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Assessing learning gains from a virtual field experience (VFE) to Orakei Korako geothermal area

Abstract

Because of its high dependence on use of the senses, geology curricula have long relied on field experiences to teach undergraduate students hands-on. Unfortunately, field trips don't always happen as much as instructors would like due to limited time and funds. Virtual field experiences (VFEs) have recently been gaining popularity in geology curricula because they are less expensive and time-consuming, among other advantages. However, not much study has been done to quantify how much students really learn from participating in VFEs. This study assesses the learning gains achieved by students from taking a Google-Earth-based virtual trip to Orakei Korako geothermal area, Taupo Volcanic Zone, North Island, New Zealand. We developed this VFE and tested it on 10 students at the University of Canterbury, Christchurch, New Zealand. Our results show that students do achieve positive learning gains from VFEs, but that they cannot be taken to replace real fieldwork entirely.

Introduction

Geology is arguably one of the most sensory subdivisions of science. Geologists must use all five senses (sight, touch, taste, smell, and sound) when approaching a problem (Schwert et al., 1999). The effective use of these senses to solve geologic problems can often be tough to teach in a lecture setting. Because of this, lab and field activities are very common in geology curricula. Evidence shows that doing something is often the best way to learn it, a concept known as "experiential learning" (Jarvis & Dickie, 2010), and field trips offer this opportunity for geology students to make observations and interpret them, as opposed to seeing lecture slides and being told which observations and interpretations need to be made.

Field trips are very effective at engraining geologic skills and concepts in students, but they come with many negative aspects. Johnson et al. 2004 lists three main drawbacks to traditional field environments. First, they "emphasize activity over learning", meaning students are often more focused on the great views, physical strenuousness of the hikes, or being with their school friends than they are on the learning content of the field trip. Second, they "limit domain of inquiry"; students can only take real-world field trips to accessible areas, they cannot be taken to the moon, mid-ocean ridges, and the like (also in Hurst, 1998). Third, they don't allow instructors to reduce the complexity of the learning environment so as to not confuse students. The complexity of the real field environment often overwhelms students, leaving them frustrated and confused (Warburton et al., 1997). In addition to these three, there are many more. Field trips are expensive and tough to carry out logistically, and often are fundamentally based on gendered assumptions of able-bodiedness (Nairn, 1999). The aforementioned reasons cover the basics as to why virtual field experiences (VFEs) have been gaining popularity recently in geology curricula and other sciences as well (see Limniou et al., 2008).

A virtual field experience (VFE) is any form of technology-based activity that students complete that simulates a real field experience. They come in many different formats and styles, ranging from complete immersive virtual reality (Bricken, 1991), to using a three-dimensional "cave" to immerse students into the mechanics of chemical reactions (Limniou et al., 2008), to combining real and virtual methods by providing access to instructional videos while in the field (Jarvis & Dickie, 2010).

The most common form of VFE, however, is that of a videogame structure. Examples range from very sophisticated and close to an actual game, involving a lot of freedom of choice on the part of the user (Dohaney et al., 2012; see Fig. 1) to ones that are closer to a virtual tour, leaving little choice to the user and are more akin to "stringing along" the student (Browne, 2005). The latter are much easier to develop, making them more common; the structure of the VFE in this study is similarly tour-like, taking students through a VFE in Google earth. In this study, students were able to click on various field trip "stops" in Orakei Korako geothermal area in the Taupo Volcanic Zone on the North Island of New Zealand to see photos, videos, and geochemical data for each geothermal feature.

A few previous studies have shown statistically that the learning gains achieved in a virtual field setting are not distinguishable from those in a real field experience (Dohaney et al., 2012; Browne, 2005; Stumpf et al., 2008).

Methods

The VFE for this study was developed in Google Earth Pro. It is a .kmz file containing 15 "stops" along the track at Orakei Korako, each one with some combination of text, embedded youtube videos, and/or photos of that specific stop. The content in each stop was aimed to inform students of different observations that can and should be made when surveying a geothermal area (see Fig. 2). The file is available by request from the author.

The VFE for this study is most similar to the Geothermal World videogame presented in Dohaney et al. 2012, and thus uses very similar methodology. Students filled out a "concept inventory" before and after doing the VFE; students were simply asked to list every type of observation they could think of taking at a geothermal feature, accompanied by why they take that observation and what it means (for example, a student might list that they would take note of the smell of a geothermal pool because it can tell them something about the geochemistry of the water). The questionnaires given to students are found in the appendix. The concept inventories were marked in nearly the same manner as Dohaney et al. 2012; in which students were given 0-1 points for listing any of the 10 identified correct answers (temperature, pH, color, clarity, algae/vegetation, activity, smell, geology/mineralogy, GPS location, and conductivity) and 0-3 for each explanation accompanying each observation listed. Thus, each pre- and post-VFE concept inventory was given a score out of 40. Learning gains for each individual participant were calculated as in Dohaney et al. 2012, which was originally taken from Hake, 1998:

$$\text{Learning gains} = (\text{post-test\%} - \text{pre-test\%})/(100\% - \text{pre-test\%}) \qquad \text{(Hake, 1998)}$$

Calculating learning gains this way controls each student against their own initial score, eliminating the differences between students' level of base knowledge in geothermal geology.

After completing the VFE and the questionnaires, students underwent a semi-structured interview, asking their opinions on the VFE's enjoyability, advantages, disadvantages, and how it could be improved.

Results

Every student who participated in the study showed positive learning gains, with 7 out of 10 students more than doubling their score after taking the VFE (see Fig. 3). Learning gains, calculated as in Hake, 1998, ranged from 0.09 to 0.85, with an average of 0.45. Learning gains were not significantly different between male and female participants. Out of the ten students studied, six had previous geothermal experience in their academic career, and four did not. Students with previous geothermal experience had slightly lower learning gains than students with no previous geothermal experience (i.e., if they had no experience with the subject they learned more), but overall there was no correlation between pre-VFE score and learning gains. Students with previous geothermal experience had higher pre-VFE scores, but there was no noticeable difference between the post-VFE scores based on experience (see Fig. 4).

In the interviews, a few common themes were present. Nearly all participants stated that they enjoyed the exercise, but also said that they couldn't ever see VFEs replacing field trips entirely. Many did state that this exercise would be useful to do before going out into the field, to acquaint them with what's expected of them. All students responded that they did think they learned valuable skills while doing the VFE. Almost none of them agreed that this is equivalent to or better than actual fieldwork for learning purposes, with the exception of one student who expressed appreciation for the fact that this required no travel and significantly less time and physical effort.

Discussion

While our exclusively positive (and relatively consistently high) learning gains are promising, this study is limited by the fact that we were only able to test 10 participants. Participants were, however, all of a science background academically and all had had *some* previous field experience in their coursework, giving them a basis of comparison when discussing how this exercise compared to real field trips in the interviews.

While students in the geology department at University of Canterbury have taken real field trips to Orakei Korako, our data are not directly comparable to theirs because they did not complete the same questionnaires before and after their field exercise. Future study should seek to directly compare real to virtual to quantify the differences; or to compare learning from fieldwork with or without a VFE as a preparatory activity. These would help elucidate the most productive place for virtual experiences in geology curricula.

Intuitively, one might think that virtual field experiences are inferior to real-life field experiences in most aspects. However, this simply isn't true. First, they tend to be much less expensive than traditional field trips (with the fully immersive virtual reality being the exception). Hurst et al. 1998 lists seven distinct advantages of computer-based field experiences: First is scale; you can display aerial, outcrop, hand sample, and thin section photos all at the same time. Second is that virtual experiences can display non-outcrop data (geochemistry, seismographs, etc.) alongside outcrops. Third is that the virtual experience is repeatable; students can do them on their own time, and you don't have to block off several days hoping that the whole class is available. Fourth is that the virtual trips can be targeted to individual needs, depending on students' ability. Fifth is that they have the possibility of being better at showing three-dimensional objects; on a computer you can view a feature from all sides very easily (within a few seconds), without having the walk all the way around it as you would in real life. Here it is also worth noting that is has been proven that students learn concepts more effectively when they are presented in three dimensions versus two (Limniou et al., 2008). Sixth, they are accessible for physically disabled students. Seventh, they require very little logistical planning, as the instructors needn't concern themselves with food, lodging, or transportation. And eighth, weather, flora (matagouri…) and fauna (seals!) are never standing in the way of a productive field day.

Nairn (1999) elaborates greatly on the assumption of able-bodiedness that is at the base of every field trip. Her study showed that many instructors fail to ask students about physical disabilities (asthma, diabetes, a bad knee, etc.) before a field trip; if they do, the question tends to be open-ended ("come see me after class if you have any medical conditions we need to know about before the trip") and students (especially females) don't feel comfortable bringing these to their professors. The tendency of field trips to be dominantly male-led and involving vigorous exercise leaves women underestimating their physical and geological abilities, and also leaves those who are less physically fit feeling like they are worse students than those who are assigned the most physically taxing field locations. Male students were overwhelmingly assigned to the steepest slopes and most physically challenging areas, contributing to feeling of inferiority in female students. In short, in traditional field trips, sexism and ableism can severely take away from the experience even for very well academically prepared students; and this would not be a factor in a virtual field experience.

Virtual experiences are inherently simplified from the real world (Hurst et al., 1998). Additionally, you don't have the interactions and conversations between students and professors. You can't replicate the teamwork, cooperation, and camaraderie that students get while actually sharing the hardships of the field together (Stumpf et al., 2008). Students echoed this sentiment in their interviews.

Conclusion

Our data show that students achieve positive learning gains from participating in virtual field experiences (VFEs). Our data do not support the idea that VFEs can replace traditional field experiences, because our data are not directly comparable to field learning gains and students emphasized in their interviews that they could not see virtual experiences substituting for real fieldwork. In short, the quantitative and qualitative data in this study support the idea that a VFE is best suited to precede or supplement true field experiences.

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Figures

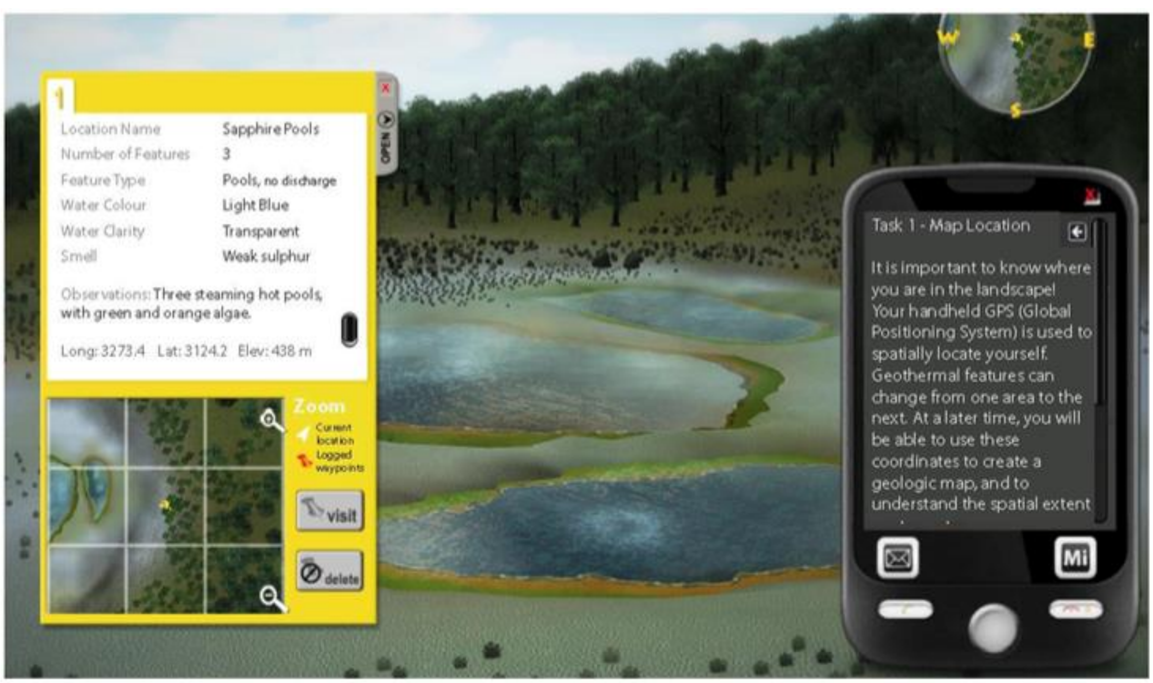

Figure 1: Screen capture from another example of a vritual field trip, Dohaney et al.'s Geothermal World videogame (Dohaney et al., 2012).

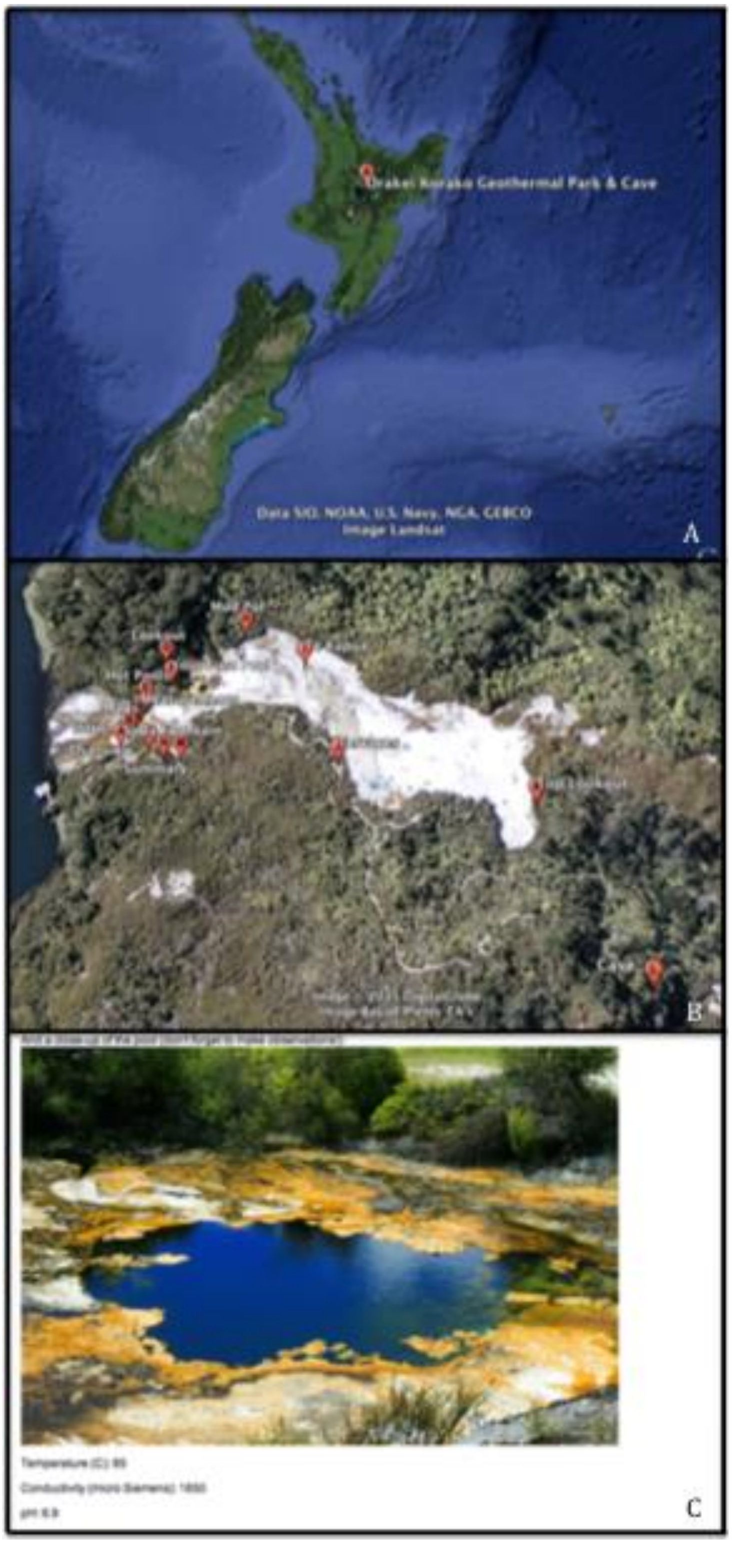

Figure 2: Screen captures from the VFE used in this study. A: Location of Orakei Korako on the North Island, New Zealand. B: Google Earth image of the whole area

with all of the "stops" students were expected to go through. C: One of the first stops' pop-up window, with a photo and geochemical info.

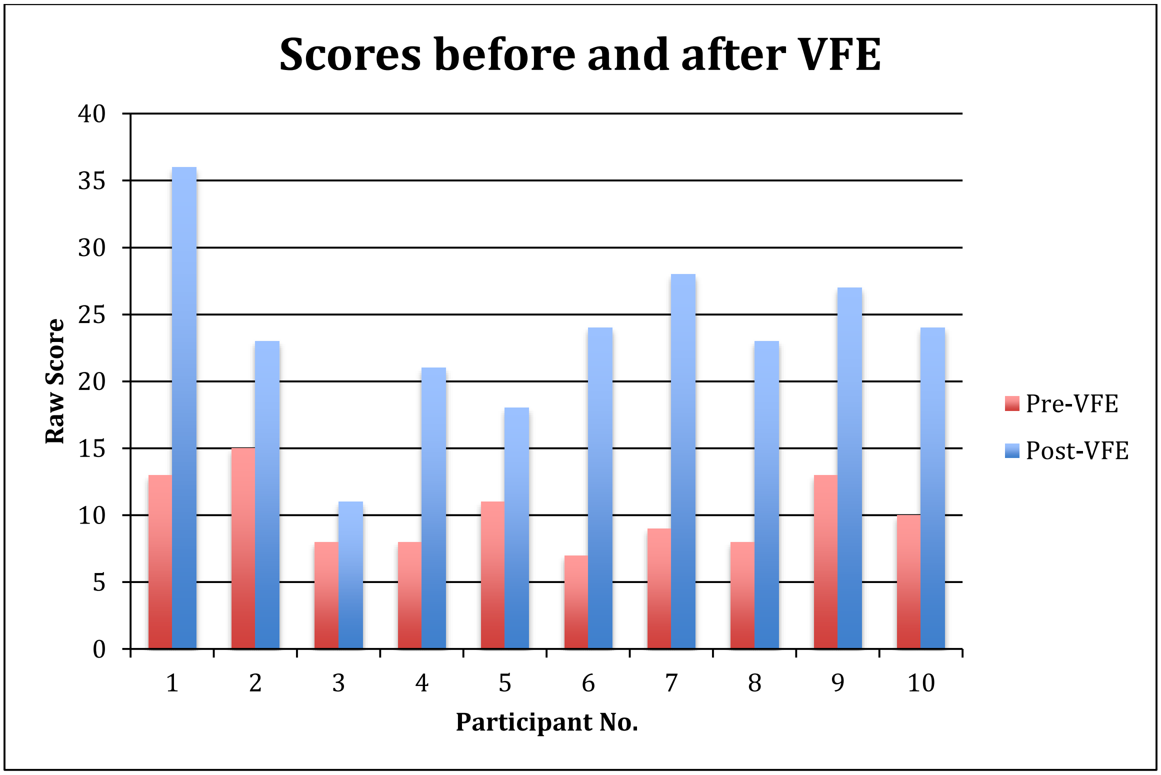

Figure 3: Scores before the VFE (shown in red) compared to scores after (blue).

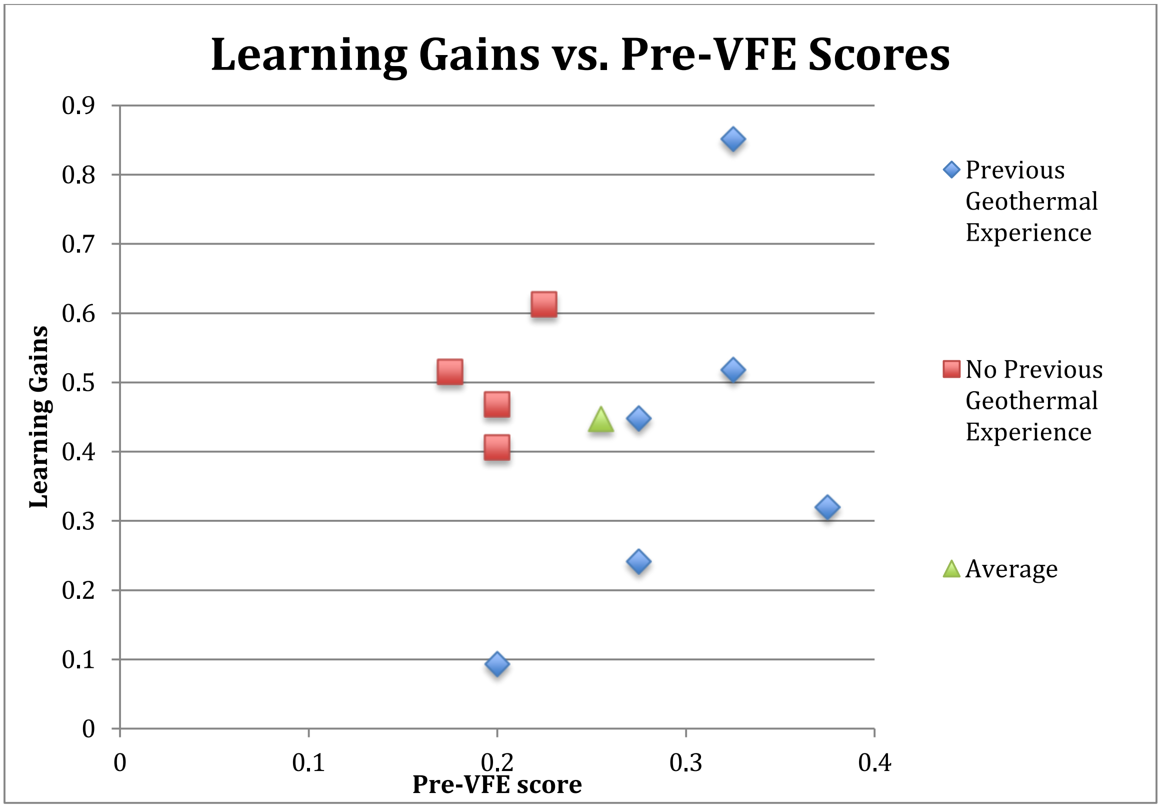

Figure 4: Plot of learning gains vs. pre-VFE scores, with students who had previous geothermal experience shown in blue, and those without previous experience shown in red. The mean is plotted in green.