TRAVELING TRUNKS OF LASSEN VOLCANIC NATIONAL PARK:
A REDESIGN OF NATIONAL PARK CURRICULA AND
ASSESSMENT FOR GRADES 9-12

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Thomas A. George
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ABSTRACT

TRAVELING TRUNKS OF LASSEN VOLCANIC NATIONAL PARK:
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Lassen Volcanic National Park (LVNP) has geologic education resources contained in a large storage tub, designed for teacher use. The purpose of this project was to redesign and add to the curricula found in the Geologic Traveling Trunks (GTT) from LVNP. The objectives of the project were to: 1) design two matrices that correlate GTT teaching resources to both California State Science Standards and National Science Education Standards, 2) incorporate GTT-based activities in an Earth Science class for grades 9-12 and assess student learning based on implementation of those activities, 3) design a field trip to Cinder Cone volcano in LVNP supported by GTT resources, and 4) design a new curriculum for grade 9-12 earth science classes using the 5E
Instructional Model Learning Targets, and assessment for teachers to use. To develop the matrices, each GTT resource was evaluated and matched to science education standards. The GTT-based activities were designed using the Karplus’ Learning Cycle and inquiry methodologies of National Science Education Standards. Student scores in a pre- and post- test before and after incorporating the GTT resources were analyzed to measure test score changes. A field trip to Cinder Cone at LVNP focused on improving student learning about volcanoes. The result of this work shows that when provided with curriculum that incorporates GTT resources, student \((n=96)\) test scores increased more than the control group of students \((n=70)\) who were taught using traditional curriculum. This suggests that the GTT-based activities led to increased learning over the control group. Students who attended the field trip \((n=3)\) performed better on classroom assignments than students who did not attend the trip. Evidence of student learning led to development of the curriculum plan to provide a complete curriculum packet (a 10-day lesson plan using GTT resources and assessment) for teachers to use.
CHAPTER I

INTRODUCTION

In 2001, National Park Service (NPS) education specialist Steve Zachary proposed an idea to the National Park Foundation as part of the Parks as Classrooms program for funding of geologic educational materials for Lassen Volcanic National Park (LVNP). The proposal specifically was to purchase or collect a variety of geologic resources relevant to LVNP, put them in a storage-type box, and send them out to public and private K-12 schoolteachers. The box, known as a Geologic Traveling Trunk (GTT) or portable education box, is for teachers to use for classroom activities, investigations, and demonstrations in addition to being a learning resource for teachers own enrichment and study. The GTTs were also designed to encourage and entice teachers to take their students on field trips to LVNP (Steve Zachary, personal communication, February 2009).

In the GTT there are four different types of resources (Appendix A). The first resource type is for content: printed materials that include geology and volcano books, information sheets on volcano types, fact sheets from the United States Geologic Survey, pictures of Lassen Peak eruptions, maps of trails, and pictures of other volcanoes.

The second type of resource is the GTT Resources Guide, written by NPS personnel. In this guide are descriptions of trunk contents, vocabulary lists, suggested
activities using items found in the trunk, assessments based on the GTT activities, and
general lesson plans for grades K-12.

Geologic specimens make up the third GTT resource type. There are four
different specimen boxes in the trunk: one box contains rocks from Lassen Peak, another
with rocks found elsewhere in LVNP, including pumice samples, cinders from Cinder
Cone and lavas of Lassen Peak. These resources are rare because they come from LVNP
where it is illegal to remove specimens.

The last type of resource in the GTT can be generalized by calling them
“student-learning tools.” In each trunk are rulers for measuring distances or dimensions
of the rocks and magnifying glasses for looking at specimens up close. These tools are for
students to use when working with rock samples.

The GTT has many resources, put together to serve students of all grade
levels. This one-size-fits-all design could be improved by making parts of the GTT grade
specific. It is also necessary to connect the GTT resources with standards that identify
goals in student learning.

Purpose

The purpose of this project is to add and revise components for the GTT to
improve student learning of volcanology and geology concepts. The GTT has a number
of useful teacher resources before the start of this project. If teachers can see what is in
the trunk and relate that to what they teach, they could use the trunk resources during
geology-based sections of their class instruction.
The first part of this project is to inventory the GTT and match the resources and activities found in the Lassen Geological Traveling Trunk Resource Guide with the California State Science Standards and the National Science Education Standards. This resulted in the design of two matrices in which each trunk resource is matched with a specific education standard. The two matrices (one matching GTT resources to California State Science Standards and another to NESS) will become part of Lassen Geological Traveling Trunk Resource Guide. The matrices will help teachers identify items in the GTT related to their grade level standards.

The second part of the project is the development of GTT-based activities and the determination of how they worked in classes. Using the ideas of Karplus’ Learning Cycle and inquiry methodologies, activities were designed to use the GTT resources in grade 9-12 earth science classes. Two teachers used the GTT-based activities for the project and one teacher did not use the GTT-based activities. Earth science students from three different classrooms were given a 15 question pre-test on volcanic concepts. I taught my classes with all ten days of GTT-based activities and tested students with the same pre- and post-test. A second teacher’s class was the control group and did not use the GTT-based resources for instruction but they did take the pre- and post-test. A third teacher taught only four out of the ten activities so they did not take the post-test.

The project has a field trip component, based on the idea that students learn better on a field trip (Dierking & Falk, 1997). Three students from my class traveled to Cinder Cone in 2008 to measure cinder size, make observations, and examine a volcano close-up. Students used a field guide I designed to be interactive during the fieldtrip (Appendix G). Upon returning home the students were given a survey about the field trip
(Appendix E). Those students also took the pre- and post-test and had higher scores than those who did not go on the field trip.

The final purpose of the project is the development of a curriculum unit. An examination of the test scores of the students who had access to the GTT-based activities group showed a larger increase than the control group. This suggested that a fully developed curriculum unit that integrates the GTT- resources would be useful in improving student learning. The 5E Instructional Model (Bybee et al., 2006) has shown improvement in student learning so it became the foundation for the curriculum plan.
CHAPTER II

REVIEW OF LITERATURE

There is much research about what curriculum can do to foster student learning, and the research will be discussed in three sections. The first section discusses the traveling trunk with the student learning that takes place in an informal learning environment like on a field trip, museum visit, or other informal visit (Dierking & Falk, 2003). The second section reviews literature about real field trips, like visiting Cinder Cone, and virtual field trips, like using the GTT, and the importance of field trips in the school curriculum. The third section discusses curriculum design and what works in a classroom as a learning cycle along with the assessment of student learning.

Traveling Trunks

Traveling Trunks (TT) often have all sorts of diverse resources (rocks or bugs or sand, etc.) and many offer lesson plans or ideas on how to use the resources, but the question is why would a teacher use a traveling trunk? There are many reasons according to the research. Roy and Petty (1997) report that “portable education boxes are cost effective in bringing in educational multimedia to the classroom.” (p. 3). The costs involved are typically shipping, as most boxes are free to loan to teachers, a helpful idea given low school funding for teaching resources. Roy and Petty (1997) also report that
the box helped cut down on curricula development as well as time saved from writing assessments.

Research on the use of a traveling box in the classroom indicates a significant increase in knowledge of the students compared to students who do not have access to resources in the traveling box. Roy and Petty (1997) studied the use of a traveling box with resources for environmental education on the introduction of wolves into a section of the Rocky Mountains. From 233 teacher comments, 97% of the responses indicated positive changes in students attitude, knowledge, or both for students who were exposed to the resources in the trunk (Moore, 1994, as cited in Roy & Petty, 1997). In another group that used trunks with resources to study songbirds in Montana, teacher responses indicate that the traveling boxes were useful as “factual supplements to science curricula” (Roy & Petty, 1997, p. 6). Respondents in the study reported few problems or conflicts with the boxes, but did not mention the effectiveness of the trunk. The summary of their research is that “research should be conducted on their effectiveness, especially in regard to attitudinal change and methods of curriculum development and review” (Roy & Petty, 1997, p. 6).

Field Trips

The GTTs were designed to help students learn about aspects of the LVNP that will encourage a field trip to the Park (Steve Zachary, personal communication, October 2008). Students and teachers alike should be encouraged to take field trips because they have been shown to help student learning (Dierking & Falk, 1997). Their research showed that the learning on field trips is longer-term learning with deeper
thinking than in a classroom environment and that students learned better from a field trip experience. Dierking and Falk (1997) interviewed fourth grade students, eighth grade students, and 20 year-old or older adults about what they remember or learned from school field trips the students had gone on earlier in their schooling. The students remembered at “least three or more content/subject matter aspects of the field trip” (Dierking & Falk, 1997, p. 215) even after many years had elapsed. Dierking and Falk (1997) report that people did not remember as much on a normal non-field-trip school day as one day on a field trip.

Kern and Carpenter (1986) conducted a study on the effectiveness of field trips on cognitive learning. They compared the results of student learning using a laboratory manual in earth science in a classroom to a field trip experience. They discovered that the classroom-bound students scored about the same as the field trip students on lower-level thinking skills such as recalling a name of an object. The field trip participants were able to articulate higher-level thinking, like comparison or synthesis skills, better than the laboratory manual-based students (Kern & Carpenter, 1986).

Research by McComas (2006) shows that the “most effective science instruction occurs when students and teachers have access to the widest number of resources possible” (McComas, 2006, p. 28) such as colleges, nature centers, businesses, museums, and parks. Such places outside of the classroom are known as “free choice learning” (FCL) opportunities (McComas, 2006). Students are involved with learning at these venues, and tend to develop learning more in the affective or emotional domain than cognitive or psychomotor learning domains (Meredith, Fortner, & Mullins, 1997). When students are brought to a FCL site, they need to be encouraged to do the activities
and engage the resources; to make it a learning experience, teachers need to check for understanding during the experience and afterwards (McComas, 2006, p. 29). Bringing students to these places will increase their interest and their chance of becoming “life-long learners” (McComas, 2006, p. 30).

Kisiel (2006) and Connolly, Groome, Sheppard, and Stroud (2006) studied how to design a field trip to maximize student learning. Kisiel (2006) suggests that students on a field trip visit be directed to the specimens and not the information placards associated with displays. Students need questions to help them to internalize the information and make sense out of it. The next lesson back in the classroom must follow-up on the ideas developed on the trip to maximize the learning of the student objectives (Kisiel, 2006). In addition, Michie (1998) reports that it is important for students to record notes in books or answer questions on worksheets during the field trip to focus students thoughts as well as to connect classroom concepts with field trip exhibits.

From the research, it is clear that field trip experiences can encourage and improve student learning. Does exposure to the resources in a traveling trunk without the field trip encourage student learning? Garner and Gallo (2005) did a study on students who took a “real” field trip to the Indian River Lagoon (IRL) in central Florida, while a comparable number of students were given a virtual field trip experience to the IRL. The virtual field trip experience involved watching video of the IRL. There were artifacts and specimens in the room the students could look at, much like what one would find in a traveling trunk from a location.

The assessment devices were the same for both groups and the results showed there was no difference in achievement scores between the physical field trip group and
the virtual field trip (Garner & Gallo, 2005). Students who went on the real field trip reported more positive attitude towards the subject, whereas the attitudes of the virtual field trip students decreased slightly (Garner & Gallo, 2005). The virtual field trip was less expensive to run, took less time, and provided the same concepts to students as the real trip. In addition, virtual field trips can be customized for the specific educational goals, whereas real field trips are somewhat set on what they offer for student learning (Zairo, 2009).

Assessment Using Pre- and Post-Tests

According to Linn and Miller (2005), pre-testing is used to determine to what extent students have learned the objectives of the new curriculum unit before it is taught. An end-of-instruction assessment (post-test) is used to certify accomplishment, provide feedback to students, and assess instruction of the curriculum (Linn & Miller, 2005, p. 137).

Effective Curriculum

“Science is an organized body of knowledge and a method of proceeding to an extension of this knowledge by hypothesis and experiment,” wrote Glenn Seaborg (California Dept. of Education, 1998, p. 3). Seaborg chaired the committee that developed the California State Science Standards of 1998 that dictates what is taught in the classrooms of California. How to teach those concepts was not part of the prescription from the Seaborg committee: that is left to the professional judgment of the classroom teacher. So, according to the research, what method is good for student learning?
In the 1960s, Robert Karplus developed what is known as the Learning Cycle (Karplus, 1977), an idea that students learn best if they are asked a question or shown a phenomena, and are given time to explore the concepts illustrated by the question or phenomena, called the Exploration Stage, in some sort of hands-on activity or laboratory experiment (Fuller, 2003). Students are encouraged to develop ideas on how things work or develop an explanation of the phenomena, known as the Invention Stage (Karplus, 1977). Instructor questions are used to challenge student thinking about how student invention matches discovery of how the phenomena is explained, known as the Discovery Stage (Karplus, 1977).

The basis of laboratory experiments builds on the ideas of Karplus (1977) and also the ideas of Constructivism (Fuller, 2003) which is the building of internal knowledge as one experiences the world (Brooks, 1986); or in a classroom setting, students construct understanding as they manipulate laboratory equipment, make observations, and form conclusions (Brooks, 1986). The learner is self-rewarded for their intelligence, their ability to piece concepts together, and to accomplish learning objectives (Brooks, 1986). Student conclusions of what is happening with the phenomena, the Invention Stage, need to be monitored, checked and challenged by teachers if the conclusions don’t represent accurate scientific knowledge. This monitoring/checking for understanding, as an assessment of student learning on a daily basis, in a minute-by-minute mode is known as formative assessment and has been shown to produce the greatest improvement of student achievement of anything a school or teacher can do in a classroom (Black & Wiliam, 1998). The GTT-based activities were
designed with these ideas of how students learn and the teacher knows what students have learned.

When designing curriculum, there are other concerns. The National Science Education Standards states, “Teachers of science need to plan an inquiry-based science program for their students” and “Inquiry into authentic questions generated from student experiences is the central strategy for teaching science” (National Research Council, 1996, p. 31). Curriculum should include these inquiry modes so that students get a better understanding of science as a process, one of the most important concepts of science (National Research Council, 1996).

Some teachers have the idea that inquiry-driven instruction means students are given a minimal amount of instruction and students are expected to learn all of the concepts that an inquiry experience could provide (Brooks, 1986). Kirschner, Sweller, and Clark (2006) showed that the minimalist constructivist approach does not work in the classroom because teachers confuse the teaching of a discipline as inquiry with the teaching of the discipline by inquiry. Teachers promote the class as inquiry, and it does not promote student learning of the concepts. For example, if a teacher puts out five rocks on the lab station and expects students to determine the identity of the rocks without any resources, the teacher is mistaken in calling this an inquiry activity. Kirschner et al. (2006) research showed that to learn new information or knowledge, some background information has to be known already to build the new information on, known as scaffolding. The research also suggests the need for the teacher to guide student learning while there is also some student discovery (Kirschner et al., p. 83). This satisfies the need for prior knowledge to be connected to newly formed knowledge. The Guided Discovery
strategy (Bykerk-Kauffman, 2006) is having someone, probably a teacher, guide the student through the process of making sense of a concept rather than the student trying to figure out the concept themselves. Pollock (2007) reports that Learning Targets (precisely worded descriptors of what students will learn), when used with other strategies noted above, positively impact and improve student learning.

A model that incorporates all of these curriculum ideas noted above is known as the 5E Instructional Model (Bybee et al., 2006). This approach uses Karplus’ (1977) ideas of exploration, invention, and discovery, and adds two components; engaging student interest and evaluating student progress toward understanding of concepts. So, according to Bybee et al. (2006), the 5E Instructional Model is Engagement (asking a question, defining a problem, showing a surprising event, or a “hook” that catches the students interest), Exploration (students get involved with phenomena and materials), Explanation (putting the abstract form of information into a communicable form), Elaboration (helps students make connections to other related concepts or apply understandings to the world), and Evaluation (to help teachers determine if the learner has attained understanding of concepts and knowledge).

Concluding Remarks

The research provides clear guidance for designing curriculum with the resources of the GTT: it should be centered on student learning (Bybee et al. 2006), be inquiry-based (National Research Council, 1996), and use directed discovery types of activities that connect previous student knowledge to the new curriculum material.
(Brooks, 1986). Students learn when they are exposed to as many instructional resources as possible, which supports the use of the GTT (McComas, 2006).
CHAPTER III

DESCRIPTION AND METHODS

Description of the Project

Content

The GTT was developed for teacher use in the classroom as an educational tool, for a precursor experience to a field trip visit to LVNP, or even in lieu of a park visit. In the GTT there are some resources that are impossible to gather independently because samples cannot be removed from LVNP. However, the curriculum resources in the GTT prior to this work were not easily implemented in many classrooms because they were not focused on specific grade levels or to specific California State Science Standards.

Some of the improvement ideas for the GTT were gathered from K-12 teachers. In October 2008, the California Science Project Inland Northern California and Redwood Science Project’s Lassen Institute drew 22 science teachers (grades K-12) to Child’s Meadows, California, near LVNP for a teacher leadership workshop. The participants taught each other about pedagogy as well as science content. At the workshop a GTT was displayed and the resources were explained. At the end of the session, the feedback from 20 out of the 22 participants was that the GTT would be more useful if there was a matrix connecting the science standards with the resources in the trunk.
Before the project improvements, a teacher could look through the list of activities found in the GTT Resources Guide. But based on teacher feedback, part of this project became to design a matrix that matches the resources of the GTT with California State Science Standards (there are cultural resources as well as biological resources in the GTT, but the scope of the two matrices is specifically geared towards the Earth sciences/geosciences for grades K-12). With the matrices, a teacher can find their grade level or a standard, and see the resources that match those standards. Both California State Science Standards and National Science Education Standards are part of the matrices (Appendix B).

The second part of this project is the assessment of student learning from the use of resources in the GTT. Assessment questions based on the resources originally included in the GTT were already designed by NPS, in the Lassen Geological Traveling Trunk Resource Guide, and they could be used to determine student learning. As part of this project, 10 days of GTT-based activities were classroom tested. These activities were assessed with a newly designed pre-test that measured student knowledge and the same questions used as a post-test. A post-test was used as a summative assessment. The objective of the pre-test was to determine what students know about volcanoes and igneous geology before being introduced to the resources of the GTT. Most concepts emphasized on the pre/post test were from the California State Science Standards. Other questions were not based on grade level standards, but were based on experimental and investigative aspects of the California State Science Standards. Additional assessments, formative in nature, are included in the final curriculum to determine if students have mastered the content. If the students
demonstrate learning about a concept, then the class can move on to different learning targets. If students do not demonstrate learning, then that concept can be retaught to the students.

The third component of the project is to develop a field trip to Cinder Cone, using resources found in the GTT. The leaflet entitled “Cinder Cone Trail Guide” (NPS, 1999) describes various points of interest, which correlate to numbered signs along the Cinder Cone trail. The leaflet points out what to look for and some basics about the volcano itself. It is not engaging, and it does not ask questions of students but is informative. Students read the information but might not retain much of the information because it requires no mental engagement. This prompted the creation of a more interactive, hands-on, minds-on approach for the field trip to Cinder Cone (Appendix G).

The new Cinder Cone field trip guide was designed for students to learn actively as they walk on the trail. At each numbered sign along the trail, the students stop and complete the corresponding activity in the Cinder Cone field trip guide. Students can talk to each other about the questions and share information as they gather data along the trail. They make hypotheses, measure ejected fragments, look for patterns in data, form conclusions, and learn more about the four volcano types.

The fourth part of the project was to develop curriculum using the GTT resources that can be used by grades 9-12 earth science teachers (Appendix C). Some activities suggested in the Lassen Geological Traveling Trunk Resource Guide couldn’t be used in 9th through 12th grade classrooms, but this project adds curriculum targeted for grades 9-12 using GTT resources. As an example, in grades 9-12, students should know there are four volcano types (refer to California State Science Standards). In the original
Lassen Geological Traveling Trunk Resource Guide there are suggestions on how to model all four types of volcanoes.

The actual curriculum plan can be found in Appendix C. Components of the curriculum include a pre-test, 10 days of curriculum that include videotapes with follow-up questions, hands-on lab activities, guided inquiry activities, exercises in critical thinking, assessment of learning, formative type assessment, and a post unit assessment similar to the pretest. The curriculum also includes Overall Learning Goals, California Earth Science Content Standards, lesson or activity timing, Learning Targets, student learning outcomes, materials, and the 5E Instructional Model outcomes.

**Audience**

The matrices are designed specifically for K-12 teachers. Because the GTT can be shipped to other states, also included is a matrix of the National Science Education Standards aligned with the resources found in the GTT (Appendix B).

The assessment of the original GTT-based activities was designed with 9-12 grade teachers as the focus group because they will use the assessments to see how effective the use of the resources are. Grade 9-12 teachers can also use the pre- and post-tests in their own classes to determine how well their students learn from the GTT curriculum.

The third part of the project targets students of grades 7-12 who go on the field trip to Cinder Cone in LVNP. If classes are not taking a field trip to Cinder Cone, parts of the activities can be modified for use in the classroom with the books and cinders found in the GTT.
The last part of the GTT project, the curriculum unit (Appendix C), is for grades 9-12 teachers to be used for an Earth science class. The emphasis is on using the geological resources of the GTT to learn about volcanoes along with information on how to use the curriculum in the classroom.

Results Expected

There are four parts to this project on the GTT, so there are four categories of results that are expected as outcomes of this project.

It is expected that teachers will use the matrix to determine what geological resources in the GTT are appropriate for each science standard, whether considering the California State Science Standards or the National Science Education Standards. It is anticipated that teachers will save time and energy using the matrices to find appropriate resources quickly, leaving more time for teaching. Final research on the use of the matrices has not been completed.

Assessment of the classroom tested GTT-based activities was used in two ways. Summative assessment (the post-test) of the original GTT-based activities was used to measure what was learned or assimilated by students, while the formative assessment in the daily curriculum was used to determine what concepts needed to be taught differently, what concepts needed further cognitive development, and in what direction the teacher should go next. If most students demonstrated they understand the class concepts, new topics were introduced and taught. If a large number of students demonstrated either a lack of understanding or misunderstanding of a concept, then those topics needed to be revisited, perhaps with a different emphasis or different teaching approach. The results of these assessments were used to develop the final curriculum.
The third component of the project is the development of the field trip to Cinder Cone Volcano (Appendix G). Students are expected to answer questions and demonstrate both observational skills and writing skills to connect their experience on the Cinder Cone trail with the science concepts of the unit. With the Cinder Cone Trail Guide, they will be able to describe differences and similarities between the four volcano types and will be able to explain how each type was formed. Students will be able to define cinder, tephra, angle of repose, and basalt. Students will also be able to measure the size differences in the tephra in relation to the distance away from the volcano’s crater.

The curriculum unit is to be used in grades 9-12 Earth Science classes. Teachers can use the curriculum and activities to help learners understand geological processes and concepts with an emphasis on volcanology. It is expected that students can learn the concepts better with GTT curriculum than with traditional earth science volcanology units because the new curriculum unit is designed with good teaching practices including using local resources like LVNP or the Sutter Buttes, using field trips as an affective motivator (assuming students like being outside looking at objects; Dierking & Falk, 1997), using inquiry-based activities (National Research Council, 1996), and the use of formative assessment daily (teachers ask students what do they know and how can they show that they know it during the course of activities; Black & Wiliam, 1998). Is it expected that teachers will also be more engaged in the field trip themselves.

It is expected that the results from the final curriculum will be that students will be involved and engaged with their own learning as they work through the activities.
It is also expected for student scores to increase due to the proven instructional practices noted above.

Limitations

There were many limitations to the project, with a varied amount of impact. The first limitation of project was funding. Originally, the field trip was a major part of the project. Having students use the resources in the GTT, learn volcano concepts in class, and then experience the geological characteristics of the LVNP was the starting place for this project. Lisowski and Dusinger (1987) indicates that the understanding, concept retention, and motivation all improve for students that have experienced a well-designed field trip. School funding for field trips has been nonexistent for two years that the field trip to Cinder Cone was intended to occur. After funding was clearly not going to be available, parents were asked to drive students to Cinder Cone. Only one parent out of 105 students was available to transport students. It is a California Education Code requirement to include all students on field trips regardless of having money, so leaving students behind was not a consideration (California Codes, n.d.). Due to lack of field trip funding the field trip date was moved from a student school day to a Saturday so more parents might be available to transport students. On the scheduled day of the field trip, no parents were able to transport students. Three students went on the Saturday field trip with the instructor. The data from their experience is important, but far too small to draw a conclusion or make a statistical inference (see Appendix F).

Another limitation was that students did not return permission slips. Data of both pre-and post-scores were extracted from student scores. In order to use that data,
parent permission had to be obtained for students. Most students from two classes out of a total of five possible classes did not return their permission slips, so that data cannot be used as a condition of human subject use (http://www.csuchico.edu/resp/projadm/form/hsrc/requirements.shtml).

Methods

The Geological Traveling Trunk (GTT) is a plastic tub filled with items from Lassen Volcanic National Park. It contains 47 separate resources. These can be classified in several main categories: books and other written materials, videos, specimens, pictures/posters, and a Lassen Geological Traveling Trunk Resource Guide. Each item from the GTT was identified or read for content, then listed on a comprehensive inventory. The items were evaluated for relevance to teaching earth science content. Two matrices were designed to link the 47 resources to 21 California State Science Standards (California Department of Education, 1998) and to seven National Science Education Standards (National Research Council, 1996), which are shown in the matrices as a number for the GTT item and a letter that corresponds to a standard. Many GTT resources matched one or more California (California Department of Education, 1998) and national standards (National Research Council, 1996).

In 2008, I designed series of activities incorporating GTT resources for an earth science course for grades 9-12. Activities are based on grade level California State Earth Science Standards. They incorporate elements of Karplus’ Learning Cycle (Fuller, 2003), Constructivism (Brooks, 1986), formative assessment (Black & Wiliam, 1986), and inquiry-based science (National Research Council, 1996). Student objectives were
created based on science standards, personal interest, and proximity to local resources (LVNP), because local connections engage students to learn (Kidwell, 2010). The activities were used in four classes in fall 2008 and five classes in fall 2009. The scores from classes in 2008 were recorded but not kept in a format that could be used for statistical study. In 2009, there were two classes taught by another teacher and I taught three classes. The first teacher did not get the release forms signed by parents to use student data for this study.

A field trip to Cinder Cone in Lassen Volcanic National Park was developed as part of the GTT-based activities. In June 2008, Dr. Rachel Teasdale and I visited the area to see what could be used for the experience with students. Cinder size changes, types of material, and qualitative observation questions were written as a fieldtrip guide in the same format as the LVNP Junior Ranger Devastated Area Park Scientist Notebook.

In fall 2008, the field trip was offered to students in the classes utilizing the GTT-resources. Out of 105 students in earth science classes, only three chose to participate in the field trip. These students were given the Cinder Cone fieldtrip guide to direct them on what to observe and measure while hiking to Cinder Cone. Students were also able to observe the four types of volcanoes from one location. The fieldtrip guide also asks students to form some conclusions about cinder cone volcanoes.

After the field trip, participating students were asked to respond to a 14-statement survey. The statements were designed to measure learning of science concepts. Students responded to each statement by circling numbers from one to five on a Likert scale (see Appendix E).
To determine the effectiveness of student learning based on the GTT-based activities, a 15 question multiple-choice pre-test was given to five classes (166 students) prior to using any of the GTT-based activities. Two classes, taught by a second teacher, were given the pre-test but he taught the same concepts using a traditional earth science curriculum, making his two classes a control group. I taught the other three classes (96 students) using the GTT-based activities.

Following the 10 days of volcanology curriculum (taught with the GTT-based activities to the experimental groups and taught with the traditional curriculum taught by the second teacher), a 15 question multiple-choice post-test was given to the same 166 students that took the pretest. The pre-test and post-test used the exact same questions. Statistical comparisons of pre- and post-test scores were determined.

A third teacher volunteered to teach the GTT-based activities in two of his classes of the same earth science course. His seventy-two students were given the pretest, but he only used four lessons of the ten-day curriculum unit. Scores from his student’s pre- and post-tests were recorded, but could not be used in this study because students in his classes did not return the human-subject release forms to publish their data. Additionally, this third teacher did not use the curriculum in its entirety, which became another factor in excluding data from his classes in this project. However, this third teacher was interviewed about his experience teaching the unit (Appendix H).

After comparing the data of the GTT class to the control group, it appeared there was a more positive change in student learning by students who had access to the GTT-based activities. This suggested that a fully developed curriculum unit that integrates the GTT- resources would be useful in improving student learning. In order to
optimize students’ learning experiences, the 5 E Instructional Model (Bybee et al., 2006) became the foundation for the design of the curriculum unit. The GTT activities were revised to include the 5 E Instructional Model for each lesson plan (see Appendix C). The process of revising the curriculum based on the original GTT-based activities is an example of an Action Research Cycle (Mills, 2003), in which a teacher identifies an area of focus (in this case, the GTT-based activities), collects data (pre and post test scores), analyzes and interprets the data (confirmed increase in student scores), and develops an action plan (use 5 E Instructional Model in the curriculum) (Mills, 2003, p. 5).
CHAPTER IV

RESULTS

There are no results for part one (the matrices) because they have not been published for use nor have they been shared with others. The matrices were not a major emphasis for the project; there might be research on how teachers use the matrices and how effective they are for the future.

For component number two, there were results that were expected, and some that were not.

First, the assessment piece was to look at test scores before and after instruction. After a series of statistical tests were run on the data from the GTT group of students compared with the control group, the results suggest that the GTT resource experience helped students to improve their understanding and learning about volcanoes. The control group did show gains as well but not as big (see data section in Appendix E).

A third teacher who used parts of the GTT-based activities reported that students were interested more in the Lassen Park volcanoes because they are close to our geographical area and there are examples of the four different types of volcanoes. He also felt students learned the course material better and were more motivated with GTT-based activities than in previous years when none of the curriculum was used in his classroom. He also reported an unexpected result for himself. He was asked about his personal knowledge of volcanoes before and after the GTT-based activity exposure. He reported
that he was much more knowledgeable about volcanoes in general after using parts of the GTT, and more knowledgeable about LVNP with the four different types of volcanoes found there.

The control student group of students who did not have access to the GTT resources had 70 students that scored a mean of 3.99 out of 15 on the pre-test as seen in Figures 1 and 2. The post-test average mean score was 5.50 out of 15, an increase of 1.51 points, which is an improvement of 38%. See Appendix F for actual scores.

![Period 2 Control Group](image_url)

*Figure 1. Control Group pre-test and post-test scores, out of 15 points, for students taught with non GTT resources, Period 2*
Figure 2. Control Group pre-test and post-test scores, out of 15 points, for students taught with non GTT resources.

Period 3 Student scores in the group that used the GTT-based activities on the pre-test had an average mean score of 4.4 out of 15 possible as seen in Figures 3, 4, and 5 (see Appendix F for scores)

In Figures 3, 4, and 5, student data from classes that were taught using GTT-based activities showed an increase of student scores of 5.07 points. Average pre-test scores are 4.4 and post-test scores average of 9.47, a 125% increase from the average mean pre-test score.
Figure 3. Period 1 pre-test and post-test scores out of 15 points, for students taught with GTT resources.

GTT Resources

Because averages can be skewed easily by data extremes, differences in pre- and post-test scores for each student were analyzed using a one-sided t-test, a statistical tool that can indicate whether mean scores are or are not caused by randomness. To determine the test statistic, a hypothesis regarding data is stated, called a null hypothesis. The null hypothesis for this data is there is no change between the pre-test and post-test scores. An alternative hypothesis about the data is that the post-test scores will be higher than the pre-test scores. It is easier to disprove the null hypothesis than prove the
Figure 4. Period 2 pre-test and post-test scores out of 15 points, for students taught with GTT resources.

alternative hypothesis, which is really the research hypothesis (Yates, Moore, & McCabe, 2000). With the project data, an increase in student scores is expected, so the one-sided t-test was performed on the data. The t-test statistic indicates whether or not to reject the null hypothesis (no change in the data) in favor of the alternative hypothesis, which states the post-test scores are higher than the pre-test scores. After the t-statistic is calculated, inferences can be made about the data. If the t-test number is bigger than 3.5 for a sample size of 32 or more students, the inference is there is a positive change in the scores (Vermeeesch, 2009).
Figure 5. Period 3 Pre-test and post-test scores out of 15 points, for students taught with GTT resources.

Another number that is calculated during the t-test is the probability number ($p$). There is a probability that the data show an improvement in student scores due to random chance (Mark Mavis, personal communication, June 16, 2009). The p-value indicates the probability that the outcome of the t-test is due to randomness. If $p$ is large ($p > 0.05$), then the increase in the scores becomes more likely due to randomness or chance, and not because of the curriculum or type of instruction. If the probability $p$ is very small ($p < 0.01$), the conclusion that the scores are higher on the post-test is more likely due to the experience with the GTT-based activities each student had, and the reason for the higher scores is not randomness or guessing by students (Yates et al.,
2000). Even though $p<0.01$ is acceptable for concluding that scores reflect real student learning, it is standard to use $p<0.05$ or 5% probability to show that the data is due to random events and not caused by a relation of the data sets to the variables. If the calculated $p$-value is more than 0.05, then the null hypothesis is accepted, and there is no relation of the pre- and post-test scores. If the $p$-value is less than 0.05, then the null hypothesis is rejected, the research hypothesis is accepted, so there is some relationship to the score changes and the experience students had with the GTT-based activities.

The one sided sample t statistic is calculated by:

$$t = \frac{\bar{x} - 0}{s_x/\sqrt{n}}$$

where $\bar{x}$ is the mean value of a set of numbers, $s_x$ is the standard deviation of the value set of numbers, and $n$ is number of values in each data set (Appendix E).

Field Trip Data

During the fall semester of 2008, 140 high school students were taught concepts of volcanism with GTT-based activities and three elected to go on the Cinder Cone field trip at the end of October. After the field trip, the three attendees were given a survey to determine how the field trip went from their perspective. Students responded to 14 statements using a Likert scale. The statements were designed from an affective perspective, indicating how the student felt about various parts of the field trip. All three students gave a 4 or 5 score (mean of 4.7) to 13 out of 14 statements. The statement “I learn better when I am given a worksheet as a guide for the field trip” scored a mean average of 2.3, indicating the students disagreed with the statement. The research shows
that learning is optimal when students have a worksheet as a guide (Michie, 1998), which contradicts the three students responses.

The three student scores on the pre-test scores were a mean 4.64 while the class had a mean of 4.68. On the post-test, the three field trip students scored a mean of 10.7 compared to a mean score of 9.4 for the students that stayed at home, an increase of 1.3 points. While this is not a large increase, it does show greater improvement than the students that did not participate with the field trip.

The field trip results to Cinder Cone are anecdotal. Unfortunately, the responses are statistically too small of a sample to form conclusions (sample size of three). However, the results are the students strongly agreed that the field trip was interesting, had good information, made science more enjoyable, helped students understand the concepts of volcanoes better, helped demonstrate knowledge in different ways, was enjoyable and the curriculum level was appropriate for the students, (student surveys, 2008, Appendix F).

The only field trip survey question with a surprise result was a disagreement where students did not think they learned using a worksheet while on a field trip (student surveys, 2008). The research (Kisiel, 2006; Connolly et al., 2006) shows worksheets, whether employing inquiry-based or open-ended question types, help retention of information from a field trip experience. The research goes on to suggest these field trip experiences are remembered long after the initial field trip if there is a debrief session in the classroom after the field trip.
Interpretation

The tested null hypothesis was there would be no change in the pre- and post-test scores and the alternative hypothesis indicates there will be an increase. Yates et al. (2000) state that if the t-value is larger than 3.8 for a sample size of 32 students, then the null hypothesis is rejected. All t-test values are high enough to infer that the gain shown on student scores can be attributed to the unit study and not by chance. There might be multiple variables that contribute to the increase of scores, such as differences in teacher instruction. Because the p values are small ($p < \text{millionths}$) in comparison to the usual p-value of 0.05, the null hypothesis is rejected, meaning that the test showed an increase in scores not because of randomness, but there is a significant increase in performance on the post-test compared to the pre-test. The average t-score for the control group is 3.88 and is 8.66 for the GTT-based activity classes. This shows greater improvement on the post-test for students who were taught with the GTT-based activities. The increase in scores with the t-test results suggests using the GTT resources in the high school earth science class could improve scores and ”improvement in scores is one way of demonstrating learning” (Linn & Miller, 2005, p. 137).
CHAPTER V

SUMMARY

In 2002, National Park Service staff at LVNP put geological education materials together in large storage boxes to be used by K-12 teachers. These GTT’s contain resources of books, videos, photographs, pictures, rocks, cinders, and a guidebook of how to use resources in the trunk along with some pedagogical suggestions for using resources in the classroom. The GTTs are also designed to encourage teachers to organize field trips to LVNP so students can experience geological resources firsthand.

Two matrices were created to match both California State Science Standards in Earth Science and National Education Science Standards for grades 2 to grades 12 (there are no Earth Science Standards for kindergarten or first grade). Because teachers are expected to teach to the standards, they tend to use class resources that they know fit the standards of their grade level. The matrices produced here can facilitate more GTT use in the classroom. One teacher that used the GTT in his classroom reported that he did not look at the new matrices but 20+ teachers recommended development of the matrices. Activities were designed around the resources found in the GTT, using the educational ideas of hands-on experiences.

Activities using GTT resources for high school earth science classes were tested to determine the effect on student learning. One teacher taught students using the GTT-based activities to be used in classrooms. Another teacher’s students in a different
classroom were used as the control group. They were taught the same volcanology concepts as the experimental group without the GTT-based activities.

Part of the curriculum unit was a field trip to Cinder Cone Volcano where students can see and experience volcanoes. The expectation was this field trip would improve learning about volcanology concepts.

After first trials using activities that utilized GTT resources and learning that students tended to score higher who had access to GTT resources than those who didn’t, an improved, more complete curriculum was designed, incorporating the 5E’s Instructional Model (Bybee et al., 2006) with standards-based activities.

Conclusions

After production of the two matrices connecting the standards with actual resources, it is anticipated that teachers will be more likely to use the GTT resources because much of the work of determining grade appropriate activities has been accomplished by this project.

Assessment of student learning associated with the use of activities using the GTT resources showed an increase in student test scores. The test group of students who had access to GTT resources scored about 2.8 times higher than the control group. This data analysis shows a t-test score of 9.47, which suggests that the score increase is related to the GTT-based curriculum and not due to chance. More study on the final, fully developed curriculum of Appendix C needs to be done in the future.

Field trips are important for learning concepts (Steve Zachary, personal communication, October 2008). Students are taught about various aspects of the earth,
specifically about volcanoes with the GTT-based activities. For the student field trip to Cinder Cone, the conclusion from this research is that field trips are important to learning. The three students that went on the field trip performed better overall than did their classmates (even with a sample size of three). The students on the field trip also enjoyed the experience and learned many of the geologic concepts found in the state standards (see student surveys in Appendix F).

Recommendations

My recommendation is that area teachers start using the GTT. The matrices will help them determine how the resources can be used in their classrooms to improve student learning. It is particularly recommended that the curriculum unit be used in grade 9-12 earth science classrooms to enhance student learning.

Another recommendation is the development of a website that supports the GTT resources. This could be hosted by the NPS as one of their “Classrooms in the Park” outreach efforts. Teachers could look at the website to see the matrices developed for this project, the hands-on activities, the curriculum unit, the Cinder Cone trail guide, and suggestions about how teachers use the GTT resources in their classroom. An online blog that connects with the online activities could be developed for sharing ideas of how the GTT are being used in the classroom.

In consideration of the actual trunks, there is a need to know where the geological samples in the GTT were collected in the LVNP (Lassen Institute teachers, personal communications, November 2008). This would be helpful as an additional resource for teacher use because in the curriculum unit students are asked to provide
possible collection sites. A site overlay map for Goggle Earth could be posted as a
downloadable file on the website. Teachers could show students where the samples came
from and could make connections to the rock sample characteristics.
REFERENCES


California Codes. (n.d.). Education *Code Section 3533-35332.* Retrieved from http://www.leginfo.ca.gov/cgi-bin/waisgate?WAISdocID=339576533+0+0+0&WAISaction=retrieve


CONTENTS OF GEOLOGICAL TRAVELING TRUNK

Books
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Lassen Volcanic, The Story Behind the Scenery
Geology: The Active Earth
101 Questions about Volcanoes
Footprints in Time
Lassen Place Names
Lassen Trails
Peterson First Guide to Rocks and Minerals
Golden Guide to Rocks and Minerals
Golden Guide to Geology
Eruptions of Lassen Peak
Through Vulcan's Eye
Indians of Lassen

Maps and Trail Brochures
Bumpass Hell Nature Trail Guide
Cinder Cone Trail Guide
Hiking Map and Guide to Lassen Volcanic National Park
Official Lassen Volcanic National Park Map and Guide

Rock Sample Containers
Volcanic Rocks  18 Rocks
Lassen Peak Rocks  9 Rocks
Cinder Cone "Touch and Feel Box"
Pumice (2 Rocks )

Video
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Posters
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Red Folder (Pictures, Photos, & Diagrams)
Lassen Peak Color Photo
Cinder Cone Color Photo
Brokeoff Mountain Color Photo
Prospect Peak Color Photo
Composite Volcano Diagram
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What's the Difference?

Blue Folder USGS Fact Sheets
Eruptions of Lassen Peak (year published 1999)
How old is "Cinder Cone"? (year published 2000)
What are Volcano Hazards? (year published 2004)

Black and White Historic Photos
#1 Eruption of Lassen Peak
#2 Crater of Lassen Peak
#3 Eruption of Lassen Peak from the Devastated Area
#4 May 22, 1915 Eruption of Lassen Peak
#5 Mudflow on Lassen Peak
#6 Lassen Peak/Devastated Area 1938

Rulers and Magnifiers
Six inch rulers
Magnifying Boxes (Magnifying Lenses in round plastic container)
APPENDIX B
Matrices of California State Science Standards with Geological Traveling Trunk Resources and National Science Education Standards

For the numbers in the matrix look at the grade standard for that grade with the corresponding letter of the standard (i.e., 3A for Grade 2 means the 3rd standard and the A substandard). A list of individual standards follows the matrix.

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<th>Grade level standard</th>
<th>Name of Resource</th>
<th>Grade 2</th>
<th>Grade 4</th>
<th>Grade 6</th>
<th>Grade 7</th>
<th>Grades 9-12</th>
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</tr>
</tbody>
</table>

Standards are from California State Science Standards, 1988.

Grade 2 California Earth Science standards:
3. Earth is made of materials that have distinct properties and provide resources for human activities. As a basis for understanding this concept:
   a. Students know how to compare the physical properties of different kinds of rocks and know that rock is composed of different combinations of minerals.
   b. Students know smaller rocks come from the breakage and weathering of larger rocks.

Grade 4 California Earth Science Standards:
4. The properties of rocks and minerals reflect the processes that formed them. As a basis for understanding this concept:
   a. Students know how to differentiate among igneous, sedimentary, and metamorphic rocks by referring to their properties and methods of formation (the rock cycle).
   b. Students know how to identify common rock-forming minerals (including quartz, calcite, feldspar, mica, and hornblende) and ore minerals by using a table of diagnostic properties.
5. Waves, wind, water, and ice shape and reshape Earth's land surface. As a basis for understanding this concept:
a. Students know some changes in the earth are due to slow processes, such as erosion, and some changes are due to rapid processes, such as landslides, volcanic eruptions, and earthquakes.

Grade 6 California Earth Science Standards:
1. Plate tectonics accounts for important features of Earth's surface and major geologic events. As a basis for understanding this concept:
a. Students know evidence of plate tectonics is derived from the fit of the continents; the location of earthquakes, volcanoes, and midocean ridges; and the distribution of fossils, rock types, and ancient climatic zones.
b. Students know Earth is composed of several layers: a cold, brittle lithosphere; a hot, convecting mantle; and a dense, metallic core.
c. Students know lithospheric plates the size of continents and oceans move at rates of centimeters per year in response to movements in the mantle.
d. Students know that earthquakes are sudden motions along breaks in the crust called faults and that volcanoes and fissures are locations where magma reaches the surface.
e. Students know major geologic events, such as earthquakes, volcanic eruptions, and mountain building, result from plate motions.
f. Students know how to explain major features of California geology (including mountains, faults, volcanoes) in terms of plate tectonics.

2. Topography is reshaped by the weathering of rock and soil and by the transportation and deposition of sediment. As a basis for understanding this concept:
d. Students know earthquakes, volcanic eruptions, landslides, and floods change human and wildlife habitats.

4. Many phenomena on Earth's surface are affected by the transfer of energy through radiation and convection currents. As a basis for understanding this concept:
c. Students know heat from Earth's interior reaches the surface primarily through convection

Grade 7 California Earth Science Standards:
4. Evidence from rocks allows us to understand the evolution of life on Earth. As a basis for understanding this concept:
a. Students know Earth processes today are similar to those that occurred in the past and slow geologic processes have large cumulative effects over long periods of time.
b. Students know the history of life on Earth has been disrupted by major catastrophic events, such as major volcanic eruptions or the impacts of asteroids.
c. Students know that the rock cycle includes the formation of new sediment and rocks and that rocks are often found in layers, with the oldest generally on the bottom.
d. Students know that evidence from geologic layers and radioactive dating indicates Earth is approximately 4.6 billion years old and that life on this planet has existed for more than 3 billion years.
Grades 9-12 California Earth Science Standards:
3. Plate tectonics operating over geologic time have changed the patterns of land, sea, and mountains on Earth's surface. As the basis for understanding this concept:
b. Students know the principal structures that form at the three different kinds of plate boundaries.
c. Students know how to explain the properties of rocks based on the physical and chemical conditions in which they formed, including plate tectonic processes.
e. Students know there are two kinds of volcanoes: one kind with violent eruptions producing steep slopes and the other kind with voluminous lava flows producing gentle slopes.
f. Students know the explanation for the location and properties of volcanoes that are due to hot spots and the explanation for those that are due to subduction.

National Science Education Standards with an emphasis on Earth Science

The standards are grouped for a collection of grade levels: K-4, 5-8, and 9-12
Match the resource found in the GTT in the left column with the grade level. The cell that intersects the two choices is the National Science Education Standard for Earth Science for that grade level (i.e., Geology: The Active Earth meets the D1 National Science Education Standards standard for Grades 9-12).


<table>
<thead>
<tr>
<th>Name of Resource</th>
<th>Grades K-4</th>
<th>Grades 5-8</th>
<th>Grades 9-12</th>
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<tr>
<td>Lassen Geological Traveling Trunk Resources Guide</td>
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<td>Lassen Volcanic, The Story Behind the Scenery</td>
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<td>Black and White Historic Photos</td>
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Standard Section D For Grades K-4

D1. PROPERTIES OF EARTH MATERIALS

Earth materials are solid rocks and soils, water, and the gases of the atmosphere. The varied materials have different physical and chemical properties, which makes them useful.

D2?

CHANGES IN THE EARTH AND SKY

D2. The surface of the earth changes. Some changes are due to slow processes, such as erosion and weathering, and some changes are due to rapid processes, such as landslides, volcanic eruptions, and earthquakes.
Standard Section D For Grades 5-8

STRUCTURE OF THE EARTH SYSTEM

D1. The solid earth is layered with a lithosphere; hot, convecting mantle; and dense, metallic core.

D2. Lithospheric plates on the scales of continents and oceans constantly move at rates of centimeters per year in response to movements in the mantle. Major geological events, such as earthquakes, volcanic eruptions, and mountain building, result from these plate motions.

D3. Landforms are the result of a combination of constructive and destructive forces. Constructive forces include crustal deformation, volcanic eruption, and deposition of sediment, while destructive forces include weathering and erosion.

D4. Some changes in the solid earth can be described as the “rock cycle.” Old rocks at the earth’s surface weather, forming sediments that are buried, then compacted, heated, and often recrystallized in to new rock. Eventually, those new rocks may be brought to the surface by the forces that drive plate motions, and the rock cycle continues.

Standard Section D For grades 9-12

D1. The outward transfer of earth’s internal heat drives convection circulation in the mantle that propels the plates comprising earth’s surface across the face of the globe.
Day 1

**Overall Learning Goal:**
To define the four types of volcanoes
To describe at least one hazard of a volcano today (there are two)

**California Earth Science Content Standards:**
- 3b. Students know the principal structures that form at the three different kinds of plate boundaries.
- 3c. Students know how to explain the properties of rocks based on the physical and chemical conditions in which they formed, including plate tectonic processes.
- Students know why and how earthquakes occur and the scales used to measure their intensity and magnitude.
- 3e. Students know there are two kinds of volcanoes: one kind with violent eruptions producing steep slopes and the other kind with voluminous lava flows producing gentle slopes.
- 3f. Students know the explanation for the location and properties of volcanoes that are due to hot spots and the explanation for those that are due to subduction.
- 9c. Students know the principal natural hazards in different California regions and the geologic basis of those hazards.

**Approximate Time:** 55 minutes

**Learning Target:** Learning Target 1 (LT 1)

**Student Learning Outcomes**
By the end of today’s activity students will be able to:
- identify importance of identifying volcanoes

**Materials:**

- Volcanoes, Glaciers, and Fumaroles videotape
- Movie Clip 29 seconds long “The Eruption of Mount St. Helens” found at http://www.youtube.com/watch?v=Wv-LxFeQwPl&feature=related
- Lassen Geological Traveling Trunk Resource Guide
- Handouts
  - Pre-test of Volcanoes
  - Learning Targets for Curriculum Unit
- Video guide for Volcanoes, Glaciers, and Fumaroles videotape
5 E’s Learning Cycle: **Day 1**

**ENGAGE:**
- Student calls up prior knowledge. Students take pre-test at beginning of class; allot 10 minutes. After they finish, collect the pre-tests.
- Show the 29 second video of Mount St. Helens eruption. Ask students if they have any questions about what they saw on the video clip. Allow questions. Ask for student answers about what they saw (ash, smoke, landslide). 3-5 minutes of class time
- Ask the question, “Could the same thing happen here”? Ask for responses. Ask students what information is needed to know the answer this question. Say to the students, “Lassen Peak is considered to be active. If Lassen Peak erupted today, would you be safe where you live or what would be the danger of an eruption”? Call on students for a verbal response. Allow 10 minutes for this question and discussion period.

**EXPLORE:**
- Students explore resources as they watch Volcanoes, Glaciers, and Fumaroles first and answer questions on the video guide, about 20 minutes of class time. Students are encouraged to work together answering the video guide questions after it is over. If time permits students also watch “Land of Renewal” as they answer the questions on the video guide; takes about 15 minutes.

**EXPLAIN:**
- Students write answers to questions on video guide and communicate with surrounding students

**EXPAND:**
- Students apply new knowledge of LVNP to engage the question in the Engage section above. How would they answer the question about their safety now? What else do they need to know to answer the question? Facilitate a class discussion about a possible Lassen Peak eruption. Is it possible? Would it affect them? How do they know?

**EVALUATE:**
- Students are graded on how well they answered the questions on worksheet.

These are 11 learning targets for this curriculum unit. Learning Targets are correlated with the day of which those topics are taught.

(Teachers note: Learning Targets are learning outcomes that focus on what students can do. They are written in student-friendly language and given to the student for use during the unit)

For the curriculum unit there are learning targets, listed below, of what students are expected to learn from this unit of instruction and what day of the unit that specific learning target will be taught.

- 1. Describe the 2 major hazards of convergent-plate boundary-type volcanoes (like Lassen Peak). Day 1 & 8
- 2. Explain the factors that determine the type of volcanic eruption that can occur. Day 2
3. List the four main types of volcanoes and their dangers. Day 2
4. Describe the various types of volcanic materials that are ejected from volcanoes. Days 3 and 4
5. Distinguish how the different types of volcanoes form. Days 3, 4, and 5
6. Explain the three types of magma and the rock types that form from them. Day 6.
7. Describe the origin of magma. Day 7
8. Explain the relationship between plate tectonics and volcanism. Day 7
9. Explain where intraplate volcanism occurs. (AKA a hot spot). Day 8
10. List and describe the 3 precursors for any volcanic eruption. Day 8
11. Put together all of the information about volcanic eruption to tell what type of volcano released the lava. Day 9.

Vocabulary of the Chapter:
Viscosity, vent, gas, pyroclastic material, volcano, crater, shield volcano, cinder cone, composite cone/stratovolcano, plug dome, caldera, intraplate volcanism, aa, pahoehoe, lahar, angle of repose, extrusive, intrusive, subduction, convergent plate boundary, divergent plate boundary, volcanic island arc, continental volcanic arc, hot spot

(Teachers note: The following are definitions for the vocabulary above. Students develop these over the course of 8 days and write them down on this paper as they experience the actual word with the definition.)

viscosity: the measure of resistance to flow.
vent: opening in surface of earth through which molten rock is released.
gas: dissolved gas held in molten rock by pressure.
pyroclastic material: the volcanic rock ejected during an eruption like ash, bombs, or blocks.
volcano: a mountain formed of lava or by pyroclastic material.
crater: deep walled depression at volcano summit.
shield volcano: a broad, gently sloping volcano built from fluid basaltic lavas.
cinder cone: volcano formed from magma under high pressure to form a steep volcano.
composite cone/stratovolcano: volcano formed with alternate layers of lava flows and explosive eruptions.
plug dome: very viscous masses of silicic lava to emerge from a vent to form a mound.
caldera: large depression caused by collapse or ejection of the summit of a volcano.
intraplate volcanism: volcanic activity within a tectonic plate away from plate boundaries.
Aa: hardened rough and blocky basaltic lava.
pahoehoe: smooth skinned basaltic lava.
lahar: mudflow or landslide composed of pyroclastic material and water that flows down a volcano.
angle of repose: minimum angle made by a volcano with the horizontal plane.
extrusive: rock formed outside the earth.
intrusive: rock formed inside the earth.
subduction: a plate margin where oceanic crust is pushed down beneath a second plate.
convergent plate boundary: a boundary in which two plates move together.
divergent plate boundary: a boundary in which two plates move apart.
volcanic island arc: a chain of volcanic islands located near a trench where subduction of one oceanic slab is beneath another.
continental volcanic arc: volcanoes formed by volcanic activity caused by subduction of an oceanic plate beneath a continent.
hot spot: see intraplate volcanism.
magma: molten rock found at depth
lava: magma that reaches earth’s surface

Name

**Lassen Volcanic National Park: Volcanoes, Glaciers, and Fumaroles**
(from the Lassen Geological Traveling Trunk Resource Guide)

1. Name two volcanoes (besides Lassen Peak) that are found in the Pacific Northwest Volcanic Arc.
   1. 
   2. 

2. Name four types of volcanoes found in Lassen Volcanic National Park
   1. 
   2. 
   3. 
   4. 

3. Name one way that scientists know Lassen Volcanic National Park is still an active volcanic site.

4. How long ago did the Lassen Volcanic Center become active?

5. Lassen Volcanic National Park was once covered with giant glaciers. Why don't we see more evidence of glaciers in Lassen Volcanic National Park?

6. The geology of Lassen Volcanic National Park shows some evidence that proves glaciers were present in its past. Name two or more pieces of evidence showing that glaciers once existed in Lassen Volcanic National Park.
   1. 
   2. 

7. Approximately how many eruptions occurred on Lassen Peak between 1914 and 1917?
Lassen Volcanic National Park: Volcanoes, Glaciers, and Fumaroles
Answer Keys for Video Response Handouts

From Lassen Geological Traveling Trunk Resource Guide

1. Acceptable answers are: Mount St. Helens, Mount Hood, Crater Lake, Mount Shasta, and Mount Rainier

2. Shield, composite, dome or plug dome, cinder cone or tephra cone

3. Acceptable answers are: gas and/or steam vents (fumaroles), boiling springs, and mudpots

4. One-half million (500,000) years


6. Acceptable answers are: U-shaped valleys and canyons, cirques, moraines, and glacial polish on rocks

7. Approximately 400 eruptions happened between 1914 and 1917
Day 2

Overall Learning Goal:
- Students are able to classify the four volcano types
- Students are able to list the characteristics that distinguish the four types of volcanoes
- Students are able to describe one of the geologic hazards of LVNP

California Earth Science Content Standards:
- 3e. Students know there are two kinds of volcanoes: one kind with violent eruptions producing steep slopes and the other kind with voluminous lava flows producing gentle slopes.
- 9c. Students know the principal natural hazards in different California regions and the geologic basis of those hazards.

Approximate Time: 20 minutes for part 1, demonstrations
35 minutes for part 2, viscosity activity

Learning Target: LT 2, LT 4

Student Learning Outcomes
By the end of today’s activity students will be able to:
- Identify the four different volcano types
- Write what viscosity is and how it affects eruptions
- Describe how gases affect various fluids and bubble formation

Materials:
Part 1
- Volcano model made of 2’x2’ piece of strong flat cardboard with a hole cut in the center to fit a one-pound coffee can. Cut both ends out of the can and push it up into cardboard with 3/4 of the can projecting above the top of the cardboard. Place sturdy paper plates around coffee can, leaning from the cardboard to the can, leaving the opening free to form a volcano shape. Secure paper plates to coffee can and cardboard base with strapping or masking tape. After all plates are in place, cover plates and cardboard base with plastic coated packaging tape.
- Can of shaving cream.
- Large tube of toothpaste.
- Package of round puffed cereal
- Small funnel to fit in top of volcano (top of can).
- Air or foot pump with 4’ extension tube.

Part 2
- Handout
- “Erupt with Glee”
- Ketchup
- Syrup, for pancakes type
- Water
- Honey
- Molasses
- Dixie cups, small bathroom type to contain the fluids
- Drinking straws for bubble production

5 E’s Learning Cycle: **Day 2**

**ENGAGE:**
- Students use prior knowledge for Part 1- students have the video guide from Day 1 returned after being scored. Students saw four different types of volcanoes yesterday. Can the active volcano in LVNP cause a hazard for the students? And what makes volcanoes different?
- Students identify problem to solve for Part 2-what sort of experiment could be done to see how thickness of a fluid and the amount of gas affects bubble making?

**EXPLORE:**
- Part 1 – Students make a hypothesis what is the difference between four volcano types.
- Part 2- Students collect data on viscosity and dissolved gases in fluids. Students explore the different characteristics of the fluids.

**EXPLAIN:**
- Part 1 – Students involve themselves with the demonstrations. Students use the cardboard, tape, and plates to build a model of the different volcano types in front of the class (two students per volcano demonstration and make sure all safety precautions are observed). Other students are invited to walk up to the volcano model after the demonstration is finished and make observations about each type of volcano demonstrated (teacher note: when finished with demonstration, ask students to write the characteristics of the volcano models on their Learning Target paper on the LT 2 line.
- Part 2-Students form generalizations about the relationship between the viscosity (the resistance of a fluid to flow) and dissolved gas by writing this relationship on the worksheet that is linked to this activity.

**EXPAND:**
- Part 1 - Students apply new knowledge of volcano models to real volcanoes.
- Part 2 - Students apply new knowledge of viscosity and dissolved gas relationship to volcanic activity on handout/worksheet.
EVALUATE:

- Part 1 - Students report how the demonstration relates to the four volcano types of the world. The worksheet is turned in to the instructor for scoring, based on how well the questions were answered from the student data. (Teachers note: the worksheet also provides learning data for the teacher as a formative assessment. It tells how well the students understand the material. It also tells where students are having problems. You should address them the next day or later. The sooner the better).
- Part 2 - Students choose a spokesperson for their group and report to the entire class what they found or discovered about fluid thickness and dissolved gases.

Erupt With Glee Viscosity Lab

(Teacher note: Before doing this activity be sure to do part 1, the four demonstrations of volcanoes as explained in the GTT Resources Guide. Students see how the four different volcanoes are modeled by how they erupt and what the eruptive material resembles in the real world)

Today we will be exploring the viscosity of fluids. Viscosity is the state of being thick, sticky or semi-fluid in consistency, due to internal friction, or how well the fluid resists flowing. Yogurt makers pride themselves on how thick and slow moving their yogurt is, so it could be said that yogurt has a high viscosity. What might have a low viscosity?

**Part 1**

**Materials:**
- Ketchup
- Syrup, for pancakes type
- Water
- Honey
- Molasses
- Dixie cups, small bathroom type to contain the fluids – 50 mL size
- Drinking straws for bubble production

At each laboratory station are five different substances in Dixie cups, and a straw. Make a hypothesis as to what their relative viscosities are. (Hypotheses will vary)

(teachers note: get 10 Dixie cups per lab station and pour about 5 mL of each fluid into a Dixie cup so you have 5 fluids in cups and 5 empty cups. The extra cups are for pouring the fluid into from one of the cups)

Now analyze the materials. Pour them from cup to cup, observing the thickness, consistency and how well the fluid pours into the empty cup. Record your data in the table below.

Then using the straw, perform a bubble test by putting the straw into the fluid; make sure the straw is at the bottom of the cup. Gently blow air into the straw, trying to blow the same amount of air for each fluid test.
1. Your hypothesis about viscosities of the fluids:
   (answers will vary)

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<tr>
<th>Fluid</th>
<th>Pourability (thick, thin, slow, fast)</th>
<th>Bubble formation (difficult to form, rises quickly, etc.)</th>
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<tbody>
<tr>
<td>Ketchup</td>
<td>Slowest and thick</td>
<td>Takes long time for bubbles to form, and messy when they do form</td>
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<tr>
<td>Syrup</td>
<td>slow</td>
<td>Bubbles form and rise to top</td>
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<tr>
<td>Water</td>
<td>Easy or quick</td>
<td>Bubbles form and move to top quickly</td>
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<td>honey</td>
<td>Slower than syrup</td>
<td>Bubbles form very slowly and move to top slowly</td>
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<tr>
<td>molasses</td>
<td>Slow and thick</td>
<td>Takes long time for bubbles to form, and messy when they do form</td>
</tr>
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</table>

2. What did the pour test tell about thickness of the fluid?
   (The most viscous fluid is the thickest, or the hardest to pour)

3. What happened to each fluid when the air bubble was blown into it?
   Did the bubble stay in the fluid? Did the bubble escape and “erupt”? What does the bubble test indicate?
   (Bubbles escape the thin or least viscous fluids. It is difficult to see bubbles in the thick fluids at first, but eventually the bubbles do come up and often splash fluid around the workspace. The bubble test indicates how well the fluid can hold a gas.)

4. Compare the materials to each other, and check your hypothesis.
   (Students find mustard is most viscous, with ketchup being second most viscous. Water is least viscous, with syrup being slightly more viscous and honey is more so.)

5. According to your data, what is the connection (or relationship) of the viscosity of a fluid and it’s gas-releasing ability?
   (The thicker or more viscous the fluid, the more amount of gas can be held by the fluid before it bubbles or erupts out.)

6. What’s the connection of this lab activity with lava/magma from a volcano? What type of volcano has which viscosity?
   (The more viscous the lava/magma, the more gas is held, and erupts more violently or messy, so the shield volcano has runny, low viscosity lava. The plug dome has very viscous lava and lots of gas. The cinder cone has low viscosity lava but has more gas. The stratovolcano has more viscous lava and has high gas content.)
Days 3 & 4

**Overall Learning Goal:**
- Students will correlate the slopes of volcanoes with the types of volcanoes

**California Earth Science Content Standards:**
- 3e. Students know there are two kinds of volcanoes: one (stratovolcano) with violent eruptions producing steep slopes and one (shield) with voluminous lava flows producing gentle slopes. (teachers note: this is how the standard reads, but there are really four types.)

**Approximate Time:** 100 minutes (2 class periods)

**Learning Target:** LT 3, LT 5

**Student Learning Outcomes**
By the end of today’s activity students will be able to:
- Draw the profile of one of 17 volcanic peaks in LVNP
- Communicate the type of volcano the group researched
- State the relationship between the steepness of their volcano and the type of volcano

**Materials:**
- Topographic Map sections of individual LVNP volcanoes
- Blank paper
- Rulers
- Books from GTT
  - Lassen Volcanic: The Story Behind the Scenery
  - Lassen Place Names
  - Golden Guide to Rocks and Minerals
  - Through Vulcan’s Eye
- Container for volcanic peak names for students to choose their peak
- Handout
  - Profiling A Volcano
  - Packet on 17 different volcanic peaks, from Through Vulcan’s Eye

**5 E’s Learning Cycle: Days 3 & 4**

**ENGAGE:**
Students identify problem to make the connection between the profile (slope) of a volcanic peak and volcano type. Ask students to look at some volcano silhouettes that are not from LVNP (see http://volcano.oregonstate.edu or http://volcanoes.usgs.gov for pictures). Ask individual students what makes some
volcanoes steep and large, others small, and still others gently sloped. Give time for responses. Allow 10 minutes for pictures and short discussion.

EXPLORE:
Students, in a group of two, explore the relationship between slope of a volcano and the type of volcano by constructing a profile of a volcanic peak and finding the type of volcano in an information sheet copied from The Vulcan’s Eye or Lassen Volcanic: The Story Behind the Scenery. The profile construction takes about 30-45 minutes. Finding the information about the type of volcano takes about 10-15 minutes. This is more than one period so two days are allotted to this activity.

Day 4
EXPLAIN:
Students explain their data of slope and the volcano type to the class. Student groups calculate the slope of the volcano in areas and share the profile with the class as a mini-presentation. While one group presents their findings, all other classmates note the slope and type of volcano on their worksheet “Profiling a Volcano”. Student presentations should take about 1-2 minutes per group, or 20-30 minutes on the second day of this activity.

EXPAND:
All students use data from all 17 groups to apply this relationship to all four types of volcanoes.

EVALUATE:
- Students write their findings on the handout and are turned in at the end of Day 4. Students are scored on how well they made a profile with a 0 to 4 point rubric. This scale is as follows: 0 score means no response or the answer does not address the question. One point means student task has not relation to assignment or minimally addresses the assignment. A two point score means there are major errors or the student response partially addresses the assignment. A three point score means the student response adequately addresses the assignment. A four point score means the assignment effectively and completely addressed the assignment.

Profiling a Volcano 2 Names:
Adapted for use from Lassen Geological Traveling Trunk Resource Guide

In the presentation of pictures you saw a few different side views of volcanoes, none of which were found in LVNP. What makes them steep and large, or small and steep, or large and gently sloped? You will discover this connection in this activity.
Working together with another person, you will choose a volcanic peak name from the container at the front of the classroom that holds the names of 17 Lassen area volcanic peaks. Next to the container you will find a series of contour maps; find the map that has your peak name on it and also find the information packet on your volcanic peak. Take a piece of paper and a ruler to your work area.

Recall making profiles in a previous instructional unit: draw a straight line on the contour map using the ruler from one side of the peak to the other, through the peak. On the blank paper write the scale of the contour map near the top of the paper. Make a line near the bottom of the paper the same length as the line you drew on the contour map. On the side draw an axis vertically, label it elevation, and write elevations like those you see of the peak on the contour map (the contour interval is 20 feet on the Lassen Topographic map). At each intersection of a contour line and the line you made, transfer that point down to the profile you are making, on the horizontal axis, with the same distance from the start of the contour map line. The elevation of the profile on the paper should correspond to the elevation on the contour map. Match the distance of the line on the contour map with the elevation and make a “dot” on the profile line. Move to the next intersection point between profile line and contour line, transfer it to the profile and put the “dot” that matches the elevation and distance you are plotting. Keep doing this with each intersection of contour line and the line you drew on the contour map until you run out of contours on the map. Connect the dots on your profile map. This is your profile that you will share with the rest of the class later in the period. Label your profile with the name of the volcanic peak.

Look at your profile and answer:

1. What is the steepest part of the profile or peak? (answers will vary)
2. Express the average slope with numbers (answers will vary from very small to 3 or 4)
   The slope is found by calculating the change in elevation in feet/change in distance in feet)

It is possible that your peak has a different slope at different places.

Using the guide and the other LVNP books available, find information on your volcanic peak to answer the following questions:

3. What is the geology of the peak? (answers will vary-all are volcanic)
4. What rocks are found there? (answers will vary)
5. What type of lava came out of the volcano? (answers will vary from basalt or dacite or cinders or pumice or obsidian or andesite)
6. What was the viscosity of the lava when the volcano erupted last? (from low up to high)

Prepare a short presentation of your peak profile (slope) and the lava rock type so that other students can record the information quickly and clearly.
Write the data here from the other groups:

<table>
<thead>
<tr>
<th>Slope</th>
<th>Volcano type</th>
</tr>
</thead>
</table>

After all groups have presented their information, look at the class data. Put all of the same volcano types together to see what the slopes are for those volcano types.

Write a conclusion that details the relationship of slope and rock type.

(The steep slope, larger peaks have dacite, andesite, or pumice. The steep, small volcanoes have cinders. Volcanoes that tend to have gradual slopes have basalt.)

(Teachers note: This assignment is turned in and scored on a 4-point rubric: see rubric description in Evaluate section of Day 3 & 4)
Day 5

Overall Learning Goal:
- To expose students to angle of repose and the factors that affect the angle.

California Earth Science Content Standards:
- 3e. Students know there are two kinds of volcanoes: one kind with violent eruptions producing steep slopes and the other kind with voluminous lava flows producing gentle slopes.

Approximate Time: 55 minutes
Learning Target: LT 5

Student Learning Outcomes
By the end of today’s activity students will be able to:
- State the relationship between the angle of repose and the size and shape of rocks that make the slopes

Materials:
- Pictures of Cinder Cone
- Cinder Cone “touch and feel” box from GTT
- Protractor
- 2 lbs. of sand
- box of Cheerios cereal or generic substitute
- Computer with internet access and projector, teacher downloads Google Earth software in advance
- Handout
  - Build A Cinder Cone

5 E’s Learning Cycle: Day 5

ENGAGE:
- Students identify problem to be solved. Students use “Fly through” Cinder Cone using Google Earth. In the “Fly To” box, type “Cinder Cone” and push the “go” button to see Cinder Cone. “Fly” around the Cinder Cone using the controls so that students can see the landscape, the slope and texture of the volcano, and take of material that formed it. Pictures of Cinder Cone can also be found at www.volcano.si.edu/education/tpgallery.cfm. Ask students what makes it challenging to hike to the top? (Note: this is the problem to be solved by the students). Students write their answers on the worksheet “Build A Cinder Cone”.
- Ask students to write a hypothesis about the angle of the volcano and what the volcano is made of.
EXPLORE:
- Students collect data about angle of repose and material used to make a scale mountain using the activity “Build A Cinder Cone” in the lab area.

EXPLAIN:
- Students share understanding of their group findings/conclusions of the relationship with rest of class.

EXPAND:
- Students form generalizations about material shape and size with repose angle in worksheet.

EVALUATE:
- Students generalize the relationship between material shape and size with the repose angle on their worksheets, which are checked for completeness and how well the conclusion matches the data.

Build A Cinder Cone

Objective: to build different volcano models to determine the affect of “rock material” on the angle of repose, or the slope of a volcano compared to horizontal.

Materials
- Cinder Cone “touch and feel” box from the GTT
- Protractor
- 2 lbs. of sand
- Cheerios or generic substitute
- Computer with Internet access.

Students are shown Cinder Cone via a “flyby” using Google Earth software.
1. What would it be like to hike or walk up Cinder Cone?

2. Would it be easy or challenging?

3. What sort of characteristics of the volcano helped to make your choice to your answer to the previous question?

4. Write a hypothesis about the angle of the volcano and what the volcano is made of.

In a group of 4-5 students, build cinder cone volcano shapes using the cinders from the cinder cone “touch and feel” box in the GTT. Pour some of the cinders in a pile on the laboratory station tabletop and measure the angle of the cinders using a protractor. Record the type of material, the size of the individual particles, the texture of the material, and the angle of the mountain in the table. After you clean up the mess of
cinders, move on to sand with the same goal of making a mountain. Try another material in the classroom like Cheerios cereal or a generic substitute. Try to figure out the connection between the type of material, the size of the material, and the steepness or angle of repose.

1. Record observations

<table>
<thead>
<tr>
<th>Material for mountain</th>
<th>Size of Particles (in cm)</th>
<th>Texture (smooth, jagged, rough, etc.)</th>
<th>Angle of repose (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cinders</td>
<td>2</td>
<td>Jagged</td>
<td>35</td>
</tr>
<tr>
<td>Sand</td>
<td>0.2</td>
<td>Rough</td>
<td>28</td>
</tr>
<tr>
<td>Cheerios</td>
<td>1 cm</td>
<td>Smooth</td>
<td>31</td>
</tr>
</tbody>
</table>

2. How is the slope related to the material the mountain is made of?

(The angle of repose is related to the size and the texture of the materials. The smoother the material, the smaller the repose angle is, and roughly textured material has a larger angle of repose. The larger the material, the steeper the angle)

3. A volcano erupts, spilling out rocks that are very jagged and approximate the size of an automobile. Should the volcano have a steeper angle of repose than Cinder Cone or shallower? Explain your answer. (Bigger rocks and more jagged means more friction so the angle of repose should be higher than Cinder Cone)
Day 6

Overall Learning Goal:
- Students can identify LVNP volcanic rocks by looking at characteristics like color and crystal size.

California Earth Science Content Standards:
- 3c. Students know how to explain the properties of rocks based on the physical and chemical conditions in which they formed, including plate tectonic processes.

Approximate Time: 55 minutes

Learning Target: LT 6

Student Learning Outcomes
By the end of today’s activity students will be able to:
- Identify 6 volcanic rocks found in LVNP based on color and crystal size.

Materials:
- Map of rock collection sites
- Rock specimens
  - Volcanic rock
  - Lassen Peak
  - Pumice
  - Obsidian
  - Basalt
  - Cinder Cone tephra
- Handout Rock ID
  - Fire It Up with Igneous Rocks Lab
- GTT Books
  - Geology: the Active Earth
  - Petersens First Guide to Rocks and Minerals
- Hand lens

5 E’s Learning Cycle: Day 6

ENGAGE:
- Students identify problem to solve like how to identify a rock. Students are shown six different rock samples. Ask how they would know where each originated from in LVNP. What were the conditions for the rock to form?

EXPLORE:
- Students, in groups of 3-4, collect data like color of rock, size of crystals, and temperature of formation from rock sets at laboratory stations.
EXPLAIN:
- Students seek possible choices of what makes the color of the rock what it is, whether the crystals are large or small, and the temperature of the rock prior to crystallizing the observed minerals.
- Students write the identity of each rock. Each student looks at descriptions of every rock to determine if they are correct.

EXPAND:
- Students apply new knowledge about rocks to where they might be found. Students will be given their worksheet from Day 3 & 4 (“Profiling A Volcano”) that has information the student recorded about 17 possible sites for the rocks of this activity.

EVALUATE:
- The instructor scores the worksheet using the rubric found on Day 2 activity. The score is recorded in the teacher’s gradebook, but only comments are written on the student worksheet. Two examples of comment-only scoring are writing what clue the student might have missed when they observed the rock originally or a comment of what to look for so they have good observations to identify the rocks correctly. Students can make corrections and justify rock name choice(s) on the worksheet outside of class time and return the corrected worksheet to the instructor for a new score that is recorded as a higher score.

Fire It Up With Igneous Rocks

Goal: Students can identify six igneous (or fire) rocks by color, crystal size, and by texture.

Materials
- Rock specimens
  - Volcanic rock
  - Lassen Peak
  - Pumice
  - Obsidian
  - Basalt
  - Cinder Cone tephra
- GTT Books
  - Geology: the Active Earth
  - Petersen’s First Guide to Rocks and Minerals
- Hand lens

In groups of 4-5 students, look at each rock sample at the laboratory station. Record the data as you observe. Make sure that you individually observe and record. Use the hand lens for close-up observations.
1. What sorts of things do you notice about the crystals in the rocks? (small crystals, large crystals, no crystals)

2. What makes the rocks different from each other? How are they similar? (size of crystals, colors, textures)

3. Record each rock sample observation below in table form in the space provided. You should have 6 rocks in one column. You need not know the name of the rock sample- you will determine that later.

<table>
<thead>
<tr>
<th>Rock sample</th>
<th>Color</th>
<th>Crystal size</th>
<th>Temperature-based on rock color</th>
<th>Intrusive or Extrusive</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. The color of the rock indicates the temperature of the mineral crystallization before it solidified. Using the simplified Bowen’s Reaction Series (from www.USGS.gov) find the color of the rock on the left side of the table and right side descriptor shows how the temperature of the minerals as they crystallized. Note: the hotter magma also has a lower viscosity.

<table>
<thead>
<tr>
<th>Color of Rock</th>
<th>Relative Temperature of Mineral Crystallization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dark colored-green, black</td>
<td>High</td>
</tr>
<tr>
<td>Intermediate colors-tan, gray</td>
<td>Medium</td>
</tr>
<tr>
<td>Light colored-pink, white, colorless</td>
<td>Low</td>
</tr>
</tbody>
</table>

In the data table above, also include the relative temperature of mineral crystallization that cooled to make the rock sample observed (look at the color of the rock and match it up with the mineral crystallization and write the relative temperature in the data table)

As you look at the different rock samples, another quality or physical property of each is the texture or crystal size. Using the hand lens, determine the crystal size for each rock sample. If crystals are large, it means that the crystals had a long time to grow, because the rock cooled slowly. This could happen under the earth surface, known as an intrusive texture. If the crystals are small or non-existent in the sample, then they crystals did not
have time to grow before the rock solidified. This quick cooling happens outside of the earth, so this type of texture is called an extrusive.

5. Classify your six rock samples as intrusive or extrusive and record in the data table. (answers will vary)

6. The final step of this activity is to determine the identity of each rock. Use the Internet or the GTT resource books (there are three rock and mineral books) to determine the identity of each rock. Record the names in the data table. (list of rocks: andesite, basalt, obsidian, pumice, cinder, dacite)

<table>
<thead>
<tr>
<th>Grain Size</th>
<th>Usual Color</th>
<th>Other</th>
<th>Composition</th>
<th>Rock Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>fine</td>
<td>dark</td>
<td>glassy appearance</td>
<td>lava glass</td>
<td>Obsidian</td>
</tr>
<tr>
<td>fine</td>
<td>light</td>
<td>many small bubbles</td>
<td>lava froth from sticky lava</td>
<td>Pumice</td>
</tr>
<tr>
<td>fine</td>
<td>dark</td>
<td>many large bubbles</td>
<td>lava froth from fluid lava</td>
<td>cinders</td>
</tr>
<tr>
<td>fine or mixed</td>
<td>dark</td>
<td>has no quartz</td>
<td>low-silica lava</td>
<td>Basalt</td>
</tr>
<tr>
<td>Medium</td>
<td>Light to pink</td>
<td></td>
<td></td>
<td>Dacite</td>
</tr>
<tr>
<td>coarse</td>
<td>gray</td>
<td>Lighter than basalt</td>
<td></td>
<td>Andesite</td>
</tr>
</tbody>
</table>

7. The “Profiling A Volcano” peak activity was returned to you. Using your list of volcanic peak names, suggest where these 6 rocks might have been collected (i.e. Raker Peak, Brokeoff Mountain, etc.)

(Teachers note: students have recorded the name of the peaks and the corresponding rock type so they match up the rocks of the activity with the peaks.)

(dacite found near Lassen Peak and Chaos Crags, andesite from Mt. Conard, Brokeoff, Mt. Diller, Pilot Pinnacle, basalt from Prospect Peak, Mt. Harkness, Sifford Mt., Raker Peak, Obsidian from Lassen Peak, pumice from Cinder Cone, cinder from Fairfield Peak, Hat Mt., Cinder Cone.)

8. Write why you chose the specific peak for these particular rocks.
Day 7

**Overall Learning Goal:** To identify volcanic rocks and distinguish between different plate boundaries.

**California Earth Science Content Standards:**
- 3c. Students know how to explain the properties of rocks based on the physical and chemical conditions in which they formed, including plate tectonic processes.

**Approximate Time:** 55 minutes

**Learning Target:** LT 6 & 7

**Student Learning Outcomes**
By the end of today’s activity students will be able to:
- Describe and identify two different plate boundaries (convergent and divergent)
- Use the vocabulary associated with plate boundaries that can result in volcanism

**Materials:**
- 2 Foam pieces 50 cm x 20 cm for each group
- Manila folder as a cardboard source
- Rock ID handout from Day 6
- Books from GTT
  - Geology Active Earth
  - Golden Guide to Geology
  - 101 Questions About Volcanoes
- Handout
  - Build A Foam Model

(Teacher note: Today is broken into two parts. The first part of today is reviewing the “Fire It Up With Igneous Rocks” to make sure students reviewed their answers to yesterday’s activity. The time allotted is 15 minutes to look at the rock samples and get help identifying the rocks, if needed.

5 E’s Learning Cycle: **Day 7**

**ENGAGE:**
- Students are shown pictures of plate boundaries of volcanoes like in LVNP, and pictures Icelandic rift valleys (Pictures can be found at volcano.oregonstate.edu/oldroot/volcanoes/index.html). Students are asked to verbally explain the differences between the volcanoes seen in the pictures.
EXPLORE:
- Students build foam models of plate boundaries using instructions provided.
- Students use GTT resources and information from USGS to explore different plate boundaries.

EXPLAIN:
- Students form generalizations about convergent plate boundaries and volcano development (oceanic plates can form two types of volcanic arcs).

EXPAND:
- Students apply new knowledge of plate boundaries to answer questions about the type of volcanoes found in Alaska, Yellowstone National Park, and Chile.

EVALUATE:
Students fill in the blanks of three cross section diagrams of each plate boundary type. The worksheet is scored on a 4 point rubric scale used before in this unit plan on Day 4.
Build A Foam Model Name

Instructions from “Plate Tectonics and Faulting Using Foam Models” by L.W. Braile (see http://web.ics.purdue.edu/~braile/edumod/foammod/foammod.htm)

Materials
- Foam blocks, 2 per group, 20 cm x 50 cm x 2.5 cm
- Cardboard from manila folders

Convergent Plate Boundary and Subduction – Cut and tape the cardboard (manila folder) along the 20 cm long edge of one block of foam. Arrange two desks of identical height to be next to each other and about 30 cm apart. Place the two pieces of foam on the tables and begin to move one piece of foam (the one without the cardboard edge) toward the other and allow it to be “thrust” beneath the other piece of foam. This movement of one plate under the other is known as subduction. The foam pieces represent two plates; both plates can be oceanic, or under the ocean. As the convergence continues, the underthrust plate will form a subducted slab of lithosphere (extending to at least 600 km into the mantle in the Earth). The subducted lithosphere (the foam that goes down under the other foam block) that heats the overlying upper plate causing melting at depths of 100-150 km as the slab is subducted into the mantle. These molten materials can then ascend through the overlying mantle and crust and form volcanoes which are often situated in a linear chain or arc about 100-200 km away from the collision zone. A deep ocean trench also forms above the point of convergence of the two plates as the oceanic lithosphere is bent downwards by the collision. In the case of an oceanic plate “diving” under another oceanic plate forms a **Volcanic Island Arc**, or a series of volcanoes in the ocean.

![Diagram of Oceanic-oceanic plate Convergence causing a Volcanic Island Arc](http://pubs.usgs.gov/gip/dynamic/understanding.html#anchor15039288)
Subduction can also occur between an oceanic plate and continental plate. Model this using the foam blocks. The oceanic plate is denser than the continental plate and moves beneath the continental plate, forming a subducted slab of lithosphere. This forms a linear chain or arc of volcanoes on the continental plate, known as a Continental Volcanic Arc.

![Diagram of Oceanic-continental Convergence causing a Continental volcanic arc.](http://pubs.usgs.gov/gip/dynamic/understanding.html)

To model divergent plate boundaries and mid-ocean ridge spreading centers, begin by placing the two 50 x 20 cm foam pieces on one desk with one edge adjoined at the ridge crest. These foam blocks will represent oceanic lithosphere at a time five million years ago and thus contain oceanic crust (the upper layer of the lithosphere) that is 5 million years old and older. Slide the two foam squares away from each other about 2 cm (this process represents the passage of time and the extension of the lithosphere in the region of the ridge crest, and rift valley, by plate tectonic motions which are typically a few centimeters per year, equivalent to a few tens of km per million years). In the real mid-ocean ridge, a void space or opening between the plates created by plate spreading would not actually develop as it does in the model. Instead, as extension occurs, volcanic processes will relatively continuously fill in the extended lithosphere, in the process creating new lithosphere. Note that the youngest rocks are in the center, along the ridge crest, and the rocks are progressively older away from the ridge crest.

As you watch the processes of convergence and divergence, make sure you “see” where the volcanoes would form or be found.
From the diagram above, write the words from the unit that correspond to the following numbers on the diagram- feel free to use the descriptors in the instructions above, the textbook, or GTT resources. (Teachers note: some of the numbered items in the diagram above are not in the standards or learning targets so they are not addressed here)

1. (lithosphere)
2. (asthenosphere)
3. (asthenosphere)
4. (asthenosphere)
5. (divergent plate boundary)
6. (mid-ocean ridge)
7. (magma source)
8. (trench)
9. (subdivision zone)
10. (continental volcanic arc)
11. (eruption)
Day 8

Overall Learning Goal:
- Students can describe volcanoes at different plate boundaries and hazards associated with volcanoes

California Earth Science Content Standards:
- 3b. Students know the principal volcanic structures that form at the three different kinds of plate boundaries.
- 9c. Students know the principal natural hazards in different California regions and the geologic basis of those hazards.

Approximate Time: 55 minutes

Learning Targets: LT 8, LT 9 & LT 10

Student Learning Outcomes
By the end of today’s activity students will be able to:
- Describe interplate volcanism, also known as Hot Spots, with examples
- List and explain the three precursors prior to the Lassen Peak eruption for a volcanic eruption.
- Identify two major hazards of convergent plate boundary volcanoes

Materials:
- Book Resources from GTT
  - Footprints in Time
  - Eruptions of Lassen Peak
  - 101 Questions about Volcanoes
- Handout
  - Day 8 “The Eruption is Coming”

5 E’s Learning Cycle: Day 8

ENGAGE:
- Students have a problem to solve. In 1914, Lassen Peak erupted. Ask students, “Can we predict a volcanic eruption”? What are the signs or precursors to an eruption?

EXPLORE:
- Students collect data from B.F. Loomis’ account of an eruption of Lassen Peak in 1914 and 1915, with an emphasis on observations he made about the volcano before, during, and after the eruption.
- Students also gather information from books (101 Questions about Volcanoes) and Internet resources about hot spots or intraplate volcanism (see http://vulcan.wr.usgs.gov/Glossary/PlateTectonics/description_plate_tectonics.html)

**EXPLAIN:**
- Students clarify pre-eruption signals and form generalizations about eruptions.

**EXPAND:**
- Students make decisions based on eruption generalizations. Students are shown data of ground noise and deformation at Yellowstone National Park. Students are asked, “Will it erupt? And if so, when? “

**EVALUATE:**
- Students write answers to the handout questions that are turned in for evaluation by the instructor, which is scored on a 4-point rubric and returned to the student.

The Eruption is Coming

Goal: to identify the 3 precursors of a volcanic eruption and to identify the two major hazards of stratovolcanoes like Lassen Peak.

Materials

Handout
- Reprints of pages 10-25, 30-46 in Eruptions of Lassen Peak, in GTT
- Reprints of pages 38-45 in Footprints in Time, in GTT

Read these pages from Eruptions of Lassen Peak, an eyewitness account of the eruptions from B. F. Loomis, a local photographer. As you read what happened, take note of those things Loomis observed by answering the questions below.

1. What were signs that an eruption was about to happen?

   (Loomis noted smoke, which is now known as gas, rumbling, steam venting)

2. There is a third precursor that was not noticed because no one went to the top of Lassen Peak. What do you think went unnoticed? (answers will vary; ground deformation or dome building is what a person would have seen if they went to the top)

   In both Lassen Peak eruptions of 1915, there were two hazards common to other plug dome volcanoes.
3. What were the two dangers that concern any official working around volcanoes?  
(Lahars and pyroclastic flows)

Discuss these findings with others in a group of 4-5.

4. Should you be concerned about a volcanic event affecting you here? Is it possible an eruption of Lassen Peak could affect you? Explain your answer.  
(not in the Chico area. If you are closer to Lassen Peak, then the concern is higher)

Using 101 Questions about Volcanoes in the GTT and Internet resources

5. Find the largest volcanic eruption in the last million years. What is it?  
(Yellowstone volcano)

6. What type of plate boundary is it located near? Or is something all together different?  
(There is no plate boundary close by. This volcano is in the middle of the plate.)

7. What is the most active volcano in recorded history? What type of plate boundary is it located near?  
(Kilauea in Hawaii. It is not close to a plate boundary.)

8. How are these two examples of volcanism different than Lassen Peak or Mount St. Helens?  
(Both are in the middle of the plate, so they are known as intraplate volcanoes or Hot Spots.)

9. Your instructor will show you data of ground noise and deformation at Yellowstone National Park. Will it erupt? And if so, when?  
(for ground noise,  
http://www.seis.utah.edu/req2webdir/recenteqs/Maps/Yellowstone.html  
For deformation, see  

(the ground noise occurs often in the Yellowstone area and appears to be normal at the time of this writing and the deformation is within normal range)
Day 9

Overall Learning Goal:
Students will be able to answer questions correctly from the Learning Targets

California Earth Science Content Standards:
- 3b. Students know the principal structures that form at the three different kinds of plate boundaries.
- 3c. Students know how to explain the properties of rocks based on the physical and chemical conditions in which they formed, including plate tectonic processes.
- 3e. Students know there are two kinds of volcanoes: one kind with violent eruptions producing steep slopes and the other kind with voluminous lava flows producing gentle slopes.
- 3f. Students know the explanation for the location and properties of volcanoes that are due to hot spots and the explanation for those that are due to subduction.
- 9c. Students know the principal natural hazards in different California regions and the geologic basis of those hazards.

Approximate Time: 55 minutes

Learning Target: All LT

Student Learning Outcomes
By the end of today’s activity students will be able to:
- Describe, recall, show, identify, and/or support the Learning Targets on the Learning Target handout

Materials:
- Handout
  - Learning Targets, given out on Day 1 of curriculum unit
- Textbook
- All GTT Resources

5 E’s Learning Cycle Day 9

ENGAGE:
- Students self-reflect on the Learning Targets they know and do not yet know.
- Students also write how well they know the Learning Targets on the handout-Students read the specific Learning Target and write a “+” in the box if they are confident they understand what the statement says. Students write a “√” if they understand part of the statement and they write a “-” if they don’t understand the statement.
EXPLORE:
- Students work together in a group of 3 or 4 communicating about each of the Learning Target statements and how well they know them. Any of the activities that were performed during the unit are available to be revisited or redone by students during class time. Students can also explore other parts of volcanology if they like and the equipment is available.

EXPLAIN:
- Students clarify understanding of the Learning Targets with other students and teacher by asking questions. The teacher can visit all groups and check their Learning Target paper for the check mark, the plus sign, or the minus sign. The teacher can ask students clarifying questions to get students to understand what the Learning Target is about. The teacher can also facilitate relearning of the concepts, either individually or classwide, depending on how many students have the same concerns about a specific Learning Target.
- Students seek new explanations from the GTT resources, websites (www.USGS.gov or www.nps.gov), or the teacher for those Learning Targets they do not understand.

EXPAND:
- Students seek further clarification and ask new questions pertaining to the Learning Targets.

EVALUATE:
- Students evaluate each other on their answers to questions they pose from the Learning Target.
- The evaluation will take place on Day 10.

Day 10 Exam Day End of Curriculum Unit
Students demonstrate their learning of the Learning Targets on the post-test.

References Cited


APPENDIX D
PRE-TEST AND POST TEST QUESTIONS
FOR ASSESSMENT OF CURRICULUM

UNIT

Multiple Choice
Circle the letter of the choice that best completes the statement or answers the question.

1. Put the magma types in order of decreasing viscosity (most viscous listed first)?  a. basaltic, andesitic, rhyolitic  b. rhyolitic, andesitic, basaltic  c. andesitic, basaltic, rhyolitic  d. basaltic, rhyolitic, andesitic

2. Which of the following plays a major part in determining the shape of a volcano?  a. elevation above sea level  b. local soil type  c. magma composition  d. nearness of other volcanoes

3. The most violent volcanic eruptions are associated with what type of volcano?  a. cinder cones  b. shield volcano  c. composite cone or stratovolcano  d. plug dome

4. A magma’s viscosity is directly related to its _____.a. depth  b. age  c. color  d. silica content

5. Which of the following factors helps determine whether a volcanic eruption will be violent or relatively quiet? a. amount of dissolved gases in the magma  b. temperature of the magma  c. composition of the magma  d. all of the above

6. A lava flow with a surface of rough, jagged blocks and sharp, angular projections is called a(n) ____.  a. pyroclastic flow  b. aa flow  c. pahoehoe flow  d. ash flow

7. Highly explosive volcanoes tend to have what type of magma?  a. magma with high silica, high viscosity, and higher gas content  b. magma with low silica, low viscosity, and lower gas content  c. magma with low silica, high viscosity, and lower gas content  d. magma with no silica, high viscosity, and no gas content

8. The particles produced in volcanic eruptions are called _____.  a. laccoliths  b. calderas  c. pyroclastic material  d. volcanic stocks
9. What type of volcano is built almost entirely from ejected lava fragments (tangerine to marble sized)?
   a. cinder cone  b. composite cone  c. shield volcano  d. pahoehoe volcano

10. The broad, slightly dome-shaped volcanoes of Hawaii are ____.  a. composite cone volcanoes  b. shield volcanoes  c. plug dome  d. cinder cone volcanoes

11. A volcano that is fairly symmetrical and has many layers of both lava and pyroclastic deposits is a ____.
   a. cinder cone volcano  b. shield volcano  c. pyroclastic volcano  d. composite cone volcano

12. Most of the active volcanoes on Earth are located in a belt known as the _____.  a. circum-Atlantic belt  b. Ring of Fire  c. Ring of Lava  d. East African Rift Valley  e. volcano belt

13. What volcanic feature represents LVNP as well as the rest of the Cascade range  a. continental volcanic arc  b. volcanic island arc  c. hot spot  d. ocean ridge

14. In general, what is true about the composition of the igneous rocks produced in association with subduction zone volcanic activity?  a. The rocks are high in silica  b. The rocks are low in silica  c. The rocks have the highest possible silica content  d. The rocks contain no silica.

15. What types of volcanoes are found in Lassen Volcanic National Park?  a. shield-type  b. composite  c. plug dome  d. cinder cone  e. all of the above  f. a and b but not d

APPENDIX E
SURVEY FOR STUDENTS AFTER CINDER CONE FIELD TRIP

Directions: The statements in this survey have to do with your opinions, feelings and perceptions regarding the Cinder Cone Field Trip project. Please read each statement carefully, and circle the number that best matches your feeling. Your responses will NOT affect your grade in the class.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
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</thead>
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<tr>
<td>1. The field trip was interesting.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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<tr>
<td>2. The field trip had good information.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. The field trip helped make science more enjoyable</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4. The activities before the field trip helped me understand the volcanism concepts of the unit.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5. The activities after the field trip helped me understand the concepts of the unit.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6. The field trip content helped me understand concepts of class better.</td>
<td>1</td>
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<tr>
<td>7. I felt I could ask questions during the field trip.</td>
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<tr>
<td>8. I learn better when I am given a worksheet as a guide for the field trip.</td>
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<tr>
<td>9. I liked the different ways of demonstrating my knowledge compared to just one test.</td>
<td>1</td>
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</tr>
<tr>
<td>10. I enjoyed the field trip to Cinder Cone.</td>
<td>1</td>
<td>2</td>
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<tr>
<td>11. Lassen Volcanic National Park is a place I will visit again.</td>
<td>1</td>
<td>2</td>
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<tr>
<td>12. The curriculum/lesson plans of this unit were appropriate for high school level-students.</td>
<td>1</td>
<td>2</td>
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<tr>
<td>13. The assessments asked me to show what I learned at an appropriate level.</td>
<td>1</td>
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<tr>
<td>14. I think the assessment questions were easy to answer.</td>
<td>1</td>
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Complete the statement: “The field trip helped me understand….
My favorite thing about the trip was …..”
If this trip was done again I would suggest changing ….
## Student Responses for survey to Cinder Cone

<table>
<thead>
<tr>
<th>Statement</th>
<th>Mean average of response</th>
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<td>2. The field trip had good information.</td>
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<td>3. The field trip helped make science more enjoyable.</td>
<td>4.7</td>
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<tr>
<td>4. The activities before the field trip helped me understand the volcanism concepts of the unit.</td>
<td>4.3</td>
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<td>5. The activities after the field trip helped me understand the concepts of the unit.</td>
<td>4.3</td>
</tr>
<tr>
<td>6. The field trip content helped me understand concepts of class better.</td>
<td>4.7</td>
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<td>7. I felt I could ask questions during the field trip.</td>
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<td>8. I learn better when I am given a worksheet as a guide for the field trip.</td>
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<td>9. I liked the different ways of demonstrating my knowledge compared to just one test.</td>
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<td>10. I enjoyed the field trip to Cinder Cone.</td>
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<td>11. Lassen Volcanic National Park is a place I will visit again.</td>
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<td>4.7</td>
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<tr>
<td>14. I think the assessment questions were easy to answer.</td>
<td>4</td>
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</table>

A response of 1 means strongly disagree, 2 means disagree, 3 means neutral, 4 means agree, and 5 means strongly agree.

As noted in the main section, the responses were all in the agree or strongly agree classification with the exception of question 8—the response was general disagreement with the statement.
DATA FROM PRE-TEST AND POST TEST SCORES

A negative number indicates the student score higher on the pre-test than the post-test.

Period 1 of GTT curriculum class

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- Standard deviation: 2.55
- t-test statistic: 10.80
- p value: 1.67x10^{-12}

Sample size: 33

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\]

\[
t = \frac{4.79 - 0}{2.55/\sqrt{33}} = 10.80
\]
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Average: 4.68  Pretest Score: 9.32  Posttest score: 4.65

- Standard deviation: 3.40
- t-test statistic: 7.60
- p-value: $8.83 \times 10^{-9}$
- Sample size: 31
### Period 3 of GTT curriculum class

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<th>Difference in Post vs. Pre Scores</th>
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Average 5.72 9.47 3.75

- Standard deviation: 2.84
- T-test statistic: 7.47
- P-value: $1.02 \times 10^{-8}$
- Sample size: 32
### Period 2 of non-GTT curriculum class (control group)

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**Standard Deviation:** 2.01

**T-test Statistic:** 3.31

**P-value:** $1.07 \times 10^{-3}$

**Sample Size:** 36
Period 3 of non-GTT curriculum class (control group)

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Standard deviation 2.50
T-test statistic 4.45
P-value 4.56x10^{-5}
Sample size 34
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If \( p > 0.05 \) then the scores are random and there is no relation between pre-test and post-test scores with curriculum.

For this sample size, if \( t > 3.5 \) then change of scores is positive and infers a relationship between score increase and exposure to the curriculum.
CINDER CONE FIELD TRIP GUIDE

To be used with the student field trip to Cinder Cone – designed by the author. Students are to hike the Cinder Cone trail, carrying this information with a pencil and some data gathering devices like a ruler, a hand lens, and a compass with angle measure. 12 students at a time hike to Cinder Cone. Along the path at certain locations students write observations or take measurements. This hike activity should take about 3 hours total time. Students need to have distance-measuring skills to use a ruler, skills of using a hand lens, and skill with a compass that shows the angle of inclination.

The activity was designed to have students interact with the trail. Students need to think about what natural phenomena they are looking at and try to make sense of it. Prior leaflets and informative booklets did not involve students with learning, and so promotes passive role with learning. This field trip guide is designed to involve students with learning.

Cinder Cone Nature Trail
Lassen Volcanic National Park

Introduction:
Imagine that you are a volcanologist, using a ruler, a hand lens, and a compass with angle measure to discover, observe, and record the geological processes found in and around Cinder Cone volcano.

Cinder Cone Trailhead/Nobles Emigrant Trail (Just off the parking lot):
1. There are volcanic rocks just to the left and there is also Butte Lake. What is the connection between the jagged rocks and the lake here? Which was first, the rocks or the water? How would you know?

2. Try to find any cinders here. What are sizes of the cinders on the trail? Record size observations and the color of the cinders. These are all basaltic rocks, so they are relatively low in silica.

Numbered Post #3:
1. Look around at the vegetation in the lava flow off the south/left of the trail. What is the oldest or largest plant? How could this information be used to determine the age of the cinder cone?

2. Record 3 different cinder sizes just off the trail. Leave the cinders after measurement.
Numbered Post #6: Fantastic Lava Beds
1. What do you observe about the rock/lava? Are the crystals large or small? Did the rock cool quickly or slowly? How do you know? Is the lava smooth or jagged?

2. Record the size of 3 different cinders here.

Stop 9: Trail to Prospect Peak
1. Prospect Peak is a shield volcano. What makes it a different shape than cinder cone? What makes the lava different for each type of volcano?

2. Record sizes of 3 different cinders here.

At The Top of Cinder Cone:
1. What could make it difficult to walk up the Cinder Cone (you might think it was difficult or maybe not)?

2. Record sizes of 3 different cinders.

3. What is the trend relating the cinder size and the distance away from the cone/crater?

4. What are the crystal sizes of the cinders? What do you suppose is the history of that cinder you looked at?

3. On the West side of the Cinder Cone is a sign with the names of the peaks in the surrounding background. You can see all four types of volcanoes from this vista point. Match the types (plug dome, cinder cone, stratovolcano/composite, shield volcano) with the Volcano name below.

   Red Cinder       Mt. Hoffman
   Lassen Peak      Mt. Harkness
   Chaos Crags

4. What characteristic(s) do you see that helped you decide on the type of volcano?
Which parts of the curriculum plan did you use?
Pretest and Posttest, National Geographic Volcanoes, viscosity tubes demo, Lassen Powerpoint, Lava Layering Parts I and II, America’s Volcanoes video, Rocks Around activity, rock samples and diagrams from volcano kit.

Which parts of the curriculum plan did you not use?
I didn’t do the demos of the four volcano types. Something along that line is needed. What do you think about the suggested activity outline? The unit went well. I did some notes/graphic organizers for the four volcano types but need to investigate a better way to present the material on the four volcanoes.

What did you do last year for volcano curriculum?
Lots of similarities. I used the CyberEd materials a lot more and did more work with rock identification.

Did you include Cinder Cones as part of the curriculum?
Nope. Too expensive for a field trip.

Did you include Lassen Park volcanoes as part of the curriculum?
Only with PowerPoint and pictures from the Volcano Kit.

What general comments do you have regarding the GTT-based activities?
It’s a good, concise unit. As mentioned above I need a better activity to compare and contrast volcano types.

What did you like? What would you change?
Many of the kids really liked the Lava Layering. Also, the Lassen volcanoes materials captured a lot of interest. I need to evaluate how best to use the viscosity tubes for global or find another viscosity activity. One that relates to silica content and gas content would be ideal.

Your students did not do a field trip to Cinder Cone. What do you think your students would get out of a field trip to Cinder Cone (neglecting the logistics of it)? Field trips are invaluable mostly for exposure. Most science students have never been to Lassen. As we discussed, a lot of frontloading and some specific tasks to accomplish on the trip would be necessary to maintain an educational emphasis.
What are your thoughts about field trips?
Great and worthwhile.

In the traveling trunk, did you look at the Geological Resources Guide?
I probably glanced at it but didn’t spend any time with it.

If so, what resources did you look at or use in your classroom for student experience?
No response

How would you rate your knowledge of volcanoes before teaching the unit?
1 – 5 scale, with 1 being novice to 5 at an expert level
3

How did teaching the unit change your knowledge of volcanoes (if it did)?
I read a lot of the material about Lassen specifically. I’m definitely more knowledgeable about the park and the Lassen Peak eruptions. 4 on the scale