Integration of Citizen Science and Virtual Field Trips:

A Case Study of MicroPlants Virtual Visits at the Field Museum

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Literature Review

Science educators often struggle to engage their students because science concepts seem abstract removed from students' everyday lives, yet need to balance interesting presentation with solid content foundations. Teachers can bring science to life in many ways, including in-class demonstrations, labs, and the student favorite: field trips. However, traditional field trips have a variety of drawbacks – such as cost, administrative burden, and distance from appropriate field sites – that limit equal access to field resources (Haris & Osman, 2015). Furthermore, while traditional field trips are often fun opportunities for students to get off school grounds, they are often flashy and inadequately planned learning experiences that are not closely linked to class curriculum and can overshadow more important concepts (Adedokum et al., 2012). Furthermore, they do not bring students into contact with real scientists who do research and make discoveries (Adedokum et al., 2015). An interesting and increasingly prevalent alternative is the virtual field trip. In a virtual field trip, students interact with real research scientists at field sites such as museums, national parks, labs, or research camps through live broadcasts over the internet (Haris & Osman, 2015). Importantly, the opportunity to interact with an actual scientist provides students with a sense of connection to real world science and scientists (Adedokum et al., 2012; Adedokum et al., 2015). Compared to traditional field trips, virtual field trips improve access to field resources for schools in low-income and in remote rural locations (Haris & Osman, 2015; Adedokum et al., 2012; Adedokum et al., 2015). In well-designed programs, high quality lessons aligned to national Next Generation Science Standards (NGSS) and curricula accompany the program to be delivered before and after the live broadcast of the main content (Adedokum et al., 2012). Virtual field trips improve content understanding (Haris & Osman, 2015) and improve student perception of science, scientists, and science careers (Adedokum et al., 2015). However,

like traditional field trips, virtual field trips tend to be standalone events that then often leave students with few resources at their home schools to pursue independent projects related to topics of interest developed through the field experience, and the flash and flair of the experience may often overrule the educational ties to class content (Adedokum et al., 2015; Mueller et al., 2012).

One excellent way that students from diverse backgrounds can get engaged and supported in real world science projects is through citizen science. Citizen science provides opportunities for laypeople, including high school students, to engage in scientific research that can connect to professional and academic scientific pursuits and lead to professionally published results (Mueller et al., 2012). A variety of programs exist for citizen science, but many of the most common and popular programs are run through research institutions and outreach centers (Mueller et al., 2012). Students and teachers report that citizen science projects increase their sense of connection to real world science (Mueller et al., 2012; Gray et al., 2012) and students show improved content understanding after connecting to real world science just as with other types of field experiences (Mueller et al., 2012). However, long-term follow-up of citizen science projects showed that few project followed through with publication of citizen results, and that most participants felt distanced from actual research scientists and even that their results and actions were devalued by professionals (Mueller et al., 2012; Gray et al., 2012). Overall, this led to no improvement in students' perception of science, scientists, and science careers (Mueller et al., 2012). Furthermore, there were mixed reports on the effect of citizen science on students' understanding of the nature of science, possibly stemming from the fact that in most citizen science projects citizens are only involved in data collection and do not see the important aspects of choosing questions, making hypotheses, analyzing and interpreting data, and reaching conclusions (Mueller et al., 2012; Gray et al., 2012). Virtual field trips and citizen science both

attempt to immerse students in real science but take complementary approaches. When combined in the science classroom, they may balance each other to provide students with a more holistic experience that includes exposure to real world science without compromising scientific literacy. This case study investigates a virtual field trip program run by the Field Museum in Chicago that integrates citizen science. The purpose of this study is to determine whether the Field Museum's MicroPlants Virtual Visit program design connects students to real science and scientists without compromising content understanding and scientific principles.

Data Collection Method

This case study focuses on one of the Field Museum's Virtual Visit virtual field trip programs for grades 9-12, "From Water to Land: A Plant's Journey from the Beginning of Time", which interfaces with the MicroPlants citizen science project which crowdsources image analysis of microscopic leaves of mosses and liverworts. For simplicity, this paper refers to this specific program as the "MicroPlants Virtual Visit". In order to analyze the design principles behind the MicroPlants Virtual Visit, especially the focus on bringing real world science to students and approach to scientific literacy, an interview was performed with Eve Gaus, the Digital Learning Manager at the Field Museum and Virtual Visits coordinator (personal communication, July 19, 2016). The semi-structured interview was recorded and transcribed verbatim. It began with questions about the basics of Virtual Visits, such as the number and demographics of students who participate in a typical Virtual Visit and the flow of a Virtual Visit. Then, questions were directed at the design principles of the MicroPlants Virtual Visit. Questions will revolve around the museum's priorities in curriculum design, including who participates in this process, the focus on connecting students to real science and scientists, the importance of scientific inquiry and conceptual understanding, and how pre- and post-lessons are

supposed to supplement the live broadcast discussion with the staff scientist. Questions about feedback the program receives from teachers and students were integrated throughout. An interview was sought with the staff scientist involved with the MicroPlants Virtual Visit live broadcast, Laura Briscoe, but she was unavailable due to involvement in field work out of the country.

The official MicroPlants Virtual Visit curriculum documents (Field Museum Digital Learning Department, 2016) were studied to analyze the program's approach to bringing real world science to students, building content understanding, and promoting scientific literacy. The curriculum was evaluated for several important aspects of strong science education based on the edTPA teacher performance assessment handbook for secondary science certification (edTPA, 2015), as well as aspects of strong field experiences (Haris & Osman, 2015). Specifically, the analysis examined alignment of objectives, standards, learning tasks, and virtual field trip content; opportunities for students to engage in scientific practices through inquiry; clear opportunities to learn science concepts and investigate scientific phenomena; and structured opportunities for students to apply knowledge gained through the virtual field trip experience. The richness of the citizen science experience was also examined through researcher use of the citizen science platform (microplants.zooniverse.org), including the online tutorial plus 1 hour of data collection. These curriculum components were scored on a Likert-type scale from 1 (poor) to 5 (excellent).

Findings

The MicroPlants Virtual Visit curriculum consists of a three-day mini-unit, with a pre-visit lesson about building phylogenetic trees of plants on day 1, the virtual field trip consisting of a livestreamed interactive broadcast with a Field Museum staff scientist (Laura Briscoe, a

bryologist – one who studies mosses and liverworts) moderated by a Field Museum educator on day 2, and a post-visit lesson involving the MicroPlants citizen science project on day 3. Aspects of strong science curricular components are summarized for the unit in **Table 1**. Based on the

Table 1. MicroPlants Virtual Visit analysis of various markers of high quality curriculum design. Data from curriculum documents (Field Museum Digital Learning Department, 2016), an interview with the dire director of digital learning at the Field Museum (E. Gaus, personal communication, July 19, 2016), use of the MicroPlants platform (microplants.zooniverse.org) were evaluated and curriculum components were scored on a Likert-type scale from 1 (poor) to 5 (excellent).

Curriculum component	**Score: 1 (poor) to 5 (excellent)**	**Rationale**
Connection to real science and scientists		
Pre-lesson	3	Similar methods to those used by real scientists, but does not highlight connections well
Broadcast	5	Meet and engage directly with a real scientist
Post-lesson	3	Contribute to citizen science, but feels distant
Connecting and applying knowledge		
Pre-lesson	3	Related to other parts of evolution unit but connections not explicitly drawn
Broadcast	5	Educator bridges curriculum to scientist's research and questions help draw connections
Post-lesson	3	Engaging in citizen science research project on same topic, but no need to use new concepts or learning
Engaging students		
Pre-lesson	4	Inductive learning activity elicits immersive and stimulating hands-on action
Broadcast	5	Meeting a real scientist in a highly interactive and question based live broadcast
Post-lesson	2	Citizen science project is real data analysis but not intriguing or intrinsically rewarding
Scientific inquiry and reasoning		

Pre-lesson	5	Inductive reasoning exercise promotes logical thinking about phylogeny relationships
Broadcast	5	Consistently engages students in thought-provoking questions, science connections
Post-lesson	1	Click-and-drag with no critical thinking or inquiry
Alignment of content and learning tasks		
Pre-lesson	4	Sort plants into phylogenetic trees like taxonomists
Broadcast	5	Learn from a real scientist about taxonomy and plant evolution research
Post-lesson	3	MicroPlants citizen science, but actual task is superficial
Alignment of objectives and standards		
Pre-lesson	5	Objective matches NGSS HS-LS4-1 nearly verbatim and lesson plan meets objective
Broadcast	4	Objectives fairly consistent with NGSS Science and Engineering Practices, emphasize nature of science
Post-lesson	1	Objective asks only to measure plants – no deeper connection to science, NGSS
Citizen science experience		
Clarity of directions	4	Intuitive interface with clear walkthrough
Engaging activities	2	All click-and-drag measurements
Replay value	1	Every task is identical
Feeling of personal impact	2	Little sense of how individual contributions lead to scientific progress

research question, the analysis naturally split into assessing the module's connection to real science and scientists versus its commitment to scientific principles and cohesive content. Overall, the module does a very good job of connecting students to real science and scientists, as the program prioritizes students interacting, engaging, and identifying with scientists, the core of

which occurs during the broadcast portion. “The main point” of the Virtual Visit, according to Eve Gaus, the Field Museum’s Digital Learning Director, “is that literally seeing someone can have a huge effect [on students], just seeing who becomes a scientist…it makes the idea of a scientist something that’s real for them.” (E. Gaus, personal communication, July 19, 2016). By giving students the opportunity to directly interact with a real researcher, students perceive science as a plausible career option. While the core component of the Virtual Visit is the broadcast itself, teachers that use the included pre- and post-lessons see “their students are better able to make connections from the topic of the broadcast to their class. It makes it less of a one-off and more like a complete experience” (E. Gaus, personal communication, July 19, 2016). The pre-lesson attempts to connect students with real science by walking them through construction of a plant phylogenetic tree using the same methods that field researchers use, but the connections are not made very explicitly and could be better explained. The post-lesson integrating the MicroPlants citizen science project does not provide a clear sense of having contributed to real research, particularly because it consists only of click-and-drag image analysis and does not provide a way for students to identify how those measurements lead to scientific progress in determining plant taxonomy. Buried in a supplemental resource on the Field Museum website is a chart that could be used for students to sort their samples into phyla based on their measurements, but it is not part of the lesson sequence and is likely overlooked by most teachers who use the lessons as provided. Overall, the Virtual Visit does a solid job of connecting students to real science, but the citizen science post-lesson falls short on this promise.

The module has a strong emphasis on scientific inquiry and reasoning and consistent content, but again the citizen science post-lesson is a weak link. The pre-lesson uses an inductive reasoning card sort that guides students through inquiry processes of hypothesis generation, data

analysis, and hypothesis revision to create a phylogenetic tree of bryophytes. The broadcast is geared to promote scientific inquiry as well as "the entire purpose is to engage students in the process of making observations and asking questions about the science" (E. Gaus, personal communication, July 19, 2016). This is accomplished by "throughout the broadcast, [asking] students questions that are similar to…the questions the scientists are asking, and start to get them to be thinking like and engaging with the scientist" (E. Gaus, personal communication, July 19, 2016). Importantly, parallels in the nature of science and scientific practices in the classroom and field or laboratory are highlighted, particularly noting "that idea that the questions and observations that [the students are] doing in the classroom are the same processes that a scientist" uses to do actual research (E. Gaus, personal communication, July 19, 2016). However, the citizen science project draws from an extremely repetitive platform that requires only superficial data collection consisting of click-and-drag leaf length and width measurements with no follow-up analysis, inquiry-based practices, or clear connections to the scientific process. Content alignment with the focus on determination of plant taxonomy is evident in the majority of learning tasks. The stated learning goal of the module is: "Students will learn the importance of citizen science and the branch of taxonomy." The pre-broadcast plant phylogeny inductive reasoning task immerses students in the processes scientists use to determine taxonomy, although the connections to the upcoming virtual visit are not explicitly included in the lesson plan. During the broadcast, the scientist and Field Museum educator collaborate to make plant taxonomy's importance come to life. The post-lesson involves doing citizen science, but the importance of the contribution fails to shine through detracting from the lesson's alignment with declared content goals. Teacher and student feedback agrees with the assessment that "it's pretty lame…a little repetitive…a little bit of a hard sell" (E. Gaus, personal communication, July 19,

2016). It is also unclear how the citizen science project advances taxonomy. As a whole, principles of scientific inquiry are upheld and the content is consistent, but the citizen science post-lesson does not meet the standards set by the pre-lesson and virtual field trip broadcast.

Discussion

While the virtual field trip component of the MicroPlants Virtual Visit meets or exceeds a variety of criteria of effective science education, the post-broadcast citizen science project is not well orchestrated to promote scientific inquiry and maintain student engagement with the virtual field trip content. The data suggest that although the Virtual Visit is a successful educational experience that exposes students to real science and scientists, the inclusion of the citizen science component is not as successful and is a strained fit. The main issues with the citizen science platform revolve around repetitiveness and, importantly, lack of scientific inquiry. Some of these issues center on the MicroPlants citizen science platform itself, which does not include elements of "gamification" or incentives like other popular biology citizen science platforms such as the protein folding crowdsourcing game Foldit (https://fold.it) or RNA folding crowdsourcing game eteRNA (www.eternagame.org), and also unlike these projects the MicroPlants website includes little information about how scientists use citizen contributions for research. However, these issues could have been addressed by a more complete post-broadcast lesson plan that introduced some kind of inquiry or critical thinking element. In its current form, the citizen science component of the MicroPlants Virtual Visit falls flat and does not promote scientific principles like inquiry that are core focal points of modern high school science education. A central limitation of this project is its case study approach which allowed investigation of only one citizen science based virtual field trip; this was partly due to convenience and time constraint as the Field Museum was near the researcher's location, but also due to the fact that few virtual

field trips currently integrate citizen science. Future studies could look more intensely for comprehensive programs that integrate citizen science with opportunities to interact with real scientists and see if other implementations are more successful.

Despite the limitations of its citizen science element, the MicroPlants Virtual Visit is highly effective in other categories, especially in connecting students to real science and scientists. This is the stated core goal of Field Museum Virtual Visits, so perhaps it is not surprising that the lesson sequence centers around this concept more strongly than citizen science. Teacher and student feedback consistently reported high satisfaction with the program, especially the opportunity to see and speak directly with a researcher. Given that many high school students are seeking career exploration opportunities and may be less excited about contributing directly to research, interacting with real scientists may be a more important focus for virtual field trips than citizen science. Future studies on virtual field trips could focus on how different programs present opportunities for students to engage directly with scientists and explore which approaches lead to more positive student reactions and opinions about scientists. The ultimate goal of virtual field trips is to bring science to life for students, and until more comprehensive citizen science platforms exist in collaboration with institutions that give field trips such as museums, then a focus on contact with scientists may be more prudent.

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