The Graduate School Perspective on Master's Degrees in STEM

William Wiener

Vice Provost and Graduate Dean

My Perspective

- Marquette University
- STEM master's degrees
  - Biological Sciences
  - Chemistry
  - Math, Stats, and Computer Sciences
  - Civil Engineering
  - Engineering Management
  - Electrical and Computer Engineering
  - Mechanical Engineering
  - Biomedical Engineering

Models

- Stand alone
- En route to Ph.D.
  - Stop-out degree
- Dual degree
- Accelerated degree
- Intra-university
- PSM

Location

- Ph.D. granting departments (PGs)
  - En route more frequent
- Master's granting departments (MGs)
  - Stand alone

Chemistry

- MS 92%
- MA 14%
- PSM 3%
- 65% finish in two years
- 30% finish in three years
- Average graduation rate is 5.4 annually
- 91% provide TAs
- 66% provide RAs
- Program Goals

Physics

- 120 stand alone programs
- 50 of 185 PhD programs have stand alone option
- More than half stand alones offer options
- Over 60% of master's grads find physics employment
- Location of program (PG or MG) influences culture and tracks
- Numbers have decreased for past 30 yrs
- MGs have small programs – typically 3 grads per yr.
- MGs face competition from PGs

Applied Disciplines

- Engineering and mathematics often have large master's programs
- Engineering has many specializations
- MS may become prerequisite for registration
  - May result in increased need for MS
- Graduates in engineering are increasing by 5.4% per year

Trends

- Graduate certificates lead to enhanced skills and better recruitment
- Accelerated degree programs include necessary competencies and allow early completion
- PSMs provide additive knowledge in leadership, management, policy, communication, business, ethics, regulatory areas
- Entrepreneurial components relating to innovation, IP, and commercialization

"The Role and Status of the Master's Degree in STEM."
National Science Foundation Rm. #375
4201 Wilson Blvd. Arlington, VA 22230

William R. Wiener, Ph.D.
Vice Provost and Dean of the Graduate School
Marquette University

I am presenting from the perspective of a Graduate Dean who has administrative responsibilities for master's programs in the Science, Technology, Engineering and Mathematics (STEM) fields. Marquette University is a Catholic Jesuit university that is classified by Carnegie as a doctoral institution with high research. The university has approximately 40 master's degree programs 17 Ph.D. programs and 6 professional doctorates. While research is not the overriding motivator for our programs, the Ph.D.s programs are the driving force in many of the STEM disciplines.

The university has STEM master's degrees in the following areas: Biological Sciences; Chemistry; Math, Statistics, and Computer Sciences; Civil Engineering, Engineering Management, Electrical and Computer Engineering, Mechanical Engineering, and Biomedical Engineering. Most of these programs offer the M.S. degree but the M.E. (non-thesis) is also offered in Biomedical Engineering. The University previously had a master's degree in Physics but now has only a bachelor's degree in that field. There are a number of professional programs that depend upon coursework from STEM departments some of which include Nursing, Dentistry, Physical Therapy, Physician Assistant Studies, Healthcare Technologies Management, Speech-Language Pathology, and Transfusion Medicine.

The CGS whitepaper entitled *Completion and Attrition in Master's Programs in STEM* states that there are four broad categories of master's degree models which include the stand alone degree, the en route to Ph.D. degree, the dual degree, and the accelerated bachelor's/master's degree. At Marquette we have programs that represent all four of these models. The en route model can be further amplified, however, to include the stop-out master's degree which is awarded as a consolation prize for those students who falter along the way to the Ph.D. and turn their dissertation into a thesis. This approach results in a sizable number of master's graduates each year. In addition, to the above mentioned models some universities have developed intra-university programs that involve more than one university and may include an institution in another country. Marquette has such programs domestically and is exploring such an international model. Yet a further model includes professional science master's degrees (PSMs). These are programs that have a specialization that is employment oriented. They typically have an external advisory board with representation from industry, have coursework beyond the discipline and often from departments outside the discipline, and require an off-campus placement.

According to CGS and ETS in The Path Forward (2010), the number of master's degrees in the U.S. is ten times larger than the number of doctoral degrees; however, this varies tremendously by discipline and therefore is not the case in all disciplines. From my experience at three universities I have found that the traditional disciplines that focus on basic research, have large Ph.D. programs, and primarily admit students to the Ph.D. with the option of achieving the M.S.

along the way. Only to a lesser extent do these programs admit students directly into their stand alone master's degree programs. At Marquette University these primarily include Chemistry and Biological Sciences. The majority of students admitted to these programs at Marquette are admitted as Ph.D. students and gain the master's degree en route. The same may be true in other similar disciplines as well.

Chemistry is one of the largest STEM programs at the University. Nationally, information on chemistry programs is gathered periodically by the Committee on Professional Training (CPT) of the American Chemical Society through questionnaires completed by graduate departments (2009). In 2006 and 2008, PhD granting programs (PGs) and master's-granting (MGs), respectively, were surveyed. The surveys included 196 PGs and 109 MGs. The master's degree programs consisted of the Master of Science (92%), the Master of Arts (14%), and Professional Master's (3%), Master's of Material Science (1%), and miscellaneous degrees (5 %) in Education and in the Natural or Integrated Sciences. The data collected show that master's degree programs account for almost 50%of the graduate degrees awarded in chemistry. On average, PGs account for 67% of the 1085 master's graduates annually. Nineteen percent of the master's programs in PGs, and 27% in MGs were interdepartmental in that the degrees were granted by more than just the chemistry department. One third of admitted students came to MGs. Half of the PGs stated that they matriculate students who specifically target the master's degree only. Approximately 65% of students finished their degrees in two years while 30% completed degrees in three years. It was found that about 69% of the programs graduated less than 5

students per year with only 3% graduating more than 18 per year. The average graduation rate at both PGs and MGs is 5.4 students per year.

Required formal credit of non research hours for the master's degrees averaged 27.3 for MGs, but for PGs, the number was more varied and the average was 20.6. In contrast, PhD programs require an average of 20 credit hours to earn the degree and thus, master's and PhD students at PGs are required to enroll in the same number of credit hours. This is less than the number for a master's degree at MGs. About 36% of MGs did not require a thesis for graduation while at PGs, 43% did not require the thesis.

In regard to financial support it is reported that 91% of MGs provide teaching assistantships and 66% provide research assistantships for their master's students. Other means of support are provided by 21% of the institutions. There were fewer PGs reporting but of those that reported, indicated that 98% provided teaching assistantships, 83% provided research assistantships, and 12% provided other means of support. It was reported that 2% did not provide any support for their master's students.

The above survey suggested that at MGs, specific program goals included 1) preparation for more advanced study (97%), 2) preparation for industry [75% (compared to 78%for PGs)], and 3) teacher training [43% (compared to 37% for PGs).

The situation in the discipline of physics is analogous to chemistry in many ways. Czujko & Henly (2005) conducted a survey of department chairs in physics and had a response rate of 82%. They report that nationwide there were approximately 120 physics departments offering stand alone master's degrees and 185 offering Ph.D. degrees. It is estimated that that more than 50 of the 185 PhD physics programs have a stand-alone master's option. More than half of the stand alone master's programs offer at least one master's degree option in a specialized area. In regard to potential employment nearly 40% of master's programs report that the majority of their students have the goal of going to work and over 60% of the master's degree recipients find employment in their discipline.

The location of a master's program in an MG program or in a PG program influences the environment. If the program is located in a PG department, the atmosphere tends to be more academically oriented and may therefore produce a more academically oriented master's program. In general it was found that the structure of the programs may include multiple degree tracks for both academic and employment-oriented degrees. Programs in employment-oriented programs tend to have specializations.

While there has been much discussion about the need to re-energize the master's degree in this field, the number of physics departments providing master's degrees has decreased steadily for the last 30 years. This was also the situation at Marquette where low enrollment caused the demise of the master's degree in the last decade.

It is reported that almost 30% of physics departments have both independent master's and PhD programs. However, sixty-three percent of physics departments permit optional en-route master's degrees. Seven percent of these programs require a master's degree en-route. The mix between en-route and stop-out programs was reported to be 650 and 450 degrees respectively in 2003.

Universities that have the master's degree in physics as their highest degree are extremely small in size. Typically, they graduate 3 master's students annually. Between 1998 and 2003, eleven MGs averaged less than 1 master's degree per year, and only 9 averaged 5 or more master's degrees.

There are three common immediate career choices for physics graduates. Approximately one-third transfer to another physics graduate program, about one-eighth enter a graduate program in a different field, and over half go directly into the workforce (Mulvey and Langer, 2005). Employment options are diverse with almost half in industry engaged in design, development, research, programming, modeling and simulation, and system administration. Another sixth find employment in technical positions in colleges and universities. Approximately another eighth find employment as high school teachers.

Master's granting programs in physics face a difficult task in trying to recruit students in a world where PGs have a great advantage. Students who are offered acceptance into PhD programs are typically all supported through research or teaching assistantships and fellowships through

most of their years of study. Therefore the MGs encounter strong financial competition from the PGs, and also from the allure of industry that recruit students without the advanced degree.

In contrast to the traditional disciplines that focus on basic research and concentrate most of their effort on Ph.D. production, the more applied disciplines such as the engineering and mathematics disciplines often place much effort into master's degree programs. The emphasis in these programs is not on the master's degree *en route* but on the master's degree as an entity onto itself. At Marquette University we find that the master's programs in engineering are stand alone and enrollment in those programs are from two to five times the enrollment of the Ph.D. programs. The same is true in Mathematics with enrollment in the master's degree to be twice as large as in the Ph.D. program. In mathematics at Marquette the department has also combined traditional fundamental math concepts with computer science and management resulting in a new leadership paradigm which is drawing in more students into the master's program.

In engineering the master's programs have many specializations within each department to encompass the various skill sets employed by active engineers. When students seek employment, they are often employed as an engineer in a sub discipline of engineering. Thus they may be structural engineers, environmental engineers, transportation engineers, and construction project managers or engineers in other areas. In engineering the MS degree and its equivalent is currently being considered as a prerequisite for registration as a Professional

Engineer. This will likely result in a greater need for graduate education for all practicing engineers in the future.

Nationwide, master's degrees in engineering increased from 2007 to 2008 by 5.4% which followed a previous two year decline (Gibbons, 2008). The number of degrees conferred in 2008 was 38,986 and enrollment of almost 93,000 in 2009. This trend points toward larger numbers of graduates over the next couple of years.

Many of the engineering departments offer graduate certificates. At most universities a graduate certificate is an acknowledgement of a group of courses taken at the graduate level which encompass a specific skill set and includes a practical application experience. The number of required courses varies but is typically between 12 and 18 credits. The certificates form two useful purposes. First they extend the knowledgebase of those individuals earning a master's degree or add to the knowledge for those already possessing a master's degree. Second, they serve as the gateway to the master's degree for students who have completed the baccalaureate. Often students will start with a certificate and then once completed will continue to earn the entire master's degree. At Marquette University we have numerous certificates that can be earned in engineering which can be stand alone and can lead to a master's degree.

A trend in graduate education is the accelerated degree program. At Marquette some examples include Biomedical Engineering, Civil Engineering, Electrical and Computer

Engineering, Mechanical Engineering, Nursing, and Speech Language Pathology. The Accelerated Degree Program is designed to provide a more efficient means to obtain a master's degree. It is based on attaining the necessary competencies rather than just a specified number of credits. The program is for students who have high academic potential and want to start taking courses that will count towards both their undergraduate and graduate degrees. The program allows students to begin accumulating credits towards completion of a master's degree while still enrolled as undergraduates. Undergraduates participating in this program are granted early admission to the Graduate School and are allowed to take specified graduate level courses during their junior year or senior year. Depending on the university and the department, usually between 6 and 12 graduate credits taken during the student's undergraduate career may be applied toward completion of their graduate degrees as long as the courses are appropriate to attain the necessary competencies, and the grades are at a "B" level or higher. This allows the student to finish the master's degree in a fewer number of semesters.

A small but growing trend is the previously mentioned professional master's degree (PSM). This degree is a combination of the traditional STEM degree with additive courses from various departments that provide knowledge in such areas as leadership, employee management, project management, policy, communication, business, ethics, and regulatory statutes. Graduates of these programs are prepared to enter the workforce and progress toward middle management positions. They do not require the advanced learning of the Ph.D. but have additional skills beyond STEM that enable them to become valuable employees. The PSM

programs have grown under the guidance of the Counsel of Graduate Schools, but future development will require an independent approval process to help assure program quality under the PSM moniker.

A further trend is the development of entrepreneurial components related to the more traditional STEM master's degree programs. Take for example the ESTEEM program at Notre Dame University where students are required to complete six credits of graduate level technical electives from either the College of Science or the College of Engineering as part of their technical coursework. These and similar courses are designed to enhance the student's understanding of core science and/or engineering. It has often been noted that students at many universities are not exposed to concepts of innovation, intellectual property, or commercialization. To compensate for this deficiency, some programs are making electives available while to prepare students for entrepreneurial activities. At other universities, certificates in entrepreneurship are developing to accompany the traditional study in the STEM field.

In conclusion, the master's degree in the STEM fields forms the foundation for the advanced study in those disciplines. Often graduates with advanced degrees will seek employment at colleges and universities, or at research centers. The master's degree serves as the highest degree attained for those individuals who will work directly in business and industry. The STEM master's degree is the backbone of the American educational enterprise.

References

American Chemical Society. (Fall 2009). *Survey of Master's Degree Programs in Chemistry*. Retrieved from http://portal.acs.org/portal/PublicWebSite/about/governance/committees/training/reports/cptreports/CNBP_023775

Czujko, Roman, and Megan Henly. (April 2005). Programs that Match Every Interest: Masters Degrees in Physics. *American Institute of Physics*. Retrieved from http://www.aip.org/professionalmasters/msreport.html

Gibbons, M.T. (2009). Engineering by the Numbers. *Profiles in Engineering and Engineering Technology.* Retrieved from http://www.asee.org/publications/profiles/

Langer, Casey & Mulvey, Patrick J. (December 2005). *Initial Employment Report: Physics and Astronomy Degree Recipients of 2002 & 2003*. Retrieved from http://www.aip.org/statistics/trends/reports/emp.pdf

Sowell, R.; Bell, N; Francis, S; Goodwin, L. (2010). Completion and Attrition in Master's Programs. *STEM*, A CGS Whitepaper.

Wendler,C; Bridgemen, B; Cline, F; Millett, C; Rock, J; Bell, N; and McAllister, P.; ETS; CGS. (2010). *The Path Forward: The future of graduate education in the United States.*