Using field trips to Banks Peninsula, New Zealand to augment Earth science learning for Canterbury schools

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ABSTRACT

The implementation of an earth systems module into a middle school curriculum would greatly enhance the students understanding of their surroundings and geological history. Banks Peninsula, an area containing many volcanic systems, is an excellent place to focus the module due to its geologic variety and proximity to Christchurch. An investigation into studies on the subject reveals that field trips increase understanding of material (Elkins and Elkins, 2007; Orion, 1997). The module would consist of three parts: a preparatory period, a field trip, and a summary component. The field trip module to Banks Peninsula would explore the areas around Lyttelton Harbor and down into Birdling’s Flat to investigate the geologic history of Banks Peninsula. Topics covered would include volcano formation and the formation of the Kaitorete Spit. This unit is an important crossover between the geologic and educational fields and serves as a way to introduce students to science in an exciting and in-depth way.

INTRODUCTION

Though field trips can be viewed as an unnecessary expense to schools, they are integral to concrete learning. They are also sometimes avoided because teachers can be unfamiliar with the organization and technique of outdoor learning (Orion, et al., 1997). Other factors that can negatively affect outdoor learning include concern for health and safety, shortages of support and resources, and school curriculum requirements (Dillon, et al., 2006). However, Field trips help solidify connections between what was taught in the classroom with real world examples of natural phenomena such as volcanoes, dikes, sedimentary features, et cetera. Outdoor learning allows students to be actively involved with knowledge construction (Orion, et al., 1997).

Field trips to Banks Peninsula could be very beneficial to schools in the Canterbury region due to its relative proximity, situated <15km east of Christchurch. The New Zealand Curriculum
already contains a “Planet Earth and Beyond” section. This section is defined by “the interconnecting systems and processes of the Earth, the other parts of the solar system, and the universe beyond. Students learn that Earth’s subsystems of geosphere (land), hydrosphere (water), atmosphere (air), and biosphere (life) are interdependent and that all are important. They come to appreciate that humans can affect this interdependence in both positive and negative ways” (New Zealand Curriculum, 2007, pg. 30). A field trip module can directly fit into this curriculum by allowing students to observe for themselves the interaction of these systems. For example, from up on Summit Road, it is possible to see Lyttelton Harbour and a panorama of the entire Lyttelton Volcanic Complex. This area was once covered with native bush, but due to deforestation by humans, sedimentation rates are increased, directly impacting the geosphere and hydrosphere of the area.

There are a variety of ways that students learn and retain information. These learning styles can be classified with students having a preference for one category or the other in each of the four following dimensions (Felder and Spurlin, 2005):

- *Sensing* (practical, prefers facts and procedures) or *intuitive* (innovative, thinks abstractly, prefers theory);
- *Visual* (prefers pictures, charts, diagrams to learn presented material) or *verbal* (prefers spoken or written explanations of material);
- *Active* (prefers working in groups, learns by doing) or *reflective* (prefers to work by oneself or with a friend);
- *Sequential* (prefers to learn in a step-by-step process or linear process) or *global* (thinks holistically, learns in large steps).

Field trips have the ability to touch on all of these learning-type dimensions. In any given class, it is probable that all of these style preferences would be represented, so it is important to appeal to each type to help facilitate learning. The module has aspects that would appeal to all.

Studies have shown the variety of benefits that outdoor learning provides. Orion conducted a study in which he compared active (field trip) vs. passive (purely lecture) learning, and found interactive learning to be more beneficial. He also found investigative learning, in which the students are actively pursuing the answers, are more productive than confirmatory learning. Proper planning for outdoor learning was essential, and also students views the teacher as more supportive (1996). In an additional paper of Orion’s, he describes the different between
a “science learning” approach, and an “earth systems” approach (Figure 1). He argues that
teaching in a systems approach facilitates more in depth learning (2007). Elkins study found that
students who had been involved with outdoor learning had higher exam scores than their student
counterparts who learned through traditional methods (2007). Nugent and Kunz came to the
same conclusion, though their study was based on preservice teachers (2008). Gonzalez found
that field-based study incited interest and enthusiasm in students for certain topics (2009). Kraft
discusses how combining motivation, emotion, and connections with the earth gives students
higher motivation to learn in the geosciences (2011). A field trip would definitely engage
students to connect with the environment around them.

The Banks Peninsula field trip module contains three parts: a preparatory period, the field
trip, and a summary component (Orion, 1989). The first and last parts would be classroom based
and consist of handouts, worksheets, and an assessment or presentation at the end. These types
of activities apply to most categories of learning types, but the field trip component can directly
apply to the active and visual learners as they explore an outcrop or volcanic feature.

The learning objectives from this module are as follows:

- Learn about the geologic importance of the area they live in.
- Gain understanding of the scientific method and field methods, and be able to summarize
  what they have learned.
- Practice teamwork and group thinking during the field trip as well as during the
  preparatory and summary exercises.

GEOLOGICAL SETTING

New Zealand runs along the Ring of Fire (Figure 2), and offers a prime opportunity for
students to learn about earth systems and give an introduction to plate tectonics and volcanism.
Banks Peninsula is close to Christchurch and contains some incredible examples of extensive
volcanism. Banks Peninsula formed as a series of volcanic complexes in the Miocene. There are
four main groups: Lyttelton (11-9.7 Ma), Akaroa (9.0-8.0 Ma), Mt. Herbert (9.7-8.0 Ma), and
Diamond Harbour (7.0-5.8 Ma) (Sewell, 1988). The two main composite volcanoes are Lyttelton
Volcano in the northern part of the Peninsula and Akaroa Volcano in the southern part (Sewell,
1988). There are numerous examples of various types of volcanic features including lava flows,
scoria cones, dykes, and domes. Though the source of magma in Banks Peninsula is still debated,
it is thought to be interpolate magmatic (volcanic happening in the middle of a tectonic plate), and not related to seduction (Hampton, 2012). There are also plenty of examples of sedimentary systems such as loess deposits (wind deposited sediments) along State Highway 75, and barrier beach formation at Kaitorete Spit. More information about specific sites is given in the Field Trip Guide.

METHODOLOGY

In February 2013, I visited Banks Peninsula, mostly centered in Okays Bay, with other visits to Pa Bay. This fieldwork was separate to the research presented here, but through this work I was very impressed by the volcanic history present in the area. Subsequent visits to Banks Peninsula included Lyttelton Harbour, Akaroa Harbour, Mt. Herbert, Governor’s Bay, and Birdling’s Flat provided inspiration for a field trip to some of these locations.

Data providing support for increased learning during field trips was provided through a variety of scholarly journal articles mentioned throughout this paper. In addition to these sources, I spoke to teachers in the area to gain feedback about this topic, as well as students who had gone through local schools.

EARTH SYSTEMS MODULE: PREPATORY PERIOD

This preliminary component will help prepare students for the field trip. This will be based in traditional class learning through lectures and activities. Lectures will center on the history of the Earth, the rock cycle/rock types, and New Zealand’s own natural history. Earth’s history should begin with the big bang, then move forward to 4.6 billion years. An activity to illustrate the Earth’s immense time scale would be to graph the history in a visual, tangible way. Each student would receive a long scroll of paper, and every meter would represent one billion years. The timeline would start at 4.6 billion years ago (4.6m) and end at the present time. The students would be given a list of important events in geologic time (first cells, first mammals, break up of Pangaea, New Zealand breaks off from Antarctica, Banks Peninsula formation, etc.) and their ages, and the students would plot these events on their timeline. This activity engages visual and active learners very well. This incorporates mathematical skills as well to convert the ages to a physical unit. Another idea would be to use Google Earth© to explore Banks Peninsula visually. It is very easy to see the topographic difference between the flat Canterbury Plains and
Banks Peninsula. From this angle, the teacher could possibly point out the different volcanic complexes and prepare the students to see these crater rims in real life. The students could come up with their own questions about the area, such as why is Quail Island there? Why does Banks Peninsula have such a rounded shape? How did the harbors form? These questions could then be answered during the field trip.

EARTH SYSTEMS MODULE: FIELD TRIP GUIDE

The field trip would begin near Cashmere in Christchurch, and make a loop stopping at various points along Summit Road, Kennedy’s Bush Scenic Reserve, Birdling’s Flat, and an optional stop at Halswell Quarry. It is recommended to do this trip in warmer weather, closer to when school starts, as it can get cold up on the crater rim and the trip requires time outside. Fair conditions are necessary to keep the roads safe for buses, as well as general demeanor. The route is mapped in Figure 3, following Dyer’s Pass Road, connecting to Summit Road, continuing onto Gebbie’s Pass Road. This connects to State Highway 75, which leads to Birdling’s Flat. Finally, going back onto HWY 75 towards Christchurch will lead to Halswell Quarry, the optional stop if time allows. According to Google Maps©, this route is drivable in 1.5 hours, but with buses, time at the stops, lunch, and a little extra time included, the field trip should take around 5 hours. Worksheets for each stop are included in the Appendix. Students can choose to work individually on the worksheets, or in groups. However, each student should turn in a worksheet.

Stop 1

The first stop is along Summit Road about 200 meters past the closed Sign of the Kiwi. There is a pull off on the right side of the road. It is important to be very careful in this area, as the outcrop is on the opposite side of the road from the pull off area. There is not much room in front of the outcrop, and while there are not frequent vehicles, there are numerous bikers speeding down the hill. In this outcrop, there are at least two visible vertical dikes (Figure 4A) displaying chilled and baked margins, with large quartz grains. The worksheets go through questions such as what was here first, the dike or the surround material? Are the dikes igneous, metamorphic, or sedimentary? How did the dikes get there? The students should sketch this outcrop so they can really focus on the differences between the dikes and the host rock. It would be noteworthy to discuss why the rocks are different colors (chemical composition, etc.). Another option is to climb onto the hill above the dikes to see across the harbor. To the right of a
stand of pine trees across the harbor, there appears to be a large, freestanding dike sticking out of
the ground (Figure 4B). This could be neat to point out, as well as the head of the harbor. This is
a good stop to start discussing smaller, intrusive volcanic features, and relate them as part of the
larger volcanic complex, introducing students to the range of spatial scales analyzed in
geoscience.

Stop 2

Continuing on ~1km up Summit Road, there is a car bay on the left hand side of the road
across from the Kennedy’s Bush Reserve (The Sign of the Bellbird). This car bay overlooks all
of Lyttelton Harbour, including the crater rim, the port, and the outlet to the Pacific (Figure 5A).
Students can see dipping lava flows and domes around the crater rim. It is important here for
students to be able to visualize the scope of the volcanic complex. The teachers could ask the
students to try to point out where other visible lava deposits are located. Quail Island is clearly
visible from this viewpoint, and one could discuss how Quail Island was part of a lava flow from
the Lyttelton Volcanic Complex (Price and Taylor, 1980), but became separated due to erosion
in the bay. Other questions to ask students include how did the harbor form? Why are there
different shapes of material around the crater? What do you think the landscape looked like
before human interference (in terms of vegetation ground cover)? This is a good place to discuss
how the native bush was removed, and the affects this could have on the landscape due to the
increased erosion rates. Asking students “does this matter?” will provoke personal opinions and
could lead to a useful class discussion. This lookout is an ideal place to get an overview of the
volcanic complex, as well as understand it’s immense scale.

Across the road is the Sign of the Bellbird, part of the Kennedy’s Bush Reserve. There
are toilets here, as well as a rest station (the structure converted from a 1814 building) and is a
good place for lunch. The view looks out over the Canterbury Plains and the Southern Alps
(Figure 5B). It would be exciting to discuss the difference between the formation of the Banks
Peninsula hills and the Southern Alps (volcanic vs. tectonic). This view also helps visualize truly
how flat the Plains are, and how much sediment had been removed from the Southern Alps to
create the Plains. This is a good location for students to see how dynamic systems create the
varied landscapes that they live on. After this stop, the field trip continues on Summit Road, until
turning right at Gebbie’s Pass Road, then turning left at State Highway 75.
Stop 3

Along State Highway 75, there are visible deposits of loess on the left (Figure 6), as well as glimpses of Lake Ellesmere on the right. This stop is optional, as there is no real good place to pull over except just on the side of the road. However, the loess (wind deposited sediments) deposits are an interesting contrast between the igneous rocks of the volcanic complexes. It is apparent, even from the road, that these karst deposits are very fine grained. Questions could include why are these so fine grained? Why are the sediments so uniform in size? These deposits came from glacial sediments that dried out after the glaciers retreated (Goh, et al, 1977). This stop demonstrates Aeolian systems, and sets up a comparison between a water/marine depositional system.

Stop 4

Continuing towards the Pacific along State Highway 75 is Birdling’s Flat. Birdling’s Flat (Figure 7) is part of the Kaitorete Spit (a barrier beach) that separates the ocean from Lake Ellesmere/Te Waihora. There is a playground here, bathrooms, car park, and is a good place for a snack/break as well. The beach is comprised of smooth, rounded, predominantly grey pebbles, and these deposits would be interesting to compare to the loess deposits. Which depositional system had more energy? Are the Birdling’s Flat grains all the same size? Why are they round? Kaitorete Spit continues down to Taumutu, and runs approximately 25 km. The Spit is technically a barrier beach, as it is connected at both ends (though weakly on the southern end), and is narrowest the updrift end and widest at the downdrift end. During the Last Glacial Maximum, the glacial outwash rivers delivered vast quantities of sediment to the coast. The barrier beach is formed from longshore drift as currents move sediments towards Banks Peninsula (Soons, 1998). There is also an outcrop/cliff to the north of the beach (walk to the left when facing ocean) that displays excellent volcanic deposits. This would be a great outcrop to sketch and discuss differences between volcanic deposits as seen earlier in the trip and sedimentary deposits at the beach.

Stop 5

This is an optional stop after leaving Birdling’s Flat and heading back towards Christchurch along State Highway 75. Halswell Quarry is a clearly marked turn off. The quarry is a series of stacked volcanic deposits, with columnar basalt on the bottom (a lava flow from the Lyttelton Volcanic Complex), scoria and ash in the middle, and a lava dome on top (producing
the jointed “Halswell Stone”) (Figure 8) (Speight, 1936). There is a thin layer of loess on top. The quarry was mined for these resources as building and road material. There is a pathway up and around the quarry, with a view from of the Canterbury Plains from the top. When coming down on the right hand side of the quarry (when facing the quarry), there is a nice view of the different volcanic layers as well as labeled samples and a sign describing the history of the quarry as well. This stop is optional (though the field trip can be tailored to each teacher’s needs) because the students may be overwhelmed by vocab and new facts by this point. The quarry demonstrates how different volcanic features can occur in the same place (such as a dome and scoria/ash deposits). The field trip already goes through volcanic/igneous rocks, but the layers within the quarry provide an example of how humans utilize different rock types for different projects.

EARTH SYSTEMS MODULE: SUMMARY PERIOD

The summary component is the final stage of this module. This last part should showcase all that the students have learned from their field trip and classroom activities. This evaluation can be done through a test on the field trip material. However, this would also be an excellent time for students to work together to put on a presentation/poster about what they have learned about their own backyard of Banks Peninsula. In the New Zealand school system, there are not a lot of student presentations done, but this is a skill that can be used later on at university or work. Students can be divided into groups to do their presentations. This helps facilitate group learning, and can teach other members of their school community. Presentations also help cement what the students have learned, as they have to teach and present the material themselves.

CONCLUSION

A field trip to Banks Peninsula for primary school students would greatly enhance their learning of various earth systems through an interactive approach. This module of outdoor learning fits into the New Zealand curriculum on earth science and would enhance that educational component. Studies have shown that field trips improve learning. Banks Peninsula is an excellent place for this field trip due to its varied geology, easy access to these geologic features, and proximity to Christchurch. Through the three parts of the field trip module, the
students would actively learn about their own environment, and can pass this information onto others in their community.

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REFERENCES


FIGURES

<table>
<thead>
<tr>
<th>Traditional science teaching</th>
<th>Earth systems teaching</th>
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<tr>
<td>The main purpose is to prepare the future scientists of a society</td>
<td>The main purpose is to prepare the future citizens of a society</td>
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<td>Multidisciplinary teaching</td>
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<td>A child-centered teaching</td>
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<tr>
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<td>The teacher is a mediator for knowledge</td>
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<td>“Chalk and talk” based teaching</td>
<td>Inquiry based teaching</td>
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<td>School-based learning</td>
<td>Multi learning environments: Classroom, lab, outdoors and computer.</td>
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<td>Teaching that is derived from the scientific world</td>
<td>Authentic based teaching that is derived from the real world</td>
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<tr>
<td>Traditional assessment</td>
<td>Alternative assessment</td>
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Figure 1: A comparison between the traditional science teaching the earth systems (ES) teaching. The addition of multi learning environments in the ES teaching is central. After Orion, 2007.
Figure 2: The “Ring of Fire” highlights the active volcanic zone of the Pacific. This activity is caused by tectonic plate interactions, mostly subduction. New Zealand is highlighted by yellow ring. Image from http://pubs.usgs.gov/gip/dynamic/fire.html
Figure 3: This image from Google Maps© shows the route of the field trip through Banks Peninsula. (A) is the starting point in Cashmere, (B) is Kennedy’s Bush Scenic Reserve, (C) is Birdling’s Flat, and (D) is Halswell Quarry.
Figure 4: (A) The red lines outline the visible dikes in an outcrop along Summit Road. (B) From on top of the dike outcrop, it is possible to see the head of the harbor, and another possible dike, circled in red, to the left of a stand of trees.
Figure 5: (A) is a picture of Lyttelton Harbor, with the Pacific Ocean, Quail Island, and the crater rim in view. (B) is the view from the Sign of the Bellbird showing the Southern Alps over the Canterbury Plains.
Figure 6: This is a loess deposit on the left side of State Highway 75. Erosion has revealed the contents of the hillside. The grains appear to be very fine and relatively uniform. Lake Ellesmere is just visible across the other side of the highway.

Figure 7: These pictures depict Birdling’s Flat on the Kaitorete Spit. The cliff face in (A) is a great one to sketch due to the variety of layered volcanic deposits, including layers of scoria and ash. The beach is comprised of mostly grey, rounded, stones, but there are pieces of agate, quartz, and volcanic rocks present. Lake Forsyth is visible to the north. The inlet is currently filled in, but it is easy to spot where the inlet is created. Kaitorete Spit, Lake Forsyth, and Lake Ellesmere are visible in Figure 3.
Figure 8: (A) depicts the “Halswell Stone” lava dome with visible, clear jointing. (B) shows the columnar jointing at the base of the quarry and the scoria/ash layers top, followed by the lava dome. These sections are separated by black lines.
APPENDIX

Name: __________________________

Date: __________________________

Field Trip to Banks Peninsula Worksheet

Stop 1:

Sketch the outcrop:

Describe darker colored rock (small grains? What shape are the grains? What colors are the grains?)

Describe the tan colored rock:
What was there first – the tan colored rock or the darker colored rock?

What are these darker colored vertical features called? __________

How do these volcanic features form? What are they made of?

From on top of the outcrop, describe and sketch the head of the harbor:

Stop 2: Sign of the Bellbird

Part 1: From the car park

Can you see other lava deposits around the crater rim? Describe and sketch one below:

How do you think Quail Island was formed?
Describe the vegetation you see around the harbor. Are there a lot of trees? Are these trees native or planted? Is there a lot of grass/gorse?

What do you think the vegetation was like before humans arrived on Banks Peninsula?

Is this a good place for Lyttelton Port?

Part 2: From the Sign of the Bellbird

What do you think are the differences between how these hills were created, and how the Southern Alps formed?

Where did the sediment that is in filling the Canterbury Plains come from?
Stop 3: Along Highway 75

These hills are composed of loess deposits—sediments that have been deposited by wind. Why are the grains so small? Why are the grains so uniform? Where could these grains have come from?

Stop 4: Birdling’s Flat

Sketch 3 of the rocks that make up the beach and describe their color, shape and size:

Do all of the rocks appear to be the same size?
Why are all of the rocks rounded?

What depositional system deposited these rocks? Wind, water, ice?

Which system had more energy to deposit its sediments – the loess, wind system or this system?
Sketch the cliff outcrop to the left (when looking at the ocean):

What could have deposited all of these layers? Why are the layers different colors?
Stop 5: Halswell Quarry

Sketch different layers you see within the exposed quarry face:

Do you think these layers came from the same source?

Would you use these materials? Why, and what for?