Supporting a Future Faculty Pipeline for Ensuring Solvent US Mining Engineering Programs
House Committee on Natural Resources
Rob Bishop, Chairman
White Paper

Overview

Industry Workforce

Numerous reports have discussed the changing demographics of the U.S. workforce and the potential impacts of the widespread retirement of the generation born between 1946 and 1964 (the “baby boomers”). The industries that support the production of energy and mineral resources, including the institutions that train their workers, and conduct research for, or regulate these industries, are impacted by these changes. These industries also are responding to increased demand for energy and products derived from minerals as the domestic and global populations increase.\(^1\)

The mining industry faces a particularly daunting challenge to replenishing its workforce. Approximately 70 percent of the mining industry’s technical leaders will reach retirement age within the next 10 to 15 years, with few experienced engineers available to replace them.\(^2\) University programs in mining engineering are also small, and almost all faculty members will need to be replaced within the next decade. Furthermore, several leading universities have eliminated mining engineering.\(^3\) However, this appears only to be an American problem as increasing enrollments in South America, Asia, and Eastern Europe have not followed this trend. This erosion of technological leadership poses serious implications for the United States.

Federal Workforce

Various agencies within the federal government have significant roles with regard to the mining and mineral industries. These governmental roles include: permitting, regulation, health and safety oversight, federal land administration, and research. However, many of these federal agencies find themselves without the requisite level of technical expertise, thereby

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\(^1\) Summary Statement from the National Academy of Sciences, “Emerging Workforce Trends in the U.S. Energy and Mining Industries: A Call to Action” PREPRINT, 2014


\(^3\) Universities that have closed their mining programs include: University of California Berkeley, University of Illinois, Ohio State, University of Minnesota, University of Alabama, University of Idaho, Columbia University, University of Pittsburgh, Texas A&M, University of Washington, University of Wisconsin – Madison and Platteville, University of Wyoming.
relegating important tasks to the less qualified which leads to systemic and pervasive consequences for the regulated industry. For example, permits for exploration or new mines will not be processed, work sites will be inspected and regulated by the inexperienced, and research into safer and healthier production will not be funded or carried out by qualified experts.

Federal agencies, like industry, are met with high retirement rates. For example, the Mine Safety and Health Administration (MSHA) (responsible for inspecting and regulating safety at mining operations) projected that 47 percent of their coal sector workforce of 1,188 would be eligible for retirement by 2016. The agency’s 583 person metal/nonmetal workforce is facing retirement of 40 percent over that same period. This phenomenon is not isolated to MSHA, as other federal agencies are facing similar retirement rates. This deficiency in expertise is exemplified by EPA. Out of EPA’s 15,326 employees none are mining engineers.

Furthermore, federal agencies are in direct competition with industry for qualified talent. Agencies are hard pressed to hire mining engineers because they are a highly demanded resource and come at an equally high price. As such, agencies find themselves at a competitive disadvantage (salary and benefits) compared to industry. Therefore, the federal government has a vested interest in ensuring the continued production of sufficient numbers of educated and experienced individuals in the coming years. To ensure adequate regulatory and permitting functions of the federal agencies governing the mining industry are being conducted, there must be the development of more mining engineers and geologists.

**US Mining and Minerals Programs**

Mining and Minerals Engineering schools produce the bulk of technical experts for the extractive industries. The majority of these mining schools were established in the late 1800’s through federal land-grant legislation. The number of Accreditation Board for Engineering and Technology (ABET) Accredited programs in the U.S. has dropped from 25 in 1982 to 14 in 2014 (Table 1).

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5 The Office of Surface Mining reported 40-50% of their employees are eligible for retirement. The median age for employees in the ocean science, technology and operations workforce is 47 with a large drop off as employees reach 56+ years. DoE Fossil Energy admits a “large portion” of their technical are is eligible for retirement. (National Academy of Sciences, “Emerging Workforce Trends in the U.S. Energy and Mining Industries: A Call to Action”, 2014)

6 As of March 2015 according to Office of Personnel Management database: http://www.fedscope.opm.gov/

7 A land-grant university is an institution of higher education in the United States designated by a state to receive the benefits of the Morrill Acts of 1862 and 1890. The Morrill Acts funded educational institutions by granting federally controlled land to the states for them to sell to raise funds to establish and endow “land-grant” colleges.

8 ABET is a nonprofit, non-governmental organization that accredits college and university programs in the disciplines of applied science, computing, engineering, and engineering technology. ABET accredits over 3,400
Table 1: Current Mining and Mineral Engineering Programs

<table>
<thead>
<tr>
<th>School</th>
<th>Location</th>
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<tbody>
<tr>
<td>University of Alaska - Fairbanks</td>
<td>Fairbanks, AK</td>
</tr>
<tr>
<td>The University of Arizona</td>
<td>Tucson, AZ</td>
</tr>
<tr>
<td>Colorado School of Mines</td>
<td>Golden, CO</td>
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<tr>
<td>University of Kentucky</td>
<td>Lexington, KY</td>
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<tr>
<td>Missouri University of Science and Technology</td>
<td>Rolla, MO</td>
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<tr>
<td>Montana Tech - The University of Montana</td>
<td>Butte, MT</td>
</tr>
<tr>
<td>University of Nevada, Reno</td>
<td>Reno, NV</td>
</tr>
<tr>
<td>New Mexico Institute of Mining and Technology</td>
<td>Socorro, NM</td>
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<tr>
<td>The Pennsylvania State University</td>
<td>University Park, PA</td>
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<tr>
<td>Southern Illinois University at Carbondale</td>
<td>Carbondale, IL</td>
</tr>
<tr>
<td>South Dakota School of Mines and Technology</td>
<td>Rapid City, SD</td>
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<tr>
<td>The University of Utah</td>
<td>Salt Lake City, UT</td>
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<tr>
<td>Virginia Polytechnic Institute and State</td>
<td>Blacksburg, VA</td>
</tr>
<tr>
<td>West Virginia University</td>
<td>Morgantown, WV</td>
</tr>
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This reduction in mining and mineral engineering programs has resulted in a decline in both faculty and the number of mining engineering graduates (Figure 1).

Figure 1: Mining Engineer Graduates (SME Guide to Mineral and Material Schools, 2013)

programs at nearly 700 colleges and universities in 28 countries. ABET provides specialized, programmatic accreditation that evaluates an individual program of study, rather than evaluating an institution as a whole. ABET accreditation, which is voluntary and achieved through a peer review process, provides assurance that a college or university program meets the quality standards established by the profession for which the program prepares its students. It is critical for a program to attract top tear engineering students and required for professional licensure of engineers in the US. (http://www.abet.org/)

9 The national mining engineering faculty population was approximately 120 in 1984 and approximately 70 in 2014. (The Society of Mining, Metallurgy, and Exploration, Workforce Trends in the U.S. Mining Industry, 2014)
These statistics for mining engineers serve as a proxy for graduates of other mining focused disciplines, such as mineral processing, extractive metallurgy, economic geology, exploration geophysics, and geochemistry for which statistics are not available. Demographics for these specialty disciplines appear to be similar to those of mining engineers.

**Reasons for Decline**

There are a number of interrelated reasons for the decline in mining engineering programs.

**Decline in Federal Research Funding:** Faculty primarily bring in federal research funding from National Institute for Occupational Safety and Health (NIOSH), United States Geological Survey (USGS), Department of Energy (DoE)/Fossil Energy, MSHA, Office of Surface Mining Reclamation and Enforcement (OSM), National Science Foundation (NSF) and Department of Defense (DoD). Faculty members at large universities are expected to bring in a minimum of $150,000 to $200,000 each year.

In the 104th Congress, funding for the United States Bureau of Mines (USBM) was eliminated during the budget cutting associated with the “Contract with America” movement. In 1994 the USBM funded $52 million in research with universities receiving a substantial portion of these funds. The loss of this funding source has been credited, by many in the mining engineering academic world, to be a root cause of a weakening pool of mining programs.

**Low Student Enrollment tied to Cycles of Industry:** In the 1950’s and 1960’s, national enrollment for undergraduates in mining engineering programs stood between 800 and 1,200 students. During the global energy crisis of the 1970’s, enrollment peaked at approximately 3,000. As time passed, commodity prices fell, energy production normalized, and in turn, enrollment fell, with enrollment hovering around 500 students during the late 1980’s and early 1990’s. Consequently, many programs closed due to poor enrollment. Since then, the enrollment has seen a gradual rise with approximately 1,600 students enrolled nationally in 2012. However, neither the number of programs nor the number of faculty has grown to meet the demands of these larger teaching loads.

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10 NSF Division of Civil and Mechanical Systems Geotechnical and Geohazards program is very limited in funding and the experience of mining engineering faculty is that proposals submitted to NSF are never funded.
11 Testimony from Mary Poulton, Dept. Head of the University of Arizona’s Department of Mining and Geological Engineering. Oversight Hearing on the Aging of the Energy and Minerals Workforce, Subcommittee on Energy and Mineral Resources, July 8,2004
12 Testimony from Mary Poulton, Dept. Head of the University of Arizona’s Department of Mining and Geological Engineering. Oversight Hearing on the Aging of the Energy and Minerals Workforce, Subcommittee on Energy and Mineral Resources, July 8,2004
University Economics: Internal evaluation of program productivity by university administrators is done by looking at a number of metrics. These include Full Time Equivalents (FTE) to professor ratio, size of department (both students and faculty), cost per degree, cost per student, and total research funding. Due to the small nature of mining programs they do not fare well using these metrics.

Reduction in State Support: From 2011 to 2012 state support for higher education across the board declined by 7.6 percent. Twenty-nine states appropriated less for colleges in 2012 than five years prior.

Loss in ABET Accreditation: A critical metric by which programs are evaluated for accreditation is whether an appropriate amount of courses are being taught. If a program does not have enough faculty members with expertise to teach all the necessary courses the program accreditation is lost. As a result enrollment drops off dramatically and the program is closed by the university on the grounds that it is no longer viable.

High Faculty Retirements Coupled with Weak PhD Supply: A paramount concern with the continued sustainability of these programs is the faculty retirement rate and the ability to fill the vacancies with qualified individuals. Results from a 2010 survey showed that of the 74 US mining engineering faculty members, 39 senior faculty members would be eligible for retirement by 2020. In addition only ten members of the faculty were 40 years old or younger. In February 2013, 14 mining schools reported that there were 18 open faculty positions, including 5 departmental head vacancies.

While the average graduation rate of mining engineering Ph.Ds. has been 15 annually, that value has recently declined (Figure 2). Note the disparity in total enrolled Ph.D. candidates and the number of degrees actually conferred.

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12 Student Credit Hours constitutes one Full Time Equivalent. To determine the number of FTE you sum the number of credits all students in the program are currently enrolled in and divide by twelve. Universities differ on what is the expected ratio of FTE to Professor should be. Around 20 FTE per every faculty member is a common approximation. Given the lower student to professor ratios at some schools it can be a challenge to university administration to justify more faculty members.

Cost per degree and cost per student tends to be high for mining programs compared to other degrees due to the low student to faculty ratio.

16 According to an annual report from the Grapevine Project conducted by the Illinois State University and the State Higher Education Executive Officers.

17 Poulton, M., “Analysis of the Mining Engineering Faculty Pipeline”, SME Annual Meeting, Conference Proceedings, February 2012.


19 Many Ph.D. are mentored and produced by new faculty going through the tenure process, as the number of Ph.D. produced is an important metric for granting tenure.
In fact this high attrition rate between starting a Ph.D. and graduating extends into the tenure process for new faculty members. One reason for this is the lack of interest on behalf of newly minted Ph.Ds. in pursuing a university career. Poulton’s 2010 survey of Ph.D. candidates found only 25% were interested in a career at a university.

This facet is particularly critical as in order to expand capacity for producing mining engineering experts the number of educators must be expanded first.

**Tenure Process**: The tenure process is an important facet of academic governance; however, it is long, formidable, and often a disincentive for new Ph.Ds. to pursue a career in the academic realm. The process begins with a newer faculty member being evaluated 5 to 7 years after starting at the university. This evaluation examines the quality of their teaching, the number of masters and Ph.D. students they graduated, the number of peer-reviewed publications they produced, service (both to the university and industry), and most importantly the amount of research funding they brought to the university. There is a high rate of attrition during the tenure process due to either burn out or simply an inability to achieve tenure. Once tenure is achieved, faculty members tend to stay until retirement.20

**Reasons and Mechanism for Federal Support**

The U.S. economy depends on minerals.21 The 2009 decision by China to restrict exports of rare earth minerals, of which it is effectively the sole producer, provided a dramatic example

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21 United States Geological Survey “Mineral Commodity Summary 2013”
when it was realized that these minerals are essential to much of the high-technology industry. Technical expertise must be maintained if any hope is to be had at developing domestic supply chains for the necessary mineral and energy assets required to maintain the U.S. economy as a global leader. Federal agencies that regulate, oversee, and permit the mining industry must be staffed with technical experts to ensure competent government programs.

Should the number of ABET accredited mining programs drop below 10, it will spell a death sentence for mining programs and the US will lose its pipeline for future extractive engineering expertise. ABET will not accredit programs that do not have sufficient similar programs from around the nation to compare each to or draw volunteers from to conduct accreditation audits.

Mineral related programs are faced with an aging faculty. These faculty members need to be replaced with individuals that can continue to train and educate the next generation of mining and mineral experts. The new faculty members face a tenure process, in its current form, that is more challenging than other STEM fields. The chief reason for this is the decline in mining and mineral specific federal funding sources to conduct needed research.

SMCRA mandates in its statement of purpose that OSM is: “(to) stimulate, sponsor, provide for and/or supplement present programs for the conduct of research investigations, experiments, and demonstrations, in the exploration, extraction, processing, development, and production of minerals and the training of mineral engineers and scientists in the field of mining, minerals resources, and technology, and the establishment of an appropriate research and training center in various States;”

OSM has a research grant mechanism however little of the money is distributed to mining schools. The Technology Development and Transfer Program within OSM could be a support mechanism. OSM’s 2015 enacted budget for the Tech Transfer Program was $14,455,000, of which only $2,145,000 was allocated to institutions to conduct research on applied science. However, of the 18 projects completed or pending from 2014, only one was at a mining engineering program. Taking a closer look at the 64 projects awarded over the past ten years, only seven were awarded to four faculty members at mining engineering programs.

The nation needs more mining engineers. To ensure more mining engineers are produced, the mining schools need to be sustained. To sustain the mining schools, they need a strong faculty. To ensure a strong faculty, new professors need to make it through the tenure process. To make it through the tenure process, new professors need to conduct research. To conduct research, professors need federal funding. Federal funding has dried up for mining engineering faculty since disbanding the USBM. OSM should provide more support to mining schools.

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22 While the “10 programs” number is not readily admitted to by ABET, this has been ascertained from discussions with faculty members familiar with the process.
23 http://www.osmre.gov/programs/TDT.shtm
24 Office of Surface Mining Reclamation and Enforcement 2016 Budget Justifications
25 http://www.osmre.gov/programs/tdt/appliedscience/projects.shtm