Professional Science Master's Programs in Mathematical Sciences

1. What is a PSM?

At the end of the 1990s a new graduate degree came to life, as a response to strong workforce demands for STEM professionals. Called the Professional Science Master's (PSM), the degree was conceived to supplement strong interdisciplinary knowledge in science and mathematics, with expertise in business (e.g. communications and project management). The PSM is a degree suitable for those who want to have a career in industry, business or government and start in jobs that require additional expertise than offered by a Bachelor's degree. The PSM programs fill a gap in the US higher education landscape that is confirmed by the rapid expansion of these programs (currently over 300) in a variety of disciplines.

In mathematics, the first PSM programs originated in Financial and Applied Mathematics (or Industrial Mathematics or Computational Mathematics), followed by Bioinformatics and Data Analytics programs, which have significant mathematics and statistics components.

2. Specific outcomes from a PSM

a. Cognitive Goals

- Analytical thinking. The strong theoretical mathematics and/or statistics knowledge should provide a framework for the deep understanding of important applied problems.
- Applied mindset. Students should become comfortable thinking mathematically and using mathematics and statistics to model real-world problems.
- Professional and leadership skills. PSMs supplement the mathematics and statistics knowledge with professional and leadership skills and fill in the gaps according to corporate needs.
- Collaborative skills. PSMs develop collaborative skills through team projects and internships.

b. Content Goals

The content goals differ between mathematics PSMs, yet unanimously focus on the literacy, reasoning and thinking in mathematics and statistics as applied to the particular field. These are addressed in the three major pillars, which are common between these programs:

- Mathematics and Statistics core courses
- Professional skills and business courses

- Real-world projects and internships

The content goals are different for the different PSM programs:

a. Industrial/Applied and Computational Mathematics

The goals are to apply mathematical and computational tools to model problems from sciences and engineering, to be able to distill the underlying mathematical model from the physical problem, develop qualitative analysis of the solution, determine the acceptable approximation, understand the importance of data and accuracy needed, finding, interpreting and conveying the results in the context of the problem and given the constraints of the data.

b. Financial Mathematics

The goals are to use mathematical and computational tools to model pricing of financial derivatives, fixed income securities and their derivatives, portfolio valuation, credit markets and risk management. Understanding of business and economics through courses regularly taken by MBA students as well as the understanding of computer programing, algorithms, database design and management, design of software systems are also important.

c. Data Analytics

The goals are to use mathematical, statistical and computational tools to analyze large sets of data and use the results for fact-based decision making. The translation of a business problem into a data problem, which can be solved and transformed into a business solution, involves the understanding of techniques for data mining, data visualization, machine learning, distributed computing and business.

d. Bioinformatics/Biotechnology & Genomics

The goals are to use statistical, mathematical and computational tools to manage and interpret biological data and to analyze and model complex biological phenomena. The development of strong statistical reasoning and computational analysis needs to blend with a good understanding of the biomedical aspects of the problem.

3. Recommended undergraduate preparation for a PSM

While there are a large variety of PSM programs in the Mathematical Sciences and related fields, each with their own admission requirements, there is a commonality of background and experience that can prepare a mathematics major for successful admission and graduation in a PSM program. Some institutions offer what is often called a B.S./M.S. (4+1years) program: high performing undergraduates that have completed the prerequisites for the PSM can take graduate courses while enrolled as undergraduates and then complete both an undergraduate degree and a PSM degree in 5 years.

This background and experience can be obtained from course work and involvement in professional activities. It is to be noted that some of the PSM programs admit students who do not have a mathematics undergraduate degree (e.g. in Data Analytics or Bioinformatics PSM programs). Because the admissions criteria are dependent on program site, we only specify universal criteria for mathematics majors here and direct readers to specific institutional sites for other cases.

a. Courses

- Industrial/Applied and Computational Mathematics PSMs:
  Calculus, Multivariable Calculus, Differential Equations, Linear Algebra, Discrete Mathematics, Probability and Statistics, Numerical Methods. Courses in engineering or sciences, depending on the area of interest, including programing/computing courses.
- Financial Mathematics PSMs:
  Calculus, Multivariable Calculus, Differential Equations, Real Analysis, Linear Algebra, Discrete Mathematics, Probability and Statistics, Numerical Methods. Courses in business (e.g. accounting), economics or finance. Experience with basic computer programming (MATLAB, R, Java, C++, Python).
- Data Analytics PSMs:
  Calculus, Multivariable Calculus, at least two courses in statistical methodology / regression, Linear Algebra, experience with statistical / mathematical computing (SAS, SPSS, R, Minitab, Python, etc.).
- Bioinformatics PSMs:
  Calculus, Multivariable Calculus, Linear Algebra, Probability and Statistics, at least two courses in statistical methodology / regression, Numerical Methods, experience with statistical / mathematical computing (SAS, SPSS, R, Minitab, Python, etc.). Additional courses in biology (e.g. cell biology, genetics, and molecular biology), organic chemistry and programing/computing.

b. Other Experience

It is important for students to have completed course work in other science, engineering and business disciplines. Alternatively, students could have previously acquired perspective on another discipline. This outside the discipline experience not only helps students in choosing the right degree for themselves, and ultimately their career, but contributes to their success in a PSM degree. Some previous experience with applications of mathematics and statistics to another field, and problem solving in a real setting is also

desired. For instance, students could have completed internships or have participated in internship-like activities.

Collaboration plays a uniquely critical role in training for a career in industry, business or government; thus previous experience with teamwork on a project is desirable. Teamwork with people from diverse backgrounds help the students see things from different perspectives. This can be done through class projects, internships, or research projects with faculty.

Demonstration of good communication skills, both oral and in written form are essential and thus students are encouraged to work on these skills during their undergraduate studies, by taking writing classes, and preparing written class and project reports. Students can also obtain oral presentation skills through math presentations delivered to a non-mathematical audience.

Bogdan Vernescu, WPI
Joaquin Carbonara, Buffalo State
Paul Eloe, U. Dayton
Aric LaBarr , U. North Carolina
Diana Thomas, Montclair State