GROUNDWORK
Furthering the Influence of Earth Science

Meeting Changing Workforce Needs in Geoscience with New Thinking about Undergraduate Education

Lori Summa*, Rice University, Earth Sciences, Houston, Texas 77005, USA, Lori.Summa@rice.edu; **Christopher Keane,** American Geosciences Institute, Washington, D.C. 22302; and **Sharon Mosher,** The University of Texas at Austin, Austin, Texas 78712, USA

What enables a geoscience undergraduate to be successful in the workforce? This is the core question for an NSF-sponsored effort to develop a community vision for undergraduate geoscience education.

Two immediate trends impacting the geosciences have motivated this effort. As the current workforce retires, there is an increasing shortage of geoscientists, even as the overall demand for geoscientists continues to grow (Martinsen et al., 2012). Traditional geoscience jobs are evolving rapidly, requiring geoscientists to expand both their breadth and flexibility to be successful in their careers. Mapping and interpretation tasks are increasingly automated, and geoscientists are increasingly called on to inform the solution of significant societal issues, such as hazard resiliency, public health and the environment, access to resources, and global security. At the same time as workforce needs are changing, undergraduate education is transforming. Educators have developed new ways to enhance student learning and new pedagogies for STEM education (Singer et al., 2012). Additionally, the academic community has a broader awareness of the need to prepare students for the next generation of geoscience careers. Finally, despite continued efforts by educators and industry, the geoscience community still struggles to recruit and retain underrepresented individuals in our programs and professions compared to other STEM disciplines (O'Connell and Holmes, 2011).

To develop a common vision that addresses this changing landscape, the NSF-sponsored effort focused on three key topics: (1) content, competencies, and skills that undergraduates need to be successful in graduate school and the future workforce; (2) the best methods of teaching and using technology to enhance student learning; and (3) broadening participation and retention of underrepresented groups and preparing K–12 science teachers to prepare the pathway to a robust geoscience workforce and an earth-literate public. The effort started in early 2014 with a summit that drew together a wide spectrum of the undergraduate geoscience education community to outline critical priorities for improving the quality of undergraduate education. This summit led to an ongoing community survey that now has over 460 responses. A follow-up Geoscience Employers Workshop in 2015 and departmental heads and chairs Summit in 2016 tested the initial results of the 2014 summit with geoscience employers and engaged department heads and chairs to develop methods for implementing change. Documentation of the summits, workshop, and the community survey can be found at http://www.jsg.utexas.edu/events/future-of-geoscience-undergraduate-education/.

The process of engaging a spectrum of employers together with the input of critical priorities from the undergraduate education community proved to be especially enlightening. Workforce discussions generated a remarkable consensus among both academics and employers, whether employers were from the energy sector, environmental and engineering consulting, mining, or public agencies: The demand for new geoscientists in the workforce continues to be strong, but the skill sets of newly graduated geoscientists do not always match employers' evolving requirements. The community survey yielded initial data on the skills and concepts considered critical to both employers and academics (Fig. 1). The Geoscience Employers Workshop further expanded input from employers regarding the skills and concepts they viewed as critical for the current and future workforce, as well as their role in helping departments implement the developing community vision. Overall, the responses from the 2014 Summit, Employers' Workshop, and survey were strongly aligned. However, the workshop participants also provided greater definition and granularity regarding the use of specific skills and concepts in their respective work environments. During those discussions, they consistently emphasized: (1) systems thinking and multidisciplinary approaches to applied problems, with a strong understanding of fundamental processes, and their linkages, and feedbacks; (2) experience in cross-disciplinary teamwork and communication; (3) appropriate quantitative skills to manipulate and apply the governing physical, chemical, and biologic equations used to solve multidisciplinary problems; (4) the ability to manage and analyze large quantities of diverse data; and (5) an appreciation for the interfaces between geology and society, including business practices, ethics, risk, environmental sensitivity, cultural diversity, and a global outlook. These employer priorities were viewed as reflective of the ongoing evolution in geoscience employment and will increase in importance over the foreseeable future. Complete documentation of the employers' discussions can be

GSA Today, v. 27, doi: 10.1130/GSATG342GW.1.

* Retired from ExxonMobil Upstream Research Company, Senior Technical Consultant.

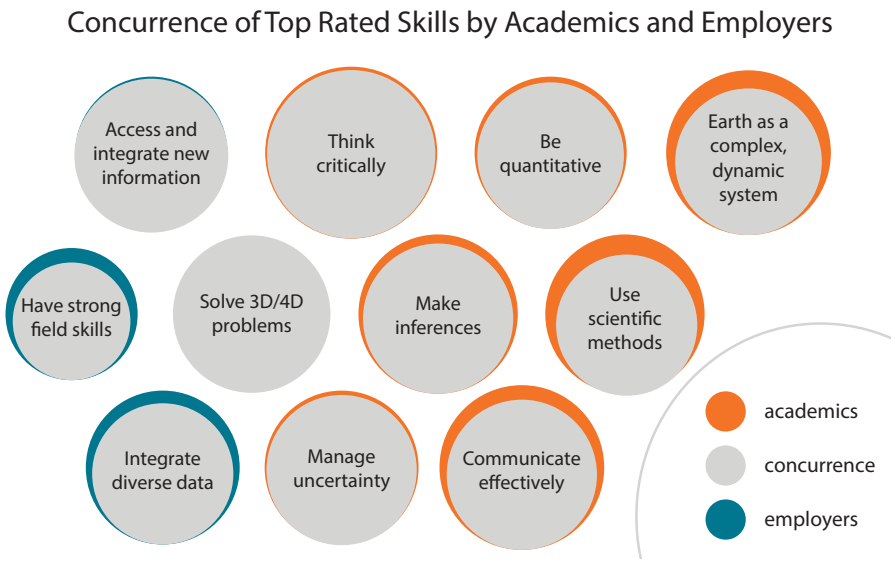

Figure 1. Highest priority skills and concepts from the community survey. Responders included ~95 employers and ~345 academics. Participants were asked to rank individual skills from 1 (very important) to 5 (not important). The size of the circles corresponds to the percentage of respondents who placed a skill in the top two categories (very important/important). The largest circle (Think Critically) had 95% very important/important responses, and the smallest circle (Strong Field Skills) had ~75% very important/important responses. Skills that received less than 75% very important/important responses were not included in the graph. The colors of the circles reflect similarities and differences between academic and employer responses. Gray centers show the percent of concurrence between academics and employers. Where the rims are blue, employers gave the skill a slightly higher weight than academics, and where the rims are orange, academics gave the skill a slightly higher weight than employers. A complete summary of the survey responses can be found at http://www.jsg.utexas.edu/events/files/HCWebinar_Sept2016_Summit-Sharon-Mosher.pdf.

found at http://www.jsg.utexas.edu/events/files/Employers_Workshop_outcomes.pdf.

As workforce needs evolve, student learning must change. Educators at the summits and contributors to the community survey agreed with employers that to prepare students for successful careers, geoscience curriculum should build around skills, competencies, concepts, and learning outcomes rather than specific disciplinary content (Fig. 2). A number of geoscience departments have already modified their curriculum and developed proven approaches for effecting change; e.g., experiential learning, independent research, problem solving and use of real data in classes, integration of math and computational methods into geology courses, incorporation of intensive written and oral communication, and implementation of robust assessment tools. There will, however, be challenges to putting these changes into practice throughout the geoscience community. Most importantly, faculty will need time, educational resources, and financial support to pilot and document new instructional approaches.

What are the next steps? More than 90 institutions have now developed individual action plans for their geoscience departments. In addition, the community survey remains open to anyone who wishes to participate: https://apps.jsg.utexas.edu/form/survey-future-of-undergraduate-geoscience-education. Employer input would be particularly welcome. Feedback from the survey, results of the summits, workshop, institutional plans, and extensive input from education conferences (e.g., Earth Educators Rendezvous) will be used to develop a formal Vision and Change document that lays out the shared community vision for undergraduate geoscience education and the actions needed to realize that vision. Sustained change in geoscience education will, however, require the persistent, coordinated efforts of administrators, educators, students, employers, and professional societies. Nonetheless, the prize remains large: it is nothing less than the opportunity to demonstrate that geoscience departments are an essential source of students to address a new generation of workforce and societal issues.

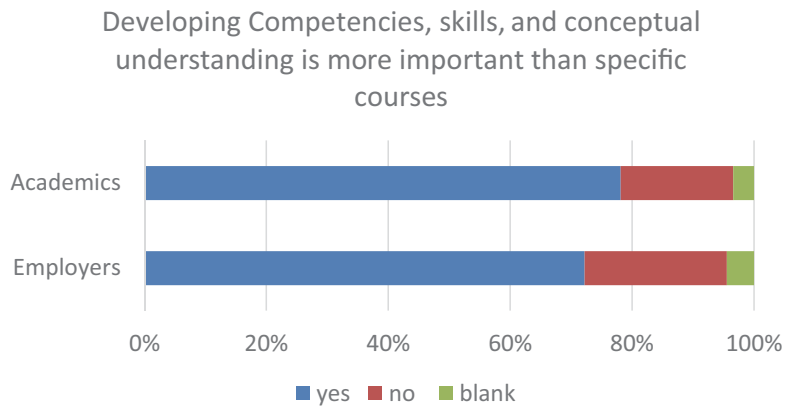

Figure 2. Results from the community survey supporting the major conclusion that developing competencies, skills, and conceptual understanding is more important than taking specific courses. Among both academics and employers, at least 75%–80% of respondents gave a positive answer to this question.

ACKNOWLEDGMENTS

The authors gratefully acknowledge contributions from members of the steering committee for the summits and workshops on undergraduate education, including Joshua Villalobos, Jeff Ryan, David McConnell, Lisa D. White, Jacqueline Huntoon, Wendy Harrison, Kate Miller, Peter Lea, and Tim Bralower. Funding was provided by National Science Foundation grant EAR1347209.

REFERENCES CITED

Martinsen, O.J., Talwani, M., Levander, R, Dengo, C., Barkhouse, B., Dunn, J.F., Link, C., Mosher, S., Tatham, R., Orcutt, J., Paul, D., and Talley, R., 2012, A U.S. human resource challenge for Earth science education and energy exploration and exploitation: The Leading Edge, 30th Anniversary Volume, v. 31, p. 714–716, doi:10.1190/tle31060714.1.

O'Connell, S., and Holmes, M.A., 2011, Obstacles to the recruitment of minorities into the geosciences: A call to action: GSA Today, v. 21, no. 6, p. 52–54, doi:10.1130/G105GW.1.

Singer, S.R., Nielsen, N.R., and Schweingruber, H.A., editors, 2012, Discipline-based education research: Understanding and improving learning in undergraduate science and engineering: National Academies Press, 282 p.

Manuscript received 2 Apr. 2017
Manuscript accepted 20 Apr. 2017