



Contact: Steve Crawford, Director
Social, Economic, and Workforce Programs
Division
202/624-5394
March 15, 2006

The Professional Science Master's Degree: Meeting the Skills Needs of Innovative Industries

Executive Summary

The Professional Science Master's (PSM) is a new degree program created to meet growing industry needs for applied scientists and mathematicians and to provide rewarding career opportunities for undergraduate science and math majors. Created in 1997 with the support of the Alfred P. Sloan Foundation, the Professional Science Master's degree is designed to be a better, faster, and cheaper alternative to traditional graduate degrees in science.

PSM programs typically require two years of study and feature cross-training in more than one academic discipline. Many of the programs include internships and training in business, technology transfer, regulatory affairs, information technology, and communications. Today there are more than 100 PSM programs at 51 universities in 20 states. PSM graduates work in industries such as bioinformatics, bioengineering, financial mathematics, computational science, geographical information systems, computation and neural systems, prosthetics and orthotics, and environmental risk management.

Professional Science Master's degree programs are of interest to states and governors because they supply the labor market with very highly skilled workers capable of working in research, development, and early stage manufacturing.

PSM degree holders tend to stay near the institutions where they study,¹ producing a regional brain gain. Because higher education institutions develop these programs in consultation with employers in their regions, the PSM gives the employer a flexible means of filling high-end workforce needs. Moreover, the average start-up cost of a PSM degree program is under \$100,000.

Although governors do not institute degree programs in higher education, there are a number of ways that governors can encourage PSM degree programs:

- Authorize an assessment to determine whether PSM programs already exist in their state and if they do, in what fields, and to evaluate how satisfied students, faculty, and employers are with them.

"PSM programs graduate individuals with the technical skills of a regular master's graduate and added business acumen. Graduates have the marketing savvy and excellent written and verbal communication skills necessary to survive in business-centric technical positions, e.g., sales engineer, project manager, lead engineer, CTO, CEO, and other executive positions."

—Kathleen Perkins, CEO, Breault Research, Tucson, Arizona

- Appoint a commission or task force, if there are no programs or too few, to examine the need for and potential benefits from establishing specific kinds of PSM programs and issue a report summarizing its findings.
- Create and finance a PSM start-up grant fund to which universities with the active participation and support of regional businesses could apply.

Background

In the 20th century the rise of science-based industries—from chemicals and pharmaceuticals to aerospace and electronics—increased demand for scientists as well as engineers. Universities met the demand through their production of Ph.D. chemists, biologists, physicists, and computer scientists, most of whom worked in research and development. More recently the rise of industries based on the convergence of scientific fields—for example, bioinformatics, financial mathematics, and the like—combined with more demand for scientifically trained managers and salespersons has created a growing mismatch between the skills of the scientists universities are producing and the needs of industry. The new industries that are so critical to a region's competitiveness need graduates who have cross-disciplinary scientific expertise and the business and social skills to manage complex projects. Yet current graduate curricula in science and mathematics focus on their own disciplines.

A second problem with the current system for producing scientists for industry is that it is costly and inefficient. Graduate programs in science and mathematics are organized by discipline and focus on producing Ph.D.-level researchers. It now takes eight or nine years in addition to the bachelor's degree to earn a Ph.D. in science. In the life sciences the median age at which Ph.D.'s land their first permanent job is 33 years. Such a long apprenticeship is clearly expensive in both time and money, including income forgone by the students. It also discourages the many bright undergraduate math and science majors who cannot afford a protracted delay of their entry into the labor market.

The PSM degree represents an effective answer to both these problems. It produces quickly and efficiently many of the applied scientists that today's high-tech industries need. To date there have been only 400 PSM graduates, but the enthusiasm of employers and the rapidity with which the graduates found well-paid jobs suggest that the demand for PSM programs will grow. That is the reason the Council on Competitiveness includes PSM programs among the recommendations of its National Innovation Initiative.²

How Does the PSM Differ from Conventional Science Graduate Degree Programs?

In 1997 the Alfred P. Sloan Foundation helped launch the Professional Science Master's degree, which is designed to prepare applied scientists and mathematicians for work in new and emerging industries. All PSM programs have been developed in concert with employers and are designed to dovetail into present and future professional career opportunities. PSM programs typically require two years of study, and most include internships. They are often cross-disciplinary, with close ties to industry, less emphasis on research than a Ph.D., and more emphasis on practical technology and business training. For instance, the Georgia Institute of Technology offers a master's in human-computer interaction that combines computer science, psychology, and communication

studies. The University of Southern California offers computational linguistics, and Michigan State University has a program in industrial microbiology. Today there are more than 100 PSM programs at 51 universities in 20 states.

The PSM degree is meant to supply intermediate-level professionals for the scientific workforce, largely in business and industry. It is a professional rather than a research degree and is intended to be equivalent to a law or business degree for young people who major in the sciences and mathematics as undergraduates. Unlike the typical science and engineering master's degree program, PSMs are not consolation prizes for those who drop out of Ph.D. programs. Instead they are terminal degrees designed in close cooperation with regional industries to prepare applied scientists and mathematicians for work in new and emerging industries.

How Do PSMs Meet Employers' Needs?

Employers have been enthusiastic participants in the PSM programs around the country because they can employ the graduates in areas of their companies that require both applied scientific knowledge and business savvy. The graduates of the PSM degree programs frequently enter new, hybrid fields such as industrial microbiology, human-computer interaction, bioinformatics, geo-information systems, computational chemistry, and industrial mathematics. They are well suited for integrator functions in the bioscience industry, such as project management, business

development, technology transfer, product marketing, and clinical and regulatory affairs. Among the other kinds of jobs for which PSM graduates are qualified are biostatistician, clinical research analyst, senior associate director for drug safety operations, process development scientists/engineers and many others.³

Employer demand for workers with these skills is growing with the growing complexity of technology and the expectations of the global marketplace for high-quality, customized yet just-in-time products and services. Product quality control and production process specialists, as well as marketing and management professionals with the applicable engineering and scientific knowledge, are critical for new product development and product realization strategies.⁴ Like the

The Professional Master's Degree in Financial Mathematics

The Professional Science Master's Degree in Financial Mathematics at the University of Pittsburgh is a two-year program with a summer internship. The core courses in the Mathematics Department include four semesters of finance, and there are additional courses in statistics, economics, and business administration at the Katz Graduate School of Business.

The goal of the program is to train a new class of professionals with strong scientific and mathematical qualifications, as well as managerial and business skills. Its graduates will occupy leadership positions in corporations that run extensive scientific operations or whose activities are affected by advances in technology. These future leaders will require analytical skills beyond what is offered by traditional curricula at the bachelor's or master's level. Graduates are qualified to fill jobs that demand a thorough understanding of the computational and analytical methods of finance and risk management and deep knowledge of new developments in modeling and computation and how best to apply them.

University of Pittsburgh Professional Science Masters Course Offerings

tool and die maker of an earlier age, PSM graduates cross boundaries by working in process and product design, manufacturing engineering, and production, although at a much higher educational level.

Their flexible curriculum designs and direct links with employers allow PSM programs to respond to the constantly evolving needs of new industries for a cross-trained, technologically prepared, and business-wise workforce. PSM degree programs draw local companies into advisory boards to help them design courses; they incorporate internships and mentorships in local companies that those companies help to devise; and they provide preferred hiring opportunities for participating firms. Senior Scholar in Residence Paul Tate, of the Council on Graduate Schools, summarizes them this way: "PSM programs are essentially aimed at placing graduates in regional business and industry. That is in fact the point of these programs."⁵

The roster of employers that have hired PSM graduates shows clearly that PSMs are meeting employer needs. The list includes such well known names as Abbott Laboratories, Batelle, Loyola University Med Center, the Mayo Clinic, Kraft Foods, Amgen, L'Oreal, Merck, University Hospitals of Cleveland, BASF, Baxter Healthcare, Motorola., Boeing, Proctor and Gamble, Conoco Phillips, Eli Lilly Pharmaceuticals, Sherwin Williams, Exelon Unilever, Level3 Communications, Fairchild Semiconductor, Upstream Technologies, Utah Transit Authority, and Weyerhaeuser Corporation, among others. In addition, PSM graduates are sought after by early stage, entrepreneurial companies, whose needs for cross-trained, technologically prepared, and business savvy graduates probably exceed those of large companies.⁶

How Do PSM Degrees Meet Students' Needs?

PSM degree programs offer bachelor's degree holders a direct path to industry. The programs are attractive to students because they prepare them for work in a variety of cutting-edge fields and yield a highly marketable degree after just two years of postgraduate study. The typical PSM graduate is 24 years old and starts out earning \$55,000 a year in business, \$45,000 in government. The median annual income for engineers with a master's degree and less than a year of experience is \$47,000; those with one to two years of experience earn \$49,000. Doctoral graduates with one to two years of experience earn a median income of \$59,000 a year. Graduates of PSM programs work in sophisticated positions such as program director (Efficente Software), operations analyst (Boeing), microbial systems analyst (AstraZeneca), forensic analyst (Connecticut State Police), reagent manufacturing division director (Ventana Medical Systems), quantitative analyst (Putnam Investments), and many others.⁷

Because of their quicker employment payoffs, PSM degree programs can encourage more college science majors to pursue postgraduate degrees. The benefits can also encourage more college students to major in science and more high school students to take science courses. Similarly, the

"The . . . Professional Master's Degree Program serves a great and constantly growing need in industry to produce students who are technically savvy and have a high degree of knowledge in the applied sciences, as well as a comprehension of the fundamentals of business and professionalism. Industry needs employees who not only understand the technical nature of their projects, but the business and legal aspects as well, and are able to communicate their mission to broad audiences."

—Lois A. Dimpfel, Vice President,
Global Services (retired), IBM
Corporation

rewards should make careers in math and science more appealing to women and minorities; indeed, 40 percent of current PSM students are women.

How Do PSM Programs Further State Economic Development?

In today's intensely competitive global economy, governors are concerned about job creation and innovation. They recognize the enormous potential of higher education to advance economic development and are searching for new ways to leverage university assets. For example, in 2003 **Ohio** Governor Bob Taft established the *Governor's Commission on Higher Education and the Economy* "to create more and better jobs for the state's citizens, increase economic competitiveness, and fuel economic growth." In 2004 **Michigan's** *Commission on Higher Education and Economic Growth*, created by Governor Jennifer Granholm and chaired by Lieutenant Governor John Cherry Jr., recommended creating scholarships for students to pursue post baccalaureate degrees in

"The Masters in Biotechnology degree program at Penn State University is a professional science masters' degree designed to prepare students for diverse career opportunities in biotechnology and related industries. So far, close to 50% of the graduates from this program have gone on to pursue careers in industry spanning pharmaceutical, biotechnology, and large consulting companies in the region; 14 percent have gone to government laboratories, another 14 percent to academic laboratories, and 24 percent continue on to advanced degrees (Ph.D. or M.D.). It is noteworthy that 55 percent of these graduates are from the state of Pennsylvania and for the most part would desire to remain in the state given the opportunity; to date, 40 percent of the graduates from this program are in industry or academia in the state of Pennsylvania."

—Loida Escote-Carlson, Director, M.S. in Biotechnology Program, Penn State University, presentation at the NGA Policy Advisors Meeting, Miami, Florida, January 2005.

science and engineering and expanding internship opportunities in emerging fields. In 2005 **Connecticut** Governor M. Jodi Rell signed legislation calling for the commissioner of higher education, in consultation with the Office of Workforce Competitiveness, to review the inclusion of nanotechnology, molecular manufacturing, and advanced and developing technologies at institutions of higher education and report back to the legislature early in 2006.⁸

North Carolina stands out for the way it has used PSM programs to further its economic development strategy. Its Golden LEAF Foundation, a nonprofit economic development corporation, funded using 50 percent of the state's tobacco settlement, underwrote a report by the North Carolina State University Biotechnology Center, "Window on the Workplace 2003: A Training Needs Assessment for the Biomanufacturing Workforce,"⁹ which concluded:

The biomanufacturing sector has grown by an average of 10 percent per year over the last several years and we project it will continue to grow at that rate. Jobs in pharmaceutical manufacturing, including biopharmaceutical manufacturing, are among the highest paid manufacturing jobs in the state. The average annual wage is \$68,210. Pharmaceutical and biomanufacturing companies now employ about 20,000 workers in North Carolina.

A key constraint on this industry's growth is the availability of skilled workers. All companies now have difficulty finding qualified employees. There is a critical need for new training programs to provide a qualified workforce for company expansions and for new manufacturing enterprises locating in North Carolina. This is especially true now in light of heated global competition to share in the economic growth possible in biomanufacturing.

The report led to both the establishment of the PSM program in microbial biotechnology (see box) and the construction of the Biomanufacturing Training and Education Center (BTEC), a \$36 million facility that the university shares with companies from the Research Triangle.

In addition to meeting the high-end workforce needs of regional companies, PSM graduates offer unique advantages to the small and early stage companies that are the engines of job creation. Technical staff in such businesses are often at a particular disadvantage in gaining access to technical information because the companies typically do not have the same information-gathering resources as larger firms.¹⁰ For emerging companies, technology transfer is literal, as in sharing R&D or manufacturing facilities, access to technical expertise, and membership in social networks. For them, technology transfer is not about patents and formulae but is know-how developed through hands-on experience or learning-by-doing. Know-how often is best transmitted through interpersonal contact, which may be difficult to arrange for reasons of distance, expense, or schedule.

Because they bridge academic departments and focus on applied research, PSM graduates can be effective go-betweens to help small companies gain access to university resources. In addition to "know-what" and know-how, they "know who"—who is working on what projects in the university and with whom. They can identify faculty who can serve as consultants or spot projects that may solve technical problems facing the company. And they can guide companies to shared university R&D and advanced manufacturing facilities.

PSM degree programs can be directly linked to technology transfer, as in the University of Arizona example (see box below).

Example: North Carolina State University

The Professional Science Master's degree in Microbial Biotechnology (MMB) at North Carolina State University was launched by the Department of Microbiology in August 2003. The program was created in response to the growing need for an improved graduate workforce in the biotechnology and pharmaceutical industries.

The two-year program provides students with competencies in science and business and includes both academic and professional training. The academic training is provided by several departments in the College of Agriculture and Life Sciences, the College of Management, and the Biotechnology Program. Students choose from a variety of courses in microbiology, genetics, toxicology, food science, plant pathology, statistics, biotechnology, and MBA-level business.

[N.C. State University Department of Microbiology](#)

Finally, according to the business journal *Corporate Location*, skilled workforce availability is a primary consideration in employers' location decisions.¹¹ For example Donna Starzecki, the human resources director of CuraGen, a leading genomics-based pharmaceutical company in New Haven, described the professional master's degree in applied genomics at the University of Connecticut this way: "Developing and maintaining a highly skilled workforce with knowledge associated with manufacturing and bringing a biological product to market under FDA approval is essential for pharmaceutical companies like ours to remain competitive in today's global economy. We need colleges and universities to offer programs that will provide the knowledge and skills needed to work in our industry."¹² PSM degree programs supply the high end of the skilled workforce pyramid, a form of human capital that industry holds in high regard.

How Can Governors Promote PSMs in Their States?

Governors who decide that Professional Science Master's degree programs can contribute to their state's economic growth can be effective champions. The first step is to learn whether there are already PSM programs in the state. If not, a governor can appoint a task force or commission to look into the potential benefits of PSM programs. A number of states have done this through examining how higher education can play a bigger role in economic development. Some states have permanent, chartered entities that regularly perform such studies. **Kentucky** funds the Kentucky Long-Term Policy Research Center with an annual budget to conduct studies such as the potential value of PSM degrees in Kentucky. Other states' governors have used their economic development agencies or higher education commissions to do the work

Once a preliminary study demonstrates the potential value of PSM degrees, the governor can promote them among college and university presidents, state higher education officers, business groups, economic development agencies, and leading legislators. They can be included on the agenda of the economic development summits that governors frequently convene. Governors can ask the higher education system to prepare a plan to implement PSMs, just as **Connecticut** Governor Rell asked that state's higher education commissioner to include nanotechnology in public higher education offerings.

If a governor chooses to subsidize the establishment of PSM degree programs in the state, the start-up costs can be quite modest. According to the Sloan Foundation, the cost of starting a specific PSM program is less than \$100,000. For less than \$1 million a state could seed close to a dozen programs. Because PSM students (or their employers) pay their own tuition, the return on the immediate investment would be swift, and the program would become self-sustaining, as, for example, MBA or Master of Social Work (MSW) degree programs are.¹³ A simple request for proposals (RFP) process, in which interested colleges and universities are expected to

Example: Entrepreneurship Certificate in Technology Transfer

Students with professional goals involving new ventures can take advantage of a special one-year entrepreneurship certificate through the Associate in Technology Transfer Program offered by the University of Arizona Eller College of Business and Public Administration's award-winning Chris and Carol McGuire Entrepreneurship Program (formerly the Berger Entrepreneurship Program)... With careful planning, students in the Professional Master's Degree Program who pursue the Entrepreneurship Certificate in Technology Transfer will not need to add extra time to their degree.

demonstrate both their capacity in the designated fields and the active participation and support of regional businesses, is a model that has served the Alfred P. Sloan Foundation well in the PSM degree programs it has funded.

Conclusion

PSM degree programs, while a relatively recent phenomenon, are already contributing to growing our own science and technology workforce for industry. At relatively little cost, states can work with their public universities to initiate or expand these programs, whose close connections to employers and technology development make them a fitting part of a state's strategy for building its competitive advantage. In addition, the structure of the PSM degree programs and their emphasis on direct participation by companies near the campus offer universities the opportunity to remain well informed about the latest developments in industry.

PSMs are a win/win opportunity. Employers benefit from the highly skilled graduates coming out of the university. PSM graduates benefit from rewarding employment opportunities, and regions benefit from retaining science and technology graduates and attracting companies eager to hire them.

Endnotes

- ¹ Paul Tate, senior scholar in residence, Council of Graduate Schools, observes, "Before PSM programs are established, a needs assessment is conducted among area businesses and industry for establishing employment opportunities for graduates, and leaders in area business and industry serve on advisory boards of PSM programs because they are interested in hiring graduates. Moreover, student internships in these businesses and industries are a standard feature of curricula of PSM programs, so that students typically have already established employment records with them prior to graduation, and it is therefore to the students' advantage to return to the same employers. Overall, then, PSM programs are essentially aimed at placing graduates in regional business and industry. That is in fact the point of these programs" (Correspondence with author, January 11, 2006).
- ² "Innovate America," Council on Competitiveness, December 2004, Washington, DC. Report by the Council on Competitiveness.
- ³ For examples of more actual job openings for PSM graduates in science and math based occupations that cross fields like bioinformatics go to <<http://www.newscientistjobs.com/splash.action>.
- ⁴ Ross DeVol, et al., The Greater Philadelphia Life Sciences Cluster, *An Economic and Comparative Assessment* (Santa Monica, Calif.: Milken Institute, June 2005), 93.
- ⁵ Tate, correspondence with author; see note 2 above.
- ⁶ For examples of actual job openings in science-and-math based-occupations that cross fields, such as bioinformatics, go to <<http://www.newscientistjobs.com/splash.action>>.
- ⁷ Many of those with science and engineering degrees work in jobs not classified as "science," such as managerial, marketing and sales, planning, and quality control positions. Most of them, however, even at the bachelor's level, report doing work related to their degrees even in mid- and late career; that probably reflects the technical content of the non-science and engineering jobs. See *Changes in the Academic Labor Market and Some Trends in the General Workforce*, Alan Rapoport, Senior Analyst, Science & Engineering Indicators Program, Division of Science Resources Statistics, National Science Foundation, in [The Changing Nature of Work and Workers in Science and Engineering](#), *Science and Engineering Indicators, 2004*, National Science Foundation, Washington, DC. available online at: <http://www.nsf.gov/sbe/srs/seind04/start.htm/>
- ⁸ "Governor Rell Signs Bill to Boost Study of Nanotechnology," press release, Office of Governor M. Jodi Rell, Hartford, Connecticut, July 14, 2005.
- ⁹ The report is available at: <<http://www.ncbiotech.org/ouractivities/spproj/workplace03.cfm>>
- ¹⁰ See Andrew Reamer et al., *Technology Transfer and Commercialization: Their Role in Economic Development* (Washington, D.C.: U.S. Department of Commerce, Economic Development Administration, August 2003).
- ¹¹ "Motives Driving Investment in Biotech Sector," *Corporate Location Magazine*, April-May 2004.

¹² *Fairfield (CT) City Business Journal*, May 16, 2005.

¹³ The Alfred P. Sloan Foundation has been successful in seeding the first 100 individual campus programs and is now turning its attention to adoptions by multiple campuses of state university systems. Start-up costs average about \$75,000 per degree program.