Technology-Enriched STEM Investigations of Place: Using Technology to Extend the Senses and Build Connections to and Between Places in Science Education

R. Justin Hougham,[1,a] Karla C. Bradley Eitel,[2] and Brant G. Miller[3]

ABSTRACT

In this article we explore how reconceptualizing the role of technology in place-based education (PBE) enhances place responsive pedagogies through technology. Combining the strengths of adventure learning (AL) and PBE, Adventure Learning @ (AL@) advances both place responsive education and online learning in science education. This is needed, as the conventional AL model lacks authentic explorations of places that are "local" to the expedition teams and the students following along. The AL@ approach promotes localized authorship and knowledge keeping. AL@ more fully realizes the potential of AL, using PBE approaches that engage students as authors of knowledge through direct field experiences and the creation of digital artifacts of scientific inquiry. © *2015 National Association of Geoscience Teachers*. [DOI: 10.5408/12-399.1]

Key words: technology, place-based education, STEM

TECHNOLOGY IN PLACE-BASED ENVIRONMENTAL EDUCATION

In the 21st century, students need to be able to communicate through a variety of mediums, be critical consumers of vast amounts of written and visual data, and possess skills and dispositions for addressing complex global issues with local implications (e.g., climate change). At the same time, scholars and philosophers have called for place-responsive pedagogies that underscore the limitations of dominant educational paradigms with respect to providing culturally relevant learning and opportunities to deeply connect to the socioecological places we inhabit (Gruenewald, 2003; Aikenhead et al., 2006; Semken and Freeman, 2008; Apple et al., 2014; Gruenewald and Smith, 2008).

The Adventure Learning @ (AL@) approach to designing and implementing curriculum holds promise for important science, technology, engineering, and mathematics (STEM) skills in students while connecting students in meaningful ways to their local communities. As practitioners of residential place-based environmental education that seek to foster scientific literacy and connect students to place, we have traveled cautiously into the cyber-enabled landscape because of a deeply rooted feeling that teachers may bring students to our programs partially to separate them from the constant influx of technology in their lives. Such technology can be a distraction to really "being" in a place. That said, we believe that the appropriate use of technology can move beyond distraction to provide tools that transform our ability to connect students to place through more focused observations of the environment using a familiar medium. In addition, technology provides opportunities for students to connect these observations to social meanings that they create and expand by sharing these observations and experiences with others.

Imagine this scenario: a field teacher uses a picture to show students a concept diagram of the water cycle; the students' attention is on the image rather than on the place. What if digital cameras were used instead to observe water in the immediate environment, thus, cataloging water in as many phases as the students can find? Digital voice recorders could also be used to capture the sounds of nature, and students could record videos of themselves sharing their thoughts on what this place means for them. In addition, these students could use digital tools to collect and upload data about the quality or quantity of the water. The data the students collected could then be visualized within an observational database used by scientists to better understand water resources at a local scale. In the first scenario, an age-old "technology" distracts from deep observation. In the reimagined scenario, observation is enhanced and transformed and students can even join the scientific community directly by contributing to larger databases used for modeling watersheds for fisheries management.

It is our position that, when used appropriately, technology can enable a deeper connection to a place through a multimedia approach to observing, describing, and visualizing the surrounding environment. Today's educators are increasingly being asked to integrate cyber-based tools into their programs. We propose that they do so in a way that increases students' ability to explore the socioecological places where they live. Our attempt to achieve this goal is described here as AL@. What follows is a description of the curricular and pedagogical approach that drives AL@, as well as some reflection on the successes and challenges of our projects to date.

MERGING TECHNOLOGY, PLACE, AND CHANGE

AL@ is a reconceptualization of the role of technology in place-based education (PBE) that enhances place responsive

Received 7 November 2013; revised 15 September 2014 and 13 December 2014; accepted 17 January 2015; published online 13 May 2015.
[1]University of Wisconsin-Extension, Upham Woods Outdoor Learning Center, N194 County Road N, Wisconsin Dells, Wisconsin 53965, USA
[2]McCall Outdoor Science School (MOSS), University of Idaho, PO Box 1025, McCall, Idaho 83638, USA
[3]Department of Curriculum and Instruction, College of Education, University of Idaho, Moscow, Idaho 83844, USA
[a]Author to whom correspondence should be addressed. Electronic mail: rjustinhougham@gmail.com. Tel.: 509-432-9390. Fax: 608-253-7140

pedagogies through technology. Adventure learning (AL) as posited by Doering (2006, 2007) is a hybrid online curricular approach we have explored within the context of a residential environmental education program at the McCall Outdoor Science School (MOSS). We posit that PBE can democratize the AL model. Thus, through technological affordances, students will be positioned to communicate their knowledge and experiences in places. We are naming the combined theoretical frameworks of AL and PBE as AL@. Through AL@, students and teachers become recognized experts in their experiences through studies of the places where they live, using freely available software and low-cost technology. Furthermore, we explore ways in which AL@ enhances our place-based programs by supporting connection and communication beyond the spatial and temporal boundaries of student experience.

PLACE-BASED EDUCATION

PBE provides an important foundation for bringing place to the forefront of student inquiries. In the book *Place-Based Education: Connecting Classrooms and Communities,* David Sobel defines place-based pedagogy as

> *"the process of using the local community and environment as a starting point to teach concepts in language arts, mathematics, social studies, science, and other subjects across the curriculum. Emphasizing hands-on, real-world learning experiences, this approach to education increases academic achievement, helps students develop stronger ties to the community, enhances students' appreciation for the natural world, and creates a heightened commitment to serving as active, contributing citizens. Community vitality and environmental quality are improved through active engagement of local citizens, community organizations, and environmental resources in the life of the school."* (Sobel, 2004, 7)

PBE is an attempt to encourage curriculum "speciation," a term Sobel (2004) uses to describe developing curricula that are relevant, authentic, and evolved from the particular context in which they are used. A central characteristic and distinguishing feature of PBE is that it aims to break down artificial constructs and barriers, like the distinctions between school and community and between nature and humanity (Smith, 2002). At its core, PBE focuses curricular attention on the socioecological places where the curriculum is enacted.

Many educational philosophers, including Gruenewald (2003), Gruenewald and Smith (2008), Semken and Freeman (2008), Orr (2004), Apple et al. (2014), and Woodhouse and Knapp (2000) have suggested that there is a need for a conception of education that extends beyond the technocratic or "learn to earn" mentality into a model in which participants gain the skills, knowledge, understanding, and desire to work toward sustaining the "cultural and ecological integrity of the places they inhabit" (Woodhouse and Knapp, 2000, 3). Smith (2007) suggests that "the opportunity to participate in learning activities that focus on real-world problem-solving can impart to children a sense of their own agency and collective capacity to alter their neighborhoods or communities for the better" (p. 192). Gruenewald and Smith (2014) write that PBE has the potential to slow the harmful effects of globalization by reclaiming the local, and they point out that many of youth's experiences with technology are through the "entertainment-style technology industrial complex" that "reinforces the narrative of economic globalization by constructing children and youth around the world as hi-tech consumers rather than citizens" (p. xv). This is a significant concern, one that we seek to address through the approach described here.

While place-based pedagogies are being widely embraced, iterations of PBE lack effective strategies that connect the place experience to other venues or digitally. There is much room to explore how PBE can effectively leverage the power of experiences with the potential of technology and digital media as tools for furthering connection to the local, rather than solely as tools that reinscribe globalization. For example, Zimmerman and Land (2014) have theorized and given preliminary examples of how mobile technologies might be used to extend the senses and deepen observations in place-based learning environments. An enhanced AL model, found in AL@, can further fill this gap.

ADVENTURE LEARNING

AL is a hybrid distance education approach that provides students with opportunities to explore real-world issues through authentic adventure-based learning experiences within both face-to-face and online collaborative learning environments (Doering, 2006, 2007; Doering and Veletsianos, 2008; Veletsianos and Kleanthous, 2009). As an approach to designing learning environments, AL has been found to motivate students (Moos and Honkomp, 2011) and inspire meaningful collaborations and inquiries for students and teachers (Doering and Veletsianos, 2008; Veletsianos and Doering, 2010). The AL approach and associated framework (Fig. 1) consists of nine principles that guide the development of the curriculum and learning environment (Learning Technologies Collaborative, 2010):

1. Adventure-based education to elicit excitement through uncertainty and risk
2. Opportunities for collaboration and interaction among learners, instructors, and experts
3. Timely delivery of media and text from the field to enhance the curriculum
4. Synchronized learning opportunities
5. Authentic narratives in which the learning experience is based on an authentic story/narrative that (a) unifies the expedition, curriculum, student activities, media, and learning experience under a common purpose and theme and (b) encourages creativity and enjoyable learning experiences
6. Provision of pedagogical guidelines to guide curricular and online learning environment use for the instructor to effectively implement an AL project
7. Identification of a location and an issue to explore (including investigation of the contextual factors surrounding the location and issue)
8. Use of the Internet to facilitate the learning experience, including delivery of the curriculum, delivery of the media, and interaction among the individuals partaking in the experience
9. A researched curriculum that is inquiry based

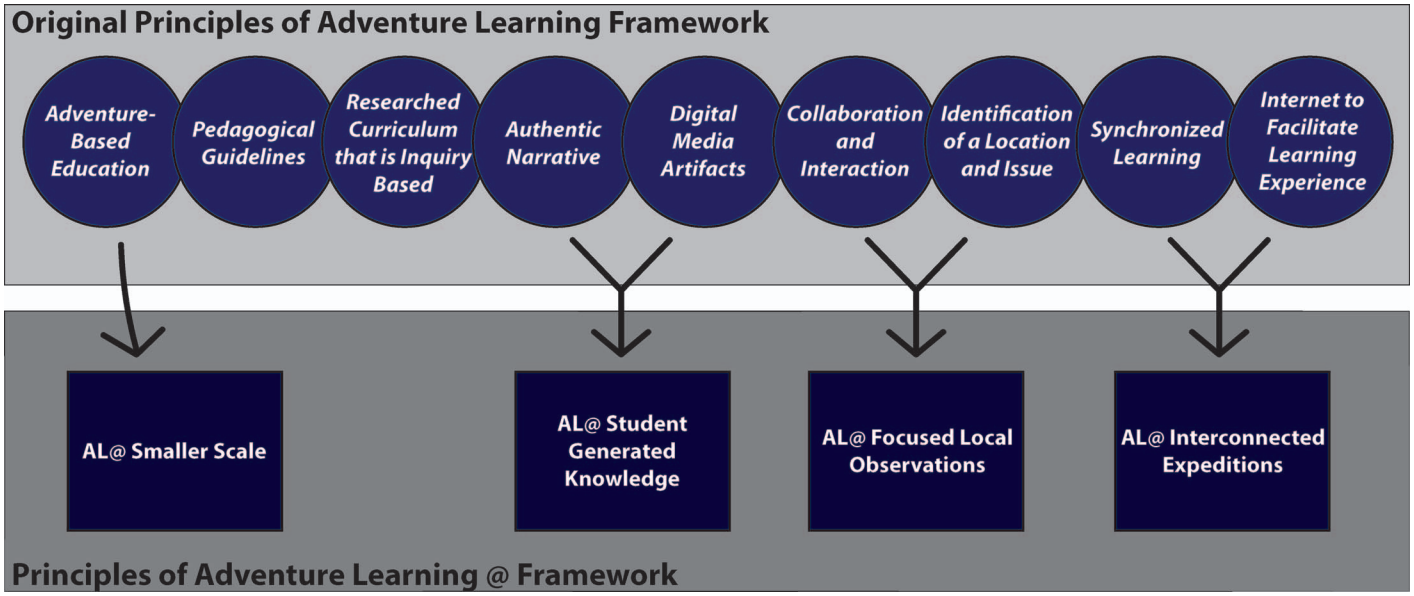

FIGURE 1: Mapping of AL principles and the AL@ approach.

AL has its roots in a project known as *GoNorth! GoNorth!*, an AL project in which a team of adventurers journeyed each year to a different circumpolar region. While in the circumpolar Arctic, the *GoNorth!* team members traveled by dogsled to numerous villages and communities on their route. The team explored Arctic cultures and traditional ecological knowledge and shared this knowledge with individuals following the expedition through an online learning environment. Taking this a step further, the AL@ approach enhances our ability to collect and analyze data and to engage students in meaningful reporting and reflection, and it makes meaning of experience beyond the limited spatial and temporal boundaries of experiential science education programs that we serve. By implementing digital tools to collect observational data, as well as narratives, the analysis of (or reflection upon) digital artifacts supports educators and learners' synthesis during, as well as after, the field time. As practitioners, we have found that while this model holds promise with respect to generating student excitement, certain aspects of the archetype run counter to some of the principles we incorporate into our programs with respect to a philosophical grounding in PBE.

AL@

In this reimagined model, which brings to bear the intersection of PBE and AL, we envision a novel context for teaching and learning about places through technology-rich curricula. We envision enabling students to explore local places through physical experiences, as well as through digital media, geospatial technologies, and online collaboration. Through the intersection of PBE and AL in AL@, we believe that each can reciprocally enhance the other. Four key distinctions in the AL@ approach are smaller scale of implementation, student-generated knowledge, focused local observation, and interconnected expeditions (Fig. 2).

Smaller Scale

Early iterations of AL (such as those found in *GoNorth!*) have sent a team of scientists and explorers to remote places with reports back to classrooms across the world. It is our estimation that this approach is limiting. The logistical complexity and high-end equipment required can make conducting an expedition unattainable for all but the most highly resourced schools. In promoting the use of relatively inexpensive and simple-to-use media collection devices (e.g., digital cameras), the barriers to participation in AL@ are negligible. Considering the audience, the location, and the science along the way, media products are assembled to represent each component of the research and/or expedition process. Guidelines for teachers and students for the practical enactment of the AL@ approach include collecting media that can be shared easily and thoughtfully consider the Web audience, place, and science curriculum. While smaller scale does not necessarily imply a focus on the local, the reduced logistical complexity of this approach significantly reduces barriers to students and teachers leading their own locally focused expeditions (Fig. 2).

Student-Generated Knowledge

The archetype model of AL positioned distant adventurers as holders and creators of knowledge. While an emphasis on student-generated knowledge is not an exclusive tenet of PBE, we have wondered whether highlighting the experiences of distant adventurers and associated content experts have undermined students' evaluation of their own ability to generate meaningful understanding about things that matter to them in the places where they live. We believe that an example of this (Fig. 2) is found at the intersection of the authentic narrative and the media elements of the original AL framework. From a developmental perspective, Sobel (2004) has suggested that students at the middle school age are still mentally grounded in the fairly small geographical areas that encompass the typical student's world experience. By rethinking the AL approach to position students and teachers as "experts in their own experiences," the AL@ approach has the potential to transform the way students and teachers think of themselves with respect to being

Original AL Principles	AL@ Principle	Explanation
Adventure-Based Education	Smaller Scale	Making AL more accessible to communities by focusing on local adventure-based learning experiences.
Authentic Narrative; Digital Media Artifacts	Student Generated Knowledge	By involving the students in data creation they become more personally involved in the learning narrative.
Collaboration and Interaction; Identification of a Location and Issue	Focused Local Observations	Students create digital artifacts around their location and study topic and share these artifacts with others.
Synchronized Learning; Internet to Facilitate Learning Experience	Interconnected Expeditions	Connecting groups of learners to the greater online AL@ community to share experiences and knowledge

FIGURE 2: Relationship between Adventure Learning and AL@.

scientists, problem solvers, and contributors to knowledge about their communities while highlighting the idea that their local community is important as a subject of learning.

Focused Local Observations

Building reflection skills is a core tenet of PBE and an important step in the progression toward an engaged and active citizenry. Wattchow and Brown assert that place as a conceptual frame is an important pedagogy:

> *"Place refers to a participatory and experiential phenomenon. Our experience of a place is always a combination of a specific location, our embodied encounter and the cultural ideas that influence the interpretations we make of the experience. This provides rich potential for outdoor educators who are already well versed in experiential methodologies. A participant learning about the significance of a place, and how their beliefs and actions impact upon it, will be well positioned to reflect on how their community may need to adapt to the challenges ahead."* (Wattchow and Brown, 2011, ix)

The richness of a grounded experience and inquiry in place lays the foundation for meaningful reflection that takes place in the digital environment. The digitized reflection is then available to a network of students locally and globally. The AL@ approach turns the narrative into a conversation rather than a story being told by someone else. By doing so, students can make valuable contributions in conversations about natural resources, local observations, and the nature of science. We assert that this extension of the AL framework is situated at the intersection of the identification of issues and collaboration, focusing more on local issues germane to students (Fig. 2). We encourage students to think of digital data collection tools as things that can extend, but not replace, the senses. For example, a temperature probe simply allows us to quantify what we can feel with our hand. A digital camera allows us to capture a finer visual observation than the one we immediately see. By positioning technology in this way, we can begin to instill the idea that technology need not be a distraction from connecting to place; rather, it can be a tool for deepening observation.

Interconnected Expeditions

In the AL@ approach, we take the existing paradigm of a single expedition team and a multitude of followers and transform this perspective into one that includes multiple expedition teams that are followers of one another. To do this, we create the foundation and tools for an array of expedition teams pursuing unique expeditions in their respective locales while contributing to an overarching adventure theme. Through a digital learning Web site hub, students and teachers have the opportunity to be part of a larger AL@ community. In the original AL framework, this is found in efforts to synchronize AL@ communities by using the Internet to connect to one another (Fig. 2). One objective of this robust media environment is to cultivate a flourishing upload and download culture among stakeholders—students, teachers, and parents—and across disciplines. Archiving of media products and generated data is essential, representing exciting information that will be accessible to participants for future content inquiries. Members of the education community will drive the integration of this material into the curriculum as it serves them, effectively democratizing and "speciating" (Sobel, 2004) the curriculum.

Examining Applied Cases of AL@

Elaborating on AL@'s four enhancements to AL, as noted in the previous sections, we reflect on the application

of these ideas as we have seen them in action in local and global cases, with students, as well as teachers, serving as expedition members. AL@ cases to be highlighted in this article include AL@Greenland (AL@GL), AL@McCall Outdoor Science School (AL@MOSS), and AL@Professional Development (AL@PD). AL@GL was a summer project for high school students looking at climate science in Greenland and at MOSS, with students in both locations. AL@MOSS occurs weekly with new middle school groups looking at climate science at MOSS. AL@PD occurs in teacher professional development workshops at MOSS that examine climate science and green energy.

AL@GL

AL@GL was a National Science Foundation (NSF)–funded project that used the AL@ approach through hands-on and Web-based climate science experiences for high school students to promote climate and science literacy. The purpose of AL@GL was to engage high school students in the U.S. and in Greenland in atmospheric research that is being conducted in the Arctic. Climate and science literacy were explored via three fundamental concepts: radiation, the greenhouse effect, and climate versus weather. Over the course of the project, students in each location engaged in activities and conducted experiments through the use of scientific instrumentation. Students were taught science research principles associated with an atmospheric observatory at Summit Station, Greenland, with the objective of connecting climate science in the Arctic to student's local environments.

The AL@GL project engaged students in an inquiry-based curriculum with content that highlighted a cutting-edge geophysical research initiative at Summit Station: the Integrated Characterization of Energy, Clouds, Atmospheric State, and Precipitation at Summit (ICECAPS) project. Approximately 35 students at multiple locations in Idaho and Greenland participated in the hybrid learning environments as part of this project. ICECAPS is an atmospheric observatory focused on obtaining high temporal resolution measurements of clouds from ground-based remote sensors, including radar, LIDAR, and infrared spectra. ICECAPS also launches radiosondes twice daily. This large suite of complementary observations is providing an important baseline understanding of cloud and atmospheric conditions over the central Greenland ice sheet and is supporting Arctic climate research on cloud processes and climate model validation. ICECAPS measures parameters that are associated with those identified in student misconceptions, e.g., different types of atmospheric radiation, the effect of greenhouse gases, and climate versus weather. Thus, ICECAPS research and the AL@GL project combined to create a learning environment and educational activities that sought to increase climate literacy in high school students and communicate important atmospheric research to a broader audience.

Student Generated

AL@GL advances the principle of students generating knowledge through the design of the expedition and the location in which the expeditions take place. By design, for AL@GL there was not a discrete expedition team whose members served as the "personalities" for the expedition. Students were empowered through the online environment and the associated curricular experiences to generate knowledge around authentic scientific research. Students participating in AL@GL synthesized their understanding of the scientific principles by conducting personal inquiries situated in the places where they were.

Local Observations

Previous AL expeditions have engaged students through stunning imagery and narratives from remote locations. While the experience within the online environment is both visually and mentally stimulating, there have been challenges in connecting students to local environments as the authors of the expedition narrative. For AL@GL, multiple student groups were tasked with using their place for scientific inquiry. Focused observations afford students the opportunity to inquire of their local environment while sharing their narrative with peers in other locations. Through the Web site developed for AL@GL, students in the U.S. and in Greenland were able to share their local inquiries with peers half a world away. Although the local environments were different (i.e., subalpine forest and tundra/ice sheet), the focused local observations served as the foundation of the narrative and conversation between student groups.

Smaller Scale

Traveling to Greenland is not a simple endeavor. Therefore, AL@GL exposes the smaller-scale emphasis of the AL@ approach espoused in this article. That said, AL@GL used existing curricular structures and programming to connect students in two locations. In addition, readily available learning tools were enlisted as proxies to the high-end instrumentation of the ICECAPS project. The work of AL@GL is projected to enable the involvement of multiple small-scale, local expeditions unified around a common theme or research questions. Thus, with common questions and instruments to support small-scale inquiries, the AL@GL example furthers our understanding of coordinating small-scale expeditions with an eye on scalability.

Interconnected Expeditions

AL@GL connected students in the U.S. and in Greenland around common scientific principles (e.g., radiation, the greenhouse effect, and climate versus weather). In essence, students in the U.S. and students in Greenland were on interconnected expeditions, albeit in different environments. Through technological affordances, geographical distances were effectively mitigated and rich multimedia narratives coming from two unique locations were supported.

AL@MOSS

AL@MOSS is an NSF-funded project involving 5th–8th grade students participating in weeklong residential field science programs at the University of Idaho's MOSS. MOSS is Idaho's only publicly operated residential science school; the mission is to facilitate place-based, collaborative science inquiry within the context of Idaho's land, water, and communities by providing experiential learning opportunities for students, educators, scientists, and citizens to foster the critical thinking skills necessary to address complex problems. More than 2,500 students take part in MOSS programs over the course of a school year.

Student Generated

The pedagogical approach at MOSS is a place-based, inquiry-driven, field science curriculum that encourages students to generate their own questions and understandings about the place they are exploring. The curriculum as a whole does promote student-centered learning and knowledge creation. As part of the AL@MOSS curriculum, students are responsible for generating blog posts daily during their field expeditions. One version of student-generated blog posts takes the form of students engaging as "science communicators," describing the ideas that they're learning about and the new questions that they're generating by being immersed in the study of a particular place. However, many of the blog posts tend toward more affective descriptions of their interactions with place—the feeling they had sitting in the aspen stand, the fun they had doing science with their friends in an outdoor setting, and the excitement they felt in seeing wildlife on the trail.

Local Observations

In the AL@MOSS project, students make many observations using what we call their "built-in science tools" (their five senses and ability to think); we also have them use digital data collection tools, such as Vernier LabQuests, with various probes (pH, temperature, soil moisture, lux, dissolved oxygen). We call these "tools that extend the senses," because they allow us to make or quantify observations that we could not make with our bodily senses alone. Observations themselves are not unique to the AL@ framework, but by having a forum for reporting on their observations, we believe students will be more motivated to observe their surroundings so that they can tell a more detailed story for those reading along online. As described above, student observations are approached from both an objective standpoint, where they quantify aspects of the environment that they can observe, and an affective standpoint, where they describe how the place itself makes them feel. While these activities commonly take place in field-based education and PBE, the opportunity to share them with a wider audience drives a different intensity in how the observations are recorded.

Having an audience is a key piece of AL@MOSS. In many cases, the students themselves are the most obvious audience for their reflections, because the blog posts are created in small field teams of 8–10 students and shared at the end of the day with the rest of the participants (50–90 students each week). Parents and other family members often follow the expeditions at a distance and sometimes comment on student blog posts and reflections; their comments tend to be "parental" (e.g., observations about the weather and the wearing, or not, of appropriate hats, gloves, rain gear, etc., or noting that students look like they're having fun). As will be elaborated below, one of the unrealized potentials of this project is to create a space for the exchange of scientific ideas between students and teachers through the digital forum. This interaction does take place in person while students are reviewing one another's field days and research projects, and we continue to adapt methods to successfully cultivate this within the online environment.

Smaller-Scale and Interconnected Expeditions

The expeditions in the AL@MOSS case are 5 days long, beginning on Monday when a school group arrives on site and concluding on Friday when the group departs. We initially planned for pre- and postexpedition activities and have included curriculum to support these activities in the Web environment. However, we've found that it is challenging to engage schools in the online environment before and after the program for a number of reasons, including teachers' lack of familiarity with the site, lack of time, and some resistance to the incorporation of more technology in the classroom. When we first planned to bring AL@ into the residential field science program, we imagined that we could use it to connect classrooms and schools to one another so that they could communicate about their similarly themed expeditions. This has not been fully realized yet, but we have found a rich audience in parents. Therefore, some of our thinking has shifted with respect the purpose of communication and the realistic expectations we can have of schools to collaborate from week to week. Each week, different schools come to participate in the program, and each week represents a different expedition; these expeditions are connected through the theme of water. The curriculum is built around this theme, and the Web environment includes lesson plans about water topics as resources for teachers, a data entry portal where students can upload data to an international water database, and areas for collaborating with other students and teachers.

The Web environment for these expeditions was built using a customized installation of a blog built in WordPress, a free blogging platform. The setup required some advanced knowledge in Web design, but sufficiently robust environments can be built with minimal skill.

AL@PD

Over the course of the last 2 years, we have pursued the AL@ approach for teacher professional development workshops offered through MOSS and supported through external grants that focus on bioenergy and on climate change. These workshops have predominately served secondary Idaho teachers, and cohort sizes have ranged between 15 and 20 people. A typical workshop mirrors many methods used at the science school, including the focused delivery of content involving project researchers as guest speakers and the use of project-based learning to drive group work at the workshop that can extend into the teachers' classrooms. Furthermore, the workshops develop and expand the approaches to science education as they pertain to the inclusion of learning technologies in the delivery of the workshop, as well as in follow-up activities.

Student Generated

In so far as the teachers served in this model are "students" for the workshop, this case falls short in realizing its potential of students generating knowledge. While these workshops include some data collection and training in using digital media, they are designed not to generate new knowledge so much as to encourage new techniques, pedagogies, and technologies in the classroom. That said, we do seek to shorten the gap between research and education, and in so doing these workshops have facilitated direct teacher-to-researcher contact, therefore advancing knowledge and inquiry. Though not particularly generating knowledge, these experiences have advanced inquiry in both the teacher and the researcher groups.

Local Observations

Within the context of global issues such as climate science and green energy, the teacher professional development experiences that use AL@ enhancements examine and communicate the local relevance of these issues. The "big picture" related to these issues is cast by our collaborating researchers and content experts. The remainder of the face-to-face and digital contact is designed to promote deeper connection to place though examination of local data pertaining to these matters that have global reach. Teachers participating in these workshops are incentivized to do so. The onsite teachers receive accommodations and a stipend, and the remote teachers "following" the work receive stipends. This produces some discourse and continued participation, though admittedly the external motivators in place to encourage this may not be scalable in all scenarios.

Smaller Scale

The teacher professional development experiences have primarily used free, or slightly enhanced, WordPress-powered sites (http://teachingadventurelearningatmoss.wordpress.com/) to communicate the activities of the workshops. Through the Web sites, teachers developed content after the end of instruction, communicated with peers teaching in other places, and provided updates on local, as well as continuing, inquiry. Using the AL@ approach for teacher professional development is affordable, though there is a learning curve to establishing and maintaining the site.

Interconnected Expeditions

Of the four AL enhancements considered in this AL@ work, the principle of interconnected expeditions is most strongly developed in the case of our teacher professional development. By connecting one teacher cohort to another and incentivizing teachers in other locations to follow and comment online, long-running themes in the curriculum of climate science and green energy continue to reach classrooms whose teachers have attended our workshops and have been exposed to our approach. Furthermore, the Web-based content generated for the workshop and continued later in other workshops becomes a part of an active resource archive that informs and supports teachers' work. In our experience, connecting to teachers who will revisit the Web site is a valuable connection to research that enlivens inquiry and discussion.

CONCLUSION

We are encouraged by the potential that the AL@ approach has for future programming as a result of cases presented above. AL@ supports direct technology-based learning for long-running questions investigated by students in the places where they are learning. Simply, we advocate, like many science educators, that students and teachers find questions in their community, choose a Web platform to share media upon, and bind the inquiry through time with a continuity of principles (such as those offered in AL@; Fig. 1), and curriculum.

In addition to the four principles outlined in this paper, several important considerations have emerged through praxis: the need for facilitator buy-in, the appropriate use of technology, and the importance of the audience. In all three cases, it became apparent that successful facilitation of the creation of materials for the online environment requires a significant commitment from the field instructors and, in the case of AL@PD, the adult participants. Creating thoughtful content for the blog takes time, and this time comes out of what would be learning time. If creating content for the blog is thought to be part of the learning process, facilitators may be more willing to give the time and effort required. If the online environment, however, is seen as an add-on or a distraction from the "real" learning, it is difficult to create rich content.

A related but different consideration is the way that technology is used to support learning. Technology for technology's sake can be seen as a distraction from learning, especially if students are not closely monitored in its use. However, our philosophy is that technology should be introduced with a purpose that clearly supports sensory observation and critical thinking. This is not a new consideration, and it brings us back to the example of a photograph as technology that could be used inappropriately (e.g., to show a picture of a tree while standing in a forest instead of observing the actual trees). In this example, a better use of technology may be to employ a digital camera to record the surface of the bark and a light meter to quantify photosynthetically active radiation.

Finally, we have noted the importance of the role of the audience. An interactive audience creates a two-way dialog that we suspect leads to deeper reflection and new questions for the content creators. When this audience is not present or is silent, it is difficult to get students to the same level of reflection in the blog. One might ask: If students blog in a forest and no one is around to read it, does it facilitate learning? For the students creating the blog post, they surely do some learning and reflection in the act of its creation. However, without an ensuing dialog, we have found that we lose out on the chance for deeper reflection and the generation of new questions. Possibly most importantly, if students do not feel that their work is being read, it is hard to convince them that it matters. The question of audience includes a question of what motivates people to follow along, especially when we have positioned students and teachers as both adventurers and followers.

The AL@ approach presents a conceptual frame for teaching and learning while exploring novel places through technology-rich curricula. By defining problems of local interest, and working with experts with local knowledge who have connections to the community, students can come to think of themselves as experts, scientists, and problem solvers within their own places. The promise of what AL and PBE bring to each other through AL@ is found through a democratized learning environment, which becomes a digital commons. Thus, community members, parents, learners, and educators are engaged in essential skills. By communicating digitally, participants are able to see how information about near and distant spaces is interrelated. The AL@ approach supports multiple epistemologies through the invitation to engage in a process that sharpens expertise in our own experience. Equipped with AL@, educators and learners can meaningfully explore what place means through sharing their experiences. Through observation, reflection, and digital artifact keeping, the AL@ approach supports knowledge keepers across the past,

present, and future narratives of places that can be connected.

As technologies will continue to evolve, so too will our conceptions of membership place, and community. Future work in this line of inquiry must address technological innovations as they are emerging in the landscape of education, research, and place consciousness. The evolution of PBE may have a measured response to technologies; however, it is difficult to imagine the discourse of PBE not including considerations for the mobile, distant, and asynchronous ways of knowing that educators and learners are participating in. Highlighting relationships and breaking down spatial boundaries can strengthen our understanding of the ways in which we are all connected.

REFERENCES

Aikenhead, G., Calabrese, A.B., and Chinn, P.W. 2006. Forum: Toward a politics of place-based science education. *Cultural Studies of Science Education,* 1(2):403–416.

Apple, J., Lemus, J., and Semken, S. 2014. Teaching geoscience in the context of culture and place: Theme issue continued. *Journal of Geoscience Education,* 62(2):157–157.

Doering, A. 2006. Adventure learning: Transformative hybrid online education. *Distance Education,* 27(2):197–215.

Doering, A. 2007. Adventure learning: Situating learning in an authentic context. *Innovate—Journal of Online Education,* 3(6). http://innovateonline.info/index/php?view=article&id=342 (accessed 30 August 2008).

Doering, A., and Veletsianos, G. 2008. Hybrid online education: Identifying integration models using adventure learning. *Journal of Research on Technology in Education,* 41(1):101–119.

Gruenewald, D.A. 2003. The best of both worlds: A critical pedagogy of place. *Educational Researcher,* 32(4):3–12.

Gruenewald, D.A., and Smith, G.A., eds. 2008. Place-based education in the global age: Local diversity. New York, NY: Taylor and Francis.

Learning Technologies Collaborative. 2010. "Emerging": A re-conceptualization of contemporary technology design and integration. *In* Veletsianos, G., ed., Emerging technologies in distance education. Edmonton, Canada: Athabasca University Press, p. 91–107.

Moos, D.C., and Honkomp, B. 2011. Adventure learning: Motivating students in a Minnesota middle school. *Journal of Research in Technology Education,* 43(3):231–252.

Orr, D.W. 2004. Earth in mind: On education, environment, and the human prospect. Washington, DC: Island Press.

Semken, S., and Freeman, C.B. 2008. Sense of place in the practice and assessment of place-based science teaching. *Science Education,* 92(6):1042–1057.

Smith, G.A. 2002. Going local. *Educational Leadership,* 60(1):30–33.

Smith, G.A. 2007. Place-based education: Breaking through the constraining regularities of public school. *Environmental Education Research,* 13(2):189–207.

Sobel, D. 2004. Place-based education: Connecting classrooms and communities. Great Barrington, MA: The Orion Society.

Veletsianos, G., and Doering, A. 2010. Long-term student experiences in a hybrid, open-ended and problem based Adventure Learning program. *Australasian Journal of Educational Technology,* 26(2):280–296.

Veletsianos, G., and Kleanthous, I. 2009. A review of adventure learning. *International Review of Research in Open and Distance Learning,* 10(6):84–105.

Wattchow, B., and Brown, M. 2011. A pedagogy of place: Outdoor education for a changing world. Victoria, Australia: Monash University Publishing, p. ix–x.

Woodhouse, J.L., and Knapp, C.E. 2000. Place-based curriculum and instruction: Outdoor and environmental education approaches. *ERIC Clearinghouse on Rural Education and Small Schools*. Charleston, WV: Clearinghouse on Rural Education and Small Schools.

Zimmerman, H.T., and Land, S.M. 2014. Facilitating place-based learning in outdoor informal environments with mobile computers. *TechTrends,* 58(1):77–83.