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Dilemmas of Promoting Geoscience Workforce Growth in a Dynamically Changing Economy

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Abstract

The geosciences as an occupation are experiencing substantial change, with a combination of economic cycles, mass retirements, and rapid technological innovation. For the next generation of geoscientists, flexibility and well-defined competencies will be key to employment resilience. These required core competencies reflect the new economy that the geosciences function in, yet most educational programs reflect the economy of the past. We examine the human capital dynamics of the geosciences in the United States as an example, and the critical challenges faced in recruiting the right next generation workforce best prepared for the rapid changes in the market including the likely new phase of the long-term cyclicity of geoscience labor demand. Mismatching educational goals and workforce needs negatively impacts individuals' career prospects without their knowledge or recognition. Historical trends inform us on likely changes with the emerging political, economic, and demographic realities that will affect the geosciences. Some of the competing interests within the workforce development process are examined for their ethical challenges, such as the need to maximize enrollments while challenging students to be ready for the workforce. This has profound implications regarding how we promote the science to students, so that we are not leading people down paths that will not yield productive careers and in turn not foster a healthy profession.

1. INTRODUCTION

Geoscience-related employment in the United States is cyclic. Historically the center of gravity has shifted as the fortunes of various industries such as petroleum, mining, and environmental consulting expand and contract. Like many technical fields in the developed world, the geosciences also face the challenge posed by the retirement of the Baby Boom generation, which is warping the dynamics of the employment cycle (Carnevale et al., 2014). Together these forces necessitate providing geoscience students and early-career employees with the skills and awareness to cope with the current and expected future dynamic change in the discipline.

Students and junior employees look to educators and employers for advice to make informed career choices. It is incumbent on educators and employers to fulfill their ethical duty to act responsibly, honestly, and with integrity (American Geosciences Institute, 2015) even as they face their own employment and professional pressures. Understanding the context of geoscience employment will help mentors provide accurate information and training to the next generation of geoscientists who must be adaptable and flexible..

2. A BRIEF HISTORY OF U.S. GEOSCIENCE HUMAN CAPITAL

Geoscience employment in the United States was first measured by the AGI Manpower Committee in 1955, as the post-war economic expansion shifted in response to the Cold War. Demonstrable growth in the demand for geoscientists in industry and government occurred in the late 1950s and early 1960s as the United States aggressively implemented petroleum and mineral strategic reserve programs and became a major buyer of commodities. However, demand decreased following this initial buildout. Through the 1960s and into the 1970s employment levels remained flat, but university geoscience enrollments grew in concert with general increases in college enrollments. With the oil embargos of the 1970s and the rapid rise in oil prices, enrollments and employment in the geosciences rose dramatically. At its highest levels, demand for geoscientists was so strong that energy companies recruited "at the endpoints" – hiring both the best faculty and lower caliber graduates (Milling, 2002).

Oil prices fell dramatically in 1986 and so did employment for geoscientists (Keane et al., 2008). As the petroleum industry shed positions, many talented individuals left the field. A number migrated, along with new geoscience graduates, to employment opportunities related to Superfund and other projects in the environmental industry. Employment demand in this new sector was met quickly, however, and created a relatively slow hiring environment for geoscience graduates until the 2010s.

Genuine structural growth in geoscience employment resumed with the broad use of hydraulic fracturing that rejuvenated the U.S. onshore oil and gas industry. This growth yielded dramatic demand for geoscientists not only working directly in the oil and gas industry but also in support services and the environmental and engineering consulting industry. The decline in oil prices in 2014 once again saw a slowing of geoscience hiring in the energy sector. However, demand has remained strong in the environmental and geoengineering industries (Wilson, 2016).

Geoscience enrollment, and especially the number of degrees awarded, most closely tracks demand from the petroleum industry. This trend is particularly marked for male students. Data from AGI's annual enrollment surveys demonstrate that between 2010 and 2014 most enrollment growth was male and, as hiring in the energy sector slowed, those individuals exited geoscience degree programs and the gender balance returned to traditional levels of approximately 44 percent female (Keane, 2016).

A recent phenomenon is the rapid increase in the number of Master's degrees awarded, with a one-year increase of 46 percent in 2012. In many industrial geoscience fields, a Master's is regarded as an appropriate terminal degree (Wilson, 2016). Perhaps not surprisingly, some geoscience departments report that occasionally doctoral students have transferred to the Master's degree to enable them to enter the industry workforce more rapidly (Wilson, 2016).

3. CURRENT PREDICTIONS FOR THE GEOSCIENCE WORKFORCE

Currently there are approximately 324,000 individuals employed in geoscience-related occupations in the United States (Wilson, 2016). This number is derived from U.S. Bureau of Labor Statistics data using several key relationships between occupations and geoscience activities. Based on an estimate of general economic growth of 1.5 percent per year and U.S. government projections (U.S. Bureau of Labor Statistics, 2017) for additional growth in the energy and in environmental and engineering industries, aggregate demand of 355,00 geoscience full-time equivalents (FTEs) is predicted by 2024 (Wilson, 2016). This prediction already accommodated expected substantial decreases in government employment. With current graduation rates there would be a deficit of 90,000 geoscience FTEs by 2024.

Open markets respond to labor shortages through several mechanisms. First, labor shortages may stifle projects especially in the resource development and infrastructure sectors. Second, individuals from other science, technology, engineering, and math (STEM) fields, especially physics, mathematics, and civil engineering, may substitute for geoscientists. Even actuarial professionals may substitute for geoscientists who work on risk assessment in sectors such as hazards and the extractive industries. The increasing use of "big data" for statistical assessments in place of technical assessments may lead to more computational experts filling traditional geoscience positions in both the private sector and government. Finally, innovation and developments in technology may reduce the demand for geoscientists. Given these potential scenarios, it will be increasingly important for geoscientists to develop a broad portfolio of skills.

4. CHALLENGES FOR ACADEMIA

Geoscience, in general, has been a counter-cycle labor market, where high commodity prices slow down the general economy but yield rapid expansion in geoscience employment. Likewise, given the inherent upstream nature of much geoscience work, low commodity prices lead to softening geoscience employment. Young adults entering the university or the workforce should understand this phenomenon and be equipped with skills to cope with cyclicity and its likely impacts on their careers.

University students choosing a major are making a profound life choice, one that may take nearly a decade to realize success. In the geosciences, a Master's degree is the degree required for many positions, especially in the private sector, so for many students, the total time from enrolling in college to employment is approximately six years. Students may choose geoscience at a time when employment prospects are high but by the time they graduate demand for geoscientists, which is often on a 5–10-year cycle, may have changed. Completing a doctoral degree may open additional options for employment, but this imposes additional time and financial costs.

Educators and mentors should help students manage expectations with some fundamental precepts. Students need to understand that economic cycles are real. Resilience depends on the student's flexibility; the geoscience workforce and profession is global and mobile so there are fewer opportunities for people who are unwilling to move (Keane and Gonzales, 2010). It is also important to impart to students that while getting a degree doesn't guarantee a job, not getting a degree will certainly reduce earnings (Carnevale et al., 2014). However, it is true that even in the worst of times the best students still get hired (Mobil Oil Company, 1999).

The mismatch between cycles of hiring and the production of students creates dilemmas for universities. Academic departments are under pressure to increase revenue from tuition fees and grants as well as graduate more students within six years of enrollment. This pressure is due, in part, to the U.S. Department of Education's College Scorecard, which rates colleges and universities on three metrics: average actual out-of-pocket annual cost, six-year graduation rate, and the median income of graduates 10 years after entering the school. These metrics motivate schools to reduce costs, increase completions, and seek ways to improve employability for the majority of their students. They also, in some cases, encourage schools to close down high-cost programs with low student numbers (Heads and Chairs Meeting of the American Geophysical Union in 2015).

The success rate for geoscience grant applications at the National Science Foundation is currently approximately 25 percent (Wilson, 2016). Increasing enrollments is seen in some departments as an alternative way to boost income. Geoscience enrollments have been at record levels since 2013 and many graduate programs report that they are at capacity (Wilson, 2016). With larger class sizes, faculty-intensive comprehensive field classes have been reduced, and the large pool of students has not countered the trend that geoscience majors have the lowest mean SAT scores of all STEM fields.

Employers report that advanced math courses are a good predictor of graduate success in the workplace (Keane, 2016). Nevertheless, there are continued deficiencies in quantitative coursework in the geosciences, in part because rigorous math requirements tend to reduce enrollments and retention (Malcolm and Feder, 2016). Consequently, U.S. universities are producing more geoscience graduate than ever, but they are not necessarily meeting industry requirements for high-quality workers available on demand.

Efforts to diversify the geoscience profession by attracting specific target populations have not yielded substantive changes in the diversity of the geoscience student body and workforce (Wilson, 2016). Efforts to engage underrepresented populations are well-motivated and can be transformative (Houlton et al., 2012), but the lack of progress raises questions of their efficacy. Other areas that may need additional attention are the lack of problem-solving skills by incoming students, the assumption that exposure to earth science in secondary schools will lead to increased geoscience enrollments, and the need to support the "middle third" of secondary students – those students who are academically capable of university study but face critical social, spatial, temporal, and economic barriers that prevent them from pursuing additional formal education (Smith, 2010).

5. CONCLUSION: SYSTEMIC APPROACHES TO LIFETIME CAREER MANAGEMENT

Given employment cycles, students and early career geoscientists must be prepared to maximize their employment resilience (Keane, 2015). The geoscience profession needs to develop a common perception of the geosciences that will facilitate movement between technical sectors within the profession. Systemic structures are needed to help individuals self-manage their education and careers.

Faculty and academic advisors need to separate themselves from the perspective that the preparation pathway for an academic career is applicable across all geoscience occupations, or that the skill sets and experiences which have made them successful apply uniformly to their students and advisees. The skillset of a successful mid or late career professional is not the same of an early career individual, and nor can assumptions be made that what constitutes necessary skills for later in a career will remain the same as the science evolves and technology changes processes. By utilizing an objective competency-based approach, the variations of skill-needs to career-desires and phases can be identified, which has been utilized in the energy sector already.

Competency-based career planning is used in parts of the energy industry (Gelling, 2013), and is central to the geospatial community's education, training and employment strategies (Johnson and Davis, 2010). Rather than focusing on the degree as the key qualification for employment, the emphasis shifts to a portfolio of competencies. Developing a competency matrix for the geosciences, in which individuals can map the learning outcomes from their degree programs and identify skills needed for future pathways, would help geoscientists identify beneficial educational opportunities that strategically enhance their career path. It would also provide a common language for employers and educators to discuss geoscience education that supports employment.

The U.S. Department of Labor has promoted the idea of competency pyramids that show the progression from basic functionality to higher-level critical thinking as new learning outcomes or skills develop. Competency pyramids highlight the need for lifelong learning and ongoing professional development. Lifelong learning experiences, however, are only required in selected licensure jurisdictions, so the onus is on individuals to take responsibility for continuously developing their competencies.

The geoscience community needs to come together to create structures and expectations that support resilient career pathways for geoscientists. Scientific and professional societies, in addition to universities, can play a major role in providing the educational opportunities, career advice, and institutional structures needed by geoscientist throughout their careers.

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