Using Mobile Devices to Engage Students in Evolutionary Thinking

STEVEN J. LYSNE, BRANT G. MILLER

Abstract

We used personal mobile electronic devices (PMEDs) to engage students in a lesson to support evolutionary thinking in an undergraduate biology course. Community-college students enrolled in Biodiversity & Evolution, a core majors biology course, met for an optional field trip at the University of Idaho's McCall Outdoor Science School (MOSS) in central Idaho during the summer of 2014. Ten students participated in the classroom and outdoor activities. Students were provided with directions and objectives for the lesson, and students' own PMEDs were used to capture images of the community of organisms in and around the outdoor campus. After returning from the field, students analyzed their digital data in the context of morphological similarities and differences to construct a phylogenetic hypothesis for the relationships of the organisms observed. Students' comments were solicited regarding the activity, and feedback was generally positive. From the teachers' perspective, students appeared highly engaged and the novel method was a success. We discuss the theoretical basis for using PMEDs and provide a detailed lesson plan.

Key Words: *Science education; instructional technology; biology; lesson plan.*

The role of information and communication technologies (ICT) in science education has increased over the past two decades (Means, 2006). ICT applications today can be divided into three primary categories: computer-based applications, web or cloud-based applications, and mobile applications (Moore & Moore, 2011). Considering how rapidly these technologies have evolved, the way we categorize ICT applications today may be different in a year's time. ICT applications occur in an environment that is mediated by technology – an environment that is not necessarily stationary or in a predetermined location like a college classroom (O'Malley et al., 2005). Examples of ICT used in science education are presented in Table 1.

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Regardless of the approach adopted by science faculty, it is difficult to conceive of a contemporary science course that does not utilize one or more instructional technologies to enhance learning opportunities. Perhaps more importantly, these technologies form the basis of our students' current lived experience (Cook & Quigley, 2013) and will constitute the environment within which they will work in their careers (Crippen & Archambault, 2012).

○ Methodology

We used a novel method (modified from Zimmerman & Land, 2014) to support evolutionary thinking in an undergraduate biology course. Zimmerman and Land reviewed outdoor mobile computing (OMC) and described three guidelines for this educational framework: (1) facilitate participation in disciplinary conversations, (2) amplify observations to see disciplinarily relevant aspects of place, and (3) extend experiences through exploring data and representations of the place. We considered this framework to develop a lesson for use at the University of Idaho's McCall Outdoor Science School (MOSS) that would support students' incipient understanding of evolutionary relationships. Situated within Ponderosa State Park and the town of McCall, MOSS provides an ideal outdoor educational environment for the study of natural and physical sciences and associated social–ecological interactions.

Ten students enrolled in *Biodiversity & Evolution* participated in the 3-day field trip during the summer of 2014. Students were instructed to bring personal mobile electronic devices (PMEDs) such as phones, tablets, or other devices capable of capturing images and accessing the web. To work within Zimmerman and

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Table 1. Examples of information and communication technologies used in science education from the research literature.

Application	Description	Role of the Student	Role of the Instructor	Reference
Animated pedagogical agents	APAs provide unlimited access to virtual scientist-mentors to assist in student learning	Learner in a small group setting, assessed formatively	Low participation; instructor acts as facilitator, mentor, subject expert; observes interactions and intervenes as necessary	Bowman (2012)
Digital pen-and-paper technology	Commercially available program for collecting and synchronizing written and audio information allows instructors to analyze the learning process	Learner as an individual, assessed formatively	Medium participation; instructor acts as reviewer, subject expert; may review notes or activities resulting from technology	Linenberger & Bretz (2012)
Mash-up tools	Use of two or more online data sets or applications to develop new applications, data sets, or questions	Principal investigator, colleague, learner assessed formatively	High participation; instructor acts as facilitator, mentor, subject expert; may be involved in the development of new applications or data sets	Crippen & Archambault (2012)
Outdoor mobile computing	Using portable electronic devices to engage students in place-based, content-driven educational opportunities	Principal investigator, colleague, learner assessed formatively	High participation; instructor acts as facilitator, mentor, subject expert; provides detailed guidance and frequent scaffolding	Zimmerman & Land (2014)
Science-based video games	Use of games in multiple electronic formats to engage students in content-driven educational opportunities	Learner as an individual or group member, assessed both formatively and summatively	Low participation; instructor acts as evaluator, subject expert; technology is likely engaged outside of school, precluding instructor facilitation or feedback	Muehrer et al. (2012)

Land's (2014) framework, we developed a comprehensive lesson plan (Table 2) that incorporated their instructional guidelines. The lesson first facilitated a multidisciplinary and multiperspective conversation about the meanings of the physical location, or place, where the activity was conducted.

This conversation developed a classification schema for place (e.g., wilderness or civilization, public or private), considered the values of place (e.g., recreation or resources), and prompted students to consider how this place was similar to or different from other places. Next, the lesson prompted students to amplify their observations by capturing them with PMEDs, preserving them for future use (i.e., observations are fleeting, but by capturing them we amplify, or extend, the duration of their usefulness). For example, when students left in the morning, they were provided very general directions to "capture images of as many different organisms as possible." Student teams of two were instructed to explore the park and return several hours later with their observations. The final piece of the lesson extended this experience by exploring the electronic data to construct phylogenetic hypotheses for the organisms observed within the park. The lesson supported evolutionary content from the summer course (e.g., evolutionary relationships can be inferred via similarities and differences among species, and phylogenetic trees represent evolutionary hypotheses), with the guiding principle that

Table 2. Lesson plan for utilizing PMEDs to support students' evolutionary thinking (modified from Zimmerman & Land, 2014).

Guideline 1	**Facilitate participation in disciplinary conversations.**
Concept	Places have histories and meanings, written both by humans and by nature.
Objective	Develop the socio-ecological narrative that already exists at a place by highlighting the historical, geographical, geological, and ecological stories of that place.
Implementation	Develop a list of questions to stimulate deep thinking about place (e.g., What is this place? What are its values? How do your life experiences influence your description and valuation of this place?). Lead students in a socio-ecological discussion to really explore places and the concepts people attribute to them.
Guideline 2	**Amplify observations to see disciplinarily relevant aspects of place.**
Concept	Biological diversity is evident in our common experience.
Objective	(1) Make observations of organisms to inform future class projects. (2) Demonstrate the diversity of organisms by capturing images of as many different organisms as possible for later analysis. Attempt to capture organisms from each major phylum discussed in class.
Implementation	Develop "handouts" delivered electronically with directions, expectations, and safety precautions; we provided a scavenger-hunt-type list of eukaryotic kingdoms and major phyla to look for; include directions for saving electronic data for later use.
Guideline 3	**Extend experiences through exploration of data and representations of the place.**
Concept	If we make careful observations and critically analyze those observations, then patterns and relationships in nature will be revealed to us.
Objective	(1) Analyze data for the best images of each "type" of organism. (2) Construct a phylogenetic tree (i.e., an evolutionary hypothesis) based on the similarities and differences of types. (3) Represent this as a captioned figure in PowerPoint. (4) Note any particularly interesting observations you made.
Implementation	Upon returning from the field, students use ICTs to construct phylogenetic hypotheses for the organisms "collected." Both formative and summative assessments can be used during or afterward. Appropriate scaffolding and ICT troubleshooting are required on the part of the instructor.

biological diversity is evident in our common experience. If we make careful observations and then critically analyze them, patterns and relationships in nature (e.g., evolutionary relationships) may be revealed to us.

○ The Students' Perspective

End-of-course evaluations submitted by students were very favorable: 100% of students were satisfied or very satisfied with their laboratory experience. In terms of engagement, one student commented that "the field trip" contributed the most to their learning in the entire term. Other students suggested that we do "another field trip at the end of the term" and commented that "taking pictures made me really want to be involved" and "the exercise we did was so fun and engaging." In terms of how the learning experience supported course content, students said that "the trip helped change the way I view nature around me," that the activity "deepened my awareness of organisms interacting," and that it "provided a deeper way of looking at the natural world." Similarly, students suggested that the "life experience" was a "great way to apply and support what we learned in class." However, students also suggested that "more time" was needed to construct the phylogenetic tree and that, while engaging, it may not have "helped expand my understanding of evolution" directly.

○ The Teachers' Perspective

From our view, using PMEDs enhanced learning via two mechanisms. First, using PMEDs is congruent with our students' lived experience (Cook & Quigley, 2013), and that makes the learning more contemporary and potentially meaningful to them. One potential drawback may be that students dislike the intrusion of learning into a domain that is so personal; however, this is a hypothesis and was not articulated to us by students. The second enhancement is that using PMEDs in an inquiry-based lesson is engaging and seemed to capture our students' interest better than the classroom activity we had used previously to support the same learning objective. It is possible that what was engaging was being immersed in the experience of MOSS, and the relative contribution of the activity cannot be isolated. Regardless, we feel that this lesson can be used effectively on similar field trips or on college campuses, as most will contain diverse assemblages of organisms for study. Further, the use of PMEDs may be effectively applied to other core competencies in introductory biology courses (AAAS, 2011), such as the relationship between structure and function or the complexity of ecological systems. Finally, our students constructed meaningful phylogenetic trees based on their observational data (Figure 1), and this was the primary objective of the activity.

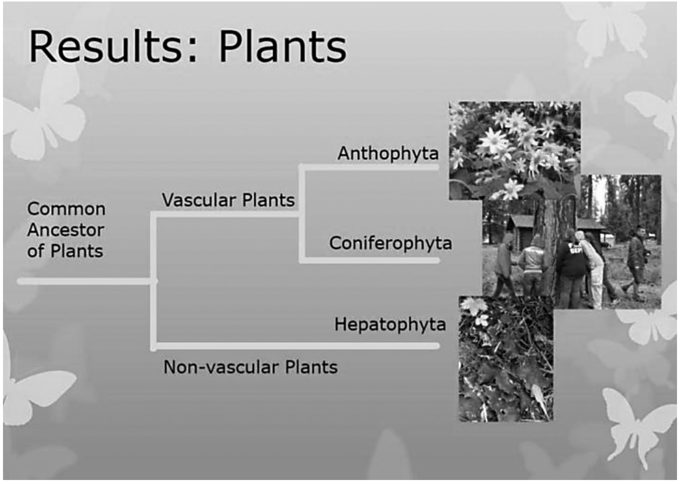

Figure 1. Example of a phylogenetic tree produced in PowerPoint by students, with images captured at MOSS.

○ Conclusion

In summary, using PMEDs to engage students in evolutionary thinking had multiple positive outcomes. The experience of OMC in a field-based context created social bonds that enhanced in-class activities. Using PMEDs is comfortable and familiar to students and teachers, and this familiarity appeared to reduce anxiety and enhance engagement with the activity. Students constructed meaningful phylogenetic hypotheses within an authentic, inquiry-based activity, which is consistent with best practices in science education. Requiring students to defend and elaborate on their phylogenetic hypotheses would improve the activity and provide an opportunity for formative and summative assessments. Although we conducted this project at a unique outdoor campus, the lesson can be easily modified for any campus environment. For example, during the subsequent term (fall 2014), we completed this activity at our urban campus in southwestern Idaho with similar success. Further, we believe that the use of OMC in science instruction could be extended to include additional learning outcomes in a variety of disciplines, including anthropology, geology, and physics.

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