Service–Learning Practice in Upper Division Geoscience Courses: Bridging Undergraduate Learning, Teaching, and Research

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ABSTRACT

Service-learning practice has been implemented in a number of upper division geoscience courses taught at the University of Connecticut. These courses include engineering geology, environmental geophysics, exploration seismology, and geology and geophysics field schools. The objectives for implementing service-learning practice are (1) to foster student interest in earth sciences through community service; (2) to enhance university outreach through interactions with communities by helping solve local geological and environmental problems; (3) to enhance students' learning ability by applying course knowledge to real-world problems; and (4) to encourage the student-centered learning process and team-work as cooperative learning. The response from participating students and local community leaders to this practice shows that service-learning is an effective way to improve geological undergraduate learning. It 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.

INTRODUCTION

Service-learning is a method by which students learn and develop skills through active participation in thoughtfully organized community service experiences. Service-learning practice has been widely adapted in higher education in the social and humanity disciplines, far more than in the natural sciences. It is even rarer in geoscience. For example, a search for 'service-learning' on the Internet using AltaVista returns 20,451 entries. In contrast, searching 'service-learning in geology' returns only 5 items, and each of these refers to a few articles in the Journal of Geological Education. Only one of these specifically refers to geological service-learning. Mogk and King (1995) adapted the service-learning approach in lower division geology classes taught at Montana State University. Other papers (e.g., Revetta and Das, 2002), do not explicitly refer to their practice as service-learning, though they do discuss service to the community through field projects. The service–learning discussed in this paper differs from those implemented in the humanities, social sciences, and lower-division geology courses in having a heavy scientific kernel emphasizing undergraduate research, rather than simple community service. It also differs from projects simply involving local field projects (e.g., Tibbs and Cwick, 1994; Tinker, 1989) by its well planned and organized systematic approach with phases of planning, implementation, reflection, summarization, and seeking feedback for future improvement.

The implementation of service-learning in upper-division geoscience courses can be justified on several grounds. First, it is well known that undergraduate enrollment in the physical sciences in higher education institutions nationally has reached an historic low (Revetta and Das, 2002). Without exception, all geoscience departments face a serious challenge to attract undergraduate students. One major reason is the lack of interest in the physical sciences and the weakened basic training in mathematics and sciences at high schools. To stimulate students in the physical sciences, numerous learning and teaching innovations have been proposed and tested in geoscience classrooms: (i) information technology has provided virtual field trips and tele-education through the Internet; (ii) new pedagogical practices include student-centered active learning and collaborative learning in both low- and upper-division geological classes. Second, it is not uncommon for universities to be quite isolated from their surrounding communities. A university's athletic programs are more likely to be recognized by the local community than its academic programs. Service-learning in the natural sciences, with real science and engineering at its center, raises the awareness of the scientific program while disseminating useful scientific knowledge.

Service-learning in geoscience can be classified as a practice of using community service as a vehicle to carry out the learning and teaching practice in geoscience education. Pedagogically, it is a student-centered learning process. It stimulates multi-lateral active interactions among undergraduate and graduate students, instructors, and local community public work leaders through carrying out the service-learning projects.

The objectives of service-learning implementation are (1) to foster student interest in earth sciences through community service; (2) to enhance university outreach through interactions with local communities by helping solve local geological and geotechnical problems; (3) to enhance students' ability to learn by applying course material to real-world problems; and (4) to encourage the student-centered learning process and team-work (cooperative learning).

This paper introduces the adaptation and implementation of service-learning into upper-division earth science courses taught in the Department of Geology and Geophysics, University of Connecticut (UConn). We first describe the service-learning environment in general. We then discuss the approach of the implementation, followed by a number of examples of service-learning projects. Finally, the evaluation of the success of a service-learning project, and responses and comments from students and local community public work leaders are discussed. Our experience indicates that service-learning is an effective practice to improve undergraduate geoscience learning, teaching, and undergraduate research. It also fosters faculty research in the pertinent field involving local-scale geological and environmental studies.

SERVICE-LEARNING ENVIRONMENT AT THE UNIVERSITY OF CONNECTICUT CAMPUS

The University of Connecticut established the Connecticut Campus Compact in 1997. It is a branch of the nation-wide Campus Compact, an organization of 520 university and college presidents, a major resource on service-learning. The Center for Community Outreach at UConn, another major resource associated with service-learning, has sponsored the annual Community Service Day in the last several years. It also encourages service-learning implementation in natural science disciplines (Wright, 1999). In fall 1997, the Department of Sociology conducted the Community Service Placements for the theme of Low Income Families. Their activities involved tutoring grammar school pupils in after-school programs, accompanying elderly residents, and participating in the Habitat for Humanity. The Institute for Learning and Teaching (ITL) at the University of Connecticut sponsored the workshop on Service-Learning in fall 1997. About 20 faculty members from a number of schools and colleges attended this workshop.

Obviously, our implementation of service-learning in upper-division geoscience courses substantially differs from the aforementioned efforts. Our emphasis has been on providing sound and useful scientific expertise through a service-learning project to the local community. It aims to solve a particular, well-defined geological, engineering, or environmental problem that senior or junior undergraduate students can solve with the knowledge learned from their upper-division courses and with supervised guidance from the instructors and local community leaders.

The service-learning component was initially implemented in two upper-division courses: Engineering and Environmental Geology, and Environmental and Engineering Geophysics, in spring 1998. These courses were ideally suited to test the community service-learning approach, with students tackling problems relating to, for example, investigation and preservation of historical landmarks, investigation of water quality, and geotechnical investigation associated with construction and development. With preliminary success, we continued the service-learning implementation into more courses. A detailed description of a couple of service-learning projects is presented after the discussion of Service-Learning Implementation.

SERVICE-LEARNING IMPLEMENTATION

To implement the service-learning project, the instructors need to work with town engineers and public works officials to select topics and projects and outline the work plans for suggested field projects. A list of suggested topics that can be completed within one semester was available for students to choose from at the beginning of each semester. The town engineers, zoning officers, or other community personnel can serve as field supervisors for service-learning projects. For early planning, students were encouraged to meet with their field supervisor soon after they had their project chosen. The progress of each project was examined periodically by the instructor and the field supervisor. A schedule of regular group meetings with the faculty and supervisors was set up to monitor progress. The results of the work were prepared in a final report with accompanying field data and graphics stored in the form of electronic files. The report needs to go through at least one preliminary draft, which was reviewed by the instructor and the field supervisor. With this intermediate checkup, the instructor can identify poorly executed projects and offer additional help. However, if the poor performance is due to lack of commitment by the student, this can be factored into the student's final grade for the course.

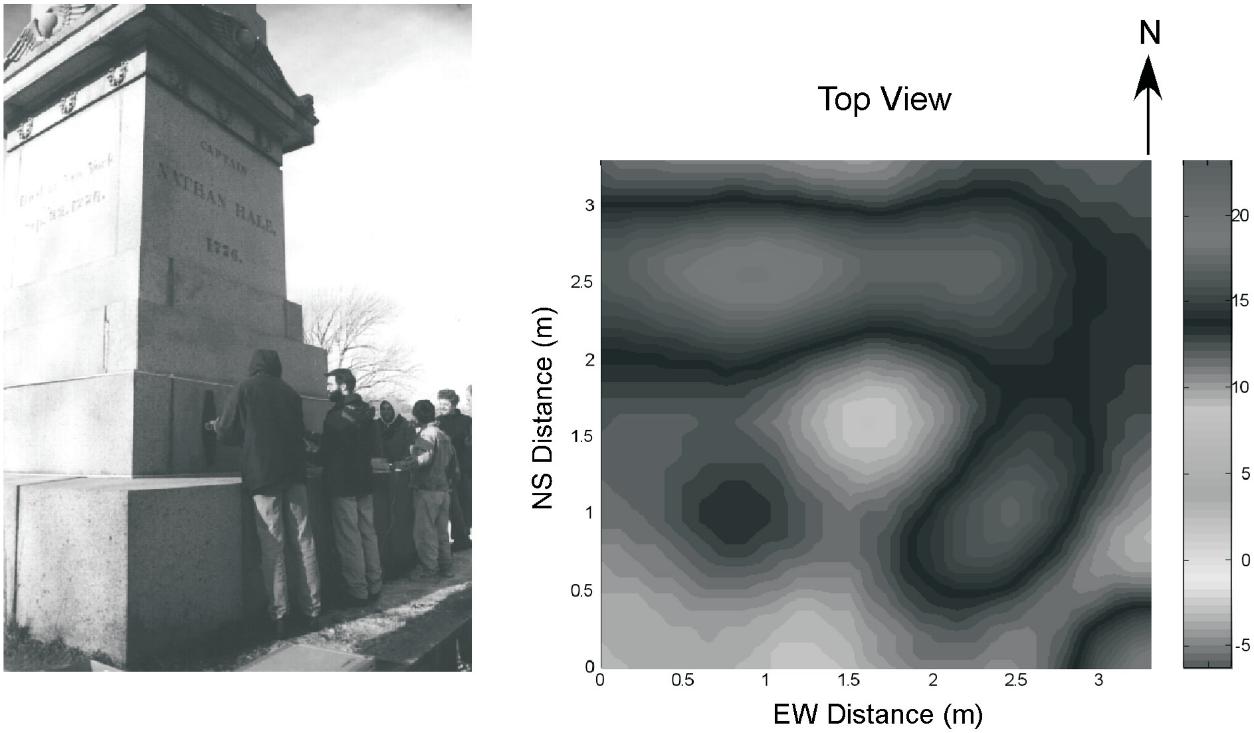
As a final reflection of the learning process, we planned to have students present their projects at the end of the semester. To encourage active and dynamic interactions, we used mainly the form of posters for final presentation. Students from different classes have a chance to view each others' research projects and get feedback. We found that the poster format presentation is more stimulating in terms of discussions and undergraduate students' comfort than a simple oral presentation.

For each class with a service-learning segment, a bound report was compiled by the instructor upon completion of the projects. Each service-learning project report was organized along the lines commonly used in the engineering consulting industry and include well-documented research information, field data, graphs, charts, maps, and so on, as well as recommended policies and implementation strategies. Preliminary manuscripts of the reports were cross-edited by students themselves and reviewed by the instructor and field supervisors. Some final reports have been used by towns in dealing with local engineering and environmental geological issues. Therefore, the requirement of professionalism in the reporting is essential for both student training and real engineering value. The quality of a report constitutes a significant fraction of the student's grade in the course.

Depending of the scope and scale of a real world geological problem, service-learning projects can be carried out as small ones executed by individual students, or an integrated one carried out by a group of students sharing different duties. Larger scale projects were saved for the geology summer field course where an entire class effort can be integrated. The examples of both small and large projects will be presented in the next section.

In summary, the procedure to implement a service-learning segment in an upper-division geoscience course is as follows:

(1) Identification of particular geological and environmental problems in the community. This can be done by talking with town authorities and zoning officers, or can be based on previous work done by faculty and students in that particular area.
(2) Students select their project by considering their interests and expertise. Students who cannot decide on a project will be helped by the supervising faculty.
(3) Inviting the town public works manager, town engineer, or zoning officer to act as the field advisor, and then introduce the student to the field officer. For certain projects (e.g., geophysical data



(a) (b)

Figure 1. Students of Geology 267 Class acquiring GPR data on the Nathan Hale Monument (a); Radar attenuation tomogram of Base Level 2 interior of the Monument foundation viewed from the top (b).

acquisition for a field project), or certain stages of a service learning project (e.g. relatively sophisticated data processing), graduate students can participate to help the undergraduates. This practice will naturally introduce research to the undergraduates, and improve the graduate's teaching skills.

(4) Meeting of the student and the field officer to lay out a plan of approach for a particular project, with the approval of the supervising faculty to insure that the workload and scope of the project are appropriate and realistic.
(5) Field project implementation with close communication between the student, the supervising faculty, and the field advisor. During the project implementation period (usually the second half of the semester), student, faculty, or the field advisor meet once a week, or at least every two weeks, depending on the complexity or scope of the project. The student is the center of this process.
(6) Preparation of report to summarize findings of the project.
(7) Reflection of the entire process by the student and faculty advisers.

EXAMPLES OF SERVICE-LEARNING PROJECTS

Many excellent prospective environmental and geological projects can be found in local communities that are suitable for the service-learning approach.

As mentioned above, service-learning projects can be divided into individual term projects and integrated efforts by a group of students. During the last several years, a total of 46 service-learning projects were carried out. Some typical projects include: investigation for sensitive lands and recommendations for their use; natural and man-made hazards; wetland assessment and preservation; fast mapping and inventory of the wetland distributions; local historic landmark preservation; and engineering site assessment for future constructions for public use. Here we present two examples for service-learning projects.

Imaging the interior of the Nathan Hale monument - The Nathan Hale Monument (Figure 1) in the Town of Coventry, Connecticut is one of the premier state landmarks maintained by the Connecticut Department of Environmental Protection (DEP). Nathan Hale has been a state hero since the Revolutionary War. The monument was constructed in 1846; seventy years after Captain Nathan Hale had been hanged by the British Army in New York with the charge of spying for the Revolution Army in the American War of Independence. In recent years, concern has been expressed over the stability of the monument (Dlugolenski, 1998, personal communication). A study conducted in 1997 by an expert in monument preservation and restoration suggested that the monument appeared to be stable. However, the conservator admitted that the suggestion had been made based purely upon visual inspection. To see inside of the foundation would have required a more sophisticated non-destructive testing system and analysis.

There is no record of what is inside the peripheral granite blocks. An historical book (p. 581, Coventry Historical Collections) speculated that the monument had been made of solid granite but without supporting evidence. It has also been suggested that it is filled with pebbles, again, with no direct or indirect evidence. Furthermore, it would be important to know if the structure is reinforced with metal. For the Connecticut DEP, the most critical issue in deciding whether the

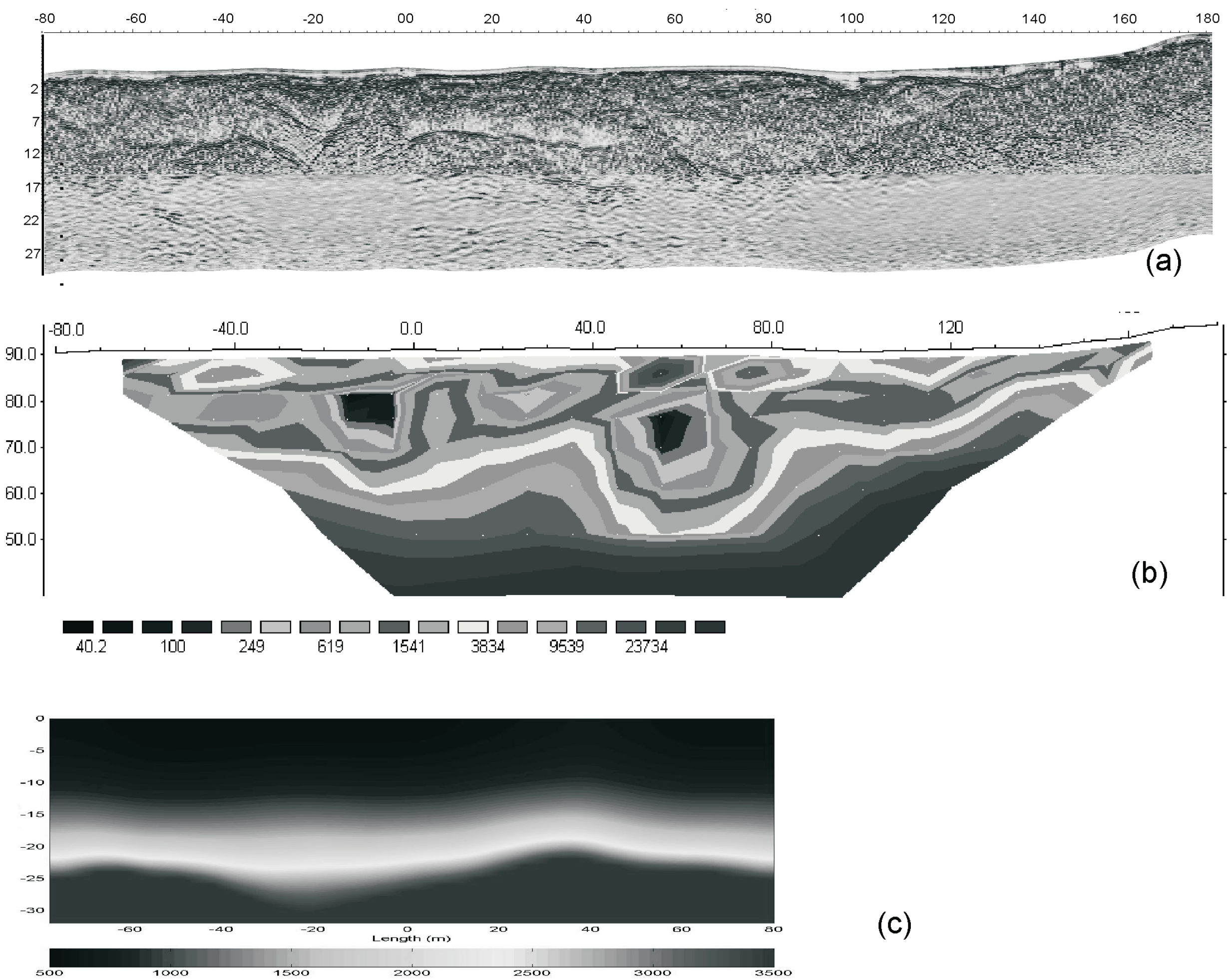


Figure 2. Geophysical survey results acquired at UConn's Willimantic River well field. (a) GPR profile; (b) Resistivity tomography with dipole-dipole array; (c) seismic velocity tomography by refraction surveys. The units for distance and depth are in meters.

monument needs major restoration is what kind of support structure is inside the monument and what condition it is in. The most feasible non-destructive way of determining the nature of the interior structure of the Monument is through use of ground penetrating radar (GPR).

With the help of a faculty member and fellow students to gather the field data (Figure 1a), a senior undergraduate acquired the 400 MHz GPR data on the Monument and helped reconstruct the attenuation tomogram (Liu, Lane, and Quan, 1998) of the interior of the foundation (Figure 1b). From the GPR tomogram, the attenuation could be clearly divided into three zones: (i) a low attenuation periphery; (ii) a relatively high attenuation middle zone, which possibly connects to all four sides; and (iii) a central area with a similar attenuation value to the granite periphery. Inside the relatively high attenuation zone encircling the central piece, the attenuation in the north part is higher than in the other 3 sides. A possible explanation is that the north side has less sunshine and is constantly shaded so that its moisture content is higher than on the other sides. This, in turn, would increase the effective conductivity of the material (high water content in the material causes higher attenuation). Based on the investigation results of this project, we reported to the state DEP that the Monument has a middle zone consisting of unconsolidated earth material with large void space and a central piece of some material similar to the granite on the exterior (possibly also granite) but not metallic. Students were happy and felt encouraged when their work received the attention of the local news media (Goldberg, 1997).

Geophysical Summer Field School: Hydrogeophysical investigations of the University well field - Geological service-learning implementation can also be used to tackle a relatively large-scale geological and environmental problem, by using the joint effort of an entire class. Students can work together in groups. Each group submits one final project report. Individual students contribute to the report with his/her skills and components emphasizing their interests. In summer 2001, a geophysical summer field school undertook a study of the University well field near the Willimantic River, Connecticut, to delineate and refine the hydrogeological setting. The University is interested in expanding the well field's capacity by adding two production wells. Hydrogeophysical data (ground penetrating radar, electromagnetic induction, dc resistivity, seismic refraction, geophysical well logging, etc.) and land survey data collected with electronic total stations (Philpotts, et al., 1997) acquired by students of the Geophysical Summer School

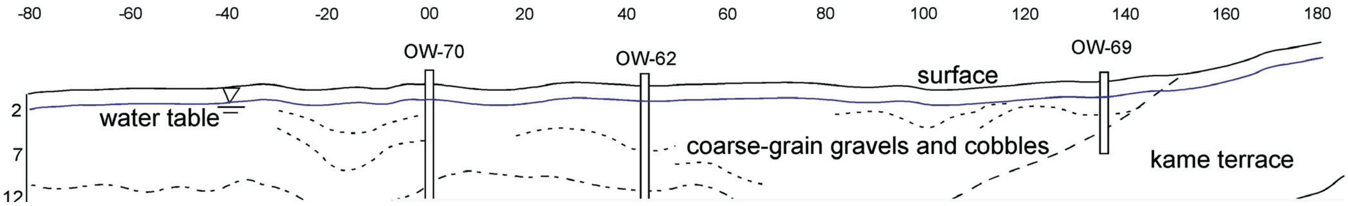


Figure 3. The reconstructed hydrogeological model of the well field based on geophysical surveys. The dots along the sediment-bedrock interface are locations with known depths to bedrock. Resistivity and neutron logs were also obtained from observation well OW-69 and OW-70. The units in distance and depth are in meters.

provided useful information for site selection for the additional wells.

From the geophysical survey results (Figure 2), a comprehensive hydrogeological model (Figure 3) has been constructed by students in the summer school class. GPR surveys (Figure 2 a) constrained two shallow structures, dominated by flow channels, at horizontal distances of x=-20 m and 60 m on the profile. The electrical resistivity tomography obtained from a dipole-dipole dc resistivity survey (Figure 2b) shows low resistivity in these two regions, suggesting much higher water content at those locations. Seismic (Figure 2c) and resistivity results both indicate the sediment-bedrock interface depth is more than 22 meters below the surface, with troughs located at x=-20 m and 60 m on the profile. The troughs most likely consist of coarse-grained highly permeable deposits marking paleo-flow channels.

EVALUATIONS OF SERVICE-LEARNING PROJECTS

A service-learning project is good if it (1) meets actual community needs; (2) involves collaboration between the school and the community; (3) provides structured time for students to think, talk, and write about what they did and saw during the actual service activity; (4) provides students with the opportunity to use newly acquired academic skills and knowledge in real-life situations in their own communities; and (5) fosters the development of a sense of caring for others. By these standards, the earth science discipline is ideally suited to this learning approach, especially at the level of upper division undergraduate courses.

STUDENT COMMENTS AND REACTION: HOW DOES THE SERVICE-LEARNING IMPROVE TEACHING AND LEARNING EXPERIENCE?

The service-learning projects were conducted in nearby towns of Willington, Mansfield, and Coventry in eastern Connecticut, as well as on the UConn campus. Evaluations and comments from students indicate the effectiveness of implementation of this form of education. The summary of the students' comments are:

i) The course has lots more hands-on experience; makes students feel they have accomplished real life work;

ii) Students feel closer to the community and get a sense of contribution to the local community. In carrying out a service-learning project for stream relocation in the town of Willington, a student had an eye-opening experience that has taken him beyond textbook learning. He said, "I have talked with several people in town and my professor for input. I want to recommend ways in which the stream can fit better into the ecosystem, can support life, and provide a better habitat. I would like to find a way to get the community more involved in continuing to monitor the area in the future."

iii) Students in the course with a service-learning component develop confidence in tackling real-world problems and are better prepared for careers once they leave the University.

The faculty members were pleased to see many high quality presentations at the end of the semester in the form of posters and oral presentations. A number of senior geology majors decided to continue their studies into geological graduate programs, either at the University of Connecticut, or elsewhere, due partially to the encouragement they received in participating in the service-learning projects.

LOCAL COMMUNITY COMMENTS AND REACTION

Town managers, state DEP officials, and public work directors who were involved in the service-learning practice highly rated the academic-public interactions through the implementation of the projects. The nearby towns strongly supported this effort and happily provided 'real-life' projects for student analysis. They found that some of the projects' data and conclusions were "most helpful both in the professional presentation and site analysis".

Furthermore, service-learning implementation has stimulated multi-lateral interactions among undergraduates, and between undergraduates and graduates, students and faculty, students and practicing engineering professionals, as well the educational institution and the local community.

CONCLUSION

The products generated from service-learning projects include: (1) A poster presentation at the end of the spring semester by participating students to fellow students, faculty and involved community administrative personnel (town managers, town engineers, zoning officers, and public work officials, etc.); (2) A final report containing student project reports for various field projects, with evaluations by field supervisors and instructors; (3) Presentations of research results at a professional conference; and (4) An improved course curriculum including service-learning component that will be used in future years.

The service-learning practice in the upper division geology courses was mutually beneficial to both the towns and the students. Numerous service-learning reports provided important information for environmental preservation, land use planning, and engineering development.

Students were stimulated and excited by the involvement of identifying and solving local geological problems. They were convinced that they had learned the course material more easily and thoroughly through tackling real world problems.

The mechanism of linking upper-division geology courses with the needs of local communities can be implemented easily through the service-learning concept anywhere in the country. The geological problems certainly will vary for different communities, but they can all provide students with an interesting challenge.

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