Using augmented reality to support observations about trees during summer camp

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ABSTRACT

This research examines how augmented reality (AR) learning experiences supported children's engagement in science. We conducted a video-based study of seven sessions over two weeks at a summer camp program. We investigated how scientific talk related to observational practices could be supported by a mobile app incorporating AR. Researchers coded videos of youth (n=35) during an outdoor program on the tree life cycle to understand science talk related to observations of trees. Findings suggested that the use of AR to support tree identification led to learner-initiated talk and observations as demonstrated by high levels of perceptual (describing) talk. Learners relied on the AR technology and peers in order to engage in this observational work.

Categories and Subject Descriptors

K.3.1 [**Computers and Education**]: Computer uses in Education – *collaborative learning*

General Terms

Design, Human Factors.

Keywords

Children, augmented reality, mobile learning, learning technologies, outdoor education, summer camp, science learning.

1. INTRODUCTION

Our project supports children to become scientific observers of natural phenomena when they use mobile technologies. Mobile technologies have been used previously to enhance data collection in outdoor settings [8, 11, 18] as well as to augment a real-world location with virtual data and scenarios [6, 15]. Researchers have reported that design elements of augmented reality (AR) can enhance children's data collection [11, 15] and engagement in science discourse [14, 17]. Building on this prior work, we conceptualize theory on the role of AR and technological supports for science learning [9] along with theory on learner talk that is a marker of the science practice of observation [2, 3]. We designed an outdoor learning experience and AR resources and tools (i.e., digital images and text that are layered on top of the physical space) to support children to coordinate their observations with evidence related to the life cycle of trees (seed, seedling, sapling, mature, and snag). This paper presents findings on the patterns of science talk that emerged during children's interaction with technology, the environment, other learners, and a naturalist guide during summer camp.

Our research question is: *How do children engage in science talk about trees, related to their observations, during an AR-enhanced learning experience during summer camp?* To investigate this question, we used video-based analyses to examine learner discourse, gesture, and socio-technical interactions.

2. THEORETICAL FRAMING

Our team is conducting design-based research [10, 17] to enhance scientifically meaningful experiences for out-of-school-time via mobile computers. This project's focus on AR technology is guided by the Strands of Science Learning offered in *Learning Science in Informal Environments* [3], with recommendations for integrating media into out-of-school-time settings. This paper focuses on the use of AR to support scientific observation practices in outdoor settings such as woods, gardens, watersheds, and parks [5, 8, 11, 14]. AR for learning is designed to "enable participants to interact with digital information embedded within the physical environment" [6, p. 735]. AR enhances learning experiences through a virtual layering of perspectives, narratives, or otherwise inaccessible information to "expand the boundaries of formal learning spaces" [13, p. 15]. Current mobile devices (e.g., iPhones, tablets) support AR functionalities in everyday settings, by bringing photos, text, and video into the learning space without specialized hardware.

Mobile technologies in outdoor settings can augment the natural world by adding digital media that enables access to non-visible information such as scientific perspectives, databases, or tools for capturing and sharing data [14]. Liu et al. [11] digitally augmented a natural pond environment using close-up images and detailed information tied to aquatic plants. Chen et al. [5] developed a mobile image-retrieval system for bird watching to simulate the educational experience of learning with a naturalist. Research findings point to gains in factual and conceptual knowledge [11] as well as participation in the identification practices of key species [5]. While these findings provide support for our work to integrate AR into a summer camp to enhance youths' learning, we extend prior research by investigating how learners use the current tablet technology to engage in observational practices during an informal learning experience.

When integrating technologies into informal environments, researchers express concern about "heads-down" interactions with technologies [7, 12] where learners engage with the screen, rather than the rich scientific exhibits or natural settings that surround them. To create engaging experiences with technology in out-of-school-time settings, researchers have leveraged the mobile

IDC '15, June 21 - 25, 2015, Medford, MA, USA Copyright is held by the owner/author(s). Publication rights licensed to ACM. ACM 978-1-4503-3590-4/15/06…$15.00 DOI: http://dx.doi.org/10.1145/2771839.2771925

computer's camera to allow children to capture, annotate, articulate, and reflect on their observations [8]. Given our focus on creating learning experiences that engage children in observations in a nature camp program, we rely on technologies that (a) enable us to digitally augment the environment without the need for internet connection, as both cellular and internet access were unavailable within the forest setting of our study and (b) support observations of the natural world unobstructed by a design that focuses learners' attention too heavily on the device. Others have designed technologies to support observations, photo documentation, annotation, and science inquiry for museum and afterschool settings [1, 4, 16]; however, given our focus on outdoor settings, we needed technology tools that could function without an internet connection on tablet devices and that were customized to one-hour programs held on a wilderness trail of the Appalachian habitat. Accordingly, we chose to develop an AR-enhanced app that allows layering of digital information within the forest setting as seen through the tablet's camera.

3. VIDEO-BASED METHODOLOGY

We conducted a video-based study of seven workshop sessions at a Nature Camp to understand how scientific talk could be supported by a mobile app using AR. In keeping with our interest in supporting science learning within informal spaces [3], we consider conversations as both products and processes of learning.

3.1 Data Collection at Nature Camp

The study took place at a Nature Center in the Mid-Atlantic region of the United States. The camp serves over 300 children annually, and each year the camp curriculum covers varied environmental education topics. The summer camp program included multiple days of hikes, guided exploration of water and land habitats, informal lessons on plants, animals, and geography in the local ecosystem, and free play, games, sing-alongs, and swimming. For six weeks, we investigated children's learning in one-hour workshops with mobile computers. This paper's analysis focuses on two of the six weeks.

The participants were 35 children who signed up for summer camp as part of their normal summer leisure activities and to meet childcare needs. The children were aged nine to twelve (typically entering fourth through six grades in the USA). Children were filmed during one-hour guided programs using an AR app deployed on iPad mini tablets. The focus of this analysis is on the students' work at the second half of the guided program as they worked in either dyads or triads with one iPad and the AR app.

3.2 Data Analysis

We examined youths' talk as they worked with AR on a photographic identification task. Videorecords were transcribed so that the speech used by the children was retained— including slang terms and contractions. To enhance transcription reliability, two researchers checked each transcript.

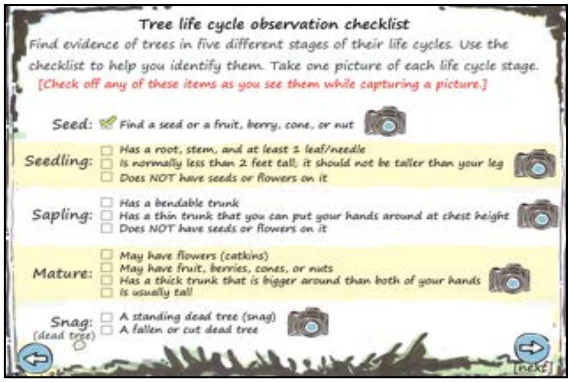
Table 1. The analytical framework [2] with data examples

Code	Description	Data from our study
Perceptual	Identify, describe	• the needles are high up
Conceptual talk	Apply category.	• It's a sapling
Connecting talk	Everyday connection	• I have a tree in my front yard . . .
Affect talk	Emotion, feeling.	• This is fun!

Next, the research team had three two-hour training sessions as a large group on Allen's [2] coding framework for science talk in Table 1. Two researchers subsequently coded the transcripts separately, achieving inter-rater reliability on each code at more than 85% agreement. Differences were resolved through discussion.

3.3 Technological Innovation

We designed a mobile app for iPads that allowed for layering the physical environment with digital photographs, text, conceptual models, and AR-enhancements for observation practices. The introductory content was organized by the tree life cycle. For each stage of the cycle, the learner touched the image to learn more, and they were directed to look around them for evidence of trees at different lifecycle stages, supporting multi-modal and multi-sensory learning experiences.



Tree life cycle observation checklist

Find evidence of trees in five different stages of their life cycles. Use the checklist to help you identify them. Take one picture of each life cycle stage.

[Check off any of these items as you see them while capturing a picture.]

Seed: ☑ Find a seed or a fruit, berry, cone, or nut

Seedling:
- ☐ Has a root, stem, and at least 1 leaf/needle
- ☐ Is normally less than 2 feet tall; it should not be taller than your leg
- ☐ Does NOT have seeds or flowers on it

Sapling:
- ☐ Has a bendable trunk
- ☐ Has a thin trunk that you can put your hands around at chest height
- ☐ Does NOT have seeds or flowers on it

Mature:
- ☐ May have flowers (catkins)
- ☐ May have fruit, berries, cones, or nuts
- ☐ Has a thick trunk that is bigger around than both of your hands
- ☐ Is usually tall

Snag: (dead tree)
- ☐ A standing dead tree (snag)
- ☐ A fallen or cut dead tree

Figure 1: User interface designed to support tree life cycle observation and photocapture of evidence in camp.

The camp program started with a naturalist eliciting children's prior knowledge about trees. After posing the question, "How do trees grow in the forest?", he led children on a structured tour of two trees emphasizing various stages of the tree life cycle. Throughout this time, the naturalist encouraged children to have a "heads up" [7, 12] experience in the outdoors by asking the learners to find exemplars of stages of the life cycle in the woods. Figure 1 shows a user interface for collecting and annotating photographic evidence of observations in the forest.

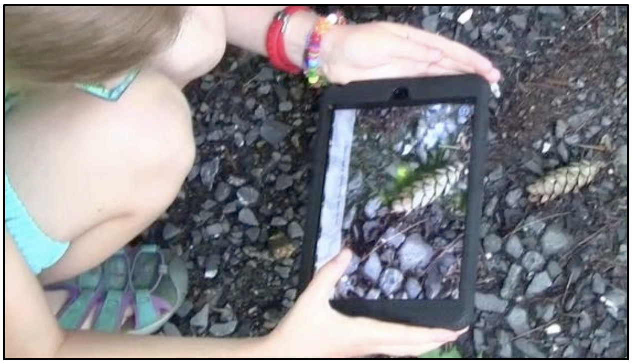


Figure 2: Child uses the AR tool to layer the criteria for a seed within her camera view of a pinecone.

After this initial structured exploration, youth used an AR tool that was embedded into our mobile app to support observational practices. This AR tool layered the criteria for distinguishing life cycle stages on top of the scene the children were observing. The criteria were viewable through the iPad's camera display in real time as text overlays and changed based on the life cycle stage a learner selected they were identifying. The criteria could be applied quickly on the trail as "check boxes to identify trees at various life cycle stages. This enabled learners to compile their photographic evidence (Figure 2) into a personalized and sharable knowledge artifact in the form of a life cycle collage, making their thinking available for knowledge-building discussions and negotiation with peers and adults.

4. DATA AND FINDINGS

4.1 Science Talk across the Children

To understand how science talk occurred within small groups during the AR activities, we conducted a line-by-line analysis of one-third of the transcripts. Data were coded [2] as shown in Table 1. Most of the observational talk was perceptual (i.e., descriptive of trees) at 64% as shown in Table 2, with less conceptual talk (i.e., applying a science category) at 29%, affective (i.e., emotional) talk at 6%, and connecting talk at 1%.

We interpret the frequency counts of the children's talk to show that during the AR portion of the camp program, children engaged in both learning the tree life cycle concept and using the outdoor setting to find evidence of these cycles in the woodland area via perceptual and conceptual talk. We posit there was little connecting talk because these learners were in camp together for the first time — with little shared history to encourage sharing of personal informal experiences.

Table 2. Science talk percentages by type in the AR phototask.

Talk	Perceptual	Conceptual	Connecting	Affective
Phototask	64%	29%	1%	6%

We conducted a second, deeper analysis of the children's science talk with peers compared to children's science talk with naturalist/adult support during the AR activities. We found 59% of the science talk in peer groups was perceptual, yet 75% of the science talk with naturalists was perceptual (Table 3). Conceptual talk had the highest percentage in peer-interaction talk configurations. Upon examining the conversational context of the science talk in both the adult-peer learning arrangement and the peer-peer learning arrangement, we found that the adult naturalists were more likely than the children to ask questions like, "Why do you think that tree is mature?" (i.e., what is your evidence for that conceptual claim?). Because the adults asked for evidence of the children's conceptual category and the peers did not, there was a higher percentage of talk that was perceptual in response to an adult's question, resulting in more utterances such as "it's tall."

Table 3. Observational talk percentages of child-only learning arrangement compared to adult-child learning arrangement.

Talk	Perceptual	Conceptual	Connecting	Affective
Peer-peer	59%	31%	1%	8%
Naturalist-peer	74%	23%	0%	2%

The naturalist-peers talk (Table 3) also showed very little affective talk: 2% during adult-child learning arrangements compared to 8% of affective talk during peer-peer learning arrangements. Again through examining the conversational context, we found the peers expressed the fun they had with this activity in the woods with utterance of surprise and delight; however, when talking to the naturalist, the children used more school-like, formal language.

4.2 Science Talk Case Studies

The above descriptions of talk frequency counts (Tables 2 and 3) provide the general trends in the children's talk during the AR activity, yet they do not show the complexity of the observational practices supported by the AR tool. To investigate how our mobile app supported observation on the camp trails, we conducted a thematic analysis of significant episodes during the AR-life cycle identification activity in one-third of the video data.

Our analysis of the episodes of learners using the AR tool on the trails during the one-hour program, demonstrated that the children articulated their observations with scientific vocabulary to describe the lifecycle of a tree (i.e., seed, seedling, sapling, mature, snag). Analyses showed that learners were also able to discern relevant scientific features of the trees (e.g., less than 2 feet tall, bendable, thick trunk). In most dyads and triads, learners used the correct scientific vocabularies more fluently towards the end of the mobile computing activity, as shown by Richard and Ben. In the following transcript, Richard and Ben were creating a photo collage of the life cycle using five tree pictures that they had taken during the day's AR activity.

> *Richard:* Yeah, that's just sapling. And then mature.
>
> *Ben:* No, that's not, that's not —
>
> *Richard:* What is it?
>
> *Ben:* ((takes a photograph)) Maybe the other one. . . That's a sapling. Then a mature —
>
> *Richard:* Mature. I've got snag ((takes a photograph)).
>
> *Ben:* There, we're done.
>
> *Richard:* This one . . . oh yeah those . . . Now we got it . . .

Above, Richard and Ben discussed which picture is a specific type of a tree (i.e., sapling) while showing their fluency in correctly identifying the tree's stage in the life cycle. In this way, the AR tool supported learners to connect evidence (via annotations placed over the digital photograph) for each tree stage in real time while the youth engaged in data collection via picture taking.

The AR tool contained information that often prompted learners to test criteria (i.e., a sapling has a thin trunk that you can wrap your hands around). Learners had an embodied sensory experience applying the criteria before making a claim about a tree's life cycle. The episode below with Belle and Mickey represents how learners commonly used AR tool to engage a multi-sensory and multi-modal learning experience.

> *Mickey*: Ok, let's see. ((reads)) "Has a bendable trunk." Yes, you just tested that. "Has a thick trunk." Yes, definitely. . . .
>
> *Mickey*: Closer to this one, so ((reads)) "May have flowers." Well, yes.
>
> *Mickey*: ((reads) "Has thick trunk." That is big . . .
>
> ((Belle touches a tree to test out thickness))
>
> *Mickey*: ((reads)) "Is usually tall."
>
> *Belle*: It's pretty tall ((looks up at tree's full height))

Mickey, throughout this excerpt, used the AR tool that was visible through the viewfinder of the iPad camera to read off criteria of each life cycle stage that she and Belle investigated. While looking for a sapling, Belle wraps her hands around a tree to test whether the tree trunk is thick enough to be a sapling in the first utterance. This pair continued to look for evidence for a mature tree through the rest of the excerpt (e.g., thick trunk) in a way that included the coordination of multiple senses and media while conducting an observational inquiry in nature.

In addition to supporting the conceptual development of the life cycle model and observational skills (as shown above with Ben, Richard, Mickey, and Belle), the AR technology supported learners to become immersed in the science activity in a playful way as shown through the elicited positive emotions. For example, many learners showed excitement when they located a specimen. Descriptions such as "this is fun", "cool" or "perfect tree" were expressed during the AR activity. Across the dataset, the summer camp children also showed accomplishment when they completed the AR-photo collage task. In one episode, learners were interested to find out whether they could download this app and showed a willingness to purchase it: "This app, I might get it". These remarks showed that the learners enjoyed the learning experience and were willing to engage in the activity again in the future.

5. DISCUSSION

We found that children's observations of life cycle stages in the outdoors were supported through AR-enhanced mobile learning experiences. We also found that children successfully conceptualized the various stages of tree's life cycle. Peers engaged in shared observational work, aided by the criteria annotated as AR elements. The observational practice was a multi-modal and multi-sensory learning experience that included the coordination of text, images, annotations, touch, physical manipulation of trees, and visual observation. When acting in a learning arrangement with peers, children engaged in observational practices that applied conceptual categories (e.g., seedling) — without asking for their evidence. While there was a counterexample (i.e., Ben and Richard), higher levels of perceptual talk occurred in adult-child learning arrangements. This descriptive talk was due to the naturalist re-voicing the AR criteria with specific forms of the question: "What is the evidence for that claim?". Even though the app's AR elements were designed to support pairings of observations and claims, coordinated supports (technological and social) were important for science learning.

These findings have implications for informal science education programs that support nuanced observations and explanations, especially in settings with little signage or educational resources. When taken with similar mobile computing efforts in other contexts [1, 7, 15], our work suggests that AR-inspired apps customized to specific settings can support young learners' observational practices in situ. A contribution of our efforts is to offer an approach to designing localized programming for summer camps, which attends to the informal learning experience.

6. ACKNOWLEDGMENTS

Our thanks to our research participants, Shavers Creek Environmental Center, the Augmented and Mobile Learning Research Group [sites.psu.edu/augmentedlearning], and our funder Center for Online Innovation in Learning [coil.psu.edu/blog/tree-investigators-using-augmented-reality-and-mobile-computers-outdoors/].

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