generation Z are growing up in a culture of self-reliance and not necessarily seeing educational institutions as the authority. Education marketers must not only seek out new platforms to engage with prospective students but must also master content marketing to answer their questions and establish credibility.

Quality of content and search engine ranking are outshining university notoriety and prestige in the eyes of the Generation Z. The older individuals in the Generation Z will be ages 20-24 in 2019, a target age for master’s marketing, meaning that enrollment marketers must target the social media platforms where this demographic is spending the majority of their leisure time. Using succinct and entertaining content on IG TV, Facebook Live, Instagram, YouTube, and Snapchat, encouraging the sharing of content, testing a variety of messaging and imagery are all tactics that will help set your institution apart.

According to a study by *Small Business Trends*, 55% of Generation Z are more likely to start a business over Millennials. This means marketers must get innovative when it comes to tapping into alumni networks as ambassadors, spotlighting affordability, and providing more information on how your insti-

tutions’ degree programs will prepare them for their careers. The PSM degree should prove especially attractive in this last aspect.

On average, it will take 18-21 months for someone to enroll from the first time they are exposed to a program. This means that timeliness and efficiency are key when it comes to implementing your marketing tactics. Using enrollment data to shape your advertising media strategy, having a clear call-to-action in your creative messaging, purchasing media on the platforms that prospective students are consuming, and directing students to a landing page that captures their information are all necessary in new enrollment efficiency.

Landing pages are a key tool for student lead generations and are more important than your actual website. With the constant flood of information that prospective students are receiving to their phones, it is important to capture their attention quickly and not bog them down with daunting text. Landing pages should include bullet points to highlight the academic aspect of a program, not paragraphs, and include more images than words. Make sure to design around your goal when creating your landing page and capture lead information, reduce the number of clicks and actions required to reach the goal, and provide the most compelling and relevant information about the program. An example of content for a landing site is:

Master of Information Management and Systems

UC Berkeley’s Master of Information Management and Systems (MIMS) program develops leaders who understand the value, complexity, and impact of information and are prepared to offer insight and breakthrough solutions.

- Two-year full-time program in the heart of UC Berkeley’s campus
- Diverse curriculum, drawing from computer science, cognitive science, psychology and sociology, economics, business, law, and communications
- Prepares students for high-impact roles in an exploding job market

Application deadline for Fall 2018: January 6, 2018.

Recent MIMS Graduates

Employers include:

Learn More

Stay engaged with the Berkeley I School! Sign up now to receive event invitations, special announcements, and other information to help you get to know the MIMS program.

First Name *

Last Name *

Email Address *

Country

United States ▼

City

State

Select State ▼

SUBMIT

Recent MIMS Graduates

Employers include:



Job titles include:

Product Manager, Business Technology Consultant, UX Designer, Solutions Architect, Data Scientist, Senior Researcher

Median salary (class of 2016):

\$115,000 salary + \$10,000 signing bonus

Marketing to Generation Z does not mean you have to reinvent the wheel when it comes to the current positioning of your institution or program, but it does require a tweaking of content to emphasize the brand values that will appeal to this generation of new students.

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The Editorial Board thanks Courtney Thornton for bringing this author to our attention.

FEATURE ARTICLE

Is the \$100,000 Master's Degree Real?

Ray J. Hoobler

Several recent articles have highlighted the cost of graduate education—explicitly addressing the master's degree; however, these articles have focused on the programs with mean debt levels of \$100,000 or higher. Examining the recently released dataset used in these reports shows that less than 3% of all master's programs are in this group with the mean of all institutions being less than half this value. This article examines the reported debt for all institutions by type (private, proprietary, and public), and further reduces the dataset to capture programs that align with the PSM initiative by filtering the reported program descriptions using key-terms associated with PSM program fields of study and program names. The results for master's degrees show mean debt of \$38,532 for graduates of public institutions, \$44,325 for graduates of proprietary institutions, and \$51,940 for graduates of private institutions.

PROVIDING AN OVERVIEW OF DEBT FOR TYPICAL STUDENTS COMPLETING THEIR MASTER'S DEGREE IS ESSENTIAL if the academic community seeks to influence public opinion; unfortunately, writing about the typical debt does not generate the shocking headlines needed to generate the online traffic desired by web-based news outlets.

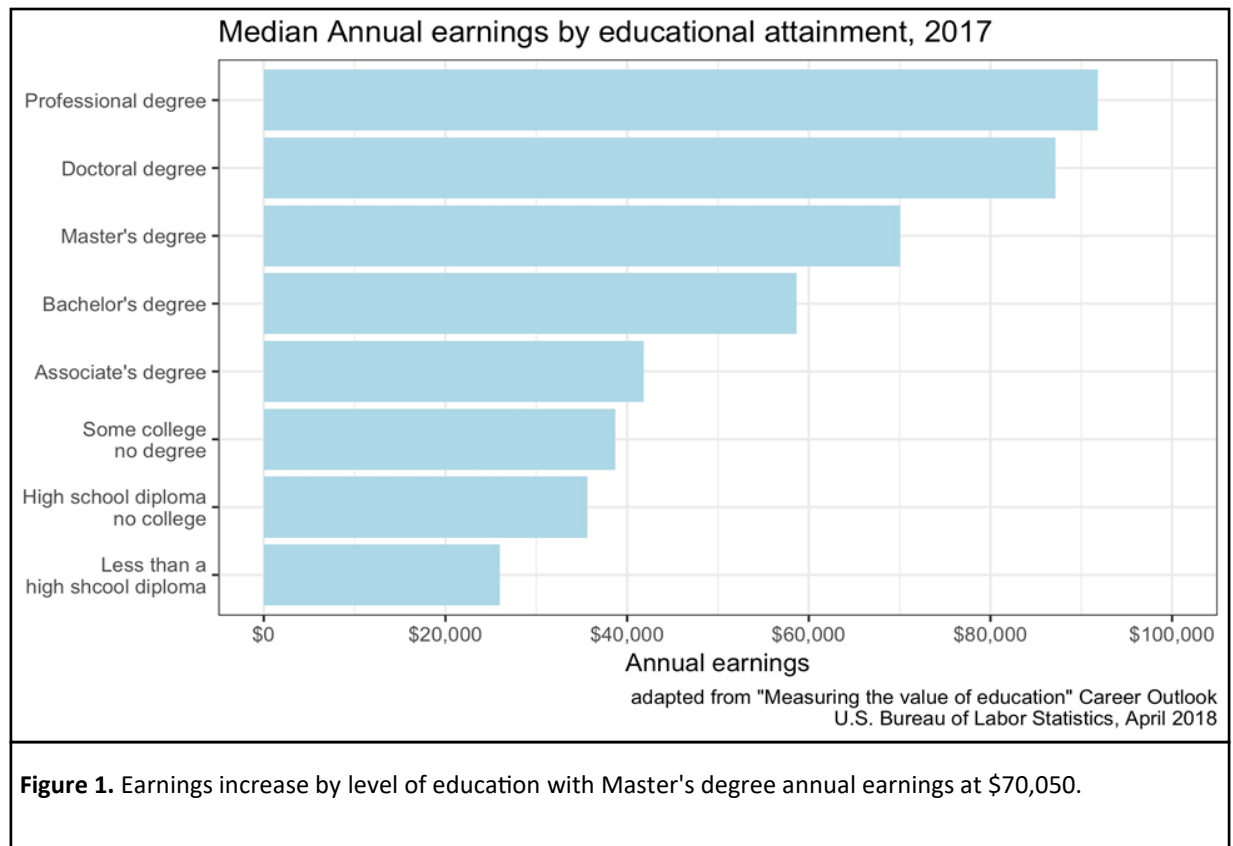
The Inside Higher Ed article from June 3, 2019, by Andrew Kreighbaum, *Six Figures in Debt for a Master's Degree*, highlights several cases where students take on excessive amounts of debt to finance their graduate educations; however, the article does not elaborate on the debt most students incur.

Also, on June 3, 2019, Kevin Carey of The New York Times specifically targeted graduate education in his article *Biggest Offender in Outsize Debt: Graduate Schools*. Here, we have guilt by association. Regrettably, the graduate program highlighted in the lead was the Institute of Art University—a proprietary, for-profit school where the “people with federal loans who graduated in 2016 and 2017 with a master's degree in design and applied arts owed an average of \$100,252.” Near the end of the article, the author highlights the significant variance in student debt between schools, but also states: “it's the less mainstream programs, where vague promises of a lucrative career are easier to make, that seem to encourage irrationally large debt.”

As counterpoints to these articles, we can refer to The Council of Graduate Schools comprehensive report, *Graduate Education and the Public Good*, published in 2008 detailing the benefits of graduate education (DePauw et al., 2008). This report focuses on benefits beyond the increase in salary; however, increasing one's earning potential is a crucial driver for many individuals deciding to pursue a graduate degree. This information is straightforward to obtain, as the Bureau of Labor Statistics consistently reports how earnings are directly related to educational attainment. Figure 1 shows the Bureau of Labor Statistics data for 2017 converted from weekly to annual earnings (Torpey, 2018).

Of course, if the level of debt required to obtain a graduate degree is too high, the ROI (return on investment) would be negative and the financial decision questionable—for most STEM professionals, graduate education can have a significant, positive impact on earnings. The 2015 report Georgetown University Center on *Education and the Workforce, The Economic Value of College Majors*, states that “STEM majors not only have the highest wages, but they also experience the largest wage growth throughout their careers.”

The analysis conducted in this work summarizes the Preliminary Loan Debt Data by Field of Study recently released by the U.S. Department of Education (referenced in the Inside Higher Ed article) with an emphasis on all reported master's level graduate programs and PSM related fields of study.



Methods

The data file for this work is publicly available (“College Scorecard Data”) as a comma-separated variable (csv) file. The downloadable zip file contains two files, one for the 2014–2015, 2015–2016 academic years and a second for the 2015–2016, 2016–2017 academic years. Two-year cohorts were used to increase the number of data points for each program and to reduce disclosure risks. This work focused on the 2015–2016, 2016–2017 dataset which contained 194,575 rows (programs) and included the following information:

- OPEID: The FSA-assigned institution identification number (truncated, six-digit version);
- NAME: The institution name associated with the OPEID;
- TYPE: The type of institution (public, private, proprietary, or foreign);
- CIPCODE: The 4-digit Classification of Instructional Programs (CIP) code identifying the program's field of study;
- CIPDESC: The text description of the field of study associated with the CIP code

- CREDLEV: The level the credential awarded to the student completing the program of study using the following levels:
 - 1: Undergraduate Certificate or Diploma
 - 2: Associate's Degree
 - 3: Bachelor's Degree
 - 4: Post-baccalaureate Certificate
 - 5: Master's Degree
 - 6: Doctoral Degree
 - 7: First Professional Degree
 - 8: Graduate/Professional Certificate
- CREDESC: The text description of the credential level;
- COUNT: The number of individuals in the cohort;
- DEBTMEDIAN: The calculated median debt amount for members of the cohort;
- DEBTMEAN: The calculated mean debt amount for members of the cohort;
- IPEDSCOUNT: The number of awards conferred, as captured by the IPEDS Completions;

The College Scorecard Data site contains additional details. (<https://collegescorecard.ed.gov/data/preliminary/>)

Filtering the dataset on the master's credential results in 32,262 programs; however, 21,078 do not report the mean debt values due to privacy concerns leaving 11,184 programs in the dataset. Unless otherwise stated, all calculated results used the DEBTMEAN and COUNT values. Focusing on these categories allowed the calculation of total debt and weighted means for these programs.

All analysis was performed using the R statistical software package (R Core Team, 2017) and the RStudio IDE (RStudio Team, 2018). Graphics were generated using the ggplot2 package (Wickham, 2016).

Results and Discussion

Mean debt: all reported master's degrees

Of the 11,184 master's programs reporting student debt, only 287 programs have a mean debt exceeding \$100,000. Of those, 234 are private institutions, 34 are public, 16 are proprietary, and three are foreign. Looking at a histogram of the reported mean debt for all programs in Figure 2, we can easily see the typical mean debt is substantially less than \$100,000. The weighted mean values are summarized by institution type in Table 1.

Mean debt: PSM filtering by field of study

Ideally, we would want to examine PSM programs as a subset of the data; unfortunately, this is not possible in the current dataset. While it may be possible to isolate PSM institutions, this would still cause issues as mean debt levels can vary considerably by programs within a given institution. In order to work around this limitation, the data set was filtered using key-terms representative of PSM programs.

During the affiliation, PSM programs self-identify the field of study using the following specific categories:

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

Matching these key-terms to the text description of the field of study associated with the CIP code reduces the number of programs to 1002 and the types of programs to 15 public and 14 private institutions. Figure 3 shows the weighted mean and range of mean debt. For these programs, the weighted mean debt is less than \$50,000 for public institutions and under \$75,000 for all but two private institutions.

In order to expand this analysis to more programs, the scorecard dataset was filtered based on a larger list of key terms. The PSM affiliation application requires the applicant also to identify the concentration/specialization:

- Biotechnology
- Bioinformatics/Computational Biology
- Pharmaceutical Sciences/Pharmacology
- Other Biological Sciences
- Chemistry/Chemical Sciences
- Computer/Information Sciences
- GIS/Remote Sensing
- Agriculture/Natural Resource Conservation
- Environmental Sciences/Climate Sciences
- Earth/Atmospheric/Ocean Sciences
- Energy/Power
- Forensic Sciences
- Statistics/Biostatistics
- Financial Mathematics
- Biomathematics

Table 1. Mean debt for students earning master's degrees calculated by institution TYPE.

Institution	Mean debt
Private	\$51,940
Proprietary	\$44,352
Public	\$38,532

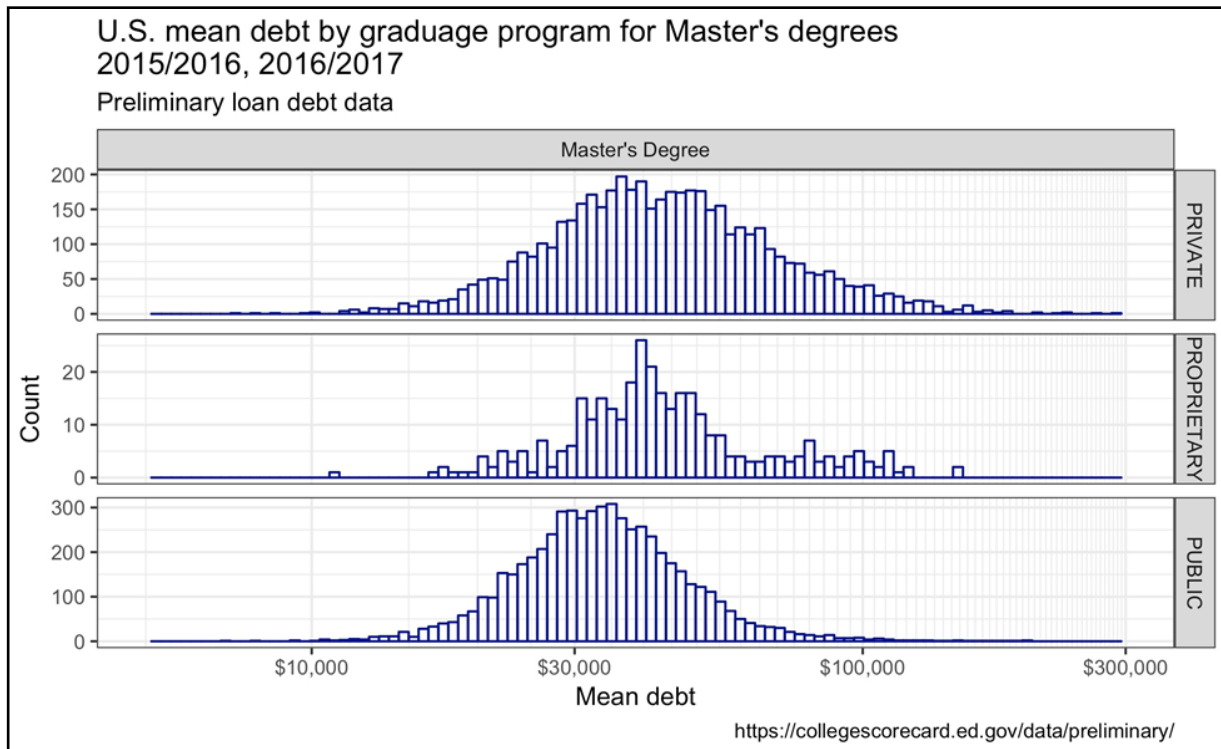


Figure 2. Mean debt for all master's degrees programs showing a log-normal distribution centered below \$100,000.

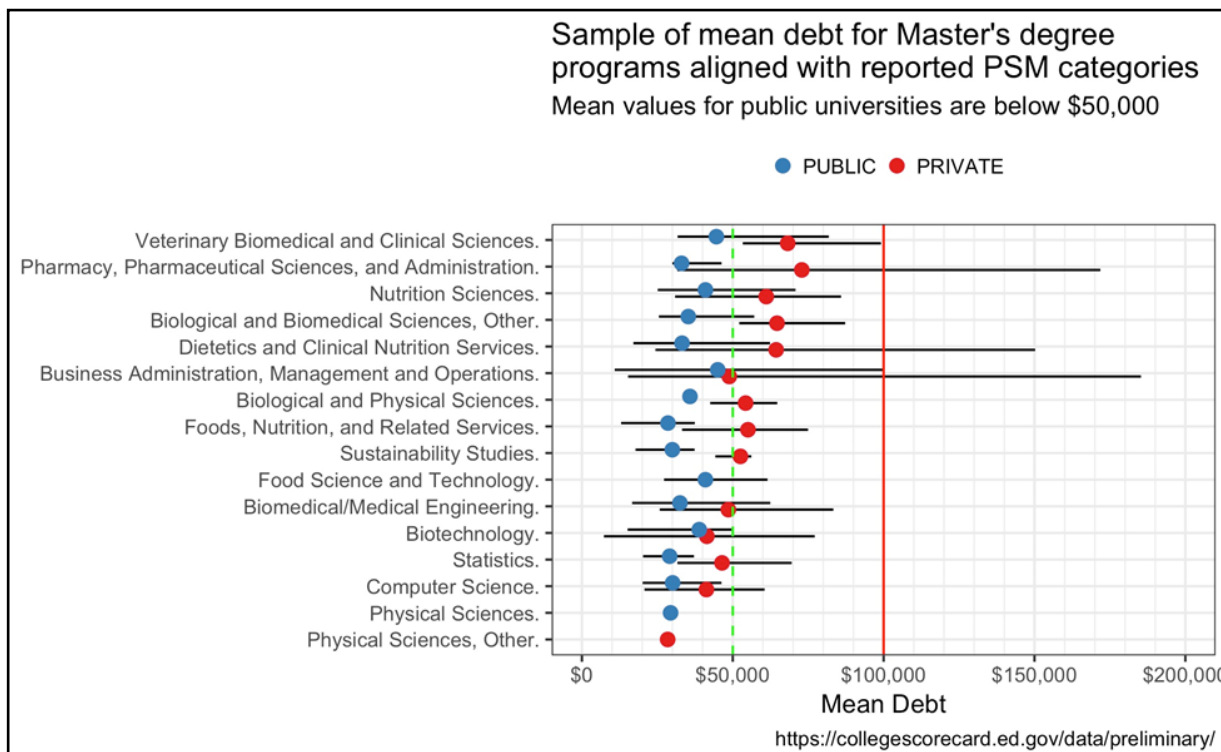


Figure 3. Mean debt of master's degree programs filtered by field of study categories as defined in the PSM affiliation application.

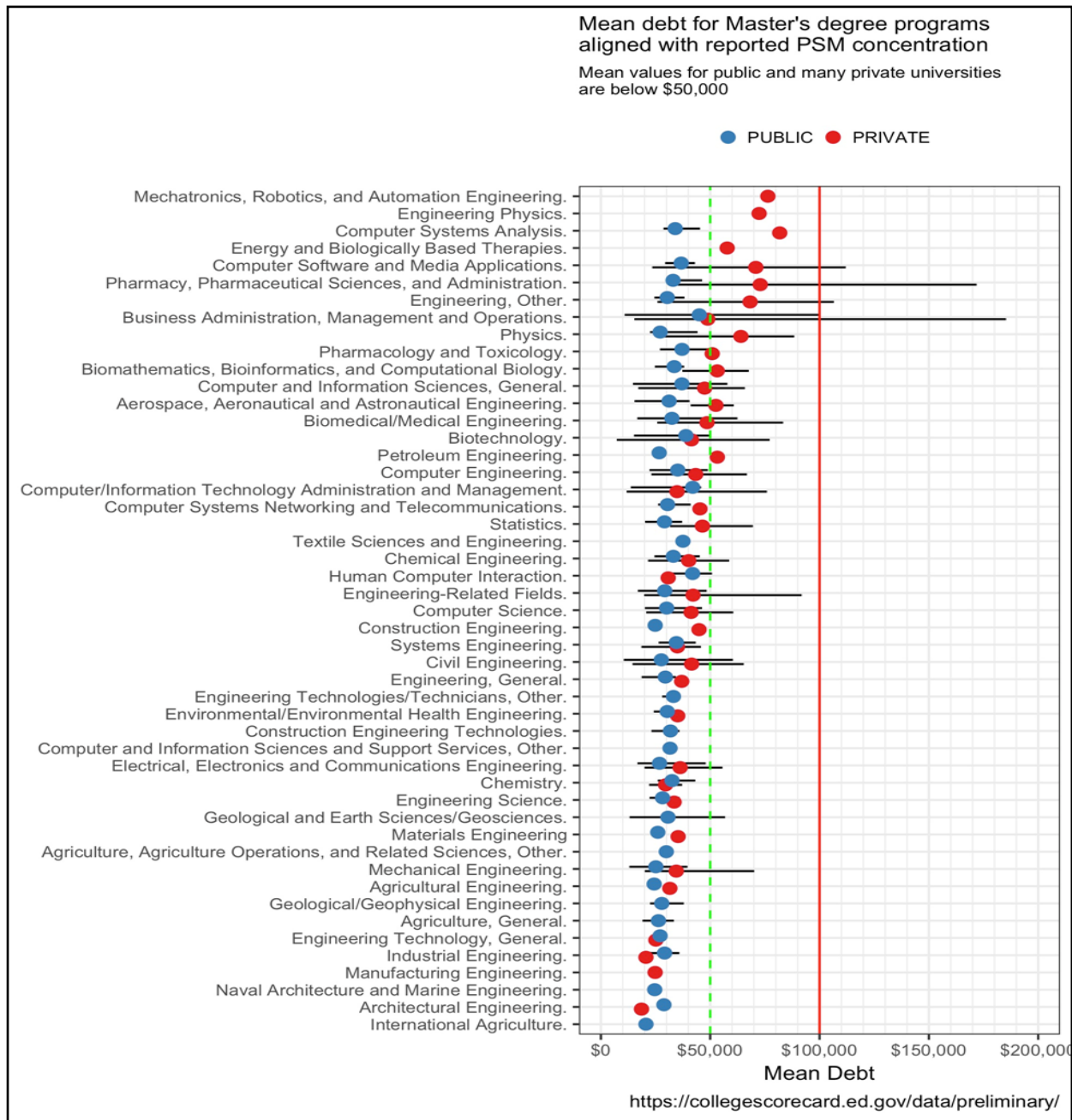


Figure 4. Mean debt of master's degree programs filtered by concentration/specialization as defined in the PSM affiliation application.

- Industrial Mathematics
- Other Mathematics
- Medical-Related Sciences
- National Defense
- Physics/Applied Physics
- Nano Science
- Other Interdisciplinary Sciences
- Engineering
- Other (Please explain)

Using this list as key-terms and matching within the text description of the field of study associated with the CIP code results in 1402 programs in 84 fields of study. The trend is similar to above and shown in Figure 4.

Finally, to generate a filter that would capture the most inclusive number of programs, PSM program names were parsed into 197 key-terms and used to match against the text description of the field of study associated with the CIP code. This analysis resulted in 3560 programs representing 174 programs of study. This dataset is too large to plot as a point range plot by each program; instead, Figure 5 shows a histogram separated by public and private institutions. Again, we can see that the most

probable mean debt is \$30,000 for public institutions and \$50,000 for private.

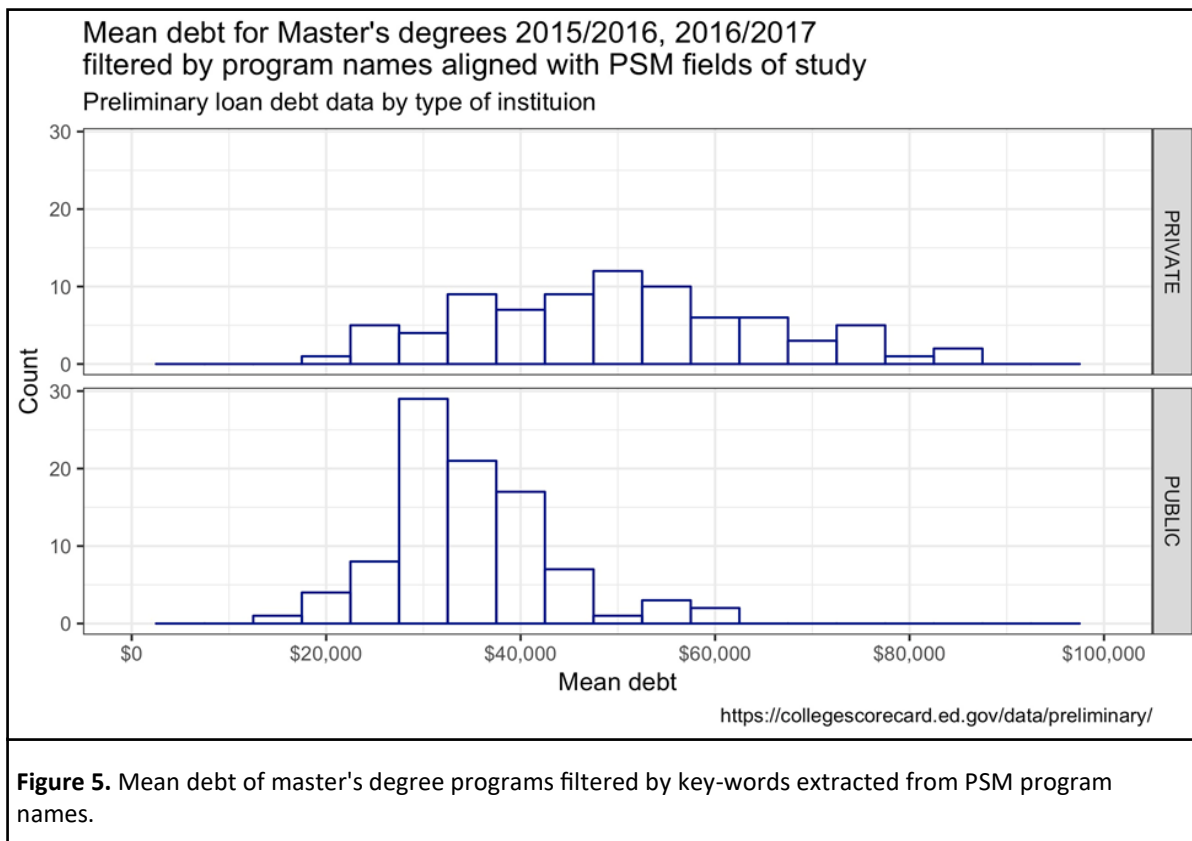
Conclusions

While it is beyond the scope of this article to address the affordability of graduate studies, the PSM community should be ready to push back on allegations of gouging students with expensive degree programs with only the allure of high-paying jobs. The data shows that for most programs, students incur reasonable levels of debt. Given the documented increased earning power associated with a graduate degree, responsible financing of graduate education is a meaningful investment for many individuals.

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IN PRACTICE ARTICLE

We All Win with an Effective Employer Advisory Board

Linda Strausbaugh, Dan Kalafatas, and Elizabeth Friedman

PSM DEGREE PROGRAMS FORMALLY BRING TOGETHER ACADEMIC AND INDUSTRIAL SECTORS THROUGH ADVISORY BOARDS. Known across the PSM world by several names (External Advisory Boards, Employer Advisory Boards, Industrial Advisory Boards, Corporate Advisory Boards, etc.), they are referred to in this article as Workforce Advisory Boards (WAB). Direct and regular interaction with an advisory board has always been a recommended best practice for PSM programs and continues to be a requirement for the affiliation process. Advisory board members provide high quality, non-binding strategic advice, especially in the areas of workforce demands and trends as well as skills that employers value. The WAB provides an important network expansion for PSM programs and students. Members have the opportunity to serve as guest speakers, instructors, and mentors. They can help students prepare for interviews and facilitate experiential learning, internships, and part-time and full-time and employment opportunities. Industry endorsements of PSM programs to university administrators and state and local government are influential. WAB members can promote the PSM degree and graduates to their counterparts in other companies.

Advisory boards may be established for each individual PSM program or shared when there are multiple programs within one institution. Although WAB composition should be primarily external to the university, a minor and appropriate representation from the institution is acceptable. Inviting an upper level university administrator to join your WAB meetings is an effective way to regularly in-

form them about your PSM program and reinforce to the institution the value the PSM degree has to employers. Equally important, the presence of an upper level administrator, at least to offer welcoming remarks, telegraphs to the corporate world that the university believes in and supports the program. Including alumni on the board can also be helpful, as they can directly inform on the value of different aspects of the curriculum and share their experiences since graduation.

How does a program director build a workforce advisory board? This is one of the most common questions asked. First, program directors should be

People volunteer because they have a belief that the organization is trying to make a difference in the world....Give potential board members information to support this belief – remind them that they are part of a much larger initiative, that they can change people’s lives.

aware that universities often have guidelines (and perhaps restrictions) on outreach from members of the institution to external parties. Consulting the appropriate unit at the university is an early step in thinking about inviting members to the WAB and in building on the university’s existing relationships with the corporate community. The

PSM program director should be prepared to expend some effort to recruit and on-board members from the corporate community and, in some cases, educate those who do not have prior experience with a PSM program or its graduates. To complement specific information on your program, the NPSMA has developed a flyer for employers to help introduce the PSM. (https://www.professionalsciencemasters.org/sites/default/files/npsma_marketing_psm_employer_flyer_sept.2017.pdf). A brief message to employers, written by two NPSMA Workforce Advisory Council members who have extensive experience hiring PSM graduates, is a powerful piece to share with potential partners. (Arnold and Moskal, https://npsma.org/resources/Publications/INNOVATOR/The_INNOVATOR_Curated_Issue_Fall_2018_FIN

[AL.pdf](#)). In building the advisory board, program directors should seek broad, inclusive representation with respect to the sector, size, and geographical footprint of the participating companies. Student populations are likely to be diverse, so it is also good practice to be mindful of diverse role models from the employer community. In selecting board members, commitment is more important than position in the company; an effective member will have time and passion for engagement.

Where does a program find board members? There are many obvious and some not so obvious places to recruit WAB members:

- Companies and businesses. Local and regional companies are especially valuable for on-site experiential learning and student visits to employment sites. Industries with national and international geographic reach provide a more global perspective.
- Small businesses. Small businesses often have limited resources and may particularly appreciate an opportunity to work with interns or capstone projects. Since smaller companies may not have their own guidelines in place, the PSM program (in cooperation with the institution's career development office, if needed) can help develop recommendations to make internships successful.
- Non-profits.
- State or federal laboratories and agencies.
- State and local workforce and labor agencies. These often have educational outreach staff who can bring practical knowledge of workforce demands for employees to the table.
- Trade associations. A WAB member from a trade group provides a way for a program to amplify its message to a large number of relevant industries. In addition, members from trade groups provide contacts to potentially garner political support for the PSM.
- Conferences that include topics in workforce development.
- Pre-existing university relationships. Faculty, staff, administrators and PSM graduates may all have contacts that can be a valuable bridge between the PSM program and employers.

How do you reach out to a prospective board member? This can be quite intimidating to some individuals. The first step, once you have a name of

someone, is to reach out by email and set up a phone call. What's the worst that will happen? The recipient will not respond or will let you know they are not available or interested! Once you connect with a person, you can discuss the position and see if there is interest, then follow-up by a more formal invitation by email. If you have a personal relationship or referral from a colleague, it certainly reduces the anxiety of cold-calling. In our experience, these preliminary conversations where you can promote the program produce very positive results. Remember that you have things to offer a prospective member: a feather in their cap on resumes, a networking opportunity, the potential to help with staffing for their companies, a voice in curriculum planning, and a learning experience for those just starting out or interested in learning something new.

The email follow-up to these calls and invitations to the WAB should be thoughtful and informative. After a potential member has agreed, a formal invitation on letterhead is appropriate and appreciated. Be sure to specify that WAB membership is a volunteer activity. Provide a concise explanation of roles and responsibilities. It is also good practice to appoint to a specific term (two or three years). Terms of members should overlap to provide continuity between years. It would be helpful to project the number of meetings for the next 12-24 months and whether they will be in person or virtual. This shows you are respectful of the board member's time. Further, the option to join meetings remotely enables geographically distant members to participate. A written reply of acceptance that includes a commitment to the board is good practice.

In our experience, the size of a WAB should be between 5 and 15 members. The duties of planning and implementing meetings of the WAB typically fall to the program director, even if the director is not the formal chair of the board. It is important to keep in mind that WAB members are busy people. Set a meeting time, prepare a succinct agenda, and stick to it. Often the best meetings are focused on a small set of issues. If it is necessary to provide information in advance, it should be well-organized, of appropriate (short!) length and content, and comprehensible on its own without the need to refer to other documents or websites. Best practice is to have meetings focused on questions for discussion by the WAB, rather than on repeating content via one-way presentations to the WAB that was already

conveyed in written documents before the meeting. Meetings should always conclude with a set of action items and measurable goals, which will give direction to the board and form part of the discussion at the next board meeting. Formal notes must be recorded at the board meeting and distributed electronically before the next scheduled meeting for a number of reasons, including enabling WAB members unable to attend to stay up to speed.

It is important to recognize that good programs evolve over time and so should the focus of advisory boards. In the early planning stages of a PSM program, its most pressing needs from the WAB are advice on workforce needs and professional competencies, and advocacy at university and state approval groups. WAB members may have suggestions on student recruitment, either through their connections with other universities or experiences with employees who want to upgrade or change areas of expertise. Once a PSM program has established itself and enrolled students it needs WAB involvement to facilitate industry participants as mentors, career advisors, course instructors, and guest lecturers. The WAB can help by offering internships, sponsoring student travel grants to professional meetings, and providing industry capstone projects. In addition to the aforementioned activities, the mature PSM program can use its WAB to create learning opportunities, provide mentoring support for graduates, promote networking events, engage industry to circulate employment opportunities, and to acculturate corporate leadership and human resources to the PSM degree (often overlooked in job descriptions).

Co-author Dan Kalafatas adds some specifics to talking points about the roles and responsibilities of a WAB member. Kalafatas was a committed WAB member at Northern Arizona University who participated in two meetings a year. He worked outside of the meetings to coach students, advise on curriculum development, provide or recommend guest lectures, and lobby on behalf of the program with the university, donors, and other companies. He estimates that he spent 30 hours per year, most of which came from his personal time. He also provides insight into why he participates. From most to least importance, his motivation for being an WAB member was: showing his belief and support for his own company's volunteer and donation program; enjoying the company of scientists and other advisory board members; finding satisfaction in shaping and

growing something with a mission in which he believes; articulating the psychology of giving and happiness; and lastly, contributing toward his company's staffing needs.

What can the NPSMA do to help programs effectively establish and use workforce advisory boards?

- One useful resource for programs would be a collection of samples or templates for: letters of invitation; charters/statements of WAB roles and responsibilities; acceptance of advisory board invitation and member responsibility.
- The Association could create a set of best practices documents with guidelines or recommendations for developing internships and capstone projects.
- A list of national and international entities that have hired PSM graduates would be useful information for programs with a local or regional presence of that corporation.
- The NPSMA could also help identify local, prospective alumni board members who graduated from other programs. PSM alumni employment is not exclusively limited to locales near the university they graduated from. The inclusion of an alumnus/a from another school's PSM program may bring fresh perspectives and new best practices.

We end by sharing four general thoughts and recommendations around volunteer board service:

- 1) People volunteer because they have a belief that the organization is trying to make a difference in the world. People want to be part of organizations that are ambitious. Give potential board members information to support this belief – remind them that they are part of a much larger initiative, that they can change people's lives.
- 2) People *want* to work. Tell board members exactly what you want them to work on and why *they* are valuable for this particular role. Reappoint those members who are adding value.
- 3) Volunteering is supposed to be fun and rewarding. Organize a reception with students after a WAB meeting. Invite WAB members to events that include students and alumni, like presentation days and social events. Make a habit of sharing student success stories with the WAB – it will be rewarding for them to know the goal of

generating career-ready professionals is being met.

- 4) It is a common misconception that people expect financial consideration. Simply do the above and say “Thank you”.

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IN PRACTICE

The Many Dimensions of PSM Programs: Modelling Regional Partners and the PSM4RST8 Campaign

Gerald B. Grunwald

TO FURTHER THE MISSION OF THE NATIONAL PROFESSIONAL SCIENCE MASTER'S ASSOCIATION, the NPSMA has established the "PSM for Our State" (PSM4RST8) campaign, with the dual goals of growing awareness of PSMs at the state and regional levels, and expanding PSM programs into states that currently do not have PSM programs. To accomplish this, several PSM4RST8 teams have established projects to focus on different components of the campaign. These aspects include covering aspects of PSM program operations and engagement with the PSM community such as utilizing virtual career fairs to promote program marketing and recruitment, and developing a variety of tools and platforms for enhanced communication of program opportunities and outcomes. Our team project is entitled "Modeling Regional Partners", in recognition that the establishment and successful operation of a PSM graduate program involves many types, levels and dimensions of partnerships. These include those built internally between a graduate program and its home institution's resources and administration, as well as those built externally that support pipelines of potential students, training of enrolled students, and employment of program alumni. This article describes the "Modeling Regional Partners" project, and seeks engagement with the PSM community to: (1) engender a dialog about the role of such partnerships; (2) collect input about the nature of and experience with the various partnerships that PSM programs have found to be critical and effective; and (3) develop this database into an NPSMA resource to support the sharing and dissemination of best practices for PSM programs.

The Multidimensional Nature of PSM Program Partnerships

For PSM programs to thrive, a variety of critical partnerships both internal and external to the program's home institution must be established and nurtured. We considered one systematic way to

functionally consider and characterize these could be to envision them extending across both vertical and horizontal dimensions, intersecting at the PSM program itself. We consider the "vertical dimension" to represent partnerships that direct trainees into the program, and those that in turn employ our graduates. The vertical partnerships would thus include (1) organizations from which our PSM program students originate and the pathways and pipelines through which they are recruited, and (2) organizations that will in turn employ our PSM pro-

For PSM programs to thrive, a variety of critical partnerships both internal and external to the program's home institution must be established and nurtured.

gram alumni as they begin their journey along their chosen career trajectories. Furthermore, program success is also dependent upon partnerships spanning along the "horizontal dimension". We consider the horizontal partners to represent those that provide resource and support to the program while our students are actively engaged as students within the program. These include (3) working relationships with our respective internal institutional partners that provide resources and support for our programs as well as our constituent students, faculty and staff, and (4) relationships established with our external community partners including business and government entities that provide locations for trainee internships, grants and scholarships, and other means of program and trainee support. Figure 1 provides a

visual representation of these multidimensional partnerships.

A Call to the PSM Community to Help Build a Resource in Support of PSM Program Best Practices

Given the task described above of “Modeling Regional Partners” with the goal of providing a PSM community resource to support the continued growth and development of PSM programs, our team seeks to identify successful examples of “vertical and horizontal partnerships” as described above. We in turn plan to compile and make available the results of this effort in a way that is accessible to and will provide a valuable resource for NPSMA member programs.

As the first step in our process is to collect information on examples of successful PSM program partnerships, we are reaching out to all NPSMA members to ask you to share pertinent information

based upon your own program’s experience by answering the following four questions:

- 1) As sources of your PSM program students, from what types of organizations, pipelines and pathways do your students originate, and how do you market your program to them?
- 2) As destinations of your PSM program alumni, what types of organizations hire your former students, and how do you help them to make these connections?
- 3) As sources of internal institutional support, who are the people and administrative units within your academic institution that help to support your program, whether financially, administratively, or in other ways?
- 4) As sources of external community support, who are the people and organizations outside of your academic institution that provide financial, training, and other means of support for your program?

As you consider these four questions in the con-

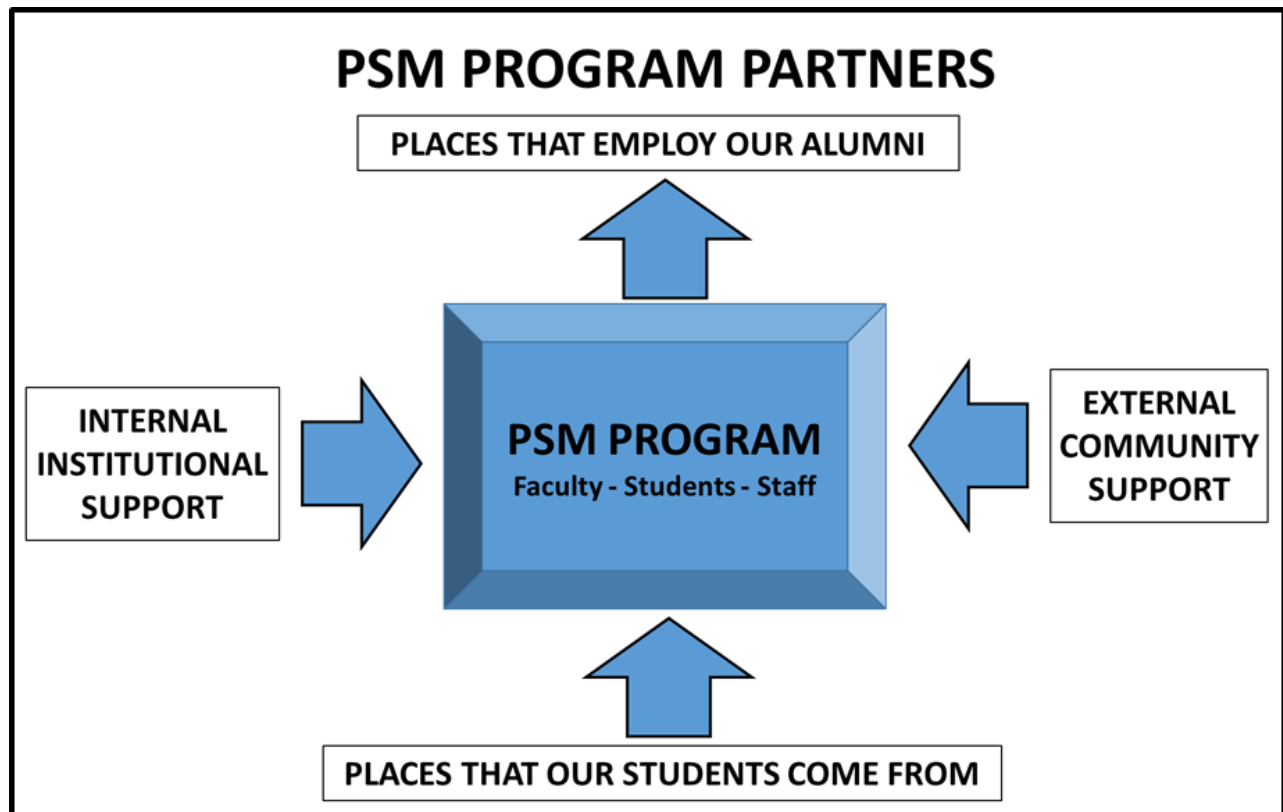


Figure 1. Critical partnerships that support PSM program success exist both within and outside of our academic institutional program homes, and both impact and are impacted by our programs.

text of your own PSM programs, we thank you in advance for your consideration of these points and for sharing your examples of successful partners of your PSM programs. To support this effort, we have established an online Survey Monkey questionnaire where you may submit this information addressing the four questions at <https://www.surveymonkey.com/r/P5PSJYZ>. We expect to provide preliminary information on the results of this outreach at the upcoming NPSMA Annual Conference in Salt Lake City Utah in November 2019, as well as an interim report in a follow-up article in a future edition of The Innovator. Through ongoing collection and dissemination of this information, our goal is to provide a dynamic resource that will both assist existing PSM programs in continual program growth, development and improvement, as well as to assist those thinking about starting PSM programs in their own academic institution while developing the internal and external partnerships to ensure success.

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FEATURE

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

Jessica Rivenbark, Jeffrey Cummings, Douglas Kline, and Laurie Patterson

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 research presented here 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.

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 ex-

perts 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).

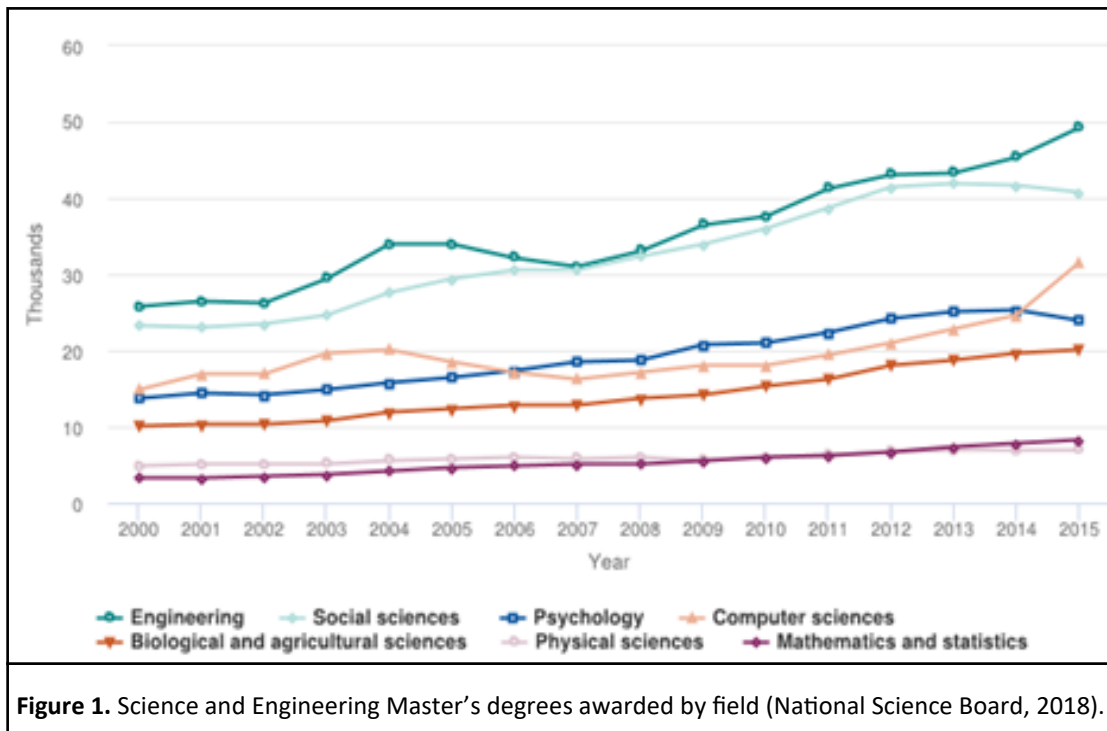
As demand continues to grow for graduates, and the popularity increases in PSM programs, questions remain around the success of these types of programs. The research presented here aims to answer four questions:

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 this 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.

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 experiential learning 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 the requirement that the university engage more with industry through employer representatives, experts and alumni through an external/ industrial advisory board (Denecke et al., 2017). This is emphasized in many of the marketing mate-

rials 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.

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.

ABOUT THIS STUDY

This 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 the level of involvement with industry experts (employers) as well as the 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.

The universities chosen for this study offer an official PSM and are endorsed on the Professional Science Master's website. The programs that were 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.

Initial contact with the universities began with the Program Coordinator listed on the Professional Science Master's website. 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.

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). The Kirkpatrick framework was chosen because of the wide application across academia and industry. Prior to data collection, the surveys were piloted with a small group of students, faculty, and staff who posed as stakeholders and completed the survey multiple times. Feedback was provided, and the survey was modified to increase readability and clarity.

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.

	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 1. Reasons for pursuing a degree in a PSM program.

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 1.

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 2 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.

There is agreement from all constituents that a majority of PSM graduates will have work lined up prior to graduation, which agrees 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 posed to all participants concerning program satisfaction, workforce preparedness, and employer involvement (see Table 3). Most alumni agree (either strongly or somewhat) with the statements that address program satisfaction and workforce preparedness. Faculty agree (either strongly or somewhat) with the statements surrounding workforce preparedness. However, there was slight disagreement with the statement that the program addresses industry needs. 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 or somewhat) 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.

	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 2. Employment Expectations (Students & Faculty) and Actuals (Alumni).			

	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 3. Satisfaction, Preparedness and Employer Involvement.			

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.

Qualitative Results

The surveys contained several open-ended items to allow 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 the 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 the 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.

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 inter-

viewees 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 collaborat-

ing 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 a 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 PSM affiliation process 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.

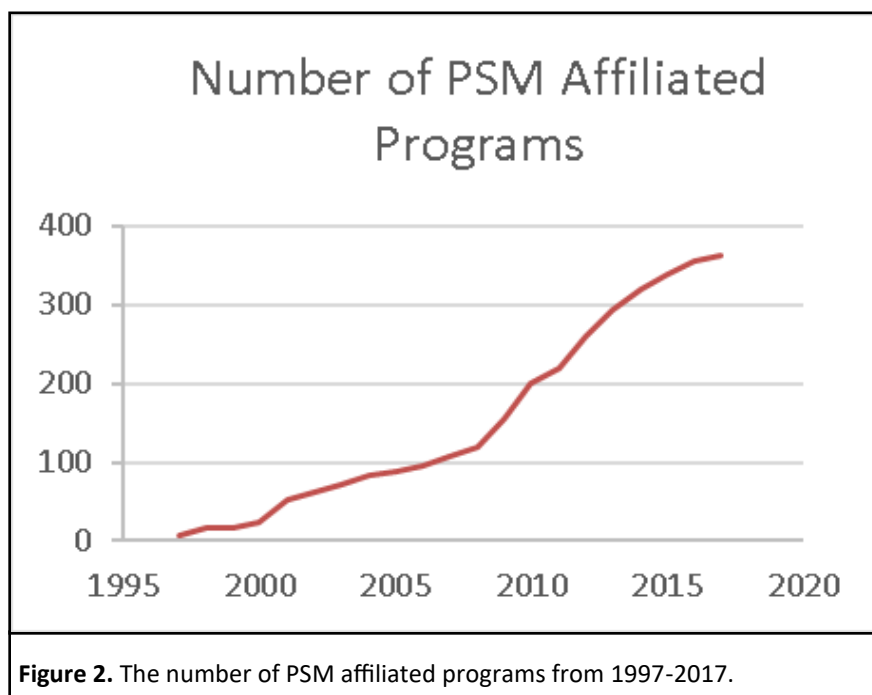
PSM Affiliated Universities vs. Non-PSM

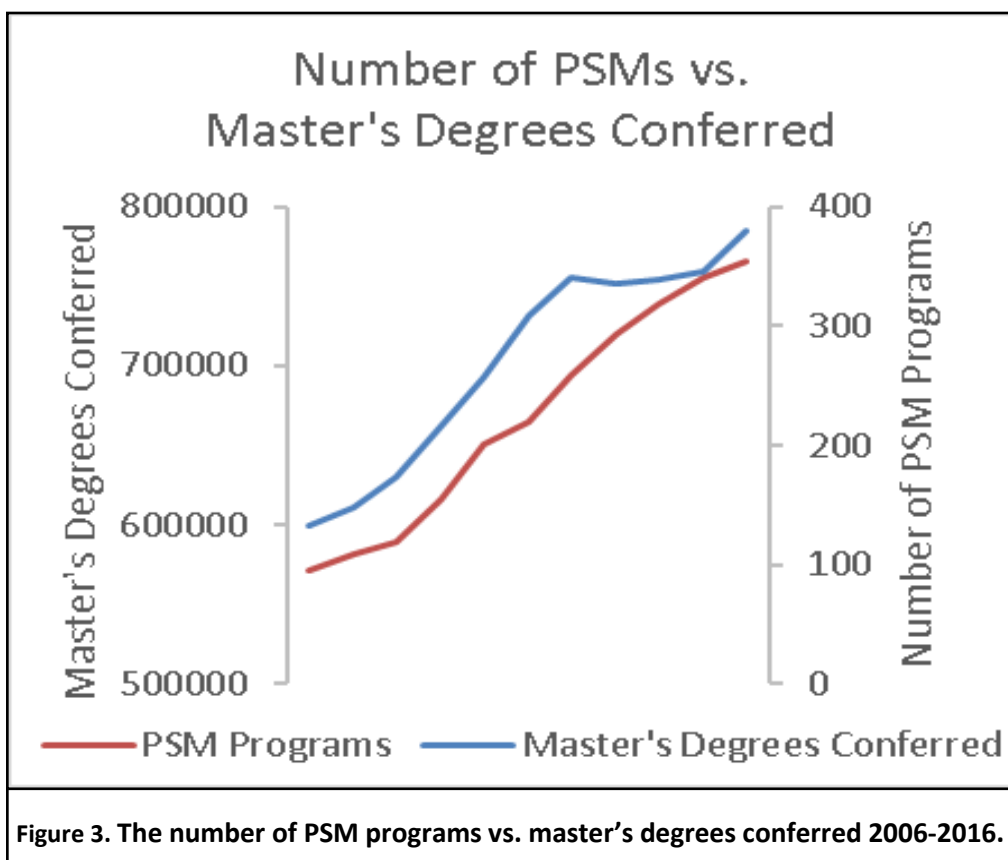
These interviews prompted a tangential research question to emerge, "Are universities conducting PSM-like graduate programs on their own without the national affiliation?" First, an examination of the number of PSM programs worldwide needed examining. Figure 2 illustrates the number of PSM affiliated 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.

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 discussion.

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 its 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 com-

puter 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.

Limitations and Future Directions

This study has some limitations. The sample size of universities ensured that computer science, information science, and other multidisciplinary PSMs were part of the study. However, with such a limited number of universities agreeing to participate, the breadth of programs represented is limited. 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 should be expanded to include all universities within a specific category to increase response rate.

Another drawback is that the population of “current students” 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. A study that partitioned students by year would solve this issue.

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. 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.

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.

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