"Living with Volcanoes": Geoarchaeology in the High School Classroom

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Abstract
Geoarchaeology continues to be a growing field, yet geoarchaeological education is largely restricted to the advanced undergraduate and postgraduate level. However, it is possible to introduce basic geoarchaeological concepts at lower levels and high school poses a suitable setting for this. Archaeology, and sometimes geology, is considerably under-represented in high schools, despite offering valuable opportunities for students to connect with the world around them, past and present, as well as possible career paths. To introduce this field and its interdisciplinary nature, a ninety minute geoarchaeological teaching activity was designed for upper year high school students in Northern England. Feedback and perspectives on content, pedagogy, geoarchaeology and interdisciplinarity were gained through an iterative pre-interview process with high school teachers of geography and classical civilisation. The activity was piloted and observed with a total of thirty students between one geography and one classical civilisation class. Students showed positive learning gains and shifts in perceptions, regardless of class enrolled, gender or additional classes studied. They responded positively to the hands-on portions of the activity in particular, whilst simultaneously finding them the most challenging. Some students did not enjoy the short, lecture portions of the activity, finding themselves easily distracted. Post-interviews support these findings and teachers were largely impressed with the capabilities of their students. The two teachers involved in the pilot found it to be rewarding and plan to use the activity as an enrichment experience for future students. Final revisions have been made to the "Living with Volcanoes" activity based on these findings and it is ready for wider implementation in any number of related high school subjects, including geology, geography, archaeology and classical studies.

Why teach geoarchaeology at high school?
Geoarchaeology combines the geosciences with archaeology, in order to ask and respond to novel questions of inhabited landscapes. Learning about the discipline offers an opportunity for students to connect with their world, past and present, through subjects that are sometimes overlooked in high school. Geoarchaeology is interdisciplinary (Donahue and Adovasio, 1985), and it can be used to show how common disciplines may be connected to provide unique approaches to problems. Interdisciplinary, or integrated, studies are valued by school educators in the geological and archaeological sciences alike and are a recommended approach to increasing the incorporation of these subjects at the high school level (Fleming, 2000; Lee and Fortner, 2005).

Initial development of the "Living with Volcanoes" activity
In order to introduce geoarchaeology and its interdisciplinary nature to upper year high school students in Northern England (equivalent to 11th Grade in North America), a pilot version of an activity focused on volcanic geoarchaeology was developed. An iterative methodology formed the basis for this, beginning with an initial informed design that was modified in response to interviews with teachers of these students.

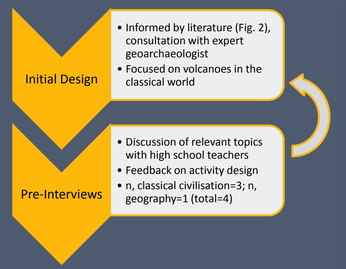

Figure 1. Initial development methodology. Used to create the pilot design for the teaching activity (Fig. 3). The initial design was continuously revised based upon the teacher pre-interviews. Teachers responded positively to the activity approach and structure but suggested further student support (i.e., key terms list, writing guide) would be helpful. Classical civilisation teachers expressed caution towards having too much scientific content in the activity. All teachers were interested in volcanic geoarchaeology but thought that Pompeii should be featured more prominently.

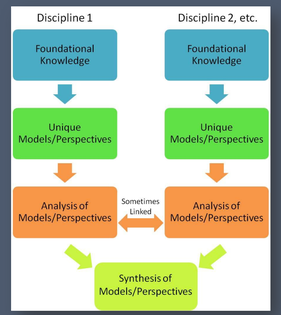

Figure 2. Interdisciplinary teaching model. This approach (Newell and Green, 1982; Klein, 2005) was used to structure the activity, by initially juxtaposing the foundational content and perspectives of the two disciplines. Following this, the disciplines were partially connected in the students' analysis and completely connected with the final synthesis portion.

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Implementation of the "Living with Volcanoes" activity
Following the initial activity development (Figs. 1 and 2), the pilot version (Fig. 3) was implemented in two classrooms – Geography and Classical Civilisation – in different schools and cities. Both of the teachers of these classes participated in the pre-interview stage. 17 students participated from the Geography class and 13 from the Classical Civilisation class, for a total sample size of 30. The Geography teacher combined two sections of their class to take part in the activity as a double length lesson (2 hours total), whereas the Classical Civilisation teacher offered students from the only section of their class the choice between this activity and a computer-based one taught by another teacher. The Classical Civilisation lessons were both at double length, but were presented as an enrichment opportunity in the topic that they were most interested in.

Table 1. Learning aims and objectives for the "Living with Volcanoes" activity.

Aims	Objectives
Compare and contrast geographical and archaeological settings and materials. **(Analysis)**	Describe some archaeological approaches and how geoarchaeology builds on them. **(Comprehension)**
Summarise the landscape history of Pompeii ca. 79 AD, incorporating both geographical and archaeological findings. **(Synthesis)**	Describe the two major types of volcanoes and some related volcanic deposits. **(Comprehension)**
Introduce geoarchaeology and its foundational concepts. **(Knowledge)**	Interpret geoarchaeological materials. **(Application)**
Explore the benefits and challenges of interdisciplinarity. **(Evaluation)**	Use these interpretations to help you explain what it was like before and during the eruption at Pompeii. **(Synthesis)**

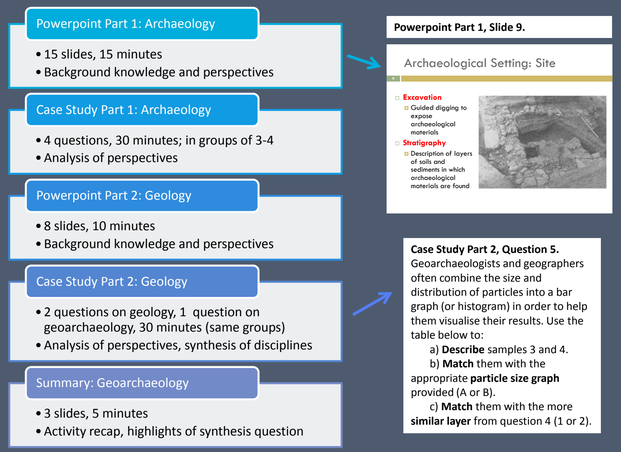


Figure 3. "Living with Volcanoes" activity outline and examples. Volcanic geology and archaeology are discussed separately, each with their own short powerpoint section that introduces the disciplines' foundational knowledge and perspectives, followed by their own case study section with questions (completed in groups) that analyse these disciplinary perspectives. Finally, a synthesis case study question ties the two together.

Activity teaching structure
After receiving the activity for preparation 2 weeks prior, the teachers of each class led the instruction of the activity pilot. Their instruction was important in order to maintain teaching continuity, promote sustainability in future activity implementation and allow for data collection by the researcher. Through the powerpoint sections, teachers followed the framework provided on the slides and added their own comments and questioning, which were relevant to their own disciplines and to the experiences of their students. During the case study questions, teachers moved around the classroom and asked/answered questions on a group by group basis (3-4 students/group). One teacher also elected to introduce and recap each question with the entire class. While the researcher was largely removed from the activity delivery, she was available to be called upon for help if needed, to make the teachers feel more comfortable with anything that they were unsure of.

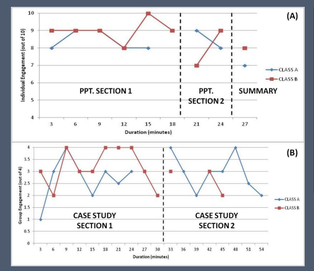
Access to the "Living with Volcanoes" activity
Contact the author (alisonjolley@gmail.com) for access to the activity powerpoint and case study questions, which may be used with attribution. Reference materials used within the activity are open access.

Data collection methods – students and teachers
A number of sources (Table 2) were used to answer two central research questions:
1) How effective is the activity at teaching the foundational concepts of geoarchaeology?
2) How effective is the activity at increasing awareness of geoarchaeology and interdisciplinarity in archaeology?

Table 2. Data sources used to determine the effectiveness of the "Living with Volcanoes" activity.

Data source	Description
Observations: student engagement	Non-participant observations taken every three minutes. Number of engaged students (during powerpoint sections, /10) or groups (during case study sections, /4) and teaching techniques recorded for each interval. Based on existing protocols (Hora and Ferrare, 2009; F. Jones, pers. comm., 2012; Kennedy et al., 2013; Lane and Harris, in prep.).
Pre-post survey: perception, knowledge, feedback	Consolidated survey taken before (10 min.) and after (15 min.) the activity, based on learning aims/objectives. 6 five point, Likert scale perception questions. 3 open-ended knowledge questions. 4 open-ended feedback questions (only asked on post). Based on related surveys (Libarkin and Anderson, 2005; Adams et al., 2006; Walker, 2006; Jolley et al., 2012).
Case study question sheets	Group notes made on the case study question sheets were collected at the end of the activity for a rough indication of student thought processes.
Post-interviews with teachers	Fifteen minute interviews with the two teachers who participated in the pilot. Feedback-based, to gauge the ease of the preparation process and activity instruction.

Observations of students during the activity: moderate to high engagement
Student engagement was moderate to high, with no significant differences between classes (Fig. 4). The average engagement during the powerpoint sections were 8.67 and 8.25 (/10) for Classes B (Classical Civilisation) and A (Geography), respectively. During the case study questions, Classes B and A averaged 3.08 and 2.81 (/4), respectively. Group engagement (case study questions) was generally more variable than individual engagement (powerpoint sections), which declined slightly during later sections.



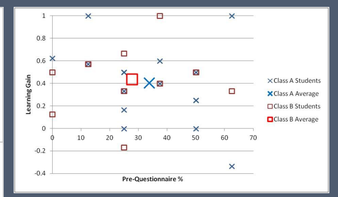


Figure 4 (left). Student engagement during the activity. Class A=Geography, B=Classical Civilisation. Class B's engagement peaked at the 15 minute mark of PPT. Section 1, following the passing around of the obsidian sample. Class A did not show the same renewed engagement with the sample. This may have been due to more questions being asked by Class B's teacher. This teacher also asked more questions during the case study sections. The gap in Class B's engagement data during Case Study Section 2 corresponds to the researcher being asked to assist with the facilitation of the rock sample questions.

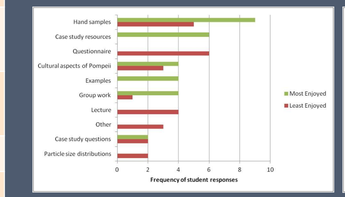
Figure 5 (right). Knowledge survey results. Class A=Geography, B=Classical Civilisation. Learning gain= [post % - pre %] / [100% - pre %] (Hake, 1998).

Pre-post knowledge survey: average learning gain of 0.42
The average learning gain on the pre-post knowledge survey was 0.42, with no significant differences between class enrolled (Fig. 5), gender or additional classes taken (Geography students that had taken at least one Classical Civilisation class and vice versa). All students were able to achieve the same outcome, regardless of their background.

Pre-post perception survey: students became more expert-like
Students averaged significant expert-like shifts on four of the six perception survey statements (/5): the usefulness of connecting disciplines (4.07 to 4.50), imagining connections between archaeology and other disciplines (4.10 to 4.50), the strength of connecting archaeology with other disciplines (4.03 to 4.57), and having a good idea about what it means to study geoarchaeology (3.00 to 4.03). Shifts were not significant on: geoarchaeology being fun to study (3.33 to 3.53) and it being time-consuming to connect disciplines (3.45 to 3.53).

Image Sources
Figure 3. Pumice on floor of Minoan structure: Antonopoulos, J. (1992). The great Minoan eruption of Thera volcano and the ensuing tsunami in the Greek Archipelago. *Natural Hazards*, 5, pp.153-168.
Throughout "Living with Volcanoes" activity, images are fair use and attributed, with the majority sourced from Wikimedia Commons.

Post feedback survey: a range of student responses
On the post-survey, students provided open-ended feedback on what they enjoyed most and least (Fig. 6) and what they found easiest and the most challenging (Fig. 7). In some cases, students' opinions were mixed (e.g. the use of hand samples, cultural aspects of Pompeii). In others, they were more uniform (e.g. the lecture component, the question on particle size distributions). Those that didn't enjoy the hand samples frequently attributed this to them being challenging rather than uninteresting or unclear, perhaps indicating that a desirable level of difficulty was achieved.



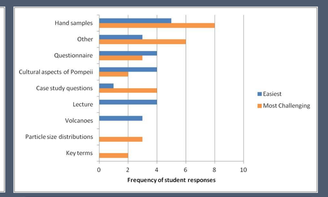


Figure 6 (left). Most and least enjoyed aspects of the activity.

Figure 7 (right). Easiest and most challenging aspects of the activity.

Case study question sheets filled out by the groups
Students were encouraged (but not required) to take notes during the activity, in order to help them with the final long form synthesis question. These sheets were collected afterward; however, many were sparsely completed. Several of those that were completed did display sophistication, e.g. *"Pompeii appeared to stem from a farming background which made it (and residents) very rich. Pompeii also appeared to have a healthy cultural background, with grand religious temples and musical instruments. The city was also at the forefront of 'modern' technology with glass and effective eating utensils."* (Group 4, Class A)

Post-interviews: teacher feedback
The two teachers who participated in the pilot study were largely positive about the experience. They were impressed by their students' capabilities with the material and were proud to see many of them highly engaged with it. They observed the hands-on content to be particularly captivating. The teachers made suggestions for changing the activity, including a bigger font size and pictures on the question sheet and a detailed answer key for the case study questions. Both teachers said that they would use the activity for enrichment or cross-curricular work in the future.

Conclusions: approaches, outcomes and future implementation
The "Living with Volcanoes" activity was developed using an iterative methodology (Fig. 1) with a structure that borrowed heavily from the interdisciplinary education literature (Figs. 2 and 3). This approach was particularly important and may prove useful for similar work in the future. The activity has been proven effective at teaching foundational geoarchaeology concepts (Figs. 4 and 5) and increasing student awareness of geoarchaeology and archaeological interdisciplinarity. It was modified based on student (Figs. 6 and 7) and teacher feedback, as well as findings from in-class observations, pre-post surveys and student responses to activity questions (Table 2). "Living with Volcanoes" is ready to be implemented in high school and early university settings.

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