Geoscience Service-Learning Literature Themes

April 5, 2016

This background document provides information on the service-learning research in the geoscience field in preparation for the National Academy of Sciences (NAS) Service-Learning in Undergraduate Geosciences Workshop, April 20-21, 2016. The document is built on the literatures searches done by the NAS, examples on the Science Education Resource Center (SERC) site, examples from Campus Compact, and Geological Society of America (GSA) abstracts. Some additional examples or materials are added from the "education for sustainable development" areas. Given the timeframe for the project, this is not an exhaustive review of the literature. Rather, this document is designed to start the conversation around the workshop questions. This document outlines the themes found in the literature and includes examples of courses. The executive summary describes the themes in a summarized format without any of the examples courses. The full document includes themes and example courses.

Suzanne Savanick Hansen and Sarah Fortner authored this report. Thank you also to Ed Laine for reviewing and contributing to the document.

Source: Wordle from GSA abstracts from Sarah Fortner described in the text

Contents

Executive Summary

1) **Workshop Question: What types of service-learning activities are currently being implemented within the geosciences community?**

A theme in the literature is the emphasis on interdisciplinary research/outreach, problem-based learning, real-world problem solving, and place-based learning. Although these areas can be included under the umbrella term of "service-learning", they do not necessarily use the standard service-learning tactics such as formal reflection papers. Many of these classes have students develop outreach material about geoscience research and present it to community members. Other examples adapt a traditional approach that includes reflection, but incorporates new modern emphasis on career-relevant skills and new open source technology.

In general, geology, particularly hydrology and water quality is popular for service-learning. In the atmospheric science area, service-learning classes tend to be climate change related. In the polar science area, the service-learning examples were typically outreach related, such as presenting research to a community.

Sustainability is emerging as a theme in higher education in general and many of the geoscience service-learning projects are also sustainability projects. The community has greatly expanded participation in interdisciplinary geoscience sustainability curriculum through the InTeGrate Program.

Geological Society of America Meeting abstracts were queried using the terms 'undergraduate service-learning' and 'undergraduate community based' for the conference years 2001-2015. The two most common curricular categories for retrieved GSA submissions were environmental and water. In addition, the central habits, skills, and connective-themes common in service-learning have grown in popularity in geoscience over this short period.

2) **Workshop Question: What are the learning goals of service-learning experiences and what student outcomes are measured?**

The assessments of the service-learning classes overwhelmingly report that these activities improve student engagement with the classroom material. In addition, students learn the technical skills, process of science skills, change agent skills, communication skills, collaboration, project management and metacognition.

3) **Workshop Question: What is known about best or effective-practices in geoscience service-learning programming (e.g., identify design principles, describe what students benefit the most, and explore the influence of handbooks and toolkits)?**

This project only looks at the literature and examples in the geoscience area, so the handbooks and tools for service-learning in general are outside off the scope of this project. SERC modules on Service Learning are noted in the main document as well as other handbooks/toolkits from the sustainability literature.

4) **Workshop Question: Is there evidence that these types of experiences lead to increased engagement/attainment in geoscience? Is there evidence about the impact on attracting underrepresented minority students to the geosciences?**

As noted above, the literature notes an increase in student engagement with service-learning projects, however there is little research focused on underrepresented groups.

5) **Workshop Question: How does service-learning fit within the preparation of future geoscientists? Would such as activity be perceived positively by future employers?**

The skills that the students learn in service leaning type classes are the ones that are needed for obtaining jobs. In this preliminary review, I did not find information on geosciences in particular. What I found is information in the sustainability literature on the related questions: *What do students want*? Millennial students care about making a difference. *What do employers want?* Employers want the skills and soft-skills that students are likely to learn in service-learning classes. *What does society need from graduates?* Society needs informed future citizens/consumers.

6) **Workshop Question: What are the challenges/obstacles to implementing these programs and expanding access to successful programs/approaches to programing?**

Challenges include a lack of faculty connections to community organizations, lack of faculty access to possible projects, and lack of time to develop the service-learning component. Other themes in this area include the perception that service-learning classes take more time, are harder to implement, and that service-learning lacks academic rigor.

7) **Workshop Question: What key research questions need to be addressed to better understand the potential contribution of service-learning in the geosciences?**

These are questions noticed that might serve as a start for a discussion:

What barriers are preventing educators from including service-learning in their curricula and how can they be addressed effectively?

What types of service-learning and accompanying assessments are best practices for acquiring:

- Increased interest in further study, research and community engagement
- Increased understanding of quality research and service-learning
- Skills to create beneficial stakeholder engagement and systemic change

How can the geosciences uniquely contribute through service-learning to help solve society's grand challenges?

How can the geosciences work effectively with other disciplines and Campus Compact to grow the use of quality interdisciplinary service-learning?

The information below summarizes the themes in the literature and from searches on the SERC and Campus Compact service-learning collections. It is organized around the workshop questions. When several questions were listed, the most relevant question to what I found was listed.

1) Workshop Question: "What types of service-learning activities are currently being implemented within the geosciences community?"

Types of Geoscience Courses Using Service Learning

The themes in the literature emphasize interdisciplinary research/outreach, problem-based learning, real-world problem solving, and place-based learning. Although these areas can be included under the umbrella term of "service-learning", they do not necessarily use the standard service-learning tactics such as formal reflection papers. Many of these classes have students develop outreach material about geoscience research and present it to community members. Other examples adapt a traditional approach that includes reflection, but incorporates new modern emphasis on career-relevant skills and new open source technology. For example Guertin, 2016, developed a course around building information literacy, higher order thinking, and communication skills. Participating introductory geology students at Penn State Brandywine crafted podcasts around partner identified needs. They conduct research and then work with a media communication specialist that helps them identify strategies for their podcast.

In general, geology, particularly hydrology and water quality, is a popular topic for service-learning. In the atmospheric science area, service-learning classes tend to be climate change related. In the polar science area, the service-learning examples are typically outreach related, such as presenting research to a community. However, no polar examples are included in the SERC or Campus Compact collections.

In the SERC service-learning collection, which features undergraduate course activities and courses, 58 activities are listed, of which 26 are tagged as geoscience. Of these geoscience activities, 14 are in hydrology, 8 in geology, 5 in atmospheric science, 3 in oceanography, and 3 in soils. Also noteworthy is that, of these 58 service-learning activities, 33 are also tagged as environmental science.

Given the breadth of practices and the strong place-based emphasis of many efforts, the Service Learning module on the SERC site also links to related modules on "experience-based education" (http://serc.carleton.edu/introgeo/enviroprojects/index.html) and "campus living laboratory" (formerly campus based education) (http://serc.carleton.edu/introgeo/campusbased/index.html).

Another related area is connecting classes with collaborative or citizen science where classes collect data used by a researcher. The scales of implementation range from a single course to a program that includes multiple courses. Institutions with civic engagement or service-learning offices often help faculty implement institutional programs.

Sustainability Theme

Sustainability is emerging as a theme in higher education in general and many of the geoscience service-learning projects could also be seen as sustainability projects. In general, sustainability education is a growing theme in higher education. There are now nearly 2,000 new degrees and programs related to sustainability, a 57% increase from 2008 and 2012 (Vincent, et al. (2013). To date, over fifty national higher education associations are part of the Higher Education Associations Sustainability Consortium or the Disciplinary Associations Network for Sustainability (DANS), including the National Association of Geoscience Teachers.

The term "education for sustainable development" (ESD) is a term most widely used outside of the United States, but is growing as a strong national trend within the US as well. ESD "enables people to develop the knowledge, values and skills to participate in decisions … that will improve the quality of life now without damaging the planet for the future." (UNESCO, 2015) Increasingly, ESD is recognized as essential to higher education's mission of making the world a better place and preparing students for the world in which they will live. In addition, the components of quality sustainability assignments (i.e. focus on creating solutions and solving real world problems) improves both student learning and recruitment, and is increasingly expected by both students and employers (Savanick Hansen, S and Rowe D (2016).

The SERC site also hosts "Sustainability Improves Student Learning", developed with leadership from NAGT as part of a US Department of Education grant. It lists disciplinary resources for geoscience, as well as other STEM disciplines. One abstract from the 2015 AASHE conference, "Making the Geoscience Curriculum More Sustainable" described how Eastern Connecticut State University is modifying the traditional geoscience curriculum so that it more fully addresses sustainability issues.

The SERC community has greatly expanded participation in interdisciplinary geoscience sustainability curriculum through the InTeGrate Program (Gosselin et al., 2013). The InTeGrate Program supported the construction, pilot, and review of sustainability curricular modules and courses that bridge the geosciences with other disciplines and support faculty in diverse institutional settings (O'Connell et. al., 2015). The InTeGrate-developed materials largely feature ESD ideas through engaging students in the exploration of authentic data and providing opportunities for reflection on learning and identifying personal connections to content. The curricular rubric used to design and revise materials also features the skills and habits of professionals, systems thinking, and interdisciplinary thinking. All developed materials are student-centered with high levels of student engagement and reflection on content. The program also supports 16 implementation programs that expand sustainability practitioners through designing and implementing built InTeGrate resources or adapting curricular elements from InTeGrate to support projects in a variety of settings and scales (e.g. program level vs. multi-institutional) (InTeGrate Program, 2015). Several of these implementation efforts expand InTeGrate concepts woven into supporting the design and implementation of service- learning projects (e.g. that feature authentic data, grand challenges to sustainability, and reflection opportunities on service and student learning).

Despite the links between geosciences and sustainability and the example courses and resources listed on the SERC site, there was little literature linking geosciences and ESD present within the search of the Sustainability Hub on the Association for the Advancement of Sustainability in Higher Education (AASHE) for the term "service-learning". Of 274 results, but only eight results were pulled for "geosciences". This hub is not a curricular center but it does

show that other disciplines are more engaged in reporting their work via AASHE. For understanding impacts on students, it would be worthwhile for the geoscience educators to participate in the Sustainability Literacy Test. This tool assesses the minimum level knowledge in economic, social and environmental responsibility for higher education students, and is currently used in 30 countries (http://www.sustainabilitytest.org/en/substainability_home).

Chalkley (2010) notes that the traditional career path for geosciences in petroleum-related careers may be one reason that the geosciences are lagging in embracing ESD. She also cites research done in the UK by Jones et. al (2008) as confirming this challenge.

Geological Society of America Abstracts

Geological Society of America Meeting abstracts were queried using the terms 'undergraduate service-learning' and 'undergraduate community based' for the conference years 2001-2015. Of those, only abstracts that featured undergraduates, service, and/or project work that served partners or informed new audiences were compiled. These are provided in Supplementary Table 1. In total, 47 abstracts were retrieved. This is likely an under-sampling with other terms such as 'outreach' would likely result in more examples.

Described efforts strongly favored giving students opportunities to conduct research (33 examples) over examples that were service focused. At the course level, Petcovic et al., 2012 described an environmental geochemistry course at Western Michigan University designed around evaluating the eutrophic and salt loading status of a local lake. Program-level efforts included using community projects in service to partners as program connective opportunities that support scaffolding between classes (Fortner et al., 2012, 2015). At the institutional level, Indiana University Purdue University at Indianapolis has a core service-learning program, the Center for Earth and Environmental Science, that connects geology and environmental science students with partners including scientists and parks managers who collect data and perform land restoration activities (Salazar et. al., 2004). After completing their experiences, students complete a reflection and write a supporting research paper. At the multi-institutional level, an example by Argyilan, 2012, described the Great Lakes Innovative Stewardship through Education Network (GLISTEN), which partners with many stakeholders that support student Great Lakes research, restoration, and outreach. Faculty build supporting curriculum that features higher-order thinking (i.e. hypothesis-testing). Instructional strategies were focused on providing relevant strategies needed for project success with combined exercises, lectures, and lab activities.

A few abstracts described paired or tiered efforts where one group of students primarily gained research expertise and another participated in an outreach component. For example, Kelso et al., 2014 detailed the Geological Reasoning and Natives Investigating the Earth (GRANITE) program which offers underrepresented high school students opportunities to conduct field research. Lake Superior State University builds project-centered research to build qualitative, communication, and teamwork expertise. The program has resulted in over 33% of participants intending on majoring in STEM fields with 100% indicating an interest in attaining college degrees. Interestingly, of the service-learning abstracts compiled, four mention working with and serving tribal leaders. Bueno-Watts (2015) conveyed that the Sustainable Land and Water Resources (SLAWR) Research Experience of Undergraduate (REU) students performed research activities informed by elders, tribal resource managers, and cultural guides who informed student research and service project design. Results were shared across teams to maximize learning.

Multiple other examples serve other underrepresented groups with noted success, and myriad examples served underrepresented groups, suggesting a potential strong thread of supporting and serving those who are underserved. One example includes Oceans of Opportunity, which delivered peer-based instruction of oceanography to roughly 300 predominantly African-American K-12 students, included a portable science outreach bus, and developed outreach activities based on modeled ODP cores (Christensen, 2006). Additionally, nine undergraduate students from predominantly underrepresented groups completed shelf and salt marsh research. The project pairs a HBCU, Savannah State University, with Georgia State University.

Many examples included multiple curricular themes or interdisciplinary and transdisciplinary themes related to investigating place or improving sustainability or public health (e.g. characterizing metal concentrations). In one example from Bently University, students engaged directly with policymakers in Washington, D.C. after they surveyed Northeastern small businesses on their attitudes re: energy (Szymanski et al., 2011). This activity inspired four U.S. Senators to draft letters to the Environmental Protection Agency (EPA) and Small Business Association (SBA) highlighting students' conclusions and seeking a memorandum of understanding between agencies.

The titles of GSA abstracts were further examined using a word count visualization called Wordle, which provides a fast and visually compelling way to gain rapid insight into potential themes (McNaught and Lam, 2010). Abstract titles were analyzed after reducing similar words to the same word (e.g. community-based to community) (see Fig. 1). The generated word cloud was limited to the top 50 words. While this tool is not a stand-alone research tool, it generates word clouds with more frequently occurring words appearing in larger text. Dominant words include are '*undergraduate' 'service' 'learn'* and *'community'*, *'environment' 'water' 'ocean' 'soil' 'sustainability'* and *'geochemistry'*. The built linkages between students and partners and/ or audiences that have distinct interests also support the high-frequency of connotated words, including '*collaborative' 'transdisciplinary'* and '*integrate'*. The generated word cloud also features the word *international*, which may not be the dominant place where U.S. service-learning occurs, but does demonstrate that six abstracts were at international field sites.

Figure 1. Word cloud generated from GSA service-learning related abstract titles from 2001-2015 created in Wordle.

The two most common curricular themes for retrieved GSA submissions were environmental (n=12) and water (n=9). Three examples featured applied skills, such as GIS, or developing cisterns or other water quality needs of developing countries. For example, an abstract by Kathleen Bower at Eastern Illinois University described a development project in Haiti where students partnered with an Illinois charitable organization and financed cisterns (2006). Students researched construction techniques. During cistern installation, students learned that not all strategies they thought would work were the best solutions.

In addition, the central habits, skills, and connective-themes common in service-learning have grown in popularity in geoscience over this short period. Similar to the abstract retrieval using keywords, GSA abstracts were queried by concepts identified in the word cloud and by other connective words associated with implementing service-learning examples. Of these searches, the word '*applied*' increased by the greatest total number (see Fig. 2). Of the terms that were associated with more than 100 submissions during the 5-year comparison periods (i.e. 2001-2005 vs. 2011-2015), the search terms '*collaboration'* and *'partnership'* increased by the greatest percentage (59% and 58%, respectively). All terms queried increased by more than 40%.

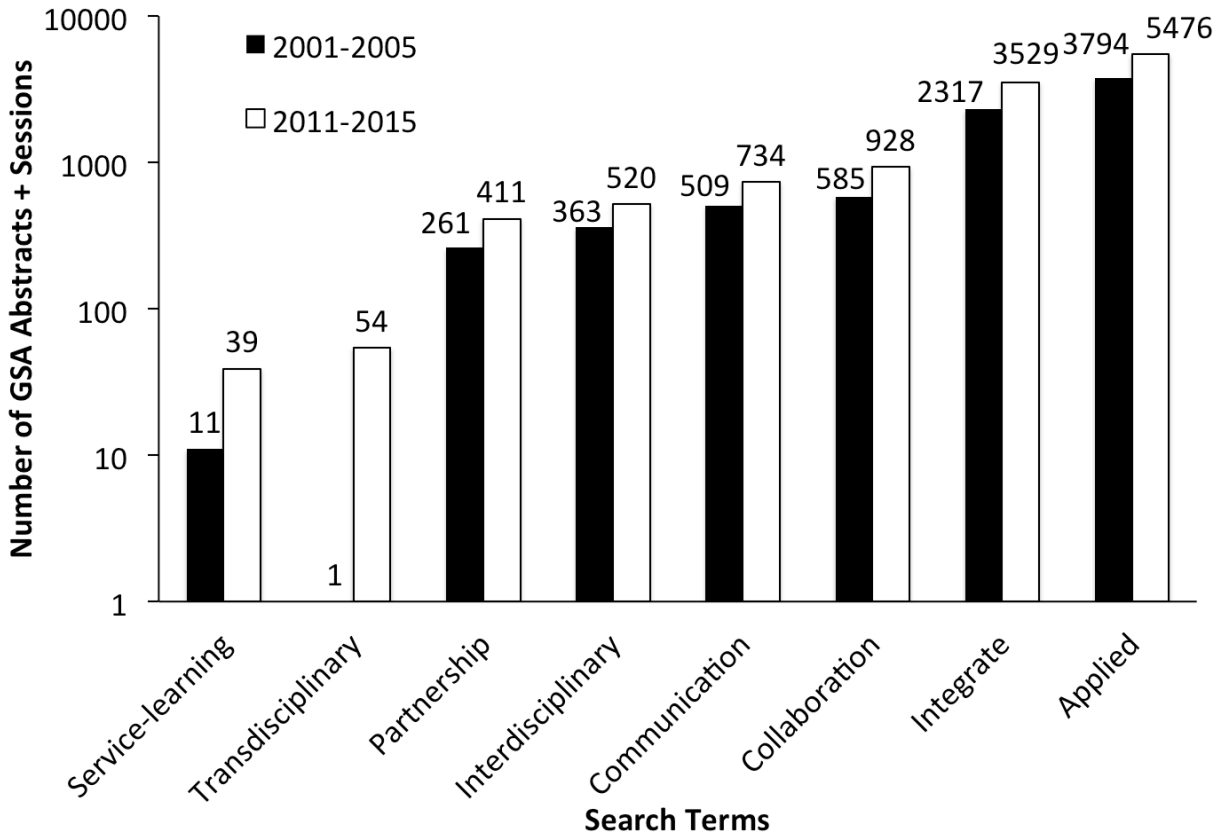

Figure 2. The number of retrievals in GSA abstracts by search term is provided for 2001-2005 and 2011-2015.

Examples of Service Learning Classes

Below are examples in each of the geoscience areas listed by project title, if provided. Examples are primarily from the SERC submissions but also include a few outside additions for disciplinary-breadth.

- **Geology, hydrology/water quality**
  - *Service Learning and Local Hydrogeology in the Classroom: An example from Anchorage, Alaska*
    - Summary: This project is designed to introduce students to a local hydrogeologic problem or issue of interest to the community. The project requires the students to learn about their local groundwater environment and apply principles and concepts that they learn in the classroom to an issue that is of concern to the public. This project provides a good introduction to "real world" problems that the students are likely to encounter as professionals. Students are required to synthesize information from a variety of sources and develop their own assessment of the problem and also to make recommendations based on their professional opinions.
      http://serc.carleton.edu/NAGTWorkshops/hydrogeo/activities/10042.html

- *Reducing pressure on a wastewater treatment plant to accelerate remediation of a polluted harbor*
  - Summary: Students present posters to community partners with strategies to reduce the quantity of water entering a local wastewater treatment plant or to improve the quality of water that needs to be treated. The strategies must be achievable and economic for the majority of people in the community. The presented information will also be summarized in an electronic format for community partners to use in the future for their advocacy work. http://serc.carleton.edu/NAGTWorkshops/servicelearning/activities/39020.html
- *Arsenic on Main St., Unity ME*
  - Summary: The ultimate plan is organizing a "Water Quality Fair" for residents of the Unity, Maine area. Students would analyze water samples brought into the community center for common water quality issues. As a pilot project, students taking analytical chemistry will analyze water samples contributed by employees of Unity College to determine the arsenic concentration and hardness during the last two weeks of April, 2010. In every case, various data about the water source will be recorded to begin assembling a water quality data base for this part of the state. Products may include student-designed brochures about water quality, lessons for K12 students developed by pre-service teachers, any other good ideas students come up with. This project is expected to "feed" student/faculty research including undergraduate theses, a publishable body of scientific work, and possibly samples sites for seasonal or long term sampling. http://serc.carleton.edu/NAGTWorkshops/servicelearning/activities/39589.html

- **Geology, soils**
  - *Investigating contaminant transport and environmental justice issues in a local watershed through service-learning projects with Sierra Club*
    - Summary: Students will be applying hydrogeology concepts and methods in the lab and the field and conducting interviews as part of a coherent characterization of water quality issues and potential risks in local low-income, predominantly minority neighborhoods. Strengths: activities engage students to relate course material to community needs and challenges, as well as benefit community partners working for change in these communities. http://serc.carleton.edu/NAGTWorkshops/servicelearning/activities/39016.html
  - *Monitoring Lead in an Urban Community Garden*
    - Summary: Students in a 300-level field course collect samples from urban community gardens to monitor soil lead as part of a continual monitoring project. . This continued monitoring helps to identify any areas of concern, and it allows us to also test areas proposed for expansion of the garden. Findings are reported back to the garden manager. http://serc.carleton.edu/NAGTWorkshops/servicelearning/activities/135228.html
  - *Ecotoxicology*
    - Summary: Graduates (~5) and upper-level undergraduate students (~15) from Biology, Chemistry and Geology will learn about the various classes

of toxicants (including those naturally occurring), how toxicants move in ecosystems and within organisms (humans, animals, and plants). Lectures will cover chemical transformations and mechanisms of toxicity. This course will also introduce the students to how controlled toxicity experiments are conducted, how data is reduced, and the power of statistical analyses to identify significant effects. A case study approach will be utilized in lecture and labs to examine the toxic effects of acidification, heavy metals, PCB, insecticides, and environmental endocrine disrupters. Students will learn about important endpoints and bioindicators of toxin exposure specific to each class of toxin and how they are used to determine human/ecological risk assessment. A service –learning component of the course will require students to conduct an independent group toxicology project with their choice of community partner. http://compact.org/resource-posts/ecotoxicology/

- **Atmospheric science**
  - *Campus Greenhouse Gas Emissions Inventory*
    - Summary: Students conduct a greenhouse gas emission inventory for their college or university as a required part of the American College and University Presidents Climate Commitment. Students analyze findings and present information to the college or university community and the Presidents' Climate Commitment committee. http://serc.carleton.edu/introgeo/campusbased/examples/greenhouseinv.html
  - *Local Solutions to Global Climate Change Created Collaboratively with a Science Museum*
    - Summary: Consequences of global climate change already include increased drought, heat waves, flood intensity, glacial retreat, and sea level rise. Solutions are needed to reduce human impact on our climate system and to respond to climate change impacts across sectors vital to humanity (food, water, health). This course examines climate change at global and local scales. Students explore climate challenges faced by local experts and create climate literacy modules collaboratively via iteration with science museum experts for a public event. This collaboration supports improved science literacy and communication. They reflect on implications for future problem solving. http://serc.carleton.edu/NAGTWorkshops/servicelearning/courses/127425.html
- **Oceans**
  - *Marine Environmental Geology*
    - Summary: Marine Environmental Geology is a problem-based service-learning course that focuses on addressing water quality issues in nearby Casco Bay. Working with our community partner, The Friends of Casco Bay, a nonprofit watchdog group, our students, study the problems posed to them and propose a program of field study, which they carry out. Working in small groups they analyze their data and present their findings orally, as posters, and as a final report. In addition to preparing them to do these projects, traditional lectures and labs briefly cover plate tectonics, sea level change, the oceans and climate change, and global fisheries. http://serc.carleton.edu/introgeo/service/examples/marineenvgeo.html

- **Polar**
  - Juneau Icefield Research Program (JIRP)
    - Summary: Juneau Icefield Research Program (JIRP) students share their glacier in a public blog. Without internet support, blog posts are sent for upload via helicopter support. Students receive lecture training in science communication (Timm et al., 2012). JIRP also has a long history of having students present research to the Atlin, B.C. community at the end of the research expeditions. This community has a vested interest in the glaciers near them.
  - *Svalbard REU program*
    - Summary: A Svalbard REU program asked undergraduates who have performed Arctic climate, water, and fjord geologic development research perform presentations to public audiences (Werner, A., et al., 2016)

Service Learning Course Examples by Level

The geoscience classes range from the introductory level courses through the advanced level, though more classes are listed at the introductory level.

- **Introductory level example**
  - *The Geoscape of Bozeman, Montana*
    - This project involved students in in-depth research, thus understanding, of the geological setting of Bozeman. Teams defined the scope of their investigations (with faculty oversight) and delegated tasks to build a knowledge base. This understanding lead to the outreach component – a poster session to present this knowledge to the campus and broader community. The poster contents were submitted in a digital form as well.
    - The long-term goal is the compilation of a printed poster (suitable for the Chamber of Commerce, for example, to distribute) analogous to those produced for the Geoscape Canada project. http://serc.carleton.edu/NAGTWorkshops/servicelearning/activities/39375.html

- **Advanced level example:**
  - *Service Learning Practice in Upper Division Geoscience Courses: bridging undergraduate learning, teaching and research*
    - Summary: Service-learning practice has been implemented in a number of upper division geoscience courses taught at the University of Connecticut. This article describes the objectives for implementing service-learning as well as the responses from participating students and community leaders to the practice. The authors find that service-learning has the capacity to foster learning, teaching, and undergraduate research, and facilitates multi-lateral interactions among students, faculty members, and local town public work professionals

- **Traditional service-learning example**:
  - Oceanography Extra Credit Beach Cleanup: Service Learning in Action
    - Students in an undergraduate general oceanography course clean local beaches for three hours as part of an organized beach cleanup event. As students pick up trash at the beach, they think about how the trash got

there and write about their reflections afterwards. As an optional activity, the students can also sort their trash and make a list of the number and type of items collected (http://serc.carleton.edu/NAGTWorkshops/servicelearning/activities/129095.html).

- **Research outreach example**
  - Hydrology Service-Learning at UVM
    - Summary: At the University of Vermont, instructors used land use change, driven by development of the University of Vermont campus and recent student occupancy of surrounding neighborhoods in Burlington, Vermont, as an opportunity for service-learning and for teaching fundamental hydrologic and geologic skills in two undergraduate Geology courses. Two students, from a Geomorphology class, used historical maps and aerial photographs of the University campus to document the dramatic increase in impermeable surfaces on campus from 4% of the land area in 1869 to 42% in 1999. In Geohydrology, student teams used aerial photography, field mapping, and door-to-door surveys to document green space losses of 40 to 50% over the past 20 years in neighborhoods inhabited predominantly by students, despite zoning controls enacted in 1973. Students used simple hydrologic calculations to demonstrate that this unregulated change in land use increased both the volume and peak flow of stormwater runoff. Senior research projects have also made field and demographic studies of individual neighborhoods and examined the percent of land use change.

2) Workshop Question: What are the learning goals of service-learning experiences and what student outcomes are measured?

Assessments of the service-learning classes (as well as the other similar classes that are considered project based or real-world), overwhelmingly report that these activities improve student engagement with the classroom material. Studies often use class evaluations or student reflection papers to show this effect (Hashmi & Carlson, 2012; Prokopy, Williams, Bowling, & Thompson, 2014). In addition, students learn technical skills, process of science skills, change agent skills, communication skills, collaboration, project management and metacognition. Examples include: Tedesco and Salazar (2006), (Shriberg and Harris, 2012). The skills that the students learn are the ones that are needed for obtaining jobs (Rowe & Hiser, 2016).

3) What is known about best or effective-practices in geoscience service-learning programming (e.g., identify design principles, describe what students benefit the most, and explore the influence of handbooks and toolkits)?

This project only looked at the literature and examples in the geoscience area, so the handbooks and tools for service-learning in general were outside off the scope of this project. However, these handbooks/toolkits were found that link to service-learning:

- Service Learning SERC modules
  - Intro Geo: http://serc.carleton.edu/introgeo/service/index.html
  - NAGT Service-learning Workshop http://serc.carleton.edu/NAGTWorkshops/servicelearning/index.html

Other handbooks/toolkits in related areas, but not necessarily in geoscience:

- The SEED Center: Campus as a Living Lab: Using the Built Environment to Revitalize College Education
- AACC Report: A Guide to Climate Resiliency & The Community College
- Education for Sustainable Development: Guidance for UK Higher Education Providers (2014)
- The Future Fit Framework An introductory guide to teaching and learning for sustainability in HE Author: Professor Stephen Sterling. https://www.heacademy.ac.uk/sites/default/files/future_fit_270412_1435.pdf

4) Is there evidence that these types of experiences lead to increased engagement/attainment in geoscience? Is there evidence about the impact on attracting underrepresented minority students to the geosciences?

As noted above, the literature indicates increase in student engagement with service-learning projects, however little research focuses on underrepresented groups. Some examples of programs designed to recruit underrepresented groups were found such as Powell, Pyrtle, and Williamson-Whitney (2005), "Minorities Striving and Pursuing Higher Degrees of Success in Earth System Science (MS PHD'S) Initiatives Professional Development Program" as well as , "Engaging Native Alaskan Students and Their Community in Local Hot Springs Research: A Project Designed to Increase Geoscience Education". In addition, Riggs, Robbins, and Darner (2007) describe the Indigenous Earth Science Project at Purdue. The program provides both on-reservation education to environmental managers and programs for high school students and younger children. C. Pride and Christensen (2007) describe the Oceans of Opportunity program to increase the number of underrepresented students. C. J. Pride and Olsen (2007) also describes outreach program for increasing African American teachers in informal education

settings. One example was found on the Campus Compact site that involved students from historically underrepresented populations.

- FOCUS (Fostering Our Community's Understanding of Science): Service Learning Experience
    - Summary: This course facilitates a partnership between area public schools and the University of Georgia. Students enrolled in this course will spend significant time in a local elementary school assisting a classroom teacher in science instruction. http://compact.org/resource-posts/focus-fostering-our-communitys-understanding-of-science-service-learning-experience/

5) How does service-learning fit within the preparation of future geoscientists? Would such as activity be perceived positively by future employers?

As noted above, the skills that the students learn in service-leaning type classes are the ones that are needed for obtaining jobs (Rowe & Hiser, 2016). In this preliminary review, there was little information on the geosciences in particular, though this information could be available in other areas outside the scope of this project. What I found is information on the related questions: What do students want? What do employers want? What does society need from graduates? Much of this information is in the sustainability education area. In case it is useful for the discussion, it is included below.

What do students want?

Millennial students are drawn to classes that have a potential to make a difference. A survey of graduate students by Net Impact found that most graduate students care about impact issues and 83% are willing to take a 15% pay cut to have a job that seeks to make a social or environmental difference in the world (Net Impact, 2014). One example in the literature is, an AGU abstract from 2010 used a student's quote in the title: "I Didn't Realize that Science Could Be So Useful: Integrating Service Learning and Student Research on Water-Quality Issues within an Undergraduate Geoscience Curriculum" (Lea & Urquhart, 2010).

What do employers want?

The most commonly cited report is Hart Research Assoc. and AAC&U (2015). The report notes that employers note that both field-specific knowledge and a broad range of knowledge and skills are important for recent college graduates to achieve long-term career success. The learning outcomes they rate as most important include written and oral communication skills, teamwork skills, ethical decision-making, critical thinking, and the ability to apply knowledge in real-world settings. However, employers feel that today's college graduates are not particularly well prepared to achieve these learning outcomes. In addition, the literature on sustainability learning outcomes supports that educating students to participate in solutions for a sustainable future also develops the skills they need to succeed in the workforce for the 21st century (Rowe

& Hiser, 2016). These same skills are the ones that geoscience students learn in service-learning classes.

A resource in this area that is designed for community colleges is the Sustainability Education and Economic Development (SEED) CENTER website (http://www.theseedcenter.org/default.aspx). It's designed for community colleges to incorporate sustainability, but many of the resources are also applicable to geoscience. They have a "Defining the Green Workforce" website (http://www.theseedcenter.org/Resources/SEED-Resources/Defining-the-Green-Workforce) that includes resources about industry and employment studies. The "Community College Green Genome Framework: Integrating Sustainability and Clean Technology Workforce Development into an Institution's DNA" is a guide and institutional self-assessment (http://theseedcenter.org/GreenGenome).

What does society need from graduates?

The important role of educating future citizens/consumers is a theme in the sustainability literature and one that is could be of interest to geoscience. The SERC "Sustainability Improves Student Learning" module notes, "Each educator has a unique and important opportunity to help our students understand the need to use knowledge to care for our global commons and help create a sustainable future" (http://serc.carleton.edu/sisl/index.html). This theme of the importance of new graduates that can rise to the challenges of climate change and designing a sustainable future is pervasive in the "education for sustainable development" literature. Real world problem solving projects are considered a key component of quality sustainability curricula. As numerous undergraduate students take geoscience as a science distribution requirement, this role can be connected to geoscience classes.

6) What are the challenges/obstacles to implementing these programs and expanding access to successful programs/approaches to programing?

Challenges include a lack of faculty connections to community organizations, lack of faculty access to possible projects, and lack of time to develop the service-learning component. Other themes in this area include the perception that service-learning classes take more time and are harder to implement and that service-learning lacks academic rigor.

Example: Strengthening STEM Education through Service -Learning: Highlights from the 2010 Learn and Serve America Higher Education STEM Grants: This report highlights the work of grantees from the 2010 grant competition. Outcomes included an emergence of interdisciplinary projects between STEM and non-STEM departments, student appreciation of the real-world learning and an enhanced understanding of the scientific elements of the course and interest in additional STEM courses. Challenges included a perception that service-learning lacks rigor. Risk management and transportation as well as a sense that service-learning was not valued by institutions (Learn and Serve, undated).

7) What key research questions need to be addressed to better understand the potential contribution of service-learning in the geosciences?

These are questions that I noticed while doing this review. I add them here as a start for a discussion:

What barriers are preventing educators from including service-learning in their curricula and how can they be addressed effectively?

What types of service-learning and accompanying assessments are best practices for acquiring:

- Increased interest in further study, research and community engagement
- Increased understanding of quality research and service-learning
- Skills to create beneficial stakeholder engagement and systemic change

How can the geosciences uniquely contribute through service-learning to help solve society's grand challenges?

How can the geosciences work effectively with other disciplines and Campus Compact to grow the use of quality interdisciplinary service-learning?

References:

Argyilan, E. P. (2012, November). Collaborations in watershed studies in northwest Indiana created through the Great Lakes Innovation Stewardship Through Education Network (GLISTEN). *Geological Society of America Annual Meeting.*

Borowski, W., Frisbie, M., Shepperson, T., Frost, L., Coyne, L., Jeck, (2013, October). Project-oriented science instruction involving general-education & undergraduates serving as mentors to underprivileged middle-school students. In *2013 GSA Annual Meeting*.

Bower, K. M. (2006, October). Applied Research on sustainable resources as undergraduate service-learning. In *2006 Geological Society of America Annual Meeting*.

Buelow, E. K., Mahoney, B. J., Kimbrough, D. L., Taylor, S. S., Nehring, B., Hutter, A., Leidel, A. (2014, October). Linking undergraduate research with community outreach in Argentina: The International Fellows Program at the University of Wisconsin- Eau Claire. In 2014 *Geological Society of America Annual Meeting.*

Bueno Watts,N., Berthelote, A. R., Lichtenberg, J., Patrick, D., Dalbotten, D. (2015, November). Sustainable land and water resources REU: Community-inspired research meets open inquiry. In 2015 *Geological Society of America Annual Meeting.*

Chalkley, B., Blumhof, J., & Ragnarsdóttir, K. V. (2010). Geography earth and environmental sciences: A suitable home for ESD. *Sustainability education: Perspectives and practice across higher education*, 93-108.

Christensen, B. (2006, October). Oceans of opportunity: a tiered approach to increasing minority student involvement in the marine geosciences. In *2006 Geological Society of America Annual Meeting*.

Crane, P., Carr, D., & Guebert, M. (2001, March). Protecting groundwater-source drinking-water supply through undergraduate student learning, teaching, research, and service. *In 2001 Geological Society of America. North-Central Section Meeting*.

Dodd, C., Landau, B., Agosta, E. (2013, October). Monitoring the fluvial system of Boeing Creek (Shoreline, WA): Developing successful service-learning in the geosciences. In 2013 *Geological Society of America Annual Meeting.*

Foos, A. (2006, October). Assessment of service-learning experiences in environmental science and geology. In *2006 Geological Society of America Annual Meeting*.

Fortner, S., Ritter, J., Burgett, A., Finster, D., Hoff, R., Phillips, R. (2015, November). InTeGrate modules and authentic community-based research as sustainability program opportunities. In 2015 *Geological Society of America Annual Meeting.*

Fortner, S. K., Ritter, J. B., Austin, B. A. (2012, November). Integrated service-learning across geoscience courses including biogeochemistry: building depth, scholarship, and community identity. *Geological Society of America Annual Meeting.*

Freile, D., Devore, M. (2006, October). Integrating field experiences in environmental science and community service: Lessons from undergraduate courses taught in San Salvador Island, Bahamas. In *2006 Geological Society of America Annual Meeting*.

Gosselin, D. C., Manduca, C., Bralower, T., & Mogk, D. (2013). Transforming the teaching of geoscience and sustainability. *Eos, Transactions American Geophysical Union*, *94*(25), 221-222.

Greenberg, J. K. (2015, November). Undergraduate service-research via predevelopment surveys. In 2015 *Geological Society of America Annual Meeting.*

Guebert, M., (2008, April) Water resources, sanitation, and community health: An international service-learning program, In 2007 *North Central Section Geological Society of America Meeting*.

Guebert, M. D. (2002, October). Developing-world Water Resources: A proposed international service-learning experience for undergraduates. *In 2002 Geological Society of America Annual Meeting.*

Guertin, 2016, Student-Generated Earth Science Podcasts for a Community Partner, Teaching Service Learning in the Geosciences, retrieved 4/16, from http://serc.carleton.edu/NAGTWorkshops/servicelearning/activities/127457.html

Hart Research Assoc. and AAC&U (2015). *Falling short? College learning and career success: selected findings from online surveys of employers and college students conducted on behalf of the Association of American Colleges & Universities*. Association of American Colleges & Universities.

Hashmi, M. P., & Carlson, K. M. (2012). Interdisciplinary Service Learning: Two Approaches to Solving One Problem. *2012 ASQ Advancing the STEM Agenda in Education, the Workplace and Society. Session 3.1*.

Haywick, D. W., Fierman, L. M., Weber, H. L., Finnegan, W. H. (2006, October). Alabama ROCKS! - A Student community project to equip public school science classes with relevant teaching collections, In *2006 Geological Society of America Annual Meeting*.

InTeGrate Project. (2015) Implementation Programs: Incorporating Geoscience throughout the Curriculum, retrieved on 4/1/16 from http://serc.carleton.edu/integrate/about/implementation_programs.html

Ito, E., Dalbotten, D., Myrbo, A., Pellerin, H., Greensky, L., Howes, T., Drake, C., Woods, P., Wold, A. (2013, October). NSF-OEDG Manoomin Science Camp Project: A model for engaging American Indian students in science, technology, and mathematics. In 2013 *Geological Society of America Annual Meeting.*

Johnson, B., Kargus, S., Steffen, J., Van Cuyk, M., Balza, E., Shears, A. (2013, October). Paying the 48th Nobel Conference forward: using student capstones to creat a curriculum on contemporary ocean issues. In 2013 *Geological Society of America Annual Meeting.*

Jones, G. (2010, November) Incorporating community service-learning into undergraduate geoscience courses, In 2010 *Geological Society of America Annual Meeting*.

Kelso, P., Spencer, M., Brown, L., Sabatine, S. Bouschor, R. (2014, October). Teaching geology in the field: a model for broadening participation and for integrative learning opportunities. In 2014 *Geological Society of America Annual Meeting.*

Koretsky, C. M., Rowbotham, K. L., Petcovic, H. L. (2010, November). Teaching environmental geochemistry an authentic field and laboratory research approach. In 2010 *Geological Society of America Annual Meeting*.

Kuban, A. J. (2015, November). Water Quality Indiana (WQI): How to expand a trans-disciplinary, project-based initiative to other STEM-strapped institutions. In 2015 *Geological Society of America Annual Meeting.*

Laine, E. P., Field, C. K. (2006, October). Problem-based service-learning in an introdury oceanography course. In *2006 Geological Society of America Annual Meeting*.

Lea, P., & Urquhart, J. (2010). ``*I Didn't Realize that Science Could Be So Useful'': Integrating Service Learning and Student Research on Water-Quality Issues within an Undergraduate Geoscience Curriculum.* Paper presented at the AGU Fall Meeting Abstracts.

Learn and Serve Higher Education (undated) Strengthening STEM Education Through Service Learning: Highlights from the 2010 Learn and Serve America Higher Education STEM Grants.

Lincoln, T. (2013, October). The Third 90 Network, a collaborative, interdisciplinary program to support under-represented students and encourage them to pursue careers in environmental sciences. In 2013 *Geological Society of America Annual Meeting.*

Linzmeier, B. J. (2015, May). Undergraduates as communicators of local geological knowledge in a sedimentology and stratigraphy course. In 2015 *Geological Society of America North-Central Meeting.*

L. Lui, A.R. Philpotts, N.H. Gray 2004 Journal of Geoscience Education v52 n2 p172

McNaught, C., & Lam, P. (2010). Using Wordle as a supplementary research tool. *The qualitative report*, *15*(3), 630.

Mogk, D. W. (2003, November). The geology of war—a service-learning project in an environmental geology course. *In 2*003 *Geological Society of America Annual Meeting*.

Moosavi, S.C. (2011, October). The Grand Isle Project: How a place-based service-learning project evolved into a research experience for undergraduates during the BP Oil Spill. In 2011 *Geological Society of America Annual Meeting*.

Net Impact. (2014). *Business as usual: the social and environmental impact guide to graduate programs for students by students, Retrieved from https://netimpact.org/sites/default/files/documents/business-as-unusual-2014.pdf*

O'Connell, K., Bruckner, M. Z., Manduca, C. A., & Gosselin, D. C. (2015). Supporting interdisciplinary teaching about the Earth with the InTeGrate website. *Journal of Environmental Studies and Sciences*, 1-6.

O'Connell, S,, Resor, P., Ku, T. (2006, October). Geoscience service-learning at Wesleyan University: Benefits for students, the college/University and the community. In *2006 Geological Society of America Annual Meeting*.

Ongley, L., Olin, J. (2011, September). Service learning: Moving scientific work into the "real world" In 2011 *Geological Society of* America International Section Meeting, Germany.

Petcovic, H., Koretsky, C., Rowbotham, K. (2012, November). An authentic research approach to teaching environmental geochemistry. *Geological Society of America Annual Meeting.*

Pollock, M., Balven, H., Gerber, T., Palter, J., Jenkins, H., Morgan, L. (2006, October). Experiencing geoscience: Enabling critical thinking through undergraduate research. In *2006 Geological Society of America Annual Meeting*.

Powell, J. M., Pyrtle, A. J., & Williamson-Whitney, V. A. (2005). *Minorities Striving and Pursuing Higher Degrees of Success in Earth System Science (MS PHD'S) initiatives professional development program.* Paper presented at the Proceedings of MTS/IEEE OCEANS, 2005.

Pride, C., & Christensen, B. (2007). *Oceans of Opportunity: Partnerships to Increase Minority Student Involvement in the Marine Geosciences.* Paper presented at the AGU Fall Meeting Abstracts.

Pride, C. J., & Olsen, M. M. (2007). Enhancing diversity in the geosciences through providing HBCU science majors training in natural history interpretation and teaching experiences in predominantly African-American communities. *Journal of Geoscience Education, 55*(6), 550.

Prokopy, L. S., Williams, R., Bowling, L., & Thompson, A. (2014). Service Learning in Natural Resources Classes: Measuring the Impacts on University Students. *NACTA Journal, 58*(3), 202-207.

Riggs, E. M., Robbins, E., & Darner, R. (2007). Sharing the land: Attracting Native American students to the geosciences. *Journal of Geoscience Education, 55*(6), 478.

Ritterbush, L. (2012, November). Cooperative gardens as science outreach education sites. *Geological Society of America Annual Meeting.*

Rowe D. and Hiser K. (2016). Higher education for sustainable development in the community and through partnerships in *Routledge handbook of higher education for sustainable development*, ed. Barth, M., Michelsen, G., Rieckmann, M., & Thomas, I., Routledge, Oxford, UK.

Salazar, K. A., & Tedesco, L. P. (2004, November). Environmental Service Learning and Community Partnerships: Applying Science-Based Solutions to Urban Environmental Problems. In *2004 Geological Society of America Annual Meeting*.

Savanick Hansen, S and Rowe D (2016) Sustainable Development Primer for Higher Education Presidents, Chancellors, Trustees and Senior Leaders, Higher Education Associations Sustainability Consortium (HEASC), Retrieved from http://heasc.aashe.org/sites/g/files/g320266/f/201603/Presidents%20and%20Boards%20Primer-DS.pdf

Schmeisser, K. E., Wright, C. L., Altheide, A. T. (2011, March). Classroom rocks: a service-learning project increasing pedagogical tools for local earth science teachers and K-12 student interested in geology. In 2011 *Geological Society of America* Northeastern and North-Central Joint Meeting.

Silliman, S. E., Crane, P. E., Boukari, M. (2007, October). Two models for student engagement in research within developing countries, In 2007 *Geological Society of America Annual Meeting.*

Sroufe, A., Allen, C., Kuban, A., Florea, L. (2015, March). Promoting public awareness of water quality- showing how trans-disciplinary students connected scientific data to the media. In 2015 *Geological Society of America Southeastern Section Meeting.*

Strait, S., Smith, N. (2010, November). Paleoview3D.org: an example of science education through the development of an open access paleontological data resource. In 2010 *Geological Society of America Annual Meeting*.

Szymanski, D.W., Bucci, G.D., Adams, V.E., Green, D.V., Markow, W.N. (2011, October). Engaging undergraduate students in energy policy through service-learning. In 2011 *Geological Society of America Annual Meeting*.

Taylor, T., Buddington, A. M. (2014, May). The geology of Mirabeau Point Park: An undergraduate service-learning research project. *In 2014 Geological Society of America Joint Rocky Mountain and Cordilleran.*

Tedesco, L. P., & Salazar, K. A. (2006). Using environmental service-learning in an urban environment to address water quality issues. *Journal of Geoscience Education, 54*(2), 123.

Timm, K., Kavanaugh, J.L. and Beedle, M.J., 2012, December. Integrating Science Communication Training and Public Outreach Activities into the Juneau Icefield Research Program. In AGU Fall Meeting Abstracts (Vol. 1, p. 08).

United Nations Educational, Scientific and Cultural Organization (UNESCO). (2016). Education for sustainable development.Retrieved from http://www.unesco.org/new/en/education/themes/leading-the-international-agenda/education-for-sustainable-development/

Vincent, S., Bunn, S, & Stevens, S (2013), Sustainability Education: Results from the 2012 Census of U.S. Four Year Colleges and Universities A study conducted by the National Council for Science and the Environment Retrieved from: http://www.ncseonline.org/sites/default/files/NCSE%202013%20Sustainability%20Full%20Report.pdf

Ward, E., Anderson, T., Hoensch, U., Kalaka, T., Lyman, J., Ostovar, K., Sjostrom, D., Ward, L. (2014) The Yellowstone River Research Center: A model for undergraduate research at small institutions. *In 2014 Geological Society of America Joint Rocky Mountain and Cordilleran.*

Werner, A., Roof, S., Brigham-Grette, J., Retelle, M., and Powell, R., 2016, Svalbard REU, Retrieved March 1, 2016 from https://www.mtholyoke.edu/proj/svalbard/project.shtml

Wilson, E., Breslin, K., Marvelle, K., Thacker, T., Fortner, S., Ritter, J. (2014, October). Soil lead distribution at two sites: implications for lead soil outreach in the Promise Neighborhood, Springfield,Ohio. In 2014 *Geological Society of America Annual Meeting.*

Van Hoesen, J.G., (2004, November). Integrating field-based service-learning into an introductory hydrology course. In *2004 Geological Society of America Annual Meeting*.

Zurn-Birkhimer, S., Kroeger, T., Filley, T., Welle, P., Jenkins, M. (2011, October). Creating a collaborative model for place-based education for Native American Students. In 2011 *Geological Society of America Annual Meeting*.

Supplementary Table 1. 2001-2015 GSA abstracts retrieved using the search terms 'undergraduate' plus 'service-learning' or 'community-based' only community-based examples that mentioned connection with partners were included. The dominant topic of the course, activity, or project is provided. The Recepients are defined as K-12, Campus, Managers (e.g. Watershed, Environmental, Parks), Community (broad or mixed-groups), International, Cloud (broad audience can be reached), & Tribal. Abstracts feature 'research' if they include research-skills beyond information literacy and data collection (e.g. analyses). They feature 'service' if they involve serve audiences beyond their classroom with many applying knowledge and/or communicating information to new audiences. If abstracts refer to specific assessments they will detail or provide assessment results they are marked yes. Only abstracts that specifically mention reflection are checked yes.

Authors	Year	Institution(s)	Title	Topic	Recipient	Research	Service	Assessment	Reflection
Crane, P., Carr, D., Guebert, M.	2001	Taylor University	Protectiong groundwater-source drinking-water supply through undergraduate student learning, teaching, research, and service	Introductory & Water	K-12	Y	Y		
Guebert, M.	2002	Taylor University	Developing-world water resources: a proposed international service-learning experience for undergraduates	Water	International		Y	Y	Y
Mogk, D.	2003	Montana State University	The geology of war--a service-learning project in an environmental geology course	Societal	Campus		Y	Y	Y
Whitman, J.	2003	Pacific Lutheran University	Watershed research: engaging students locally	Water	Managers	Y	Y		
Van Hoesen, J.G.	2004	Green Mountain College	Integrating field-based service-learning into an introductory hydrology course	Introductory & Water	Managers	Y			Y
Salazar, K. A., Tedesco, L.	2004	Indiana University-Purdue University Indianapolos	Environmental service learning and community partnerships: Applying science-based solutions to urban environmental problems.	Environmental& Water	Managers	Y	Y	Y	Y
Pollock, M., Balven, H., Gerber, T., Palter, J., Jenkins, H., Morgan, L.	2006	Duke University	Experiencing geoscience: Enabling critical thinking through undergraduate research	Research Methods	NA	Y			

O'Connell, S,, Resor, P., Ku, T.	2006	Wesleyan University	Geoscience service learning at Wesleyan University: Benefits for students, the college/University and the community	GIS & Geochemistry	Community	Y	Y		
Foos, A.	2006	University of Akron	Assessment of service learning experiences in environmental science and geology	Pre-Service Teachers	Managers	Y	Y	Y	Y
Christensen, B.	2006	Adelphi University	Oceans of opportunity: a tiered approach to increasing minority student involvement in the marine geosciences	Introductory	K-12	Y	Y	Y	
Laine, E. P., Field, C. K.,	2006	Bowdoin	Problem-based service-learning in an introductory oceanograph course	Oceanography	Community	Y	Y		Y
Freile, D., Devore, M.	2006	New Jersey City University, Georgia College & State University	Integrating field experiences in environmental science and community service: Lessons from undergraduate courses taught in San Salvador Island, Bahamas	Field Studies	Community		Y		
Bower, K. M.	2006	Eastern Illinois University	Applied Research on sustainable resources as undergraduate service learning	Environmental & Sustainability	International		Y		
Haywick, D. W., Fierman, L. M., Weber, H. L., Finnegan, W. H.	2006	University of South Alabama	Alabama ROCKS! - A Student community project to equip public school science classes with relevant teaching collections	Introductory	K-12		Y		
Silliman, S. E., Crane, P. E., Boukari, M.	2007	University of Notre Dame, Universite d'Aborney-Calavi	Two models for student engagement in research within developing countries	Applied	International		Y		Y
Guebert, M.	2008	Taylor University	Water resources, sanitation, and community health: An international service-learning program	Applied	International		Y		Y
Jones, G.	2010	Community College, Bellevue College, Lake Washington	Incorporating community service-learning into undergraduate geoscience courses	Overview	NA		Y		
Koretsky, C. M., Rowbotham, K. L., Petcovic, H. L.,	2010	Western Michigan University	Teaching environmental geochemistryL an authentic field and laboratory research approach	Water & Environmental	Community	Y	Y	Y	Y

Strait, S., Smith, N.	2010	Marshall University	Paleoview3D.org: an example of science education through the development of an open access paleontological data resource	Paleontology	Cloud		Y		
Zurn-Birkhimer, S., Kroeger, T., Filley, T., Welle, P., Jenkins, M.	2011	Purdue University, Bemidji State University	Creating a collaborative model for place-based education for Native American Students	Field Research	Tribal, Community	Y	Y		
Rothenberg, M., Gelb, L., Appleby, C., Sherrod, B., Taylor, S., Henck, Schmidt, A.	2011	Oberlin	GIS and community-based learning in an undergraduate classroom	GIS	Community	Y	Y	Y	
Syzmanski, D.W., Bucci, G.D., Adams, V. E., Green, D. V., Markow, W. N.	2011	Bentley University in Waltham, MA	Engaging undergraduate students in energy policy through service-learning	Policy	Policy-makers	Y	Y	Y	Y
Moosavi, S.C.	2011	Rochester Community Technical College	The Grand Isle Project: How a place-based service-learning project evolved into a research experience for undergraduates during the BP Oil Spil	Introductoy	Managers	Y	Y		
Schmeisser, K. E., Wright, C. L., Altheide, A. T.	2011	University of Southern Indiana	Classroom rocks: a service-learning project increasing pedagogical tools for local earth science teachers and K-12 student interested in geology	Pre-service teachers	K-12		Y		
Ongley, L., Olin, J.	2011	Unity College	Service learning: Moving scientific work into the "real world"	Environmental	Community	Y			
Freile, D., Duzgoren-Aydin, N.	2012	New Jersey City University	Integrative community based research between faculty, graduate, undergraduate, and high school students: the case of heavy metals in urban soils Jersey City, NJ	Environmental	Community		Y		
Argyilan, E. P.,	2012	Indiana University	Collaborations in watershed studies in northwest Indiana created through the Great Leakes Innovation Stewardship Through Education Network (Glisten)	Water	Managers	Y	Y		

Petcovic, H., Koretsky, C.,Rowbotham, K.	2012	Western Michigan University	An authentic research approach to teaching environmental geochemistry	Environmental	Community	Y	Y	Y	Y
Fortner, S., Ritter, J., Austin, B.	2012	Wittenberg University	Integrated service learning across geoscience courses including biogeochemistry: building depth, scholarship, and community identity	Environmental	Community	Y		Y	
Ritterbush, L.	2012	Californian Lutheran University	Cooperative gardens as science outreach education sites	Environmental	Community	Y	Y		
Dodd, C.., Landau, B., Agosta, E.	2013	Shoreline Community College	Monitoring the fluvial system of Boeing Creek (Shoreline, WA): Developing successful service learning in the geosciences	Water Quality	Community	Y	Y		
Borowski, W., Frisbie, M., Shepperson, T., Frost, L., Coyne, L., Jeck, A.	2013	Eastern Kentucky University	Project-oriented science instruction involving general education and undergraduates serving as mentors to underpriviledged middle-school students	Environmental	K-12		Y	Y	
Ito, E., Dalbotten, D., Myrbo, A., Pellerin, H., Greensky, L., Howes, T., Drake, C., Woods, P., Wold, A.	2013	University of Minnesota, Fond du Lac Tribal and Community College	NSF-OEDG Manoomin Science Camp Project: A model for engaging American Indian students in science, technology, and mathematics	Earth	Tribal & Community	Y	Y		Y
Johnson, B., Kargus, S., Steffen, J., Van Cuyk, M., Balza, E., Shears, A.	2013	University of Wisconsin-Fox Valley	Paying the 48th Nobel Conference forward: using student capstones to creat a curriculum on contemporary ocean issues	Oceanography	K-12		Y		
Lincoln, T.	2013	Albion	The Third 90 Network, a collaborative, interdisciplinary program to support under-represented students and encourage them to pursue careers in environmental sciences	Environmental	K-12		Y		

Ward, E., Anderson, T., Hoensch, U., Kalaka, T., Lyman, J., Ostovar, K., Sjostrom, D., Ward, L.	2014	Rocky Mountain College	The Yellowstone River Research Center: A model for undergraduate research at small institutions	Field Research	Community	Y		Y	
Taylor, T., Buddington, A. M.	2014	Eastern Washington University, Spokane Community College	The geology of Mirabeau Point Park: An undergraduate service-learning research project	Field Research	Community		Y		
Buelow, E. K., Mahoney, B. J., Kimbrough, D. L., Taylor, S. S., Nehring, B., Hutter, A., Leidel, A.	2014	University of Wisconsin-Eau Claire	Linking undergraduate research with community outreach in Argentina: The International Fellows Program at the University of Wisconsin- Eau Claire	Introductory	K-12 & International	Y	Y		
Wilson, E., Breslin, K., Marvelle, K., Thacker, T., Fortner, S., Ritter, J.	2014	Wittenberg University	Soil lead distribution at two sites: implications for lead soil outreach in the Promise Neighborhood, Springfield Ohio	Environmental	Community	Y	Y		
Kelso, P., Spencer, M., Brown, L., Sabatine, S. Bouschor, R.	2014	Lake Superior State	Teaching geology in the field: a model for broadening participation and for integrative learning opportunities	Field Research	Tribal	Y		Y	
Bueno Watts,N., Berthelote, A. R., Lichtenberg, J., Patrick, D., Dalbotten, D.	2015	Salish Kootenai College, University of Minnesota	Sustainable land and water resources REU: Community-inspired research meets open inquiry	Water	Tribal	Y			Y
Fortner, S.., Ritter, J., Burgett, A., Finster, D., Hoff, R., Phillips, R.	2015	Wittenberg University	InTeGrate modules and authentic community-based resarch as sustainability program opportunities	Sustainability	Community	Y	Y	Y	Y

Greenberg, J. K.	2015	Wheaton College	Undergraduate service-research via predevelopment surveys	Applied	International	Y	Y		
Linzmeier, B. J.	2015	University of Wisconsin-Madison	Undergraduates as communicators of local geological knowledge in a sedimentology and stratigraphy course	Sedimentology	Community	Y	Y		
Kuban, A. J.	2015	Ball State University	Water Quality Indiana (WQI): How to expand a trans-disciplinary, project-based initiative to other STEM-strapped institutions	Water	Managers	Y		Y	
Sroufe, A., Allen, C., Kuban, A., Florea, L.	2015	Ball State University	Promoting public awareness of water quality-showing how trans-disciplinary students connected scientific data to the media	Water	Community	Y	Y		