Rapidly Evolving Industry Requires New Skills for Aspiring Geoscientists

September 2020 Heather Saucier, Explorer Correspondent

There is no question that sweeping technical advancements have pushed the petroleum industry into a new world – one of tremendous data and unimaginable efficiency in exploration and production. Geoscientists who began their careers decades ago hand-drawing maps and relying on hazy 2-D seismic data now plow through piles of detailed digital information, inching closer to the day when dry holes could become the exception rather than the norm.

Are upcoming geoscience graduates prepared to enter this rapidly evolving industry?

The American Geosciences Institute has reported a significant disparity between the skills of newly graduated geoscience students and their preparedness for the workplace.

“Changes are needed in university departments for students to be successful,” said Christopher Keane, director of geoscience profession and higher education at AGI. As a result, “studies are being done to determine what the future of geoscience looks like, what students should be expected to know and how that fits into higher education.”

To better understand the divide between graduates’ skills and employers’ expectations, the National Science Foundation called upon the University of Texas’ Jackson School of Geosciences in 2014 to host the Summit of the Future of Undergraduate Geoscience Education for more than 200 educators and representatives from the industry at large and professional geoscience societies.

Lori Summa

Sharon Mosher

Christopher Keane

“It was so successful we realized we needed to take additional steps,” said AAPG Member Sharon Mosher, former dean of the JSG and summit chair. “We learned that a lot of students coming out of undergraduate programs don’t have all they need to get into graduate school, get hired or stay employed.”

Mosher later collected input from 260 additional educators and employers from subsequent gatherings through 2018, including a geoscience employers’ workshop and a department heads and chairs summit. She also received more than 500 survey responses from people who could not physically participate.

Their feedback reflected the fact that the geosciences have become more interdisciplinary, multidisciplinary and transdisciplinary, resulting in a need for students to have strength in their own disciplines as well as the ability to work across disciplinary boundaries. Research, applications, technology and data have all changed in the geoscience field, creating an immediate impetus for changes in how and what students are taught.

“There was a remarkable consensus on what the core competencies and skills of a person with a bachelor of science degree in geoscience should have,” said Jeffrey Ryan, a professor of geology at the University of South Florida. “Now, schools can think about how what they are doing for their students maps to these.”

Data Analysis and Field Experience

Changes need to occur in curriculum, content, competencies and skills, Mosher said.

Higher math skills are important. Geoscience has become more quantitative and computational, and students are not necessarily being encouraged to take differential equations, linear algebra, statistics and risk calculation, she said.

“Most students in their jobs won’t be deriving differential equations, but they will be using software tools that apply those equations to solve problems in major geoscience fields. They need to understand the critical variables and the quality of the predictions you make using the tools,” explained AAPG Member Lori Summa, a retired geologist from ExxonMobil, adjunct faculty member at Rice University and summit organizing committee member.

However, “you can’t just dump a pile of math on students and expect them to know how to use it,” Ryan said. “We have to show them how it’s used. They’ll need to be able do serious computations using that math and get answers based on real data.”

Emphasizing the importance of working with real data, industry representatives encouraged more field and research experiences.

“Independent research experience is one of the best tools for developing skills,” Mosher said. “Field experience plays a key role in 3-D visualization skills, community building and testing hypotheses.”

More developed critical thinking skills also are needed in the workplace. The industry has seen major advancements in visualization and geospatial tools, massive amounts of quantitative information, and computational modeling and simulation.

“Undergraduate students must be prepared to use rapidly advancing technologies and big data in the future,” Mosher said.

Summa added, “They need to know how to compile the right data, analyze data quality, understand uncertainties and make predictions with incomplete data.”

Students also should be able to take a “systems approach” to geoscience. They need to look at Earth processes as a whole, rather than as individual parts. “Geologic reasoning must occur over multiple scales of time and

space," Summa explained. "Many diverse datasets are needed to make predictions about Earth systems, and we want students to practice using those datasets to solve real-world problems."

Teamwork and project management skills also made the list of necessary skills, so graduates can work effectively in interdisciplinary teams and across cultures.

And, while communication often isn't taught in a geoscience curriculum, it is a skill employers want. "The next generation of graduates should be able to engage in effective two-way communication with scientists and non-scientists," Mosher said. "They need to be able to do this with different audiences in writing and orally – explaining things to their peers, to management, engineers and the public."

And, as the industry's current downturn has shown, employers are especially looking for geoscientists with diverse skillsets who can "lane shift," or transition to other needs of their organization, Keane said.

Many might be surprised at the backgrounds of some of today's new hires.

"The oil industry is hiring graduate-level volcanologists and statistical paleo-biologists. They know how to deal with statistics and probability," Ryan said. "It's all about being able to show what you have learned and using it to useful ends."

Pedagogy and Use of Technology

The JSG summits revealed that effective methods for instilling the desired skills and competencies are readily available to geoscience educators. These include collaborative and integrative projects that involve teams, interdisciplinary projects, fieldwork and research experiences, Mosher said.

Educators also should more vigorously incorporate technology, visualization, simulation, modeling and analysis of data into students' education, as appropriate.

Active and experiential learning are heavily stressed practices. "Today, looking information up is easy," Mosher said. "But students have got to be able to use it. They have got to be assigned projects that require access to real data and solve real problems."

Students also need to better understand broad concepts. Ryan recalled "a complete consensus among industry representatives that understanding the Earth's climate system is critical, including what climate is, how it works, and the hydrologic, atmospheric and solar system phenomena that are affecting climate change. Where are we teaching this? It's actually littered across the curriculum – it's not a focus. How do we connect all this content for students?"

He continued, "Department heads need to start discussions with their faculties to get them to recognize and think about what is happening at the program level, not just in their courses. And students need to understand this just as well as the faculty do. They need to know what the outcomes of their education should be, to properly select their courses and internships."

Preparation of K-12 Science Teachers

Large numbers of geoscientists are projected to retire in the next several years, and at the same time, the number of geoscience jobs is expected to grow, reports AGI. Filling this gap will be a challenge.

"There are a lot of geoscience departments that are at risk," Summa said. "There are declining enrollments because the geosciences are not viewed as critical on some university campuses."

Geoscience teachers at the primary and secondary levels are key to planting seeds of interest and boosting the number of geoscience majors, Mosher said.

“Only a small percentage of middle and high school students take a geoscience course, but it can be covered in many science classes.” Mosher said. “Better preparation of teachers is essential so they can instill an interest in geoscience careers.”

There also is a need for universities to produce more geoscience teachers. High schools that offer introductory geoscience courses and general education courses with geoscience components could be effective in recruiting future geoscience teachers.

Furthermore, two-year colleges are playing an increasingly important role in the education of undergraduates – a fact that makes increased collaboration and curriculum alignment between two- and four-year colleges “imperative,” she added.

It was also agreed that exposing future geoscience teachers to collaborative fieldtrips and research experiences would allow them carry their experiences into their own classrooms to inspire students.

The Future

“Participants were very enthusiastic about returning to their departments and incorporating new strategies,” Mosher said of the summits. “All were encouraged to be ambassadors and tell others about the emerging community vision for undergraduate geoscience education and to help them implement that vision.”

Department heads and chairs developed action plans for their institutions and have been submitting progress reports to Mosher, who has been regularly following up with universities to track changes being made based on the summit’s findings.

Most report progress with evaluating and revising their curricula. They found the feedback from the summits “very useful,” and some have encouraged and incentivized professional development for their faculty, resulting in increased usage of active learning, Mosher said.

AGI is assisting by working with summit organizers to develop a vision and change the document and toolkit based on the summit outcomes. They are currently in the draft stage and will be sent to geoscience departments across the country, Keane said.

The vision and change document will address a variety of issues, from the demands on future geoscientists, to the curricula and pedagogical transformations needed to improve student outcomes, to reframing what the educational journey of a geoscientist looks like – all the way through their career. The toolkit will provide actionable assets to assist departments, faculty, and students in implementing change, Keane added.

“What is important is that students are prepared to continue to learn as the geosciences grow and change and as the students’ interests and employment change,” Mosher said. “The perception of what a geoscientist is and does must be broadened.”