MEASURING THE IMPACT OF USING MOBILE DEVICES ON STUDENT LEARNING IN AN OUTDOOR SCIENCE CLASSROOM

by

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DEDICATION

For my Mom

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ABSTRACT

The purpose of this study was to measure the effect of using mobile devices on student learning in outdoor science instruction. Quantitative and qualitative data were collected to determine if there was a measurable change in student mastery of content and in students' attitudes towards science instruction outdoors. Additionally, the study aimed to discover if students' use of mobile devices facilitated self-guided learning. The intervention took place over an eight-week period in the winter of 2015, involving 33 seventh grade science students at New Canaan Country School, an independent suburban day school in New Canaan, CT. During the intervention, students completed a unit in the field on forest ecosystem structure and function. One group used mobile devices for tasks in the field while the other group worked without devices. During the second field unit on winter adaptations, the intervention switched so that by the end of both units of instruction, each group had used mobile devices. Assessments were administered during and after each unit; students also completed attitude surveys and questionnaires, and they participated in interviews.

INTRODUCTION AND BACKGROUND

New Canaan Country School, a pre-K to 9th grade independent day school in New Canaan, Connecticut, occupies a 75-acre suburban wooded campus. The acreage includes a vernal pond with boardwalk, outdoor classroom, ropes course and challenge structures, and miles of trails through hardwood and conifer forests. We have well-equipped laboratories, Smartboards on the walls and carts full of iPads, as well wireless Internet access in every building. Every student in the seventh, eighth and ninth grades carries a laptop to school and checks homework on the school website. Technology has become an integral part of a student's day at Country School. These are students of privilege for the most part, and there is an increasingly wide socioeconomic gap between the majority of the population of 600 students and the percentage of those receiving financial aid. Our student body self-identifies as 20 percent diverse, and there is an even gender split across the four divisions on campus: Early Childhood, Lower School, Middle School and Upper School. I teach seventh, eight and ninth graders – our Upper Schoolers. My class sizes vary, from as small as nine to as large as nineteen. Math classes are tracked by ability starting in the seventh grade. This creates a de facto tracking in science classes, funneling students into eighth grade sections as well, since the schedule backs science and math. By ninth grade, science is tracked intentionally; there are standard and honors classes in biology.

The school's mission statement declares that we value the "curiosity of children and respect childhood as an integral part of life." The mission further defines our work with students to include the teaching of environmental responsibility. With the societal changes impacting childhood that have caused what Richard Louv (2005), author of "Last Child in the Woods'" has termed "nature-deficit disorder," there has never been a more important time to get students outside to explore their world. My goal this school year was to get out of the classroom to teach science and to instill that environmental responsibility in my students by using our campus forest as our classroom. Outdoor education can provide meaningful contextual experiences that expand classroom instruction (Knapp, 1996) and create "place-conscious" learners who develop an ethic of care for their surrounding natural communities (Smith and Williams, 1999). Since technology has become so ubiquitous at school, it seems counter to being in nature to bring technology outdoors, but mobile devices have made it possible for teachers to take to the woods with new tools for teaching, and for their students, new ways to learn. My students have become so proficient in technological skills that regardless of their track in math or science, any one of them can find his or her way around a laptop, tablet, smartphone, or almost any other mobile device. They tend to communicate and share more on these devices than in person, and there are very few students who do not own some type of device.

Educational researcher, Sugata Mitra, winner of the 2013 TED Prize, said that "unlocking the power of new technologies for self-guided education is one of the 21st century superhighways that need to be paved." (Mitra, 2013) Before I took my classes down to the trails and into the woods this past fall, I asked students to download an application (app) called "LeafSnap" for identifying trees. Without previewing or instruction from me in the use of the app, students were soon teaching each other how to snap a photo, enter it in the database, compare it to the list of possibilities, and then once identified, add it to a collection for the trees in their assigned campus plots. They brainstormed other apps that could be used outside to add to their plot descriptions and inventories, and when we got back to the classroom, they made a list of what else they might want to know and how they could find out about it using their mobile devices for our next outdoor class. Over the course of the unit, they recorded audio, stills and video, global positioning systems (GPS) coordinates, elevation, and wind speed using smartphones, iPod Touches, and iPads. They found apps I had never heard of and taught me how to use them. The level of engagement and interest displayed by students during the outdoor activities in this unit was notable for the time and focus sustained on the tasks and the amount of direct communication between students. They were more engaged in the tasks and more cooperative with each other as they collected data – much more than I observed during our classroom lessons or during experiments they conducted indoors which were designed to meet similar expectations. It wasn’t too much of a stretch to assume that my students would be enthusiastic about going outside because they are rarely out of the buildings for academic classes, but I didn’t expect the degree of focus and engagement I observed.

I was curious to know whether the experiential nature of learning science outdoors was enhanced by the use of mobile devices. My research questions were: 1) In what ways does the use of mobile devices impact learning in outdoor science instruction? 2) Does the use of mobile devices change student attitudes towards learning science outdoors? 3) Will the use of mobile devices impact the level of a student's self-guided learning?

CONCEPTUAL FRAMEWORK

Using technology in the classroom has evolved from the days of a few teachers on campus that were early adopters using computers as productivity tools, to today, when entire student populations are working on laptops and carrying handheld, mobile devices throughout their school days. This evolution has happened rapidly over the past two decades and with implications for student learning that are unfolding just as quickly. Educational researchers could barely keep up with the pace of change a decade ago as new devices and their technologies became a part of the learning landscape (Guri-Rosenblit, 2005). Internet access and the ease with which apps can be downloaded to portable computing devices have made more information available to learners than ever before. Opportunities for self-guided learning have increased as a result of these powerful tools in students' hands that don't necessitate a teacher's direction or even presence.

Modern technology in outdoor science instruction may seem like an oxymoron; it can be argued that getting outside and back to nature to teach should have the additional benefit of getting students to unplug and get away from looking at screens. It has been noted that electronics and mobile devices in nature-based experiential learning may serve to compromise and further separate a learner's connection to the natural world (Cuthbertson, 2004). However, after my experience teaching the seventh graders' fall unit with smartphones and tablets, I wondered about the potential for enhancing instruction and improving student learning in science through their use, so that became the focus of my research this spring.

There is evidence for the positive role of mobile devices in inquiry-based science learning; some studies show an increase in student comprehension with their use. Researchers in Sweden used a high school environmental science class in their test case for the potential of smartphones, digital pens and probes to increase students' engagement in data collection. The students reported that using smartphones in the field was fun, that it expedited the work, and their post-questionnaire responses indicated that upon reflection, they increased their understanding of the topic (Vogel, 2010). For a bird-watching activity with elementary school students in Taiwan that employed mobile devices to scaffold students' observational skills, a formative evaluation of the activity found that children had exceeded the learning expectations of the activity's goals (Chen, Kao, & Sheu, 2003).

Other studies discovered that students used mobile devices to teach themselves. A game called *Savannah*, designed to be played outdoors using GPS-enabled devices to help students understand animal behavior, was shown to encourage self-directed learning among the children in the simulation at an elementary school in the UK (Benford, S., Rowland, D., Flintham, M., Drozd, A., Hull, R., Reid, J., Morrison, J. and Facer, K. (2005); Facer, K., Joiner, R., Stanton, D., Reid, J., Hull, R. and Kirk, D. (2004). Project *Ambient Wood* (Rogers, Y., Price, S., Fitzpatrick, G., Fleck, R., Harris, E., & Smith, H. (2004) had 10-12 year olds exploring woodlands with an assortment of mobile technologies. The researchers concluded that collaboration and self-directed inquiry processes among the children were very much in evidence (Rogers, et.al., 2005).

The potential not only to impact student attitudes towards learning but for students to construct new meaning from outdoor experiences using technology was also shown in the literature. In an experiment testing fifth graders' level of knowledge about plants in their school garden, the class using mobile technology to support their outdoor learning demonstrated greater gains in the acquisition of new knowledge and learning in context than the class that didn't have the support of mobile devices (Lai et al., 2007). Similarly, the authors of a science learning activity for fourth-grade science club members studying aquatic plants created a mobile learning environment that they found increased knowledge and understanding of the content as well as students' learning motivation (Liu et al., 2009).

While there is certainly mounting evidence for the successful implementation of mobile technologies in outdoor investigations to improve student learning, there are challenges as well – for both teachers and students. In classifying mobile learning, Frohberg (2006) defined the use of mobile technologies by context; physical context is one in which their role is to provide support to a learner who explores a designated learning environment, such as a farm, museum or forest. The student gains knowledge through making his own experience, determining his own focus and cooperating with other learners. Frohberg notes that learner- centered settings are inherently difficult to manage since despite the independent nature of the learner's process, the teacher must still scaffold, coordinate and ultimately control the activity. Observations of the limitations of mobile devices in outdoor settings include students who become too distracted by their devices and students who work alone when the activity's intent was collaboration. Other concerns are the risks of technical problems, inappropriate uses of mobile technologies and the addiction to electronic stimuli (Morgan, 2010).

Additionally, in a small study done by a researcher in a university setting, the author found that all undergraduates surveyed agreed that using mobile devices could support science learning, with a later finding that when students used their devices in the field, retrieving data was problematic unless students were given time and instruction for using cloud storage tools (Nykvist, 2012). For science teachers of middle school students, planning time to debrief students and to help them organize data once it's retrieved from their devices is essential to minimize information overload and to manage how that data is recorded and backed up.

Still, an overview of the research on inquiry-based science investigations in informal settings reporting the benefits to student learning of handheld, mobile technologies significantly outnumbers those studies identifying disadvantages. The results of one pilot study in which fifth graders did field work at a pond are mirrored in many results of outdoor studies that have integrated mobile technologies: students were motivated and engaged in collecting authentic data and they connected their questions to the data while in the field, so they were able to construct meaning and advanced understandings from their investigations (Stuadt, 1999). The ubiquitous nature of mobile technology provides educators with the opportunity to tap into students' everyday use of their devices to unlock powerful learning tools for outdoor science education.

Determining the actual benefits and advantages to student learning that mobile devices afford was the focus of my study.

METHODOLOGY

I chose my two largest seventh grade classes for an intervention in the winter of 2015 to investigate my research questions, which were: 1) In what ways does the use of mobile devices impact learning in outdoor science instruction? 2) Does the use of mobile devices change student attitudes towards learning science outdoors? 3) Will the use of mobile devices impact the level of a student's self-guided learning? There were 33 students in the study; 14 boys and 19 girls. Most were academically average to above average students in a pre-K to 9, independent school population that is 20% students of color. The academic environment is competitive, particularly with respect to secondary school placement, and as such, students are motivated to earn good grades. Approximately 80% of the ninth grade graduating class will go on to attend private day and boarding secondary schools.

For the first unit of instruction, the class of nineteen students used their mobile devices in the field while the class of fourteen went into the field but did not use their devices. Next, a second unit was taught outdoors with no use of devices for the class of nineteen, while the class of fourteen brought their devices to perform tasks outside. See Table 1 below for the sequence of the treatment and non-treatment units with their respective curricular components.

Table 1
Schedule for Treatment and Non-Treatment Units

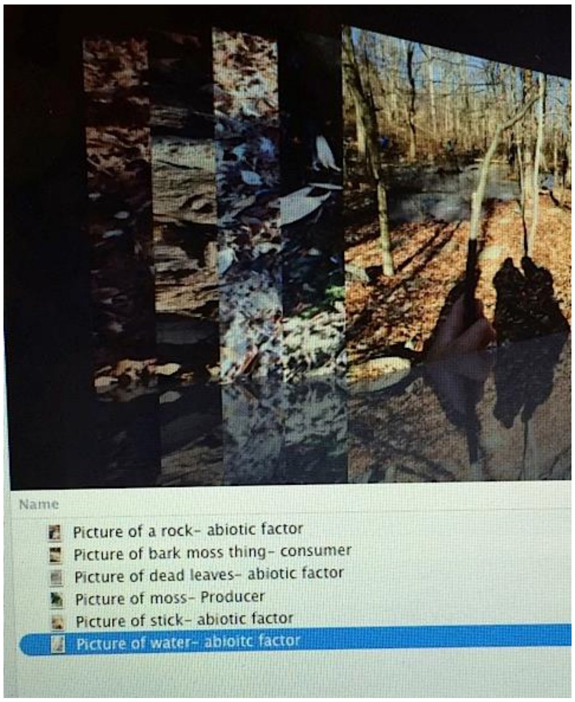
	UNIT 1 Jan. 5 – Jan.30, 2015	UNIT 2 Feb.2 – Feb.27, 2015
Group A	TREATMENT GROUP mobile devices used for unit on deciduous forest ecosystem structure and function <u>unit content</u>: food web and nutrient cycling (using the device's camera and apps: *Leaf Snap, Journey North, Backyard Scats and Tracks,* elevation, maps, weather)	NON-TREATMENT GROUP no mobile devices used for unit on winter adaptations of organisms <u>unit content</u>: relationships between adaptations and abiotic factors (using hard-copy field guides and students' field journals)
Group B	NON-TREATMENT GROUP no mobile devices used for unit on deciduous forest ecosystem structure and function <u>unit content</u>: food web & nutrient cycling (using hard-copy field guides and students' field journals)	TREATMENT GROUP mobile devices used for unit on winter adaptations of organisms <u>unit content</u>**:** relationships between adaptations and abiotic factors (using the device's camera and apps: *Critter Trax Lite, iTrackWildlife Lite, Backyard Scats and Tracks, Eco Map Lite*, elevation, maps, weather)

Both units covered the same respective content across the treatment and non-treatment groups and required students to perform the same unit-specific tasks. To discover if there was an impact on student learning, I administered the same teacher-generated summative and formative assessments to both groups to assess their mastery of the content in each unit. A survey was administered pre- and post intervention to both groups to assess any change in student attitudes towards learning science outdoors (Appendix A). A questionnaire asked students to report in writing on their engagement in lessons as a result of using mobile devices, as well as to reflect on any opportunities for self-guided learning that resulted from their use (Appendix B). Students self-selected to be interviewed based on their answer to item number 9 on the questionnaire, which asked if they would be willing to discuss their responses (Appendix C). See Table 2 below for the triangulation matrix with my data sources.

Table 2
Data Triangulation Matrix

Focus Questions	Data Source 1	Data Source 2	Data Source 3
Primary Question: 1. In what ways does the use of mobile devices impact learning in outdoor science instruction?	Teacher-generated tests: baseline, pre- and post-intervention	Formative assessments	Teacher observations and journal
Secondary Questions: 2. Does the use of mobile devices change student attitudes towards learning science outdoors?	Pre- and post intervention student survey	Student questionnaire/ interview	Teacher journal
3. Does the use of mobile devices impact the level of a student's self-guided learning?	Student survey	Student questionnaire/ interview	Teacher journal

Students in treatment groups created digital portfolios of their field observations by downloading, labeling and organizing their photos on their laptops (*see Figure 1*). During the non-treatment testing periods, students used lab notebooks in place of mobile devices. They recorded objects similar to those found by students in the treatment group but their observations lacked a visual component, even though they were encouraged to draw or sketch what they found *(see Figure 2).*



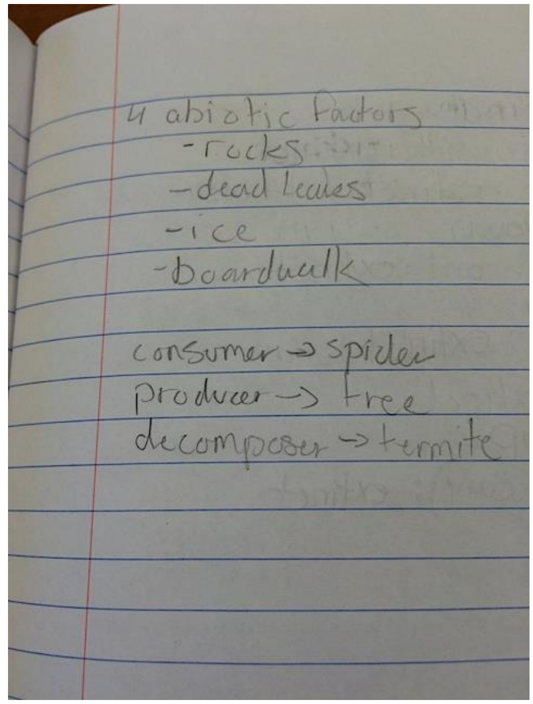


Figure 1. Student digital photo portfolio. *Figure 2*. Nontreatment student record of observations.

The two classes chosen for this study were sectioned heterogeneously; they were not tracked by ability. However, my class of nineteen students has been consistently weaker academically this year than my class of fourteen students, in which a majority of the students take accelerated math.

The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained (Appendix E).

DATA ANALYSIS

Data were analyzed to compare results of test scores before and after each topic unit to see if student use of mobile devices suggested better mastery, comprehension and application of content. Qualitative data were collected to measure any shift in student attitudes towards learning science and to see if there was any evidence of self-guided learning in an outdoor setting when specific mobile apps were integrated with instruction.

Impact of using mobile devices on learning

Overall, the impact on student learning is inconclusive. However, the approach did seem to increase learning for students in the higher achieving group (n = 14). Their average score was significantly higher on the test taken after the treatment than the non-treatment test. The formative assessment *Exit Card* helped me determine the degree to which students were able to assimilate some of the more difficult vocabulary in the unit (Appendix D) and as such, provided me with a focus for scaffolding the continuing introduction of new terms when needed. This same group's Exit Card results reflected a higher average score and better self-reported comprehension during the treatment period as compared to the non-treatment period. For the lower achieving group (n = 19), there seemed to be no effect whether there was treatment or not. Their mean scores were pretty much unchanged for both the test administered after treatment and for the test with no treatment during the unit. Their formative assessment results mirrored their test results. For both Exit Cards administered to this group, responses indicated no change in their comprehension of the vocabulary, and students did not self-report improved mastery of the content. See Table 3 for treatment and non-treatment scores for both groups.

Table 3
Treatment and Non-treatment scores

TEST 1 *Ecosystems: Populations & Food Webs*	TEST 2 *Ecosystems: Abiotic Factors & Adaptations*
TREATMENT *Mean: 77.9%* *St. Dev = 4.6* *(n=19)*	TREATMENT *Mean: 91.8%* *St. Dev = 2.7* *(n=14)*
NON-TREATMENT *Mean: 85.1%* *St. Dev = 3.6* *(n=14)*	NON-TREATMENT *Mean: 78.9%* *St. Dev = 2.8* *(n=19)*

In comparing the two groups' pre- and post- treatment test score class averages, the higher achieving group's (n=14) gain score percentage was 49.63, much greater than the other group's, at 6.65%.

<u>Student attitudes towards learning science outdoors with mobile devices</u>

The impact of the use of mobile devices on student attitudes was positive. Data was collected using Likert scale survey and questionnaire responses before and after the treatment periods to determine shifts in attitudes. Pre-treatment surveys showed that the entire population of students was predisposed to a positive learning experience outdoors as evidenced by their "agree" (36%) and "strongly agree" (64%) responses to the statement, "I enjoy learning science outdoors." Their post-treatment responses to the same statement were identical. Pre- and post-treatment surveys (Appendix A) reflected 82% and 84% agreement respectively with the statement "I think that using a mobile device for an outdoor science class will help me learn the content better." When asked in the questionnaire (Appendix B), the majority (82%) of students indicated that they enjoyed the class more when using mobile devices. Students indicated that the use of mobile devices helped them better visualize concepts. For example, one student said, "using my device always makes me enjoy class more because you can look at the pictures you took and really figure out what is going on." Additionally, many students commented on how using mobile devices increased ownership. For example, one student said, "I enjoyed using my mobile device outside during science class because we got to use interesting apps that were on our phones or electronics and we got to do the work and tap into our creative sides with photos and projects that were based on what we did outside."

While the entire study group remained unanimous in its outlook on their enjoyment of outdoor science education, and questionnaire responses revealed that adding a mobile device had a generally positive effect, not all students were supportive of technology's role in enhancing their learning experience. In some cases the addition of a mobile device became a distraction. Whether or not distractibility as a factor in learning could be attributed to the use of phones and iPads was perceived as a possibility for 33% of students before the treatment. After treatment, fewer students saw distractibility as a potential problem, but 24% still agreed with the statement, "I think that using a mobile device for an outdoor science class will distract me from learning." One seventh grader wrote on the questionnaire in response to "While working with your device outside, was it helpful to have the device as a learning tool?," "These devices almost take away from the world that surrounds us, and though the devices are helpful I dislike strongly using them in the outdoors. When I walk outside I want to play and learn and have fun, not being forever linked to Wi-Fi and connection." Another student had a similar comment: "I think that it takes you away a little bit." This factor of distraction could have been due to taking attention away from experiencing the outdoors because of having to focus on the device, or could have been due to the distraction inherent in the device. The ability to stay on task and to employ a tool for its appropriate and intended use were mentioned in more than one interview with seventh graders in this study. In a somewhat resigned-sounding comment, a seventh grade boy told me that "I did it because it is now what modern technology is, and it should be used, but for me it is also a distraction." In follow-up interviews, students were asked to elaborate on their questionnaire comments, and one noted, "… using our phones makes science fun if you use it for the right things."

Evidence of self-guided learning with mobile devices

Due to the autonomy afforded a learner with a handheld mobile device in the field, I was interested to know if access to mobile devices would lead to online exploration of related content. Survey results showed that students might have engaged in self-guided learning more often when given the tools and the opportunity to use them during the treatment period. There was a substantial increase between pre- and post-treatment survey responses - from 18% to 39% - from students who agreed with the survey statement, "I think that using a mobile device during science class outdoors gives me the freedom to learn things on my own." If learning something well enough, absent a teacher's direction, to teach it to someone else can be considered evidence of self-guided learning, then a number of students were teaching themselves and passing their knowledge on to their peers during this study. They most commonly found themselves showing classmates how to use apps, and one response was more specific, recalling that the student taught a peer "what squirrel tracks looked like." One of my more quiet students, someone who is usually not likely to ask a question, told me in our interview, "if I don't know something about what I am looking for I can ask Siri or use one of the many science apps that I've downloaded – it creates a more fun and interesting environment and allows the opportunity for hands-on learning of science."

INTERPRETATION AND CONCLUSION

My research focused on the following three questions: 1) Does the use of mobile devices impact learning in outdoor science instruction? 2) Will student attitudes towards learning science change if they use mobile devices during outdoor instruction? 3) Is there any evidence that the use of mobile devices impacts the potential for students' self-guided learning?

In looking at whether or not the use of mobile devices had a measurable and significant effect on learning outdoors, this study showed that their use actually correlated with higher assessment scores, but only for a particular group of my students. Outcomes for the strongest math and science students were significantly higher with mobile devices than for those who were academically weaker. Students reported better recall and retention of content, improved connection to the content in context, and a sense of being in charge of their own learning. It may be that on a developmental continuum, those adolescents who were conceptually more advanced could apply and transfer the potentials for learning with a mobile device more readily than those not as far along on the developmental trajectory. For my weaker students, smartphones and iPads may have been more of a novelty, and from their relative status value (which model do you have?) to their entertainment value (what games did you download?), those concerns superseded their value as academic tools and a student's ability to focus on them as such. Even though these pre-adolescents have grown up with a lot of technology, it didn't necessarily follow for them that using these tools in an academic setting was a logical extension or even intuitive in the case of using educational apps. It's possible that the huge increase in children's access to smartphones has been recent enough that my students' generation hasn't had the advantage of fully integrating them into their academic lives.

The results of my study were not conclusive enough to say that they support earlier research showing students increased their understanding of topics when using mobile devices for fieldwork (Vogel, 2010). There was some positive quantitative impact for one group of students on a unit assessment, but the qualitative feedback from all students was definitive: they enjoyed class more with their devices. During the treatment, students were observed collaborating, showing each other their photographs, and documenting their experiences. Their level of engagement and communication around the content seemed greater than in the classroom; this increased level of motivation and engagement has been observed in earlier studies (Staudt, 1999). Students were asking each other questions to confirm or clarify their use of the apps with respect to the content they were finding. Some of the students I have who tend to be either quiet or academically weak and don't risk asking questions in class, were outside using their phones, eager to ask questions, to show me what they found, and to describe their observations. Additionally, it should be noted that a small percentage of my students identified an issue that emerged for them, one described by Cuthbertson (2004): that electronics in nature-based experiential learning may serve to compromise a learner's connection to the natural world.

VALUE

This study has confirmed for me that mobile devices can be valuable learning tools in outdoor science classrooms. While the quantitative results of the study only showed gains on a single set of assessments for a specific population of students, there was qualitative evidence that pointed to improved attitudes among the entire test population with the use of mobile devices. The treatment in this study increased a majority of students' enthusiasm and willingness to participate actively in lessons and for that reason, I'll continue to include the use of smartphones and tablets when we go outside. Digital photography and video recordings could become more prominent in students' demonstrations of their mastery of content since many students said that their photos were helpful for retention of vocabulary and for review. Additionally, the visual and audio digital components of field observations can help facilitate differentiation for a wider range of learners by providing them with another avenue for collecting and recording data.

I also plan to leverage the advantages of mobile devices with experiential science in ways that may benefit my quieter and risk-averse students. There were a number of occasions during the treatment units of this study that these students were more engaged and collaborative with their peers and with me than they were typically in the classroom. The autonomy that mobile devices allowed them in our informal, natural settings seemed to empower them to communicate more freely.

After hearing my students' opinions about the potential for distraction while using their devices, I plan to create curriculum for outdoor science education in the future that integrates technology, but also takes into consideration the learner's connection to nature. In reflecting on ways to help keep the use of mobile devices focused on positive interactions with nature instead of detracting from students' experiences, I think it will be important for me to remember that any device is just a tool. It should be part of the process rather than a focus of the lesson. For example, if we build trail markers for the Outdoor Classroom next fall, smartphones and tablets can be helpful in a number of different parts of the project such as site selection and plant identification. I can assign tasks that require specific apps for finding the information to include on the marker or to construct the marker frames. In designing rubrics for projects like this, the criteria for mobile devices' use can be outlined and expectations detailed for students to follow. With advance planning – reviewing and testing of apps - and careful scaffolding of the introduction of mobile devices into my lessons, I'll be assessing outcomes next school year to see if my students are benefiting. The results of this action research have convinced me that there could be greater potential for keeping students excited and invested in science by giving them the opportunity to use mobile devices in the field.

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APPENDICES

APPENDIX A

STUDENT SURVEY

To be given before and after intervention.

Participation in this research is voluntary and participation or non-participation in this survey will not affect your grades or class standing in any way.

1. I enjoy learning science outdoors.

Strongly disagree Disagree Agree Strongly Agree

2. I think that using my mobile device (smartphone, iTouch, etc.) during an outdoor science class will help me learn the content better.

Strongly disagree Disagree Agree Strongly Agree

3. I think that using a mobile device for an outdoor science class will distract me from learning.

Strongly disagree Disagree Agree Strongly Agree

4. I think that using a mobile device during science class outdoors will give me a chance to learn more than just what is assigned during the class.

Strongly disagree Disagree Agree Strongly Agree

APPENDIX B

STUDENT QUESTIONNAIRE

Purcell Data Collection Instrument: Student Questionnaire

To be administered after the treatment.

Participation in this research is voluntary and participation or non-participation in this survey will not affect your grades or class standing in any way.

Please answer these questions directly in this document.

1. Do you enjoy learning science outdoors? Why or why not?
2. What type of mobile device did you use outside during science class?
3. Did you enjoy using your mobile device outside during science class? If so, why? If not, why not?
4. While working with your device outside, was it helpful to have the device as a learning tool? If so, can you give an example? If using your device was not helpful, please explain.
5. Did you experience any difficulty with the use of your device while outside? If so, please explain the nature of the difficulty.
6. While working with your device outside, did you teach a friend something using your mobile device?
7. After using your device outdoors in science class, did you enjoy class more? Enjoy class less? Or did using the device not have an effect on whether you enjoyed the class or not?
8. Do you use a mobile device for any of your classes other than science? If so, state which class or subject area.
9. Would you be willing to participate in an interview about your responses to these questions?

APPENDIX C

STUDENT INTERVIEW QUESTIONS

Purcell Data Collection Instrument: Interview Questions

Prior to the interview, students were told that they were asked to participate in an informal interview because they stated they were willing to do so on the questionnaire they filled out. They were also told that participation in the research was voluntary, and participation or non-participation in the survey would not affect their grades or class standings in any way.

1. In your questionnaire, you indicated that using your mobile device outside was helpful and you gave an example of how you used it.
   In what way(s) was it helpful?

Did your mobile device allow you to:

- access information more quickly?
- record information more easily or in a new way?
- send information (to yourself or classmate or teacher)?

2. Did using your device help your understanding of the topic?

3. Did being able to use your device change your attitude towards going outdoors for science class?

4. Can you explain an instance during our classes in the field when you either taught yourself something new by using your device for something you hadn't originally intended to use it for?   Or did you teach someone else how to do something on a device? If so, what was it?

APPENDIX D

EXIT CARD FORMATIVE ASSESSMENT

Exit Card #1 – formative assessment administered during Unit 1

Number your index card from 1 to 4. Write the letter of the correct answer next to the number. Hand in your card on the way out.

Symbiotic Relationships
Answers:

A. commensalism
B. mutualism
C. parasitism
D. predation

Questions: For each pair of organisms, choose the letter of the answer that best describes their relationship.

1. tick - White-tailed deer
2. Eastern grey squirrel – Northern Red Oak tree
3. Red-tailed hawk - chipmunk
4. Raspberry Bush – Blue Jay

Exit Card #2 – formative assessment administered during Unit 2

Ecosystem Structure
Number your index card from 1 to 4.

1. Write 2 abiotic factors of our forest ecosystem.
2. Write 2 biotic factors of our forest ecosystem.
3. Write the name of a forest eukaryote and its niche.
4. Write the name of a different forest eukaryote. Write an adaptation it has evolved and what it's for.

APPENDIX E

IRB EXEMPTION

MONTANA
STATE UNIVERSITY

INSTITUTIONAL REVIEW BOARD

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MEMORANDUM

TO: Caryn Purcell and Eric Brunsell

FROM: Mark Quinn, Chair *Mark Quinn CJ*

DATE: November 24, 2014

RE: *"Use of Mobile Devices in an Outdoor Science Classroom"* [CP112414-EX]

The above research, described in your submission of November 24, 2014, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

_X_ (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

_X_ (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.

___ (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

___ (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.

___ (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

___ (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.