# A Service-Learning Project on Volcanoes to Promote Critical Thinking and the Earth Science Literacy Initiative

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## ABSTRACT

Students in Honors Physical Geology at Louisiana State University (LSU) participated in instruction in eighth- to ninth-grade geology and geography classes in East Baton Rouge Parish Schools (EBRPS) to help meet community needs. LSU students created instructional materials and reflected on the service activity to gain a deeper understanding of course objectives, an appreciation of Earth science as it relates to the global community, and an enhanced sense of civic responsibility. The service-learning project focused on an historical volcanic eruption and consisted of four parts distributed throughout the semester: K–12 teacher interview, research paper, poster and presentation to peers, and classroom teaching. Reflection, peer review, teamwork, and revision were emphasized. Presentations focused on Earth Science Literacy Initiative (ESLI)'s "Big Ideas" (e.g., humans can mitigate but not control natural hazards). LSU students' perception of their learning from reflections/class evaluations indicated that they moved from "remembering–understanding" to "analyzing–evaluating–creating" within Bloom's Taxonomy hierarchy. LSU students also gained valuable experience in creating, reviewing, and revising written and oral communication. Based on K–12 teacher responses, EBRPS students learned about volcanoes, deepened their understanding of plate tectonics, and learned about college. Service learning requires a strong desire for collaboration among all participants. Communication and coordination are vital to success so that everyone has the same expectations, knows his/her role, and problems are identified and resolved. © *2013 National Association of Geoscience Teachers*. [DOI: 10.5408/11-271.1]

*Key words*: service learning, Earth-science literacy, critical thinking, volcanoes, K–12 outreach, communication skills

## INTRODUCTION

Research on teaching methods and retention documented that passive teaching methods such as lectures, reading, audio–visual, and demonstrations have low retention rates of 30% or less, whereas active teaching methods such as group discussions, practice, and teaching others have significantly better retention rates of 50% or higher (Sousa, 2006). In addition, student understanding of processes is often superficial and does not represent the higher levels of Bloom's (cognitive) Taxonomy (Table I; Bloom et al., 1956; Anderson et al., 2000) such as analyzing and evaluating. For example, most students know that volcanoes are associated with subduction zones. However, a common misconception is that the subducting oceanic lithosphere melts rather than the overlying mantle material. The critical role of water in inducing melting is also often forgotten. A comparison study in introductory geology courses by McConnell et al. (2003) documented improvement in exam scores, knowledge retention, and logical thinking skills in classes with an active learning style. Udovic et al. (2002) demonstrated the effectiveness of active learning in promoting understanding of essential concepts, the process of scientific discovery, and critical thinking skills in introductory biology classes. In addition, they found that students in active learning classes had a greater appreciation of science and its role in society.

In addition to a desire to improve students' scientific knowledge and critical thinking skills, Louisiana State University (LSU) has an institutional commitment to promoting communication skills and community engagement. Launched in 2005, LSU's Communication Across the Curriculum (CxC) program is a multimodal, multifaceted program designed to improve the writing, speaking, visual, and technological communication skills of undergraduates (http://www.cxc.lsu.edu). LSU's Center for Community Engagement, Learning, and Leadership (CCELL) promotes the integration of teaching and service to promote civic responsibility and to improve learning and social accountability while "strengthening LSU's commitment to being an exemplar of an engaged public research university" (http://uiswcmsweb.prod.lsu.edu/ccell).

In this case study, we present a service-learning project on historical volcanic eruptions. We describe the process of creating a service-learning project and its implementation in the fall semester of 2010. Finally, we reflect on the outcomes of this service-learning project from the prospective of the LSU students, East Baton Rouge Parish teachers, and the project coordinators.

## SERVICE LEARNING

Service learning is a "course-based, credit-bearing educational experience in which students participate in an organized service activity that meets identified community needs, and they reflect on the service activity in such a way as to gain further understanding of course content, a broader appreciation of the academic discipline, and enhanced sense of civic responsibility" (Bringle and Hatcher, 1999). Service

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learning has been shown to have a positive impact on students' academic learning (Driscoll et al., 1996), improve students' abilities to apply their learning to real-world situations (Eyler and Giles 1999), and increase student satisfaction with college (Astin and Sax 1998).

Service-learning practice has been implemented in a number of geoscience courses taught at various colleges and universities in the United States. Mogk and King (1995) used a class project to prepare a public forum on seismic hazards in southwestern Montana. Other groups have incorporated service to the community into local field and/or laboratory oriented geosciences classes including geophysical characterization of the subsurface for environmental problems (Tibbs and Cwick, 1994; Revetta and Das, 2002), land use and runoff changes (Nichols, 2003), wetland and floodplain ecosystems (Tedesco and Salazar, 2006), and hydrogeology/water quality (Tinker, 1989; Kossmann et al., 2011). Some universities have incorporated service learning into research projects in several upper-division geoscience courses (e.g., Liu et al., 2004). The Science Education Resource Center at Carleton College maintains a collection of service-learning resources including a model for designing projects, example projects, tips for finding community partners, and assessment information (http://serc.carleton.edu/NAGTWorkshops/servicelearning/index.html).

The service-learning project described here was implemented in the fall semester of 2010 with a class of 21 Honors College students. The Honors College at Louisiana State University uses small class sizes to enable students to participate in small peer-discussion groups while developing closer relationships with their professors. Course work is designed to encourage community involvement and develop leadership skills through project-based learning and service work.

This project is different from prior efforts in service learning described above in that it involves non–geoscience majors in an introductory geoscience class, and the community partner is the local public schools. The community service involves teaching others (K–12 students) rather than providing a specific service such as water quality analyses to a community partner. This is similar to service-learning classes of English as a second language, in which students tutor older immigrants at community centers.

In addition, the class project requires LSU students to plan and implement a classroom lesson as part of a team, reflect on their service activity, summarize the results, and seek feedback for future improvement.

### What is Reflection?

Accordingly, LSU's CCELL reflection allows students to think critically about their service experience, pose questions, explore personal/professional development and values, enhance personal and professional goals, and examine the systemic causes of societal problems. Reflection requires students to put "facts, ideas, and experiences together to derive new meaning and understanding."

Effective reflection should have the following components (Bringle and Hatcher, 1999; Howard, 2001):

- A clear link between service experience and course learning objectives
- A structured prompt regarding description, expectations, and assessment criteria
- More than one opportunity for reflection so that students can practice and develop capacity
- Instructor feedback so students can improve their critical analysis
- Provide opportunities for students to explore, clarify, and alter their values

According to Howard (2001), reflection not only helps students with course-specific skills and knowledge, but also helps students develop problem-solving and critical-thinking skills as well as become active learners through application and collaboration. In addition to academic goals, reflection helps students meet civil goals such as leadership skills, respect for diversity, citizenship, and social responsibility.

### Planning a Service-Learning Project

Planning an historical volcanic eruption presentation as a service-learning project was done with the guidance and support of CCELL at LSU. CCELL provides a forum in which community members and LSU faculty, staff, and students collaborate on local projects that are designed to meet specific needs of both participants. This group holds periodic training sessions on service-learning community partnerships and has produced a handbook to guide the collaboration, implementation, and follow-up processes. Service learning involves integration of service into learning objectives. In other words, service conducted by college students in Honors Physical Geology followed by their reflection on that service must assist them in achieving the learning goals of the course (see "Learning Objectives," below). In addition, the service performed by LSU students has to genuinely benefit the community partner.

In order to meet these two goals, there has to be a true reciprocal partnership between the service-learning course instructor and the community partner. Based on prior contact and proximity to LSU, the East Baton Rouge Parish Schools (EBRPS) were chosen as the community partner. The authors met face to face on several occasions as well as exchanged numerous e-mails to determine how LSU students could provide a service to EBRPS students, and how that service could be used to help LSU students achieve course learning objectives. After much discussion, it was determined that the service-learning project should have four components spread out over the semester: (1) a teacher interview at the K–12 school followed by student reflection, (2) research paper, (3) presentation and poster with peer review and revision, and (4) K–12 classroom presentation, student reflection followed by revision, a second classroom presentation, and final student reflection. The interview and classroom presentations were done in groups of two or three, but each student individually reflected on the experience. Assignment prompts are contained in the Supplemental Materials (available at: dx.doi.org/10.5408/11–271s1).

## SERVICE-LEARNING PROJECT ON HISTORICAL VOLCANIC ERUPTIONS

Each student was assigned an historical eruption by the instructor. Examples of eruptions include Tambora, Indonesia, 1815; Krakatau, Indonesia, 1883; Mount Pelee, Martinique, 1902; Ruiz, Columbia, 1985; Unzen, Japan,

1792; Laki, Iceland, 1783; Kelut, Indonesia, 1919; Vesuvius, Italy, 79; El Chichón, Mexico, 1982; and Pinatubo, Philippines, 1991. Criteria used in the selection of eruptions were significant damage to people and property, style of eruption (ash flow, lava), type of geohazard (pyroclastic flow, mud flow, starvation, or tsunami), multiple events (e.g., Vesuvius in 79 and 1631 or Ruiz in 1845 and 1985), and availability of adequate resources for the project (books, articles, images, etc.).

## Learning Objectives

Course assignments, learning objectives, and associated levels of Bloom's (cognitive) Taxonomy are listed in Table II. Virtually all of the service-learning assignments promoted higher-order thinking skills such as applying, analyzing, evaluating, and creating (Table I).

A primary learning objective for this course is for students to demonstrate an understanding of the Big Ideas of Earth science from ESLI (Table II; Wysession et al., 2009; http://www.earthscienceliteracy.org/index.html). Volcanic eruptions are excellent examples of the Big Ideas that "humans can mitigate but not control natural hazards" and "catastrophic processes produce enormous changes" (Wysession et al., 2009). They also touch on "Earth's rocks provide a record of its history," "Earth's systems are dynamic" and "Water's unique properties are essential to Earth's dynamics" (Wysession et al., 2009). In addition, there is ample information available for first-year college students to produce a lesson plan on an historic volcanic eruption. Finally, most people are interested in volcanic eruptions.

This class is designed to improve students written, visual, and oral communication skills. This semester-long service-learning project requires students to do both formal and informal writing; create an oral and poster presentation; revise their presentations based on peer, instructor, and K–12 student review; and reflect on the experience (Table II).

Another learning goal for this class is for students to explain the applications of Earth science as it relates to the global community (Table II). Dangerous volcanic eruptions occur in many but not all parts of the Earth. Understanding what areas are at risk and why is important for society at large.

Finally, working in teams, discussions with peers, teachers, and K–12 students, peer review, and revision of work promote leadership and teamwork skills and provide an introduction to scientific discovery as a collaborative process.

## Teacher Interview

The teacher interview allows an LSU student to meet his/her assigned teacher, see the school, and discuss his/her presentation. It is an opportunity for students to investigate his/her mission, determine the expectations and needs, inventory the classroom and his/her team's assets, and consider worst-case scenarios. EBRPS teachers volunteered to participate in the project. Teachers taught either eighth-grade Earth science or ninth-grade geography. While LSU and EBRPS are both in the same parish, their student bodies are dramatically different. LSU students are mostly white and middle class. EBRPS students are predominantly African American and poor. Total public district student enrollment in 2010–2011 was 42,322. Parish wide, EBRPS students are 82% African American (individual schools range from 47 to 100%), and 83% district wide qualify for free or reduced lunches. Thus, it is essential for the LSU students to visit their assigned school to observe the environment in which they will do service and have their questions answered.

LSU students could ask their assigned teacher whatever questions they wished, but they were also required to ask certain questions (see the Supplemental Materials) about the EBRPS students, including their interests and backgrounds, prior activities related to volcanoes, and any Earth science concepts that were difficult for K–12 students. LSU students were also required to determine what equipment was available for their presentation, what their time limits would be, and whether EBRPS students would be allowed to ask questions.

Afterward, LSU students were required to reflect on their experience in terms of their expectations of the K–12 school, what challenges they would face in preparing their classroom presentation, and how they planned to work as a team (see the Supplemental Materials).

## Research Paper

Each student wrote a three- to five-page research paper in response to a detailed and structured prompt from the instructor (see the Supplemental Materials). In the paper's introduction, the student had to describe or diagram the plate tectonic environment in which the volcano formed, provide a location map, and summarize any earlier eruptions

**TABLE I: Bloom's Taxonomy.[1]**

| Thinking Skill | Key Words |
|---|---|
| Remembering: Can the student recall or remember the information? | Define, duplicate, list, memorize, recall, repeat, reproduce state |
| Understanding: Can the student explain ideas or concepts? | Classify, describe, discuss, explain, identify, locate, recognize, report, select, translate, paraphrase |
| Applying: Can the student use the information in a new way? | Choose, demonstrate, dramatize, employ, illustrate, interpret, operate, schedule, sketch, solve, use, write |
| Analyzing: Can the student distinguish between the different parts? | Appraise, compare, contrast, criticize, differentiate, discriminate, distinguish, examine, experiment, question, test |
| Evaluating: Can the student justify a stand or decision? | Appraise, argue, defend, judge, select, support, value, evaluate |
| Creating: Can the student create new product or point of view? | Assemble, construct, create, design, develop, formulate, write |

[1]Modified from Overbaugh and Schultz (http://ww2.odu.edu/educ/roverbau/Bloom/blooms_taxonomy.htm).

**TABLE II: Assignments, learning objectives, and Bloom's Taxonomy.**

| Assignment | Learning Objectives | Bloom's Taxonomy (Key Words) |
|---|---|---|
| Research paper | ESLI Big Ideas | Remembering, understanding, applying |
| | Written communication | |
| | Learn by writing | |
| PowerPoint presentation | ESLI Big Ideas | Applying, analyzing, evaluating, creating |
| | Oral communication | |
| | Learn by discussion | |
| | Teamwork and leadership | |
| Poster | ESLI Big Ideas | Applying, analyzing, evaluating, creating |
| | Written communication | |
| | Learn by writing and discussion | |
| | Teamwork and leadership | |
| Peer review of presentation and poster and revision | ESLI Big Ideas | Analyzing, evaluating |
| | Oral and written communication | |
| | Learn by discussion | |
| Team visit to school and reflection | Oral and written communication | Understanding, applying, analyzing, evaluating |
| | Learn by discussion | |
| | Community and leadership | |
| Presentation in K–12 classroom and reflection | Oral communication | Remembering, understanding, applying, analyzing, evaluating, creating |
| | Learn by discussion | |
| | Community and leadership | |
| Second presentation in K–12 classroom and reflection | Learn by discussion | Remembering, understanding, applying, analyzing, evaluating, creating |
| | Oral communication | |
| | Community and leadership | |

in the region. In the main body of the paper, he/she has to provide a summary of the events associated with the eruption and its impact on people and property, as well as an illustration of the type of eruption that occurred. Next, in the discussion session, the student had to summarize how the region has recovered since the eruption, recent volcanic activity, as well as assess the likelihood that a major eruption will occur in the near future. Finally, students had to properly verify and cite the sources of information and any images used in the research paper.

## Presentation, Poster, and Peer Review

Next, the LSU students were divided into 10 teams to produce a 10- to 12-min presentation and a poster. This was an opportunity for them to combine information from individual research papers and add additional content such as photos, maps, audio clips, and/or video clips. The assignment prompt (see the Supplemental Materials) also required that the presentation/poster be appropriate for an eighth-grade audience. The assignment required students to use critical-thinking and communication skills as well as higher levels of knowledge in Bloom's Taxonomy (Table II). In their presentation/poster, they had to determine how to explain Earth processes such as plate subduction in simple terms. For example, a number of groups used one car riding over another during a head-on collision as an analog for plate subduction at a convergent boundary. They also had to replace vocabulary such as *pyroclastic flow* with more descriptive terms. The students were also evaluated on how well their presentation/poster would engage an eighth-grade audience.

A staff member from CxC gave a 40-min presentation to the class on how to create scientific presentations/posters, as well as discussed available resources at the CxC studio including staff support, practice rooms with SMART boards, and video equipment to record practice sessions.

Both the presentation and poster underwent peer review. Each group gave their presentation to the entire class. The other students were asked to rank the presentation in terms of being clear and easy to understand; focusing on important issues; being accurate, complete, and relevant; facts and/or visuals being properly cited; ensuring the presentation was age appropriate; and honoring time limitations as well as providing written suggestions for improvement. A grading rubric (Table III) was given to students ahead of time and discussed in class.

Studies at other universities in chemistry, biology, and economics documented that students taught with peer review performed better on exams (Pelaez, 2002). Creation, peer review, and revision of lesson plans and poster helped students develop important skills such as analyzing, criticizing, describing, and reviewing (Tables I and II). Peer review also gave students first-hand experience of the "collaborative process of construction and refinement of knowledge, the subjective nature of evaluation and peer review, and the role of creativity in research" (Trautmann et

**TABLE III: Presentation/poster assessment rubric.**

| Criterion | Point(s) | Comments |
|---|---|---|
| Presentation/poster clear and easy to understand | 2 | 40 |
| Presentation/poster focuses on important issues<br>Explain causes/provide plate tectonic context<br>Describe events before/during eruption<br>Discuss aftermath/recovery/future eruptions<br>Conclusions and/or opinions supported by research | 4 | 50 |
| Facts/visuals properly cited | 1 | 5 |
| Presentation within time limit | 1 | 12 |
| Age appropriate/engages audience | 2 | 46 |

al., 2003). Thus, peer review fits into ESLI Big Idea no. 1 on the scientific method.

Peer review of oral presentations generated 153 written comments (Table III) distributed among the five categories provided in the rubric. Forty of the comments were about the clarity of the presentation. These comments varied: basic organization/sequence of material, animations that were distracting or did not work, talking too fast or not loud enough, text too small, poor quality images, and slides being too busy. The largest number of comments dealt with problems in content. These included missing sections (e.g., recovery after eruption); terms not explained or improperly explained, such as how magma is produced at a subduction zone; and the need for better or additional illustrations, especially with regard to plate tectonic context. There were only 5 comments regarding proper citation of work, even though several presentations had omissions in that area. The 12 comments regarding time limit were directed toward one presentation that was over 20 min and another that was less than 6 min.

Comments on age appropriateness of the presentation fell into two categories. Some comments involved vocabulary such as *viscosity* and *basaltic,* or conceptions such as subduction not explained in terms an eighth grader would understand. Other comments were about whether content was appropriate for eighth graders. This involved both pictures and a video that showed dead bodies.

Figure 1 shows a Frank Foumier photograph of a young girl trapped in rubble after the Ruiz eruption in 1985. The young girl ultimately died. Many peers felt this was not appropriate for eighth graders. The in-class discussion also highlighted the important point that damage associated with natural hazards is also determined by the ability of local organizations to respond—the young girl died from gangrene and hypothermia after being trapped for several days.

Posters were peer reviewed outside of class on the ReviewBasics.com Web site. Posters were uploaded, and reviewers invited peers via e-mail to view and comment on the poster at their convenience. Figure 2 shows a student poster of the Laki volcano, with a single peer's comments superimposed. Each group had to review posters from two other groups. Thus, each poster received from four to six reviews. Reviewers could not see other reviews, but authors could see all reviews either individually or collectively. ReviewBasics.com allows positive, neutral, and negative comments/corrections. Overall, the number and quality of student comments on posters was much better than in presentations. Peers spent more time on viewing posters, and some reviewers came back more than once to comment. In other years, posters were printed and placed in the LSU Geology building so peers could view them. Peers posted their reviews on a class blog.

Students had to revise both their PowerPoint presentation and poster after peer review. Students were graded on how well they responded to reviewer comments. In general, students responded adequately to reviewer comments. However, this was not always the case. One team retained a short video that was distracting and did not pertain to the subject, despite negative comments from both the instructor and peers. Another group's final poster was essentially identical to the original poster, presumably because they ran out of time.

### Classroom Teaching and Reflection

Finally, each LSU team used the materials developed above, after revision based on instructor comments and peer review, to teach 20- to 30-min sessions in two K–12 classes, including questions and answers. After the first classroom session, LSU students were required to individually reflect on their experience in terms of how the presentation was received, and how they could improve the presentation for the next time. After both classroom sessions, the LSU students were required to individually reflect on the experience in terms of how it impacted their understand of volcanoes and plate tectonics; the impact of geohazards on people and property; what important information the LSU students shared with eight- to ninth-grade students; and how they felt about service learning (see the Supplemental Materials). K–12 classroom instruction by LSU Honors students was not directly observed by the LSU instructor.

## EVALUATION OF SERVICE-LEARNING PROJECT

A quantitative assessment to measure cognitive and affective gains for several semesters of the class, including experimental and control groups with pre-/postassessments was impractical. Honors Physical Geology is taught less than once a year. Moreover, there is no viable control group. The regular sections of Physical Geology use the same textbook and cover roughly the same material. However, these classes are much larger (~250 students), have different instructors, and the students are less academically accomplished than the Honors students. Thus, there are too many variables to

**FIGURE 1: A 13-year-old girl trapped in the rubble of the Ruiz eruption in 1985. Photo: Frank Fournier. Used with permission of the photographer.**

know whether the higher scores in LSU's assessment of general education classes by the Honors section can be attributed to service learning or other factors.

In the absence of a quantitative assessment, LSU student reflections are used in assessing students' perception of what they have learned. Liu et al. (2004) used college-student comments from course evaluations to evaluate curriculum. Mohadjer et al. (2010) used an oral pretest, followed by discussion groups of some of the affected elementary school students to assess the impact of their program. K–12 teacher comments are used to judge the impact on K–12 student learning.

## LSU Student Reflections

LSU students were asked to reflect on their service at two points during the semester, after the K–12 teacher interview and at the end of the project. Reflection questions are contained in the Supplemental Materials.

Reflection questions after the K–12 teacher interview asked students to explore the larger community, assess their audiences, consider potential pitfalls, and inventory their personal and team assets in preparation for teaching (see the Supplemental Materials). For example, LSU students were asked if the school and students met their expectations, and if there were any surprises. One student commented, "The teacher was very helpful and welcoming...99.9% of the students were African American, and the school was in a low socioeconomic area...There was a great emphasis on academics and respect." Another student reported being assigned to a special-needs class. "A middle school geared toward teaching overage students. A nontraditional education, but I did not expect the school to be so run down and small." LSU students were also asked what challenges they would face in the classroom. Responses included the following:

> *"I know that when I was in high school, and we had subs and speakers I didn't pay attention at all. So we will have to make the presentation where it can keep their attention."*

> *"...students have learning disabilities, difficulty paying attention, and some have been in and out of juvenile hall."*

> *"...relating the information in an engaging way while also keeping in mind the possible difficulties the children might have in understanding it."*

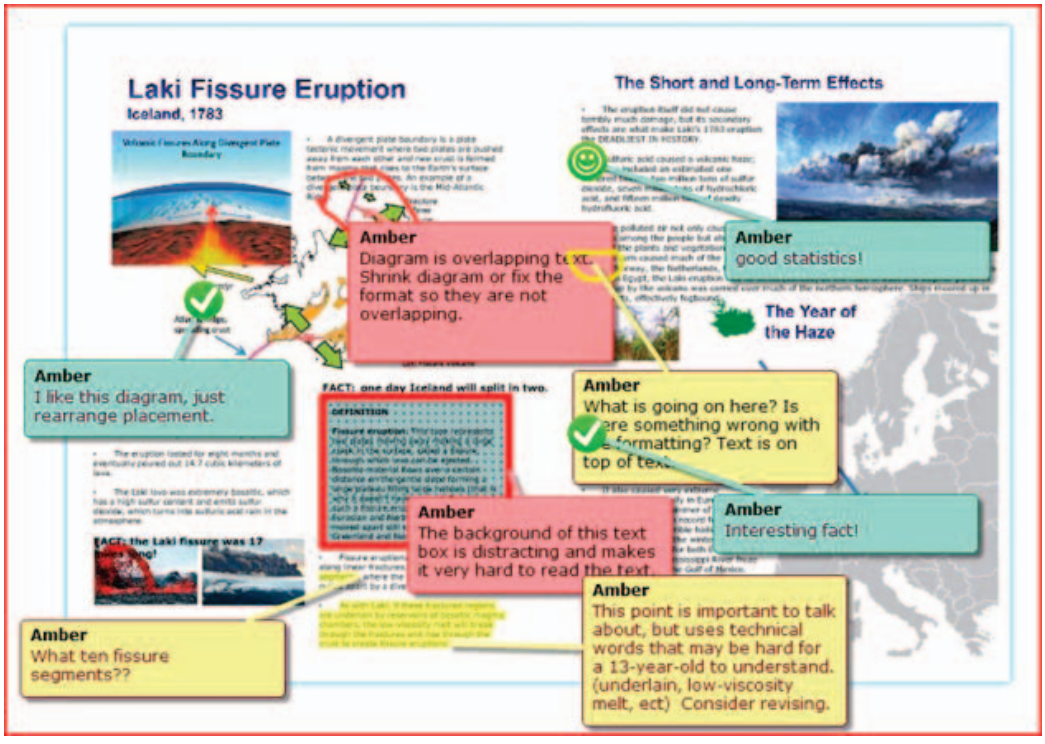


**FIGURE 2: Student poster on the Laki eruption of 1783, with peer review comments superimposed.**

Finally, they were asked about team work and communication. Most students viewed their teams as a positive: "We communicate in person, through email, and over the phone to get work done and complete assignments. We both are confident speakers who are not going to have a problem talking in front of the class." However, there were some problems as evidenced by one student's statement that "I have not been able to meet with my partner to discuss strategy in preparing for the presentation."

At the end of the semester, students were asked to reflect not only on the success of their teaching effort and what they might have done differently, but also on what they learned and their perceptions of what the K–12 students learned (see the Supplemental Materials). Student reflections regarding their perception of a deeper understanding of the course material mostly highlighted a greater appreciation of system science. For example, "I learned a lot more about the specific plate tectonic processes that create volcanoes. I hadn't completely understood that topic…in class." LSU students were required to explain why their assigned volcanic eruption occurred where it did in the context of plate tectonics, which is part of the ESLI Big Idea on geohazards. Volcanoes are not ubiquitous or random. They occur only in specific areas, and thus are only a geohazard in some areas on Earth. Similarly, LSU students believed they had a better understanding of the connection between plate tectonics and climate. "I certainly understand the global processes of the climate with intensity and detail."

LSU student reflections on the most important information they shared with K–12 students also focused on the ESLI Big Idea that humans can mitigate but not control natural hazards:

> *"The people of Vesuvius were going about their everyday lives when this catastrophic eruption occurred. It was unpreventable and unavoidable."*

> *"The kids came to understand that a volcanic eruption that takes place in a Third World country does not have the same impact of the exact same eruption that was to hit a country that was better aware and knowledgeable, with better building codes and evacuation plans."*

> *"They don't have to worry about facing a volcanic eruption in Baton Rouge, Louisiana. I think information about preparedness for natural disasters and where volcanoes occur is considered "enduring understanding" for a scientific literate citizen."*

Finally, LSU student reflections on service learning were overwhelming positive:

> *"…it's more fun than it is work, and I got to go to a part of Baton Rouge that I had never been to."*

> *"Throwing us into this to coordinate and create on our own is something that doesn't happen very often in a modern school setting and should occur more often."*

> *"This experience can apply to other situations in my life when I join the workforce and have to coordinate my schedule with my coworkers in order to meet and complete tasks."*

While only one student was an education major, many students reflected on this first teaching experience and whether it made them more or less interested in teaching as a possible career path. LSU student comments on service learning on the teaching evaluations, which were blind and not available to the instructor until after the semester was over, were also uniformly positive. It is noteworthy that no one dropped the class because of service learning.

### EBPPS Teacher Comments

While not used to evaluating LSU students, participating EBPPS teachers were asked to comment about the experience, as well as make recommendations for the future.

Most teacher comments about the service-learning project were positive, indicating that having college students explain science concepts was beneficial for their students. They also stated that the experience helped spark student interest in plate tectonics and curiosity about other historic volcanic eruptions. Another benefit of service learning documented by many teachers was that their eighth- and ninth-grade students had the opportunity to ask questions about college in general.

Negative teacher comments were limited to two teams of LSU students that had problems. In one instance, a group member missed the bus and had to reschedule his presentation. Many of the LSU students did not have cars. Public transportation in Baton Rouge is not reliable, and this was a concern from the beginning, as participating EBRPS were from all over the parish. The other LSU team had problems working together both in terms of schedules and personalities. Many Honors students take 17 h or more per semester and have other activities, so coordinating with team members for this project was difficult.

K–12 teacher recommendations for the future included having the LSU students explicitly tie their lesson plan to Louisiana's Grade-Level Expectations (GLEs), providing more hands-on instruction such as bringing rock and mineral samples, and providing guidelines for dress by LSU students.

## DISCUSSION

Volcanic eruptions and their ensuing destruction are fascinating to students. In addition, volcanoes are an excellent example of Earth-system science and interactions between Earth processes and humans. Thus, a semester-long service-learning project on historical volcanic eruptions allows students to cover many of the ESLI Big Ideas (Wysession et al., 2009), both inside and outside of class. The most obvious connection is Big Idea (BI) no. 8, "Natural Hazards Pose Risks to Humans," including "humans cannot eliminate hazards, but can engage in activities that reduce their impacts" (BI 8.7) and "natural hazards shape the history of human societies" (BI 8.2). The volcano project also touches on various aspects of BIs 1–7 (Wysession et al., 2009). For example, by researching past eruptions students learn how rocks and other material provides a record of Earth's history (BI 2.1) and how soils essential to agriculture can develop decades or centuries after an eruption (BI 7.6). Students are also required to document the connection

between mantle convection, plate tectonics, and volcanic eruptions (BI 4.3 and 4.5). As noted during peer review of posters, students better understand the role of water in the process of magma generation at subduction zones (BI 5.4). For some historic eruptions, such as Krakatoa or Laki, students can see the relationship between volcanic eruptions and climate (BG 3.4 and 3.7) as well as potential impacts on life (BI 6.6). Finally, an historical perspective makes the important point that "new observations continuously refine our understanding of Earth" (BI 1.7).

The Cognitive Domain in Bloom's Taxonomy (Bloom et al., 1956; Anderson et al., 2000) involves knowledge and the development of mental skills. The six major categories from simplest to most complex are "Remembering," "Understanding," "Applying," "Analyzing," "Evaluating," and "Creating" (Table I). A typical introductory class tends to focus on remembering (recall of information) and understanding (understanding meaning or interpretation of instructions). The service-learning project described above requires students to use concepts introduced in class in a new situation (applying) and differentiate concepts into component parts so that the LSU student understands the organizational structure (analyzing). Each team creates both a classroom presentation and a poster from their separate research papers (Table II). Peer review of other team's products as well as internal reflection also promote analysis (distinguish fact from inferences) and evaluation (make judgments about the value of ideas or materials). Table II summarizes each assignment in the service-learning project and correlates it with learning objectives and Bloom's cognitive taxonomy.

In addition to higher-order thinking, an additional predicted outcome of the service-learning project is the increased retention of material concepts learned (Udovic et al., 2002; McConnell et al., 2003). Teaching others is the most powerful learning methodology (Sousa, 2006). The LSU students presented the information on their historical volcanic eruption to their peers followed by teams teaching eighth- to ninth-grade students. The LSU students were also asked to incorporate into their instruction the connections to plate tectonics in order to build on the eighth-grade Earth Science or ninth-grade World Geography curriculum.

Service learning also exposes students to the Affective Domain in Bloom's Taxonomy (Bloom et al., 1956; Anderson et al., 2000), which involves growth in feelings or emotional areas (Table IV). LSU students learn to listen to others with respect during peer review and when in an eighth-grade classroom (receiving phenomena). There is active participation on the part of learners (responding to phenomena). LSU students learn to value diversity as well as show the ability to solve problems (valuing). Finally, teamwork and revision of behavior in light of prior classroom experience shows evidence of a value system that controls behavior (internalizing values).

Although we did not document LSU students' attitudes and opinions before the public school visits "in areas of town they had never visited," their comments led us to believe they left with positive feelings about the public schools and value of the diversity of students that they met. As described above, during the peer-review process, there were class discussions that took place about specific examples of human death and destruction (Fig. 1) and what material would be appropriate to share with a younger audience. The discussions created a learning environment in which these feelings were recognized rather than simply a sideline to the academic understanding of geohazards.

As with any first endeavor, there were some unforeseen problems that will be addressed in the future. The most obvious of these was not instructing LSU students in what constituted appropriate dress as a visitor to a public school (future prompts will include dress guidelines). In one instance, an LSU team submitted reflections on a teacher interview that did *not* occur. This was not discovered until the end of the semester when EBRPS teachers turned in their comments. In the future, students will have to turn in a form signed by their teacher with their reflections. While most students found collaborating with other students helped the project, in one instance, one team member did not fully participate and in another instance, the team members had major conflicts. The next time, we will spend class time discussing conflict resolution. After some discussion, the authors decided that keying the LSU students' presentation to GLEs was the teacher's responsibility. Rock samples to supplement lesson plans will be made available in future years.

A good service-learning project has the following components:

(1) Meets community needs
(2) Collaborates between the school and the community
(3) Structures time for students to think, talk, and write about the service activity
(4) Provides opportunity for the student to use newly acquired academic skills and knowledge in his/community
(5) Fosters a sense of caring for others (Liu et al., 2004)

By these standards, geoscience courses (even at the introductory level) are ideally suited for service learning. The authors collaborated on a service-learning project in 2011–2012 for a different class by using the recent earthquakes in Haiti, Chile, and Japan as subjects. Other geohazards such as flooding, hurricanes, tornados, or sea-level rise could also be used, depending on what is of local interest. Other potential

**TABLE IV: Bloom's Taxonomy: Affective Domain—growth in feelings or emotional areas.**

| Category | Key Words |
|---|---|
| Receiving phenomena | Awareness, willingness to hear, selected attention |
| Responding to phenomena | Active participation on the part of the learners |
| Valuing | The worth or value a person attaches to a particular object, phenomenon, or behavior. |
| Internalizing values | Has a value system that controls their behavior. The behavior is pervasive, consistent, predictable, and most importantly, characteristic of the learner |

topics include water resources, as every major city in the United States has problems with availability or quality of water, or hydrofracking either for oil/gas or geothermal energy. Eighth-grade Earth science is the most obvious community partner for schools, but geoscience is also taught in elementary school and high school biology, chemistry, and physics. The public could also benefit from additional information about geoscience. Student-organized public forums on seismic risk associated with hydrofracking or waste disposal would be particularly beneficial (Mogk and King, 1995). Finally, while it is more difficulty logistically to offer service learning in large lecture classes, LSU offers service learning as an optional portion of a class.

## SUMMARY

The service-learning projection on historical volcanic eruptions reinforces selected ESLI Big Ideas in LSU students. The project requires LSU students to attempt to master higher levels of knowledge (e.g., applying, analyzing, evaluating, and creating) in Bloom's Taxonomy hierarchy for the Cognitive Domain, and provide training in the Affective Domain (receiving phenomena, responding to phenomena, valuing, and internalizing values). Based on reflections and class evaluations, LSU students also seemed to have positive attitudes toward students from low socio-economic environments and an increase in sensitivity to the toll taken on human life and property by natural catastrophic processes. Finally, LSU students gained valuable experience in creating, reviewing, and revising written and spoken communication. K–12 teacher comments indicated that EBRPS students learned about volcanoes, how volcanoes are related to plate tectonics, and about college.

Service learning requires a strong desire for collaboration among all participants (LSU instructor and students, EBRPS science coordinator, teachers, and students). Communication and coordination are vital to success, so that everyone has the same expectations, knows his/her role, and problems are identified and resolved.

Service learning did not have a negative impact on either enrollment or evaluations for Honors Physical Geology. All participants felt that it was fun and a worthwhile endeavor. Everyone is onboard to do it again.

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