Facilitating Place-Based Learning in Outdoor Informal Environments with Mobile Computers

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Abstract

This paper advocates for place-based education to guide research and design for mobile computers used in outdoor informal environments (e.g., backyards, nature centers and parks). By bringing together research on place-based education with research on location awareness, we developed three design guidelines to support learners to develop robust science-related understandings within local communities. The three empirically-derived design guidelines are: (1) Facilitate participation in disciplinary conversations and practices within personally-relevant places, (2) Amplifying observations to see the disciplinary-relevant aspects of a place, and (3) Extending experiences through exploring new perspectives, representations, conversations, or knowledge artifacts. Last, we link theory to practice by illustrating how the three guidelines were applied in one outdoor science learning project called Tree Investigators.

Keywords: informal learning; mobile computers; place-based education; theory-to-practice; learning environments; outdoor education

One advantage of mobile computing is that mobile devices can use location awareness features to support learners as they engage in contextual activities (Priestnall, Brown, Sharples, & Polmear, 2010; Rosenbaum, Klopfer, & Perry, 2006). We advocate that perspectives on location awareness can be combined with perspectives on science-related place-based education (Lim & Barton, 2005) to inform design principles for technologically-enhanced informal science education. By combining place-based learning with location awareness, we codify strategies that support informal learners to reflect and externalize developing understandings (Kafai, 2006; Linn, 2006). In this paper, we derived design guidelines for mobile computing from the informal education and education technology literatures. The initial part of the paper will orient readers to placed-based learning and location awareness for mobile computers. Next, we discuss three empirically-derived design guidelines with implications for mobile computing. Last, we link theory to practice with an example—the *Tree Investigators* project that used mobile computers to support science learning about trees and flowering plants in an outdoor Arboretum.

Place-Based Education Goal	Mobile Design Guideline	Mobile Computing Strategies to Support Place-based Learning
Attend to the diverse meanings and history of a place	1) Facilitate participation in disciplinary conversations and practices within personally-relevant places	• Provide a conceptual organization (Quintana et al., 2004) of the primary characteristics of a place. Structure content presentation, mobile website interface, examples, and resources around important place aspects. • Include references to common sources of prior knowledge (Bell et al., 2009) to integrate old and new perspectives (Linn, 2006).
Support culturally-appropriate norms and pedagogies	2) Amplify observations to see the disciplinary-relevant aspects of a place	• Direct attention to specific features or characteristics that highlight important disciplinary concepts (Eberbach & Crowley, 2008; Huang, et al, 2010; Rieger & Gay, 1997). • Provide contextualized expert guidance (Linn & Slotta, 2002) to encourage deliberate comparison and explanation with images (Liu et al, 2009) or text and guiding questions (Yoon, et al, 2012).
Incorporate fieldwork, inquiry, authentic artifacts and representations	3) Connect local experiences to those of general, disciplinary concerns through exploring new perspectives, representations, conversations, or knowledge artifacts	• Capture and annotate artifacts of a place for making thinking visible (Smith & Blankinship, 2000; Land, Smith, & Zimmerman, 2013). • Provide visualization of non-visible aspects of a place through technological augmentation (Rogers et al. 2004). • Collect and share data (Rogers et al. 2004; Tan et al, 2007) to support the development of an artifact (Kafai & Gilliland-Swetland, 2001).

Table 1: Design guidelines and strategies for place-based education using mobile devices

Location Awareness and Place-based Learning

Current work in mobile educational technology focuses on location awareness to enhance learning (Klopfer & Squire, 2008; Squire & Jan, 2007). Researchers studying augmented reality (AR) use location awareness to create context-sensitive and place-dependent (Dunleavy, Dede & Mitchell, 2009; Dunleavy & Dede, 2014; Dunleavy, this issue) approaches that leverage aspects of a physical setting to engage learners. Context-sensitive AR projects commonly use “participatory simulations” where a fictional scenario is added to a local setting. Two examples of participatory simulations are Environmental Detectives with an environmental engineering gaming narrative (Klopfer & Squire) and Outbreak @ the Institute with an influenza scenario (Rosenbaum, Klopfer, & Perry, 2006).

Recent efforts by the European Technological Enhanced Learning community (Brown, 2010) have asked researchers to consider “context” more holistically so that context includes interactions with other computer users, the computer, the physical location, and others in the physical location (Sharples, 2010). This interactional view of context provides a challenge for mobile computing: how can developers and educators design for mobile learning as contextual, interactional learning? Our analysis of the literature suggests that science education’s place-based learning is a construct that includes this interactional view of context.

What is Place-Based Education?

Place-based education (Sobel, 2004) advocates designing curriculum to make school-based learning more relevant to everyday life through a focus on local issues. Place-based education engages people in activities within and about communities to advance meaning making (Smith, 2002; Sobel, 2004). Place-based education highlights disciplinary concepts that are embedded within local systems, histories, and interactions. Researchers adopt place-based education (Lim & Calabrese Barton, 2006) to transform disciplinary information from abstracted knowledge to local knowledge that is related to communities’ cultural practices (Gruenewald, 2003).

Semken (2005) offers a framework for science-related place-based teaching that: (1) focuses on the natural history of a setting, (2) attends to the diverse meanings that a place has for people, (3) incorporates investigations relying on authentic artifacts and representations, (4) encourages ecologically sustainable and culturally appropriate pedagogy (including case-based and project-based opportunities) and (5) increases the “sense of place” of learners and teachers. Place-based teaching values indigenous knowledge (Semken, 2005) and incorporates experiences from those outside of dominant culture (Greunwald, 2003). In this way, place-based teaching includes all learners as they connect new science-related ideas to community-based experiences. We adopt the view that place-based learning can connect out-of-school learners to their communities.

Research and Design Framework for Outdoor Informal Mobile Computing

We reviewed the education technology and informal science education literatures to derive design guidelines and strategies for integrating mobile computers in informal learning environments. These design guidelines (Table 1) bring place-based education to mobile computers in ways that build on the location awareness features of tablets, phones, and handhelds.

Guideline 1: Facilitate participation in disciplinary conversations and practices within personally relevant places

Guideline 1 supports learners as they participate in disciplinary-relevant conversations and practices within their community. This guideline builds from, but is an alternative to, imposing an external game or narrative on a setting. Instead, this place-based guideline suggests developing the disciplinary narratives already embedded in a place through highlighting the historical, geographical, geological, ecological, and architectural stories in local communities.

Present a classificatory or organizational scheme for understanding the place. Central to supporting the exploration of a physical environment, a key strategy is to structure content, interface, and resources around a classificatory scheme for understanding a place. An image-based conceptual organizer (Quintana et al., 2004) of the primary characteristics of a place or domain of study within a place can serve this introductory function. Presenting models that highlight only a few attributes of a place allow learners to comprehend a place's significance. Designers can add layers of complexity to the organizational scheme over time as learners gain expertise.

Include references to common sources of prior knowledge. Designs for mobile devices that use a place-based learning approach include explicit references to sources of prior knowledge (e.g., familiar locations in the community), as it has been shown that people integrate prior knowledge and new knowledge in meaning-making (Brown, Bransford, Ferrara & Campione, 1983). Conversations that connect prior knowledge to new experiences are an "essential learning behavior" in informal environments (Bell et al., 2009, pg. 143), allowing for learner articulation and reflection.

Guideline 2: Amplify Observations to See the Disciplinary-Relevant Aspects of a Place

Guideline 2 focuses a learner to make observations of a place that might not typically be visible without expert knowledge. This guideline emphasizes the importance of using mobile devices to help learners to see aspects of a place that have disciplinary value. For instance, visitors may walk through a botanical garden and only enjoy the garden's beauty. For learning purposes, place-based strategies focus visitors to see the biological knowledge embedded within the garden, along with its aesthetic value.

Focus on core elements of a place. Mobile computers can utilize textual prompts, photographic images and other representations to focus learners to observe only the most important elements of a place. Focusing is related to conceptions of channeling (Quintana, et al, 2004) where an educator limits complexity by channeling the learners' attention to very specific disciplinary characteristics. Research indicates that the process of making observations that are in alignment to disciplinary practices is complex yet under-appreciated (Eberbach & Crowley, 2008; Smith & Reiser, 2005). Furthermore, disciplinary background knowledge is needed in order to identify what is important to observe (Smith & Reiser). Liu et al. (2009) provided focusing support via photographs presented on a mobile device depicting an actual scene of a school's aquatic pool. Students were cued to recognize where they should look in the pool, through accessing scientific information and images about the plants. Close up images of plants were provided that would otherwise be difficult for students recognize. Including amplified perspectives on mobile computers can provide the foundation for further learning.

Provide contextualized expert guidance (Quintana, et al, 2004) to encourage deliberate comparison and explanation. Experts notice key comparisons to develop explanations (Linn & Slotta, 2000). Mobile technologies afford capabilities such as photo and video display that can be used to highlight important cultural, ecological, geographical, historical, and/or geological aspects of a place so learners compare and contrast characteristics to build explanations. Smith and Reiser (2005) developed a software environment for science learning where learners used video data to create explanations of animal behavior. Contrasting photographic cases also serve as data from which learners create conceptual explanations about disciplinary characteristics (Smith & Reiser). For instance, presenting photographs of flowers similar to and different from those currently in bloom, can promote observational inquiry and explanation building related to biological form and function.

Guideline 3: Extend Experiences through Exploring New Perspectives, Representations, and Data

Guideline 3 relates to capturing and organizing products of learning activities in order to support deeper thinking about a place over time. To advance learners' place-based learning, we advocate including knowledge-generative tasks (Scardamalia & Bereiter, 1994) so that community knowledge becomes useful knowledge, not inert knowledge.

Capture and annotate artifacts of a place for making thinking visible. Technology can support reflection and articulation of new knowledge (Linn, 2006), if artifacts are captured for sharing. Given the photographic capabilities of the mobile computers, learners can make digital artifacts of a place for future examination and to making thinking visible to peers (Bell, 1997). Reflection on one's experiences is readily supported if captured in audio, video, images, or written logs so that can be analyzed later (Land, Smith, & Zimmerman, 2013). Learners use mobile computers to annotate video and digital photographs, to support prolonged engagement in disciplinary thinking. Prior work with annotated video has shown the role that annotating digital images can play in learning (Stevens & Martell, 2003). We posit that artifacts captured and annotated from mobile devices can: (a) promote reflection on activities as they unfold that might normally be tacit, (b) build connections between disciplinary practices and everyday life, and (c) highlight aspects of a developing explanation that warrant further investigation (Land, Smith, & Zimmerman).

Provide visualization of non-visible aspects of a place through technological augmentation. This design guideline emphasizes presenting new information about the place, through various models and representations (Edelson, 2001). Due to climate or seasonal transformations, economic growth or shrinkage, or historical and cultural changes, learners may need information that is not readily visible. The goal of augmenting this information is to provoke reflection and discussion by users about their surroundings (Rogers et al., 2004). The Ambient Wood Project (Rogers et al.), for instance, involved a variety of augmentations that could be accessed via PDA within an outdoor woodland to "reveal abstract processes taking place in the habitat (e.g., photosynthesis), enabling the students to discover things they might not notice otherwise (p. 5), such as with pre-recorded sounds of bird sounds or insect scuttling. Scholars have also designed image repositories to make visible the changes to a location over time. Kafai and Gilliland-Swetland (2001) engaged students in documenting field trips by collecting photographs and integrating them with historical images to understand environmental change. Smith and Blankinship (2000) and Smith (this issue) connected student photographs to historical image archives to allow students to investigate changes in local urban planning and architecture.

Collect and share data to support the development of an artifact. Our final recommendation builds from perspectives to advance critical thinking through constructionist learning (Harel & Papert, 1991) where learners create artifacts to articulate and refine their emerging understandings. According to Kafai (2006), creating artifacts encourages knowledge-in-use by developing physical or digital objects that represent emerging understanding. Creating artifacts on a mobile computer extends the learning activity from the original place to a new setting later in time. The artifacts to support knowledge building can include data collection from a place-based investigation. Rieger and Gay (1997) for instance, designed a mobile fieldwork environment where learners inputted plant height and soil pH into a database to pool data across groups. To encourage peers to communicate and to develop artifacts to support learning, Tan et al (2007) designed a mobile interface that allowed for learners to capture and share photographs, sounds, and video clips from a wetland. Back in the classroom, the learners used this wetland data in reports and projects related to their science learning experience.

Theory to Practice

Design Guidelines Applied to the Tree Investigators Case Study

To understand the three guidelines for place-based learning with mobile computers, we present a design case study. In Tree Investigators, we developed AR elements on a mobile website to support learners' engagement with biology in an Arboretum. The Tree Investigators learning objectives were for learners to explore deciduous and evergreen trees by comparing local trees to each other as well as to non-native species.

The Tree Investigators project provided families and fourth-graders on field trips with an outdoor learning experience to observe trees like a botanist— understanding the important ecological and biological concepts relevant in their own community. Learners accessed content via quick response (QR) codes applicable to the trees onsite and thus personalized the science learning to the site, to the learners' prior experiences, and to community landmarks. The design goal was to provide a "heads-up" (Hsi, 2003) experience, where learners engaged in conversation and discovery-based activities at the Arboretum supported by mobile devices rather than spending the full Arboretum visit looking at tablets, phones, and Internet-enabled mp3-players.

Design Guidelines for Place-based Learning at the Arboretum

Through presenting the Tree Investigators case, we illustrate how these guidelines can support informal outdoor education. To attend to Guideline 1, facilitate participation in disciplinary conversations at the Arboretum, we selected important and common trees to the local ecosystem of the learners. The design organized conceptually on deciduous and evergreen trees; it included a simplified organization by choosing eight tree species (four evergreen and four deciduous) that had distinctive attributes, so learners could more easily comprehend biodiversity of trees. The Tree Investigator design choice allowed learners to develop an understanding of their unique community's flowering plants and trees in a global biodiversity framework.

We leveraged learners' prior knowledge by including trees common in the community such as the white pine and white oak. The local trees were paired with contrastive non-native species, such as the limber pine shown in Figure 1. At a finer-grain level, design choices in the Tree Investigator mobile website included text that made references to common landmarks in the local community as well as reference to shared cultural experiences relevant to 10-year old children to evoke prior knowledge to support meaning-making.

In Guideline 2, we used images to support learners to amplify observations, so the learners could see the flowering plants and trees within their community in a scientific manner. First, we focused on core elements of trees needed for identification by including only three characteristics per tree, as shown in Figure 1, with content for leaves, needles, fruit elements or bark features. Second, we used prompts to focus the learners' observation to specific locations on the actual tree specimens, such as "look halfway up the white oak tree trunk." Third, Tree Investigators relied on contrastive photographic examples as contextualized expert guidance, as shown in Figure 2. The images encouraged learners to compare life cycle differences of trees (young and old) and provided guidance on how leaves, flowers, and fruit change within seasonal cycles.

Our case study research findings (Zimmerman, Land, McClain, Mohney, Choi & Salman, in press) indicated that the 25 participants relied on the contrastive images to understand the different types of trees as evidenced by conversations on-site.

To support Guideline 3, extending experiences through exploring new perspectives, representations, conversations, and knowledge artifacts, we used a combination of commercial mobile apps and developed AR markers to enable peer and family discussion about the Arboretum's plants. With fieldtrip groups, we encouraged the capturing of photographic artifacts of flowering plants. Learners annotated their self-taken photographs to represent ideas about flowers, as shown in Figure 3. We augmented seasonally non-visible animals to the gardens, so that learners accessed video clips of insects on flowers to show pollination processes. For families and for learners on fieldtrips, we included conversational prompts and questions about the flowering plants' and trees' scientific aspects to foster the collection and sharing of data within small groups.

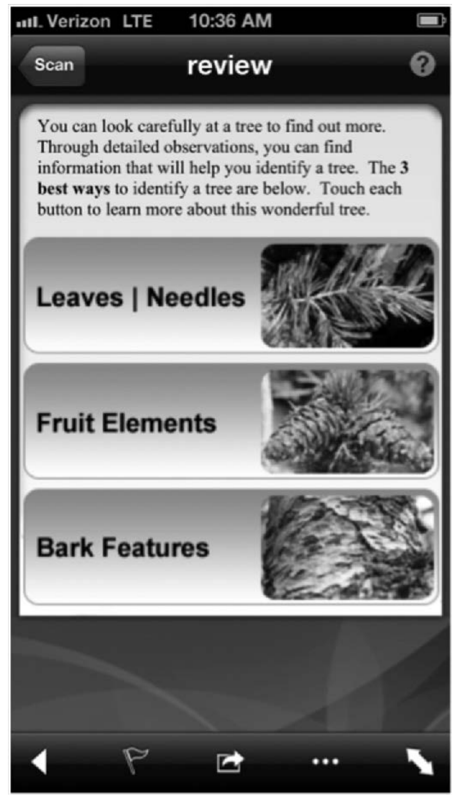

Figure 1. The limber pine was selected as a contrastive non-native species for learners to compare with the white pine, a local conifer species.

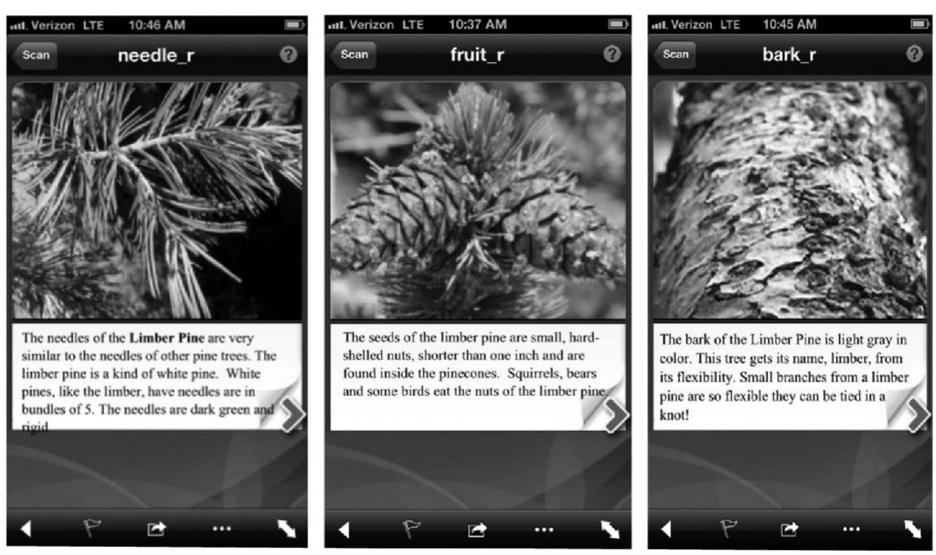

Figure 2. Photographic images were used to compare and contrast to specimens on-site. We also included images, such as the pinecone in the middle, that were not always seasonable present.

Figure 3: a learner annotates an image of a tulip by labeling the parts of a plant that are related to pollination over her digital photograph.

Conclusion

Through an analysis of place-based learning and location awareness research, we extend mobile technology scholarship with a design framework to facilitate place-based learning in informal outdoor environments. We used the literature to develop three guidelines to support learners in informal settings: (1) facilitate participation in disciplinary conversations and practices within personally relevant places, (2) amplify observations to see the disciplinary-relevant aspects of a place, and (3) extend experiences through exploring new perspectives, representations, conversations, or knowledge artifacts. Our design framework is positioned to apply to mobile computers in outdoor informal settings or across settings; however, future research could apply the place-based framework in school-based settings to further advance perspectives related to mobile learning in formal education.

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