Chapter 33
Screens on Trails: Digital Environmental Science, Arts, and Humanities Learning for Biocultural Conservation

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Abstract The H.J. Andrews Experimental Forest (HJA), a Long-Term Ecological Research site in the Oregon Cascades, hosts long-term ecological research on the old growth forest and a long-running artist- and writers-residency program. This interdisciplinary investigation of place is featured on the Discovery Trail, an interpreted learning experience in the HJA for middle and high school students. The environmental science, arts, and the humanities (eSAH) inquiry-based curriculum on the Discovery Trail aims to facilitate engagement with both content and place, while providing learners opportunities to develop their own relationships with place through sensory interaction. The content is delivered through portable tablet computers (iPads), which allow for place engagement across time and season through audio and video media. While research on digital technology use in the classroom demonstrates a host of benefits, technology in field-based contexts is much less studied. We conducted an exploratory mixed methods study to investigate the impacts of technology on the Discovery Trail on learner engagement with place and content. Results show both benefits and challenges to learner engagement when using the tablets. In this chapter, we describe our research with 108 middle school learners from central Oregon on the Discovery Trail, as well as provide suggestions for content delivery and group preparation that can address potential challenges of employing this innovative pedagogy for biocultural conservation.

Keywords Affective learning · Digital technology · Engagement · Environmental education · Place-based relationships

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R. Rozzi et al. (eds.), *Field Environmental Philosophy*, Ecology and Ethics 5,
https://doi.org/10.1007/978-3-031-23368-5_33

33.1 Introduction

Deep valleys and high peaks, towering Douglas firs, a floor of moss, and swift, clear mountain streams all characterize the H.J. Andrews Experimental Forest (HJA), one of 28 sites in the US Long-Term Ecological Research (LTER) network (LTER 2017). The LTER network is a collection of field sites across a range of biomes that are supported by the National Science Foundation for long-term study of place (HJA 2017a). Located in the Cascade Mountain range of central Oregon, the HJA's landscape is dominated by old growth forests blanketed in moss, the canopy of which is home to many charismatic species like the northern Spotted Owl (HJA 2017a).

In the HJA, environmental science, art, the humanities, and education intersect with the study of long-term change in the forest (see Swanson [Chap. 32] in this book for more of this story). This is the heart of the Discovery Trail (DT), an environmental science, arts, and humanities (eSAH) educational experience for middle and high school field trips in the HJA. Developed in 2015, the DT interpretive learning experience was designed to introduce learners to the landscape, forest management, and place-based ecology, as well as foster personal reflection about one's own place relationships and associated responsibilities. Through the integration of place-based ecological research, arts, and humanities, the interdisciplinary DT curriculum aims to foster biocultural conservation by facilitating the development of both knowledge about the ecosystem, as well as care for the natural world through interaction, reflection, curiosity, and wonder.

During the DT experience, student groups are guided through a series of stops along a half-mile forest trail. The inquiry-based curriculum is formatted on portable tablet computers (iPads) which are shared by groups of two to three students. The use of digital technology allows for the inclusion of multimedia elements in the curriculum, including videos and audio clips. This format enables a place experience across time and season, providing learners access to critters, places, and events they typically would not see on a forest visit, including the high canopy and the creek at flood volume. The digital platform accompanies learners' personal interactions, self- and group-reflections, and sensory explorations of the forest. The tablets also provide a non-invasive way to archive student assessment data, while facilitating increased student on-trail hours in a site with limited staff capacity.

Digital technology use in STEM (science, technology, engineering, and mathematics) learning environments has numerous benefits (Lakshminarayanan and McBride 2015). However, the use of digital technology in field settings is less studied, and likely has some limitations, including the simple intrusion of screens as a mediator of an immersed nature experience. To explore the use of digital technology as a delivery medium for an innovative field-based eSAH curriculum, we have been researching the impacts of the tablets on learner engagement with place and content on the DT. Content engagement is important for overall learning, particularly for encouraging persistence and maintaining motivation during learning experiences (Fredricks et al. 2004; Kuh et al. 2008; Reeve and Tseng 2011; Henrie et al. 2015). Place engagement, as we use the term, describes the depth with which a learner interacts with the storied built and natural landscape, a critical element of building relationships with places, and thus a central element of biocultural conservation. While scholarship on technology use in the field is limited, there is some hesitation in the literature about the use of screens on the trail because of the potential for distraction or a philosophical tension with taking technology outdoors to mediate the place experience (Anderson et al. 2015). If this is the case, then the learning medium on the DT—tablets—would prevent our learning goal for the trail experience, i.e., place-based learning, connections to the natural world, and biocultural conservation.

In 2018, we conducted an exploratory study on the DT to investigate the impacts of digital technology use on the learner experience. In this study, we asked the question: *What are the impacts of a digital curriculum on learner engagement with place and content?* Our results reveal both benefits and challenges to tablet use on the trail, with the positive impacts to biocultural conservation outweighing the logistical hurdles associated with using technology on the trail. In this chapter, we will describe our research with 108 middle school learners from central Oregon on the DT, as well as provide suggestions for content delivery and group preparation that can address potential challenges of employing this innovative pedagogy for biocultural conservation.

33.2 Background

33.2.1 The H.J. Andrews Experimental Forest

The US LTER network includes 28 sites with the shared mission to “provide the scientific community, policy makers, and society with the knowledge and predictive understanding necessary to conserve, protect, and manage the nation’s ecosystems, their biodiversity, and the services they provide” (LTER 2017). Inquiry across the network is primarily ecological, though a number of sites (21 of 24 total sites in 2014) also host social science and/or arts and humanities inquiry (Goralnik et al. 2015). All sites are committed to education and outreach as central goals and some, including the HJA, also conduct research on these activities. The HJA in particular aims to “support research on forests, streams, and watersheds, and to foster strong collaboration among ecosystem science, education, natural resource management, and the humanities” (HJA 2017a). The HJA comprises 15,800 acres of mountainous old growth and managed forested terrain within the Lookout Creek watershed (Fig. 33.1). The forest is co-administered by the USDA Forest Service’s Pacific Northwest Research Station, Oregon State University, and the Willamette National Forest. Foundational research at the HJA includes important studies on forest and stream ecology and forest management; ongoing long-term data collection includes climate, water quality, and forest succession.

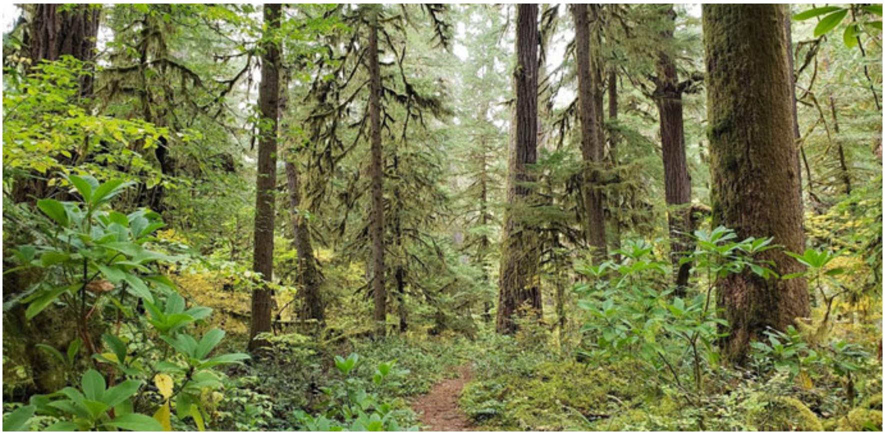

Fig. 33.1 The HJA is home to towering Pacific Northwest old-growth trees such as Douglas fir, cedar, and hemlock. These iconic giants have grown uninterrupted for hundreds of years with some of them now exceeding 250 feet (75 m) (HJA 2017a)

The HJA also hosts a long-running arts and humanities residency program in collaboration with the Spring Creek Project for Ideas, Nature, and the Written Word at Oregon State University. Visual artists, writers, philosophers, and musicians spend 2 weeks in the forest to reflect on place, interact with scientists, and conduct their own scholarly and creative work. Since 2004, over 90 artists, writers, and humanities scholars have participated as residents in the HJA.

33.2.2 The Discovery Trail

In 2012, the DT loop was developed near the HJA headquarters to provide an opportunity for visitors to observe the characteristic ecosystems of the HJA forest (Fig. 33.2). The HJA hosted close to 1800 total visitors in 2018, and because much of the landscape is difficult to navigate due to steep terrain and active scientific studies, the DT provides these visitors an accessible outlet for exploration. In 2015, an eSAH digital interpretation of this trail was created specifically for middle and high school field trip groups.

In 2017, an additional quarter-mile trail extension was added to the original DT. This un-interpreted part of the trail is used for a silent sensory walk by field trip groups, whereby learners walk quietly and spaced apart to observe the forest with their senses. This experience effectively primes students for the DT learning experience by focusing their attention on place and their somatic experience.

The 5-h typical DT field trip experience begins with a brief orientation by HJA staff, who share a poem about the relationship between science and art, often part of "Art of Science" by Vicki Graham, a 2006 HJA writer-in-residence (Box 33.1).

Fig. 33.2 The trailhead for the Discovery Trail loop

Box 33.1 The final three stanzas from "Art of Science" (Brodie et al. 2016, p. 71–73) by Vicki Graham, a 2006 HJA writer-in-residence

Begin with love, a composite of science, art, imagination, and the pure world of the senses–with the things the hand can touch: The peeling papery bark of a yew, the curve of a snail shell, the beard lichen's wiry hair–with color and taste and smell and the call of a thrush at dusk, the velvet glide of a spotted owl	Begin with love and the questions the heart asks: Why stones arrange themselves in lapped patterns on a gravel bar. How old growth trees resist the quickly mutating pathogens that attack them. Where the orchid lacking chlorophyll gets its sugars. Let the body then the heart learn the forest and remember: Data collection, computer analysis, digitized imaging begin with hand and eye, tongue, nose, and ear	And while the pencil hovers Over the page or the hand grips A water gauge, the scientist Has time to stroke the willow leaf's silk, Breathe in the lemon scent Of chanterelles, follow the arc Of a swallow's flight. The artist, too, has time to taste and touch.

Table 33.1 The 11 learning objectives and activities of the DT, including four Next Generation Science Standards (NGSS) crosscutting concepts, and an example of an activity that fulfills that objective

Learning objective/activity	Example activity
Place reflection and observation	Observing tree species
Creative activity	Drawing plant leaves
Personal reflection	Reflecting on how the growth that occurs in a forest after a disturbance is similar to how one changes after a disturbance in their own life
Values reflection	Reflecting on what the learner appreciates about forests
Mindfulness activity	Reflecting on what life is like for animals that live in HJA, meditation while listening to forest sounds
Creative writing	Reading aloud a short story about the relationship between a native American tribe and salmon, then interpreting the meaning of the story
Graph or diagram	Interpreting graphs of average rainfall, reading a diagram of the carbon cycle
NGSS: Stability and change	Learning about how logjams and flooding impact normally stable water bodies
NGSS: Cause and effect	Learning about how a forest disturbance changes plant communities
NGSS: Patterns	Comparing graphs of average rainfall to time lapse photos of Lookout Creek
NGSS: Systems	Learning about nutrient cycling and forest food webs

The students are then invited to participate on the solitary sensory walk on the un-interpreted trail. After a short debrief at the DT trailhead, student groups of two or three are taken to their first inquiry station and given their iPads. Each student group visits three of the ten interpretive stops, with each grouping of three stops designed to provide equivalent learning activities and objectives (Table 33.1). The stops include content related to HJA science, forest management, and forest dynamics, as well as reflective activities and creative content related to work from the HJA artists- and writers-in-residence (HJA 2017b). In addition to interviews with scientists and content from the long-running ecological inquiry at the HJA, the DT curriculum also includes writers reading poems and essay excerpts written during forest residencies and artist interviews about their creative process and HJA-related work. The intention is to provide opportunities to get to "know" the HJA through multiple modes of inquiry, as well as scales of perception: near and far; past, present, and future; ground and sky; interpreted and personal; human and animal; science and art. Ultimately, we hope that attention to both cognitive and affective learning outcomes—both learning and feeling—will lead learners to deeper understanding and potentially care and responsibility for the forest.

33.2.3 *The Discovery Trail and Field Philosophy*

The field philosophy (Goralnik et al. 2012, 2014, 2015, 2016; Goralnik and Nelson 2014, 2017) framework of our study is rooted in relational and care-based ethics, driven by the notion that right action derives from acting in ways that support the maintenance and wellbeing of our relationships (Warren 1990, 2000; Noddings 1984, 2002, 2005). As learners come to understand themselves to be in relationship with place(s), or to view place as a relational other worthy of moral consideration, they may also start to shift their actions in ways that reflect their responsibility within that relationship (Goralnik et al. 2020) (Fig. 33.3). Our approach aligns with Field Environmental Philosophy (FEP) (Tauro et al. 2021) in the shared focus of addressing the 'extinction of experience' common in contemporary educational settings (Anderson et al. 2015). The DT experience bridges the divide between mediated knowledge—the scientific, artistic, and literary narratives shared in the curriculum on the tablets—and direct encounters with the natural world, through guided meditations, sensory activities, reflection, observation, imaginings, and experiences in the forest (see Rozzi et al. 2006, 2008). Similar to FEP, we also hope to facilitate deeper connections between humans—in our case middle and high school learners—and the natural world, or rather place, which includes the

Fig. 33.3 At *Station 6: Lookout Creek,* students learn about the relationships between the forest, river ecology, and Indigenous storytelling. The entirety of the HJA, all 15,800-acres, belongs to the Lookout Creek watershed (HJA 2017a)

intersection of the natural world with layers of human relationships with the landscape over time, e.g., scientific, artistic, storytelling, land management, subsistence, political, recreational, psychological, emotional, and spiritual.

We have designed the DT learning experience around an environmental pedagogy of care (Goralnik et al. 2012), which bridges care-based ethics with scholarship in experiential and place-based learning (Gruenewald 2003; Knapp 2005), environmental education (Hungerford and Volk 1990; Goralnik and Nelson 2011), and emotional engagement (McCuen and Shah 2007; Skinner et al. 2009). This pedagogical foundation can lead to critical thinking and moral imagination in longer-term field philosophy experiences, as documented by Goralnik and colleagues in their work in Isle Royale National Park (Goralnik et al. 2014; Goralnik and Nelson 2014, 2015, 2017). An environmental pedagogy of care, as well as programming guided by this framework, is rooted in other examples of humanities-based field learning (Algona and Simon 2010; Johnson and Frederickson 2000), and foundational scholarship in environmental, place-based, and experiential learning. It uses empirical tools to describe learning and moral awareness in response to integrated field-based eSAH curriculum.

33.2.4 Digital Technology Use in the Learning Environment

Today's middle and high school students have been called "digital natives" due to their constant exposure to digital technologies (Prensky 2001). This fluency with technology has led many educators to use digital learning techniques in their classrooms to capitalize on student interests and strengths (Manuguerra and Petocz 2011), making digital learning the most rapidly developed method of learning in the past decade (Sebastian et al. 2012). A 2012 meta-analysis about the relationship between digital technologies and student academic achievement found that positive impacts of technologies have been consistently identified by researchers in many different learning contexts (Higgins et al. 2012; Lakshminarayanan and McBride 2015). Examples include the ability of digital technology to: foster deeper learning through guided critical thinking and problem solving (Kim et al. 2008); support student autonomy by allowing students to learn at their own pace and take ownership of the inquiry process, which can increase interest in learning (Kim et al. 2008; Lakshminarayanan and McBride 2015); and increase understanding of science and mathematics (Higgins et al. 2012). Digital technology can also improve learning facilitation, because it is portable and easily integrates multimedia elements like videos (Kukulska-Hulme et al. 2007).

Research on digital technology use in outdoor education contexts is limited, but while we might assume that many of the same benefits of technology in the indoor classroom apply, there are also reasons to proceed with caution when embracing technology in the field. Research—not specifically focused on environmental learning or field-based experiences—suggests that student dependence on technology can contribute to "alienation from nature" (Ruchter et al. 2010), the opposite of what we hope to accomplish with field-based environmental education. Richard Louv, author of *The Nature Principle: Reconnecting with Life in a Virtual Age*, echoes Leopold (1949) when he writes: “we cannot protect something we do not love, we cannot love what we do not know, and we cannot know what we do not see. Or hear. Or sense.” (Louv 2012, p. 104). In other words, a relationship with nature is critical to the development of the motivation to care or protect it. Do screens inhibit these relationships in field-based learning? Or, is it possible to use digital technologies in the outdoor classroom in ways that do not *distract* from nature, but rather *enhance* connection-building? Our work on the DT is a step toward answering these questions.

33.2.5 Digital Tools in the Outdoor Learning Environment

Since the experience of being “digital natives” has changed the way learners think and process information (Prensky 2001; Selingo 2018), incorporating digital technology into the curriculum represents an innovation that accommodates the strengths and preferences of some learners (Prensky 2001). Learning according to one’s preferred learning style improves learners’ motivation to learn and to understand content (Wolf 2003; Kacoroski et al. 2016). While students are comfortable with technology use in general, the use of digital technologies in the field environment is likely an unfamiliar experience for most learners. Novel experiences like this—using a familiar tool in an unfamiliar context—can create excitement and motivate students to learn (Anderson et al. 2015). However, there are limited studies on the use of digital technology in field-based contexts like the DT to assess how it might support or detract from the outdoor learning experience (Kacoroski et al. 2016; McClain and Zimmerman 2016). Since learners today are increasingly alienated from nature (Ruchter et al. 2010), it is crucial to find ways to integrate digital tools in the field learning experience that balance the learning benefits and potential distractions.

Recent scholarship does suggest that it is, indeed, possible for learners to be engaged both with place and content in the digitally-mediated outdoor education classroom. In describing their study of a tablet-guided nature trail experience for students aged 8-11, McClain and Zimmerman (2016) offer suggestions for thoughtful digital field-based curriculum development, including prompts that require “heads-up” or “tactile investigation” to provide opportunities for students to engage directly with nature. This kind of activity encourages learners to engage with the landscape beyond the screen, instead of solely engaging with the technology (McClain and Zimmerman 2016). Being thoughtful about the integration of these activities can elevate the benefits of technology on the trail while addressing limitations.

33.2.6 Affective Learning

Research shows that learning requires cognitive, behavioral, and affective engagement (Reeve and Tseng 2011). The affective component refers to students' beliefs, feelings, and attitudes, including their emotional reactions to the learning experience (e.g., curious, excited, bored, or frustrated). Positive emotions increase affective engagement, while negative emotions decrease it (Fredricks et al. 2004; Reeve and Tseng 2011). Affective engagement is critical to the development of responsible environmental behaviors, one of the main goals of environmental education (Hungerford and Volk 1990; Littledyke 2008). This is because of its role in fostering a positive attitude toward the environment (Iozzi 1989) and its ability to cultivate a connection and a sense of respect, awe, and understanding of our place in the world (Littledyke 1996, 2008), as well an internal locus of control, or the feeling that one's actions can have an impact. On the DT, one way we engage the affective domain is through the integration of arts and humanities in the curriculum, which invites observations and expressions of feeling and emotion in the learning process more than science alone often encourages (Davis 2008; see Goralnik et al. 2020).

Recent scholarship on eSAH learning experiences shows that this kind of deeply interdisciplinary learning can contribute to changed attitudes about the natural world, a better understanding of complex socio-ecological systems, and emotional engagement with environmental issues, which can in turn foster pro-environmental intentions or action (Goralnik et al. 2016, 2020). Additionally, eSAH integration can increase learner capacity for creative and innovative thinking and decision-making, which are important skills for STEM-based problem solving and applying scientific concepts in the real world (Daugherty 2013). On the DT, art and humanities content—including poems, literary essays, visual art, Indigenous stories, values discussions, history, reflection and drawing—is integrated alongside place-based science curriculum, so that feeling and imagining about the natural world is rooted in concrete landscape dynamics. "Writers see the research work itself, such as long-term field experiments, in emotive terms the scientists themselves seldom use, such as faith, empathy, and love" explains Fred Swanson, an HJA scientist and eSAH collaborator (Swanson 2015, p. 18). This distinction is important, as Robin Kimmerer, an HJA writer-in-residence explains, because "The data may change our minds, but we need poetry to change our hearts." (Kimmerer 2004). Together, these creative perspectives can facilitate affective engagement in ways science, often presented as objective, cannot (Davis 2008), which in turn can foster meaningful learning (York 2014). The idea at the heart of the DT is that weaving environmental science, arts, and humanities together nests cognitive and affective learning on the trail. This is important for broad learner engagement, including content and modes of learning that appeal to all kinds of learners, and for facilitating feeling (and doing) in the process of learning.

33.2.7 Learning and Place Engagement

Engagement is a widely studied educational construct that can be applied across learning contexts (Connell 1990). It consists of three primary components: cognition, emotion, and behavior (Reeve and Tseng 2011) (Table 33.2). How a learner engages with content depends on many conditions, including the difficulty or simplicity of the material, the educator's or student's attitude, and the motivation to learn associated with perceived control and relatedness (Reeve and Tseng 2011). When a learner is engaged to the fullest extent in all three areas, many positive outcomes such as increased persistence and motivation have been documented (Fredricks et al. 2004; Henrie et al. 2015; Kuh et al. 2008).

In our work in environmental education, we also consider engagement a metric to describe the depth with which a learner interacts with a place. We call this "place engagement." It might also include interactions that take place *within* a learner, the internal experience of forest immersion, including the emotional connections learners make during creative or reflective activities (Fig. 33.4). The DT experience aims to strike a balance between student engagement with both content and place, with the goal of both imparting ecological knowledge as well as fostering feeling and emotional connections to the forest through the development of place relationships (Goralnik et al. 2020).

33.3 Methods

To explore the impacts of the digital curriculum on learner engagement with place and content, we compared two learner experiences on the Discovery Trail: (1) learners who used the digital curriculum on iPads, and (2) learners who used a printed curriculum workbook. Participants included the students and teachers from four eighth-grade classes from a single middle school in Eugene, Oregon. The two teachers both taught all of the students, but in different subjects (science and language arts). We used an exploratory, mixed methods approach, which enabled us to work with a large sample size, while at the same time provide rich context about the learner experience.

Four groups of students visited HJA on four separate days during May of 2019. Two control classes used the standard tablets and two experimental groups used an adapted equivalent paper version of the curriculum that we developed for the study. Translating the curriculum between a digital medium that featured multimedia elements to a paper version required some content and format modifications, including replacing open-ended questions with multiple choice, streamlining and condensing text, replacing videos with screenshot images and text, and replacing audio clips with text transcripts. Some content was adapted specifically for the different medium, so that the paper copy was not just a less dynamic version of the digital version, but a purposeful representation of the curriculum in its own right. The

Table 33.2 Descriptions for each of the three constructs of engagement (cognitive, emotional, behavioral) and place engagement in an environmental education context, including definitions and examples of what each component looks like in an education setting. These components are collective, not summative, and the DT aims to engage all components often at the same time throughout the experience. The example of Station 9 shows how all four engagement components are woven together in practice on the DT. Definitions and descriptions are borrowed from Fredricks et al. (2004), Dienno and Hilton (2005), and Reeve and Tseng (2011)

Engagement type	Component	Definition	Descriptions	Example from the Discovery Trail
Content engagement	Cognitive **(a)**	Being thoughtful and willing to invest the psychological effort required to comprehend material and master skills	Active self-regulation to sustain engagement, the use of strategic learning strategies to organize, monitor, and evaluate progress	*At Station 9: Sounds Maps* students listen to an interview recording of an HJA researcher explaining how she uses sound in her research on birds in the forest. Students are then asked inquiry-based questions about the content of the interview **(a)** before being prompted to set the tablet down and quietly listen to the forest **(d)**. After a few minutes, the voice narration instructs students to pay attention to the variety, direction, and strength of sounds around them **(c, d)**, then to map the sounds on paper using images, arrows, text, or symbols **(a, c)**. Afterward, students are asked to reflect with their group on how they felt while listening to the forest **(b, d)**, and then consider other times in their lives they have felt similarly **(b)**. The station wraps by asking learners to notice any connections between the scientist's bird research and their own sound mapping activity **(a)**
	Emotional **(b)**	The affective reactions to learning, such as how pleasurable and enjoyable learners find an experience, and their identification and sense of belonging with place	Learners are enthusiastic, anxious, sad, happy, curious, feel like they belong and are valued	
	Behavioral **(c)**	The amount of active participation and effort demonstrated by learners in learning tasks and in the classroom	On-task, paying attention, persistence at tasks, following directions, no conduct issues, asking questions, contributing to discussions	
Place engagement	Holistic (multi-sensory) **(d)**	The depth to which a learner interacts, considers, and connects with a place as a built and natural storied environment	Tactile investigations of landscape elements, spiritual connections to or an expressed feeling of ease in place, pointing out objects to peers, immersing oneself in a sensory experience in the landscape, or remarking on landscape features or observations	

Fig. 33.4 Students looking up at the tree canopy to observe patterns in how different species of trees are distributed in the stand around them during *Station 4: Forest Succession*

learning objectives for each station remained the same in the paper version, so while the two experiences were not identical, they covered the same concepts and material, making them equivalent versions of the same curriculum.

We used a pre- and post-survey consisting mostly of five-point scale Likert-type questions to measure (1) affective attitudes; (2) connection to nature; (3) engagement; and (4) content knowledge. The affective attitude section asked students to what degree they agree or disagree with prompts asking about their feelings about four prominent themes within the DT experience: science, nature, art, and digital technology. The connection to nature section combined items from the Connectedness to Nature Scale, a commonly used scale that was developed to measure an adult's emotional connection to the natural world (Mayer and Frantz 2004), and a modification of this scale that was adapted for fourth-grade participants (Cheng 2008). The combination of items designed for adults (Mayer and Frantz 2004) and fourth-grade students (Cheng 2008) was chosen to tailor our study for middle and high school learners.

The engagement section, on the post-survey only, included Likert prompts designed for this study and guided by the definitions for each engagement component (adapted from Cheng and Wu 2015) about how students perceived their own engagement during the experience. Items included statements like "the lessons on the trail were enjoyable" and "I often found my mind wandering from what I was supposed to be focusing on." The content knowledge section was designed to assess student understanding of four Next Generation Science Standards crosscutting concepts that are integrated into the DT curriculum: stability and change, cause and effect, patterns, and systems (NGSS 2013). The pre-surveys also collected basic demographic information and contained one open-ended question asking the students what they hoped to learn on the DT. The post-surveys included an additional section asking about specific activities on the DT, and three open-ended questions about what students learned, what they enjoyed, and what they disliked during the field trip. Illegible responses were not included in the analysis.

Additionally, we conducted participant observation and recorded extensive field notes during the trail experience. One researcher stationed herself at several stops along the trail—enough out of the way so as not to distract the students yet within hearing range of student conversations—and observed groups as they engaged with the inquiry and content at that stop. Field notes focused on engagement-specific behaviors such as: (a) "heads-up observations," when the learner responded to the curriculum by observing their natural surroundings; (b) "pointing," which indicates the learner is connecting a concept learned in the program to their natural surroundings, and (c) "tactile investigation," which indicates a learner is using touch to investigate a natural object that is referenced in the curriculum (McClain and Zimmerman 2016). Observations also noted distraction, socialization about off-task topics, and non-curriculum focused behaviors. We also interviewed both teachers before and after the field trips. These interactions contributed insights about the DT experience as a whole, while also capturing additional information about the teachers' expectations and experience with the tablets, expectations for and observations of student learning and engagement during the experience, observations of field trip impacts in the classroom, and overall satisfaction and perceived usefulness of the DT experience.

Statistical analysis of the Likert survey data was completed using the statistical software SPSS (IBM 2019). The shift in mean between the pre- and post-surveys was calculated for each component. Unpaired t-tests using the change of mean between the pre- and post-surveys were used to identify statistical differences in pre- to post-survey shifts depending on medium, i.e. tablets or paper books (Table 33.3). Paired t-tests were used to find differences between the pre- and post-surveys, which allowed us to see whether any of the measured constructs

Table 33.3 Statistical results from unpaired t-tests conducted on the mean pre- to post-survey shifts and on mean post-survey engagement scores between tablet and paper book-users. Threshold for significance is a p-value < 0.05

Construct	*N*	Mean shift in tablet-users (SD)	Mean shift in paper book-users (SD)	*p*-Value
Attitude toward *science*	84	0.131 (0.530)	−0.026 (0.566)	0.183
Attitude toward *nature*	84	0.103 (0.347)	0.038 (0.473)	0.471
Attitude toward *art*	84	−0.048 (0.386)	0.0179 (0.447)	0.474
Attitude toward *digital technology*	84	0.0159 (0.016)	−0.0519 (0.495)	0.531
Connection to nature	84	0.170 (0.358)	0.0003 (0.601)	0.170
Content knowledge	64	0.353 (0.884)	0.133 (1.008)	0.357
Construct	*N*	*Post-survey mean in tablet-users (SD)*	*Post-survey mean in paper-book users (SD)*	*Sig (2-tailed)*
Engagement	85	3.362 (0.492)	3.334 (0.569)	0.809

changed before and after the DT experience regardless of the instructional medium used.

Short-answer survey responses, interviews, and field notes were coded using an emergent thematic analysis (Hesse-Biber and Leavy 2008). Transcripts were read multiple times, noting themes in the margins. Themes were then condensed into codes to eliminate redundancy and a codebook was created for each data source. All data were then re-coded with the associated codebook, and codebooks were adapted if/when new themes arose. Data were then deductively analyzed with the final codebooks when no new themes arose. All results reflect categories of related codes that emerged in this final stage of the analysis.

33.4 Results

33.4.1 Survey Questions

For each of the constructs we measured (attitudes, connection to nature, engagement, and content knowledge), Likert scores were aggregated into a single mean and checked for reliability with a Cronbach's alpha test. Knowledge questions, each worth one point, were scored right or wrong out of five. Only participants that responded to at least 75% of the questions within each section were included in the analysis for that section.

Results from the paired t-tests showed a significant increase in content knowledge after the DT experience across all students. Before the DT experience, the average score out of five questions was 67%, whereas 73% answered correctly after the experience. These results indicate that both versions of the curriculum are effective at facilitating content engagement, at least enough that students are learning concepts. However, we did not find any statistically significant differences between the students that used tablets ($n = 51$) versus the students that used paper books ($n = 43$).

However, the survey likely did not capture the whole picture. We found no statistically significant differences between the pre- to post-survey shifts that occurred between the tablet and paper book-users (Table 33.3). This result shows that neither medium seems to be better or worse than the other, at least statistically. The qualitative participant observation data shows a more nuanced and different result than the survey, and thus provides a richer understanding of student engagement.

33.4.2 Participant Observation

Participant observation data showed that there were indeed barriers to engaging with content and place on the DT, though different barriers were associated with the tablets and the paper books. For example, groups using the tablets expressed frustration when experiencing technology issues, such as slow Wifi. Negative emotions, like frustration due to technology not working properly, can negatively impact a student's affective engagement (Reeve and Tseng 2011). Although students using paper books did not experience technology-related frustration, we did observe them skipping entire sections of the lesson, shuffling past some pages of instruction, a clear sign of being disengaged from the content. This is a challenge specifically associated with the paper books because the tablets require responses on each page before advancing the screen. Therefore, tablet-users needed to participate with the content on each page at some level.

There were also barriers observed *across* the tablet and paper book groups. Regardless of medium, students frequently expressed frustration with the number of questions embedded in the lessons and the difficulty of the questions and content. When a lesson is too challenging for a student, they often disengage (Turner et al. 1998). Students were also observed disproportionately engaged with the content rather than the place. Examples of place engagement, such as tactile investigation of objects in the forest or pointing out forest features to group members (McClain and Zimmerman 2016), were rarely observed in either group. Students were frequently observed spending a majority of their time at each station looking down at the tablet or paper book. Since this was seen across all student groups, the curriculum itself could be a barrier to place engagement, not the medium of transmission. While this detail was not reflected in the survey data, it is an important result.

33.4.3 Teacher Interviews

The pre- and post-interviews with the two teachers gave further insight into the DT experience, teacher perceptions of student engagement, and teacher thoughts on tablet-usage in general. The teachers stated convenience, ease of use, and multimedia capabilities as the main benefits to using tablets on the DT. They did not perceive any significant limitations. When asked to identify key differences between how students engaged with the tablet versus paper curriculum, neither teacher observed major differences in the level of commitment students were putting forth to complete the lessons. This result is notable because psychological investment to learn a lesson is one sign of cognitive engagement (Fredricks et al. 2004). One teacher said that regardless of medium, the students "were engaged with [the experience]. They were curious. They paid attention." Both teachers also expressed positive feelings toward using the tablets and thought the multimedia elements were exciting and novel for the students, feelings that can increase engagement (Fredricks et al. 2004).

Although the teachers did not perceive any significant content engagement limitations with the tablets, they had concerns about the difficulty of the curriculum for middle school-aged students. This finding also was reflected in the participant observation field notes. To mediate this concern, one teacher suggested two different versions of the DT curriculum, one for middle school learners and another for high school learners. They also had insightful ideas about how to modify the curriculum to increase engagement specifically for middle school learners and thereby improve the student experience. We plan to partner with the teachers in the future as we revise the curriculum.

33.4.4 Open-Ended Survey Questions

The four short open-ended questions on the surveys also provided deeper insight about the student experience. Two primary themes emerged during the qualitative analysis. The first identified a disconnect between what the students wanted to learn about and what they actually learned on the DT. For example, “forest animals” was the most frequent answer to the question “what do you hope to learn about at H.J. Andrews?” (36%). The second most common response was “climate change” and what they can do in their personal lives to mitigate environmental damage (24%). Currently, neither of these subjects are prominent in the curriculum. Students are more likely to be cognitively engaged in the content when they are interested in the subject matter, so adding more material in line with student expectations and interests, or better preparing learners for the experience and what to expect, could increase their overall engagement (Fredricks et al. 2004).

The second theme that emerged was that the experience was too much work and too little fun. When asked what their least favorite part of the DT experience was, 33 of 73 responses (45%) indicated *doing the work on the DT*. More specifically, students noted that there were too many questions, the videos and readings were too long, and the stations included too many activities.

Notably, when asked about their favorite part of the experience, the highest number of learners mentioned the silent sensory walk (23%). Other common responses described being present in the forest, for example: being outside, smelling and hearing the forest, walking on the trails, and being in a peaceful and quiet environment. Having a positive emotional reaction to the experience is a critical component of being affectively engaged, so if the experience featured a more satisfactory balance between focused learning and free exploration in the forest, the students might not only learn more, but also have a more positive experience (Fredricks et al. 2004). When students are cognitively engaged in work, but not provided sufficient opportunities to fully engage with the forest to facilitate other kinds of engagement, their overall engagement level will be sub-optimal. The challenge with responding to this critique is that teachers cannot justify a forest field trip if the experience does not satisfy classroom learning objectives. At the same time, biocultural conservation goals are not accomplished if the students are disengaged in the experience. We will have to negotiate this balance moving forward. Longer field trips would offer one solution, allowing us to provide equal time doing structured learning activities and unstructured exploring, though the remoteness of the site makes longer trips challenging unless they are overnight.

33.5 Discussion

Upon triangulating the results from the surveys, observation notes, and teacher interviews, we draw three main conclusions. First, some differences exist in engagement between students that use tablets and students that use paper on the DT, but neither greatly outweighs the other in contributing to engaged/disengaged behaviors. Second, on the DT, engagement with content and place depend more on the curriculum itself rather than the medium that is used to deliver the curriculum. Third, tablet-led experiences can be modified to increase both content and place engagement to facilitate an overall more enjoyable and beneficial experience, thereby supporting broader learning goals. Making thoughtful modifications to the curriculum can contribute to a more enjoyable experience for the students while also increasing their engagement. This effort will allow a better balance between place and content engagement, and ultimately positively impact place relationships, affective engagement with the forest experience, and biocultural conservation outcomes.

The study described here applies our previous field philosophy work in a new direction by exploring the impacts of short-term experiences in place and with younger learners, who are less steeped in the theoretical and popular culture dialogues about environmental issues, responsibility, and history. Recent scholarship on the DT demonstrates that these types of short-term, ethically grounded approaches to field-based environmental science, arts, and humanities (eSAH) learning can catalyze both passive and active place relationships (Goralnik et al. 2020), whereby learners either feel cared for by the forest, or even develop the motivation to care for the forest, as a result of their eSAH trail experience. This is a novel finding, as most place relationship literature focuses on repeated interactions with place over time. While longer-term immersive experiences in place are likely preferable for a host of reasons (Ardoin 2006; Kudryavtsev et al. 2012; Semken et al. 2009; Wattchow and Brown 2011), they are not always feasible for broad audiences, and may not even be appropriate for learners with little experience in the natural world, who need to acclimate to the sensory experience and conditions of learning beyond the classroom. The present study narrows the focus of our previous work on the DT to begin to understand more concretely why and how students engage during the eSAH trail experience. This work is important because engagement, especially emotional engagement, is integral to the learning process, and also a key ingredient in the development of care for the natural world. Therefore it is a necessary step toward biocultural conservation.

33.5.1 Limitations

All participants were middle school students belonging to a single middle school. While our results are relevant for this age group, our sample is small and the research is exploratory. More research is necessary to understand engagement across audiences, including high school learners, who are a target audience for the DT. We also experienced some incomplete data due to survey logistics and miscommunication between the teachers and the research team. In future studies on the trail, we will mediate these challenges with more streamlined and focused data collection tools and processes. Finally, our results are rooted in the context of a specific eSAH curriculum created for the DT experience. More research is necessary to understand this comparison across contexts.

33.5.2 Suggestions for Best Practices and Next Steps

While our results are exploratory, they do address novel and relevant questions related to innovative field philosophy methods. By identifying barriers to content and place engagement, we can revise the curriculum to provide a more meaningful, personal forest experience that engages and immerses students in place and with the forest ecology, art, and humanities content. Our sense is that there are more subtle differences between the tablet and paper curriculum experiences that are not reflected in our data, therefore we intend to further develop the qualitative data protocol (perhaps including interviews with student participants) to better capture the student experience. This insight will help us revise the curriculum in a way that it increases both content and place engagement by including more "heads up" prompts. These activities will reduce the time students spend looking at the tablet screen and encourage deeper engagement with place. In practice, these prompts can involve asking students to look for and observe specific objects in the forest, as well as encouraging them to engage in more tactile or sensory investigations. We can also incorporate additional audio narration into the curriculum that invites students to set down their tablets and fully sense their surroundings without the screen. Currently there are several activities like this in the DT curriculum, including the sound mapping activity, a color observation activity, and a drawing activity. This kind of passive tablet use simultaneously facilitates both content and place engagement and offers an effective way to balance the benefits and limitations of technology use in field learning environments for biocultural conservation.

Acknowledgments We conducted this research at H.J. Andrews Experimental Forest, which is funded by the US Forest Service, Pacific Northwest Research Station, and the National Science Foundation LTER Grants: LTER8 DEB-2025755 and LTER7 DEB-1440409. We would also like to acknowledge Adam Kennedy, whose work with the digital curriculum and database management made this project possible, and Ginny White, Chris Smith and Matt Viehdorfer, who developed the application and database for the digital curriculum. We appreciate the support of an anonymous donor to the Discovery Trail and the NSF Graduate Research Fellowship Program, which supported the lead author's contributions.

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