5. **Program Effectiveness – Outcomes Assessment**

The Department of Geology and Geophysics offers 11 degree programs at both the undergraduate and graduate level. The purpose of the programs and learning outcomes of each of the programs are described here:

**BS in Earth Science Composite Teaching**

*Program Purpose*

The Earth Science Composite Teaching major meets state requirements for Earth Science, Integrated Science, and Physical Science teaching endorsements. It provides students with the knowledge and skills to teach Earth Science, Physical Science and Integrated Science. It provides students with the knowledge and skills to build upon the curricula described by the Utah State Office of Education for the above programs. It provides students with the knowledge of math, chemistry, physics, and biology required to understand the earth sciences.

*Learning Outcomes*

- Demonstrate mastery of the geosciences, chemistry, physics, astronomy, biology, ecology, math and atmospheric sciences that allow them to meet State requirements for Secondary Science Endorsements in Earth Science and Integrated Science and Secondary Licensure Program requirements within the College of Education.
- Understand the nature and origin of the materials that make up the Earth.
- Understand the dynamic processes that operate within the Earth from its deep interior to the surface.
- Understand geologic time and how it is measured.
- Understand the geologic evolution of the Earth and the development and evolution of life on Earth.
- Demonstrate proficiency in basic geologic field skills.
- Demonstrate comprehension of the scientific literature, and skill in oral and written communication of scientific results.
- Ability to organize content for student learning and select appropriate evaluation methods to measure student mastery of the content.
- Ability to provide differentiated instructions and curriculum, adaptations, and modifications necessary to promote student learning.
- Ability to adapt instruction to cultural and language differences and to provide effective large group, small group and one to one instruction.
- Ability to assess student learning, including development and administration of assessment instruments and using the results to modify student placement and instruction.
- Demonstrate skills for student learning/classroom management.
- Understand teaching professionalism and ethical responsibility.
- Ability to engage in lifelong learning and understanding of the need to do so.
- Ability to pass the Level I Praxis Exam.

BS in Geological Engineering

Program Purpose
The undergraduate program in Geological Engineering is reviewed and accredited by the Engineering Accreditation Commission of the Accreditation Board of Engineering and Technology, Inc. This degree program trains students in engineering fundamentals and their practical application to the physical earth. The mission of the geological engineering program is to educate and train through teaching, research, and develop the critical thinking and communication skills necessary for students and faculty to contribute to the solutions to difficult engineering problems within the context of the natural earth. The program objectives are as follows: (1) The students will be capable of utilizing their backgrounds in engineering and earth science to contribute to solutions to difficult engineering problems within the context of the natural world. Students will be able to analyze problems, design experiments, evaluate information, and communicate results both individually and as part of a team. (2) The students will know and understand fundamentals related to the two following aspects of geological engineering: 1) fluid flow and contaminant transport in the subsurface; and 2) geomechanics related to stability of subsurface materials. (3) The students will be educated in fundamental and current issues in the above aspects of the geological engineering profession, will know the steps required to attain a career in geological engineering, and will be shown the value of a desire for lifelong learning within and outside the geological engineering profession. (4) The students will be educated within an environment that fosters honesty, integrity, and a strong engineering and work ethic. Design experiences aimed at incorporating real-world constraints into solutions to engineering problems are integrated into the curriculum at various stages, culminating in two capstone engineering design experiences taught within the context of groundwater remediation and geological hazards.

Learning Outcomes
- Ability to apply knowledge of mathematics, science, and engineering.
- Ability to design and conduct experiments, as well as to analyze and interpret data.
- Ability to design a system, component, or process to meet desired needs.
- Ability to function on multi-disciplinary teams.
- Ability to identify, formulate, and solve engineering problems.
- Understanding of professional and ethical responsibility.
• Ability to communicate effectively.
• Understanding of the impact of engineering solutions in a global and societal context.
• Recognition of the need for and ability to engage in life-long learning.
• Knowledge of contemporary issues.
• Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
• Ability to engage in lifelong learning and understanding of the need to do so.
• Ability to pass the Fundamentals of Engineering examination, thereby allowing them to immediately begin training for Professional Engineering licensure upon graduation.

BS in Geoscience

Program Purpose
The undergraduate program in Geoscience educates students to apply the principles of chemistry, physics, mathematics, and biology to understand the composition, structure, and history of the Earth, and the processes that govern them. Earth science coursework encompasses theoretical, field, and laboratory components with the goal of a fundamental understanding of how the Earth works and how it has evolved through time. Such knowledge is vital to addressing societal needs and problems such as locating and characterizing mineral, energy, and groundwater resources, assessing seismic and other geologic hazards, and evaluating and remediating environmental contamination. An undergraduate degree in Geoscience thus provides both pre-professional training for future scientists, and prepares decision makers and other citizens to make informed choices about pressing societal issues. Students may choose among three emphasis areas: (1) Geology, which focuses on fundamentals of geology including the composition and formation of geologic materials, the processes that operate inside the Earth and on its surface, the Earth’s history as recorded by rocks and their spatial arrangement, and the history of life as recorded by fossils; (2) Environmental Earth science, which focuses on an integrated view of the geosphere, atmosphere, and biosphere and interactions between them; and (3) Geophysics, which focuses on the use of physical methods to image the internal structure of the Earth and account for processes operating in the Earth. Each emphasis area provides a broad foundation in fundamental science that prepares a student for post-graduate work in the Earth sciences or in other professional specialties in which Earth Science knowledge is useful (e.g., environmental law, Earth resource management).

Learning Outcomes

• Program graduates will have demonstrated a mastery of the geosciences that allow them to succeed as graduate students in geology, environmental earth science,
geophysics, or in related fields, as students in professional schools, or as entry-level employees in industry or government.

- Program graduates will have an understanding of the nature and origin of the materials that make up the Earth.
- Program graduates will understand the dynamic processes that operate within the Earth from its deep interior to the surface.
- Program graduates will have an understanding of geologic time and how it is measured.
- Program graduates will have an understanding of the geologic evolution of the Earth and the development and evolution of life on Earth.
- Program graduates will have the ability to apply basic principles of mathematics, chemistry, biology and physics to geologic issues.
- Program graduates will demonstrate skills in reading comprehension of the scientific literature, and in oral and written communication of scientific results.
- Program graduates will demonstrate proficiency in geologic field skills and in solving integrative, field-based problems in Earth science.
- Students nearing graduation will be able to make informed choices as to postgraduate opportunities for education or employment.
- Program graduates will be prepared and qualified to pass the professional geologist licensure examination.
- Students will understand the place of the Earth sciences in the larger picture of the intellectual landscape of inquiry, including connections between science and, history, philosophy, ethics and the formulation of public policy.
- Ability to engage in lifelong learning and understanding of the need to do so.

**ME in Geological Engineering**

*Program Purpose*

The ME program in Geological Engineering is a non-thesis program that prepares students for professional careers in characterization of and the design of engineering solutions to meet societal needs and challenges in geologic settings. This includes exploration and exploitation of natural resources and characterization and remediation of geologic hazards and environmental contamination. The ME degree is satisfactory for some private sector professional careers in engineering applications of Earth science knowledge.

*Learning Outcomes*

- Mastery of the geosciences that allows success as a professional engineer in industry or public service.
Proficiency in accessing and utilizing the professional scientific literature.
Proficiency in oral and written communication of scientific results.
Thorough understanding of the origin and composition of the geologic materials that make up the Earth.
Thorough understanding of the dynamic geologic processes that operate within the Earth’s interior and on its surface.
Thorough understanding of geologic time, in both relative and absolute terms, and how geologic time is measured.
Thorough understanding of the evolution of the Earth and of the evolution of life on Earth.
Ability to use principles of mathematics, chemistry, biology and physics to solve geologic problems.
Proficiency in solving field-based problems in Earth science.
Ability to engage in lifelong learning and understanding of the need to do so.
Understanding of the role of the Earth sciences in helping to solve societal problems related to natural resources, natural hazards, energy, environment and global climate.
Understanding of the place of the Earth sciences in the larger picture of intellectual inquiry, including connections between science and history, philosophy, ethics and the formulation of public policy.

**MS for Secondary School Teachers in Earth Science**

*Program Purpose*
The Master of Science for Secondary School Teachers (MSSST) program is designed to provide experienced, practicing teachers with a deeper understanding of content and content-based pedagogical knowledge to improve their teaching practice. It builds depth in the areas of geology, geophysics, chemistry, ecology, meteorology, and astronomy and fulfills the requirements of the Utah State Office of Education for endorsements in Earth Science, Physical Science and Integrated Science. The program consists of coursework, a summer research project and a final master project designed to give teachers first-hand knowledge of the scientific process.

*Learning Outcomes*
- Demonstrate mastery of the geosciences, chemistry, physics, astronomy, biology, ecology, and atmospheric sciences that allow them to meet State requirements for Secondary Science Endorsements in Earth Science and Integrated Science.
- Understand the nature and origin of the materials that make up the Earth.
- Understand the dynamic processes that operate within the Earth from its deep interior to the surface.
• Understand geologic time and how it is measured.
• Understand the geologic evolution of the Earth and the development and evolution of life on Earth.
• Develop a first-hand understanding of science practices and skills and translate those experiences into their classroom teaching.
• Demonstrate proficiency in basic geologic field skills.
• Demonstrate comprehension of the scientific literature, and skill in oral and written communication of scientific results.
• Ability to engage in lifelong learning and understanding of the need to do so.

**MS in Geological Engineering**

**Program Purpose**
The MS program in Geological Engineering prepares students for a professional career in characterization of and design of engineering solutions to meet societal needs and challenges in geologic settings. This includes exploration and exploitation of natural resources and characterization and remediation of geologic hazards and environmental contamination. The MS degree is commonly desirable for private sector professional careers in engineering applications of Earth science knowledge.

**Learning Outcomes**
• Mastery of the geosciences that allows success as a professional engineer in industry or public service.
• Completion a significant body of original engineering research, the results of which are actually or potentially publishable in peer-reviewed professional venues.
• Proficiency in accessing and utilizing the professional scientific literature.
• Proficiency in oral and written communication of scientific results.
• Thorough understanding of the origin and composition of the geologic materials that make up the Earth.
• Thorough understanding of the dynamic geologic processes that operate within the Earth’s interior and on its surface.
• Thorough understanding of geologic time, in both relative and absolute terms, and how geologic time is measured.
• Thorough understanding of the evolution of the Earth and of the evolution of life on Earth.
• Ability to use principles of mathematics, chemistry, biology and physics to solve geologic problems.
• Proficiency in solving field-based problems in Earth science.
• Ability to engage in lifelong learning and understanding of the need to do so.
• Understanding of the role of the Earth sciences in helping to solve societal problems related to natural resources, natural hazards, energy, environment and global climate.

• Understanding of the place of the Earth sciences in the larger picture of intellectual inquiry, including connections between science and history, philosophy, ethics and the formulation of public policy.

**MS in Geology**

*Program Purpose*

The MS program in Geology prepares students for a professional career in the Earth sciences, particularly in exploration and exploitation of mineral, energy, and groundwater resources; and recognition, characterization, and remediation of geologic hazards and of environmental contamination. The MS degree is the standard preparation for most private sector geologic careers that involve practical application of Earth science knowledge.

*Learning Outcomes*

• Mastery of the geosciences sufficient for success as a professional scientist in industry or public service.

• Completed a significant body of original research, the results of which are actually or potentially publishable in peer-reviewed professional venues.

• Proficiency in accessing and utilizing the professional scientific literature.

• Proficiency in oral and written communication of scientific results.

• Thorough understanding of the origin and composition of the materials that make up the Earth.

• Thorough understanding of the processes that operate in the Earth’s interior and on its surface.

• Thorough understanding of geologic time, in both relative and absolute terms, and how geologic time is measured.

• Thorough understanding of the geologic evolution of the Earth and of life on Earth.

• Ability to apply principles of mathematics, chemistry, biology and physics to geologic problems.

• Proficiency in solving field-based problems in Earth science.

• Ability to engage in lifelong learning and understanding of the need to do so.

• Understanding of the role of the Earth sciences in helping to solve societal problems related to natural resources, natural hazards, energy, environment and global climate.

• Understanding of the place of the Earth sciences in the larger picture of intellectual inquiry, including connections between science and history, philosophy, ethics and the formulation of public policy.
**MS in Geophysics**

**Program Purpose**
The MS program in Geophysics prepares students for a professional career in the application of physical methods such as seismology and measurement of potential fields to exploration and exploitation of mineral, energy, and groundwater resources, and to recognition, characterization, and remediation of geologic hazards and environmental contamination. The MS degree is the standard preparation for most private sector careers that involve practical application of geophysics.

**Learning Outcomes**
- Mastery of geophysics that allows for success as a professional in industry or public service.
- Completion of a significant body of original geophysical research, the results of which are actually or potentially publishable in peer-reviewed professional venues.
- Proficiency in accessing and utilizing the professional scientific literature.
- Proficiency in oral and written communication of scientific results.
- Thorough understanding of the origin and composition of the geologic materials that make up the Earth.
- Thorough understanding of the dynamic geologic processes that operate within the Earth’s interior and on its surface.
- Thorough understanding of geologic time, in both relative and absolute terms, and how geologic time is measured.
- Thorough understanding of the evolution of the Earth and of the evolution of life on Earth.
- Ability to use principles of mathematics, chemistry, biology and physics to solve geologic problems.
- Proficiency in solving field-based problems in Earth science.
- Ability to engage in lifelong learning and understanding of the need to do so.
- Understanding of the role of the Earth sciences in helping to solve societal problems related to natural resources, natural hazards, energy, environment and global climate.
- Understanding of the place of the Earth sciences in the larger picture of intellectual inquiry, including connections between science and history, philosophy, ethics and the formulation of public policy.
**PhD in Geological Engineering**

**Program Purpose**
The PhD program in Geological Engineering prepares students for a professional career in basic research or higher education with an emphasis on characterization of, and design of engineering solutions to meet societal needs and challenges in geologic settings. This includes exploration for and exploitation of natural resources and characterization and remediation of geologic hazards and environmental contamination. The PhD degree is the standard level of preparation for academic careers in geological engineering and for careers in the private sector and public service that emphasize original research.

**Learning Outcomes**
- Mastery of geological engineering knowledge and skills that permits success as a professional engineer in academia, industry or public service.
- Completion of a major body of original geological engineering research, the results of which are published in peer-reviewed professional venues.
- Proficiency in accessing and utilizing the professional scientific literature.
- Proficiency in oral and written communication of scientific results.
- Thorough understanding of the origin and composition of the geologic materials that make up the Earth.
- Thorough understanding of the dynamic geologic processes that operate within the Earth’s interior and on its surface.
- Thorough understanding of geologic time, in both relative and absolute terms, and how geologic time is measured.
- Thorough understanding of the evolution of the Earth and of the evolution of life on Earth.
- Ability to use principles of mathematics, chemistry, biology and physics to solve geologic problems.
- Proficiency in solving field-based problems in Earth science.
- Ability to engage in lifelong learning and understanding of the need to do so.
- Understanding of the role of the Earth sciences in helping to solve societal problems related to natural resources, natural hazards, energy, environment and global climate.
- Understanding of the place of the Earth sciences in the larger picture of intellectual inquiry, including connections between science and history, philosophy, ethics and the formulation of public policy.
PhD in Geology

**Program Purpose**
The PhD program in Geology prepares students for careers in basic research and higher education. The PhD is the standard level of preparation for academic careers in geology, and for careers in the private sector and public service that emphasize original research.

**Learning Outcomes**
- Mastery of geology sufficient to succeed for a professional career in basic research, in either academia, industry or public service.
- Completion of a major body of original geologic research, the results of which are published in peer-reviewed professional venues.
- Proficiency in accessing and utilizing the professional scientific literature.
- Proficiency in oral and written communication of scientific results.
- Thorough understanding of the origin and composition of the geologic materials that make up the Earth.
- Thorough understanding of the dynamic geologic processes that operate within the Earth’s interior and on its surface.
- Thorough understanding of geologic time, in both relative and absolute terms, and how geologic time is measured.
- Thorough understanding of the evolution of the Earth and of the evolution of life on Earth.
- Ability to use principles of mathematics, chemistry, biology and physics to solve geologic problems.
- Proficiency in solving field-based problems in Earth science.
- Ability to engage in lifelong learning and understanding of the need to do so.
- Understanding of the role of the Earth sciences in helping to solve societal problems related to natural resources, natural hazards, energy, environment and global climate.
- Understanding of the place of the Earth sciences in the larger picture of intellectual inquiry, including connections between science and history, philosophy, ethics and the formulation of public policy.
**PhD in Geophysics**

*Program Purpose*
The PhD program in Geophysics prepares students for a professional career in basic research or higher education with an emphasis on the use of geophysical methods to answer Earth science questions. The PhD degree is the standard level of preparation for academic careers in geophysics and for geophysical careers in the private sector and public service that emphasize original research.

*Learning Outcomes*
- Mastery of geophysical knowledge and skills that permits success as a professional geophysicist in academia, industry or public service.
- Completion of a major body of original geophysical research, the results of which are published in peer-reviewed professional venues.
- Proficiency in accessing and utilizing the professional scientific literature.
- Proficiency in accessing and utilizing the professional scientific literature.
- Proficiency in oral and written communication of scientific results.
- Thorough understanding of the origin and composition of the geologic materials that make up the Earth.
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- Understanding of the role of the Earth sciences in helping to solve societal problems related to natural resources, natural hazards, energy, environment and global climate.
- Understanding of the place of the Earth sciences in the larger picture of intellectual inquiry, including connections between science and history, philosophy, ethics and the formulation of public policy.
5.1 Learning outcomes assessment procedures

Various outcomes assessment measures have been implemented for each of the different programs over the last 7 years, but have not been consistent between programs. Forms of assessment have included online course evaluations submitted by students, feedback from graduates via exit interviews, evaluation of recent graduate job placement, periodic alumni surveys, and informal contacts with employers and graduate student advisors.

Formal outcomes assessment of the Geological Engineering programs began in the fall of 2010. For this, the department relies upon its decades-long experience with similar metrics for the American Board of Engineering and Technology (ABET)-accredited undergraduate Geologic Engineering program. This assessment program provides a model for how we evaluate all of the degree programs. Assessment of graduate and other undergraduate degree programs will be accomplished using four tools:

1. Documentation of retention and graduation rates. At the beginning of each academic year, the chairs of the Graduate and Undergraduate Affairs committees obtain rosters of students enrolled in all academic programs from the department Academic Coordinator. Similar rosters of graduating students will be collected prior to May graduation. From these statistics, gathered over many years, a clear picture of retention and graduation rates of students can be ascertained.

2. Exit interviews of students completing their degrees. The Undergraduate Affairs Chair conducts exit interviews of all students eligible for graduation at the end of each academic year. The essence of these interviews will be summarized on forms similar to those currently used by the Geological Engineering Committee for ABET.

3. Alumni surveys. Randomly selected graduates (both graduate and undergraduate students) of the department will be canvassed every three years by the Department Academic Coordinator and/or the Development Officer.

4. Round Table feedback. The department has hosted an annual “Round Table” forum consisting of the Department Chair and selected faculty, alumni, and friends of the department. Part of the purpose of this forum is to ascertain the current effectiveness of department programs and to conduct envisioning for future initiatives. The Round Table has been and will continue to be used to gather anecdotal evidence on the effectiveness and general visibility of departmental degree programs.
Additionally, another rigorous assessment tool used to evaluate the degree of accomplishment of the program educational outcomes is tracking and documenting the students’ performance in the Fundamentals of Engineering (FE) examination. Each year, the outcomes assessment measures are analyzed during the Faculty Retreat in order to evaluate the progress of students and identify new strategies that would increase the degree of attainment of the expected learning outcomes.

During the 2014-2015 academic year, the Department of Geology and Geophysics began a wide-ranging discussion on implementing program outcomes assessment for the Geology and Geophysics undergraduate curricula. The goal was to map faculty-defined learning goals to each class in the curriculum and ultimately make revisions to the curriculum.

Each faculty member was asked to choose a subset of learning goals that were contributed by their class. Responses were coordinated with other instructors if multiple instructors existed. Contrasting responses for a given course were allowed and identified. Instructors tracked evaluations of contributions of their course to the instructor-identified goals. These occurred primarily via end-of-semester student evaluations.

Identification of learning goals was performed in terms of discussed and emphasized. Instructors identified only those learning goals that were significant for their class, since implementing and tracking student responses (e.g., on end-of-semester evaluations) are performed by the instructor.

The MSSST Earth Science program has undergone a formal external evaluation, as well as internal formative and summative evaluation since its inception in 2013. The MSSST Earth Science program was approved by the Board of Regents in 2013 and two cohorts of 16 and 15 teachers were recruited in 2013 and 2015, respectively. The Utah Educational Policy Center (UEPC) conducted the external program evaluation, which involved pre- and post-surveys of program participants. Assessment of content-knowledge gains was done by administering pre- and post-Praxis exams on Earth Science Content Knowledge. The Praxis exams are standardized tests that are given to teachers across the state and the country prior to granting teaching endorsements. Assessment of student-outcomes (i.e., the students of the teachers in the MSSST program) was also carried out for the second MSSST Earth Science cohort. Indirect measures include assessing the number of MSSST graduates that are still teaching and/or are in teacher-leadership positions. The assumption behind these measures is that by providing teachers with a community of like-minded learners, advanced training on content knowledge, and support for implementing new pedagogy into their classrooms, that they will be empowered and respected as professionals, leading to a decrease in attrition.
5.2 Outcomes assessment feedback

Undergraduate Capstone Field Sequence: Geologic Field Methods and Summer Field Camp

Geologic Field Methods (GEO 4500) and Summer Field Geology (GEO 4510) together constitute the undergraduate capstone educational experience for Geoscience BS candidates in all three emphasis areas, and for BS candidates in Geological Engineering. GEO 4500 is taught spring semesters and requires all other geoscience core courses as prerequisites. Students conduct field studies – geological mapping, outcrop measurement and description – for 4 hours each week, in order to determine depositional environments, structural deformation, emplacement dynamics, geotechnical characteristics, and geologic hazards associated with rocks exposed along the Wasatch Front. In Summer Field Geology, GEO 4510, students undertake two complex field problems, each of two weeks duration, during which they independently map a 3- to 4-square-mile area, describe lithologies and rock textures, measure bedding, faults and folds, prepare cross sections and stratigraphic columns, interpret the geologic history, and present results in professional technical reports.

A primary learning outcome is that “Program graduates will demonstrate proficiency in geologic field skills and in solving integrative, field-based problems in Earth science.” An equally important outcome is that program graduates should be proficient in communicating results of scientific and engineering studies both orally and in professional reports. To this end, GEO 4500 fulfills the University of Utah upper division technical writing requirement.

Assessment feedback for the capstone field sequence consists of numerical and written student evaluations, exit interviews of undergraduates conducted by either the Department Chair or Undergraduate Affairs Committee Chair, and anecdotal accounts of conversations with students, alumni, and employers of alumni. These are strongly positive, in regard to both the utility of the learning outcomes in students’ subsequent careers and to the quality of the courses.

Numerical ratings of the courses typically range 0.3–0.6 points higher (on a 6-point scale) than the department average in all areas. Evaluation comments include: “The hands-on application in this course is unparalleled. Learned so much.” “Probably the best, but the hardest course I’ve ever had. It was very challenging. I learned a great deal. It was also fun, the one class I was really glad to be in.” “A particular strength of this course is its ability to not only introduce important information and skills in lecture, but also provides an outlet for students to actively practice and utilize said skills during lab. The lab reports in particular forced us to really think about what we had learned and observed, as well as
what other researchers had discovered, and pull all of that together into a cohesive technical report.”

In exit interviews conducted by the Department Chair 2014-2016, 17 out of 24 students listed Field Methods among their favorite/most valuable undergraduate courses. Graduate teaching assistants for the Field Methods/Field Camp sequence have received the departmental Outstanding Teaching Assistant of the Year award for the last six years. Employers consistently remark on how highly they value our majors’ field qualifications and their communication skills, and alumni regularly report that their experience in writing technical reports has proven extremely valuable in their careers, often gaining them earlier promotion than their peers.

MSSST Program

Teacher content knowledge for both the 2013–2015 and 2015–17 cohorts was assessed via the Praxis standardized exam for Earth Science Content Knowledge. Of the 12 teachers in the 2013–15 cohort who submitted scores, all passed the exam, with 11 showing statistically significant gains. All 12 of the 2015–17 teachers who submitted exit Praxis scores passed the exam with an average 9% increase from their pre-program scores.

Student-level (students of the teachers in the MSSST program) outcomes were assessed for both cohorts to see if the program was having a positive impact on students in Utah schools. Criterion Reference Test (CRT) scores were used to assess impacts on the students of the 2013–2015 cohort. Unfortunately, only two years of data were available as the state was transitioning to a new standardized testing system. No statistically significant gains were seen at the student level for the teachers in the first two years of the program but it’s possible that the results would have been positive had we had data for the teachers after they completed the program. Thirteen teachers from the 2015–17 cohort submitted student science proficiency data for the 2013–14, 2014–15, and 2015–16 school years. The data show a remarkable average student proficiency increase of 24%. These results suggest that the program is not only impacting teachers’ content knowledge but is positively influencing student outcomes as well. 100% of the teachers who participated in the program stated that they felt they were a better teacher because of the MSSST Earth Science program.

Student Exit Interviews

Graduate exit interviews were conducted from 2014–2016. Within this time period, interviews were conducted with 25 Geology BS graduates, 4 Environmental Geoscience BS graduates, 7 Geophysics BS graduates, 2 Earth Science Composite Teaching BS graduates, 3 MS graduates, and 4 PhD graduates. These interviews indicate that the
students queried have had a positive experience (e.g., “learned more than I could have imagined,” “Fantastic!”). There was some concern among undergraduates about increasing class sizes for required field-based core courses that benefit from more one-on-one faculty-student interaction. Some Geophysics undergraduates complained of inadequate offering of core courses that made scheduling and sequencing difficult.

<table>
<thead>
<tr>
<th>Open-ended Responses from MSSST Program Exit Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive Professional Development</td>
</tr>
<tr>
<td>The MSSST program is a great idea and I am incredibly thankful for it. As a biology teaching major it was hard to teach about earth science which is a part of my curriculum, but now I feel much more comfortable and am able to come up with better lesson plans because of the MSSST program.</td>
</tr>
<tr>
<td>I have, as have so many others, attended conferences and workshops where a lesson of some sort was required at the end. Each time it was a joke. This was different because the new format was taught explicitly and then, immediately after we began working on it. I have been more resistant to best practice science teaching for a while now. I think that if I were not to have been a participant, I would still be so. I am quite happily surprised to see that I am more motivated to be a better teacher and actually apply what I know.</td>
</tr>
<tr>
<td>The program was an excellent opportunity to apply some of the ideas of scientific investigation that I teach my students. My faculty mentor and the other faculty were helpful.</td>
</tr>
<tr>
<td>Excellent program. All my expectations were met or exceeded. Courses were relevant, different and gave a solid understanding of Earth Science and science in general. Participating in science (research) and field work were the highlight.</td>
</tr>
<tr>
<td>My teaching philosophy has been drastically altered by these experiences and the TRF workshop helped me learn how to use 3D methods in my class to make sure students are getting the same learning experiences. Thank you for this entire experience! For the first time, learning in my classroom makes more sense!</td>
</tr>
<tr>
<td>Support</td>
</tr>
<tr>
<td>I feel more connected to the scientific education community after this program</td>
</tr>
<tr>
<td>I loved the research experience and the cohort set up. I would not have survived the program without that collegiality and support.</td>
</tr>
<tr>
<td>Future Plans</td>
</tr>
<tr>
<td>Wish I could do more and would love to help develop content and teach teachers how to REALLY teach.</td>
</tr>
<tr>
<td>Appreciation</td>
</tr>
<tr>
<td>Thank you for investing in me. I am very grateful for this experience.</td>
</tr>
</tbody>
</table>
Alumni satisfaction

The success of our programs is indicated by employment opportunities pursued by our alumni. Here is a sample of alumni titles/employers:

- Vice President and Chief Engineer, Summit Lynch Consulting and Engineers
- Professor of Physical Geology, Sierra College
- Design Engineer, Texas Instruments
- Senior Geologist, Chevron Exploration & Production Company
- Hydrogeologist, USA Corps of Engineers
- Environ. Geologist, Groundwater Technology Inc.
- EVP, Exploration & CSO, NEOS Geo Solutions
- Senior Seismologist and Geologist, AECOM
- Managing Partner, Calder Richards Consulting Engineers
- VP of Exploration & Capture, Hess
- Regional Technology Manager, Ch2M Hill
- Chairman and CEO, Orogen Energy
- Professor & Chair Geology & Geodynamics, Universität Tübingen
- Director of Environmental Health & Safety, University of Wyoming Dept. Environ. Health & Safety
- Chief Geologist, California Resources Corporation
- President, Sustainable Research Technologies
- Principal Scientist, Sandia National Laboratories
- Director Geothermal Technologies, US Department of Energy
- Director of Environmental Risk, KPMG LLP
- CEO, Baytex Energy Corp.
- President, Freeport-McMoRan Copper & Gold
- Environmental Sustainability Manager, Intel Corporation
- Senior Vice President, Exploration and Development, Whiting Petroleum Corp.
Over the last 5 years the Department of Geology and Geophysics has received an average of $791,313 in donations from an average of 454 gifts per year. These gifts come from alumni and friends of the department as well as corporations and foundations. Many of the gifts from corporations and foundations are made possible through alumni who advocate with their company on behalf of the department.

Alumni stories reported to Development Officer:

- I recently met with an alumna who said that the Department of Geology and Geophysics at the University of Utah is her family and that she fondly remembers her time here. She is very grateful for the education she received that prepared her for a career as a geologist with the United States Navy.
- In a meeting this week I saw an alumnus of our department get visibly emotional talking about the love he has for the department and how well it prepared him for a career in geology. He spent 24 years on the faculty at another university including time as department chair in Geology. He mentioned how meaningful his experience was here and how grateful he is that he chose the University of Utah.
- While in Denver last week I met with two women who graduated from the department around the same time. One is now working as a geophysicist for Anschutz Exploration and the other has her own consulting company working on earthquake studies. They credit the department with getting them into great jobs and helping them develop a lasting friendship.
- Recent regional alumni events in Houston, Seattle and Denver have been very well attended. Our recent open house/presentation by Dr. Chan was standing room only. We filled the auditorium and two overflow rooms.

Many alumni come back to speak in classes, meet with professors or attend open house events. The department has incredibly loyal alumni and everyone I speak with tells me about how influential the professors were for their learning and preparation for their careers.
5.3 Degree completion data

**Figure 5.3. Degrees Awarded by Academic Year (data from OBIA)**

Undergraduate degree completion numbers have increased steadily over the last several years. The number of PhD students completing their degrees has remained fairly static, while MS completion has increased.
Table 5.3.1: Enrollment in Earth Science Composition Teaching Major

<table>
<thead>
<tr>
<th>Academic Year</th>
<th># Majors in ESCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010-11</td>
<td>5</td>
</tr>
<tr>
<td>2011-12</td>
<td>7</td>
</tr>
<tr>
<td>2012-13</td>
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</tr>
<tr>
<td>2013-14</td>
<td>9</td>
</tr>
<tr>
<td>2014-15</td>
<td>8</td>
</tr>
<tr>
<td>2015-16</td>
<td>3</td>
</tr>
<tr>
<td>2016-17</td>
<td>2</td>
</tr>
</tbody>
</table>

Enrollment in the Earth Science Composite Teaching (ESCT) major has been fairly low from year to year, with enrollment peaking at 9 in 2013-14 (see Table 5.3.1). Fifteen teachers have graduated from the Earth Science composite major in the last 10 years.

For the MSST program, 94% (15 of 16) teachers in the 2013-2015 cohort graduated on time with their cohort. One teacher did not graduate due to failing performance in coursework. All (16 of 16) teachers in the 2015-2017 cohort graduated on time with their cohort. The high retention and graduation rates are attributed to: 1) careful screening of applicants, 2) selection of faculty instructors and mentors who were supportive of these non-traditional students and were able to accommodate their full-time teaching schedules and highly variable backgrounds, 3) a plan of study designed to deepen teachers’ understanding of the content in the Utah State Science Core, and 4) a monthly cohort seminar where teachers developed professional skills in terms of content-based pedagogy and leadership, 5) highly subsidized tuition through grants to the MSSST program from federal and state agencies.
Table 5.3.2: Graduate Degree Completion/Attrition Data  
Department of Geology and Geophysics 2010-2017

<table>
<thead>
<tr>
<th>Entering Student Cohort Academic Year</th>
<th>Number of students newly enrolled in master’s program</th>
<th>Number of students newly enrolled in doctoral program</th>
<th>Number of students in cohort who left before completing master’s degree</th>
<th>Number of students in cohort who completed master’s degree</th>
<th>Number of students in cohort who left before completing doctoral degree</th>
<th>Number of students in cohort who completed doctoral degree</th>
<th>Average time to complete master’s degree</th>
<th>Average time to complete doctoral degree</th>
<th>Number of students in cohort remaining in graduate programs</th>
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</thead>
<tbody>
<tr>
<td>2010-11</td>
<td>17</td>
<td>2</td>
<td>3</td>
<td>14</td>
<td>1</td>
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<td>3</td>
<td>5</td>
<td>1</td>
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<tr>
<td>2011-12</td>
<td>20</td>
<td>6</td>
<td>3</td>
<td>17</td>
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<td>4</td>
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<td>4.75</td>
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<td>6</td>
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<td>13</td>
<td>2</td>
<td>2</td>
<td>2.3</td>
<td>3.5</td>
<td>6</td>
</tr>
<tr>
<td>2013-14</td>
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<tr>
<td>2016-17</td>
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<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>7</td>
</tr>
</tbody>
</table>
5.4 Employment

The national job outlook for geoscientists and geological engineers is estimated each year in the government’s Occupational Outlook Handbook. Their current projection is:

“Employment growth of 18 percent is expected for geoscientists and hydrologists between 2008 and 2018, which is faster than the average for all occupations. The need for energy, environmental protection, and responsible land and water management will spur employment demand... Graduates with a master's degree in geoscience can expect excellent job opportunities, but Ph.D.s may face competition for research and college teaching jobs.”

“Mining and geological engineers, including mining safety engineers, are expected to have employment growth of 15 percent over the projections decade, faster than the average for all occupations.”

An informal faculty survey of graduate student job placement for students graduating from our graduate programs shows that for the students for whom data were available since 2010 (n=93), 35% moved on to positions in the oil and gas industry, 32% of the graduate students have gone on to academic positions (pursuing additional advanced degrees, postdocs, and faculty positions), 16% have positions with government agencies (including Utah Geological Survey, US Geological Survey, national laboratory positions, EPA positions, etc.), ~8% have gone on to positions with environmental consulting or remediation firms, and 2% have gone on to teaching positions.

For the MSSST program, 93% (14 of 15) teachers from the 2013–15 cohort are still teaching or working in Utah public schools. One teacher left the profession to start a family. At least four teachers are teaching in IB/AP programs. Several are heads of the science departments at their respective schools. 93% of the 2015–17 cohort is still teaching or working in Utah public schools and one teacher is teaching in California. One graduate is currently the head of the Salt Lake City School District Science Department. Another is head of the Alpine School District Science Department. One teacher will be departing the teaching profession at the end of the 2017 school year to pursue a PhD in Science Education.