The Dissertation Committee for Gregg W. Orr Certifies that this is the approved version of the following dissertation:

Untethered Learning: A Mixed Methods Study of Mobilized Adventure Learning

Committee:

Paul E. Resta, Supervisor

Min Liu

Joan E. Hughes

Diane L. Schallert

Karen D. French

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by

GREGG W. ORR, B.A.; M.Div.

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Dedication

I dedicate this dissertation to my darling wife, Cherie, who has patiently encouraged, supported, and prayed for me through this long process. “Many daughters have done nobly, but you excel them all” (Proverbs 31:29, New American Standard Version).

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Untethered Learning: A Mixed Methods Study of Mobilized Adventure Learning

Gregg W. Orr, PhD

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Supervisor: Paul E. Resta

Mobile technologies now afford unprecedented opportunities, resources, and possibilities for learning. Among them, is the opportunity for students to engage in hands-on, out-of-classroom learning activities such as Adventure Learning. Since 2007, Adventure Learning has developed as an educational framework for using information and communication technologies to connect learners with expeditionary teams where video-based communication provides a sense of adventure for learners. The study was conducted in a public high school where an Environmental Science teacher used mobile learning technologies to create Adventure Learning projects where students participated both fin the classroom and as members of an “expeditionary team.” It was also intended to examine both the benefits and challenges in implementing ubiquitous mobile technologies in the field, combined with the use of student-centered pedagogies in their classrooms. The major questions of the study asked how did a teacher leverage mobilized Adventure Learning to design learning activities? And how did active participation in a mobilized Adventure Learning project affect student interest in the subject of Environmental Science? The study involved examining the ways the teacher leveraged the affordances of mobile technologies to create a hands-on, collaborative, and Adventure Learning environments outside of the classroom. The hands-on learning activities were designed to enable students to gather first-hand information related to environmental science. Subjects in the study included a high school Environmental Science teacher along with 104 participating students. Using a mixed methods approach, qualitative data were gathered through observations of learning activities, interviews and focus groups and artifacts. Quantitative data were gathered through surveys administered to the students before and after the treatment. The results indicated that, contrary to the teacher's expectations, students indicated a preference for learning through book and lecture rather than hands-on discovery of information in both pre and post treatment surveys. Results of the study also demonstrated differences in learning preference relating to percentage of students participating in field-based, hands-on learning activities or in lecture-book classroom learning activities. Recommendations for future research and for educational practice are offered. Limitations of the study include the small sample size and short time duration of the study.

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Chapter 1: Introduction

Innovations in educational technology and new approaches to the learning process have led to many enhancements for the K-12 learning experience. Because of ubiquitous connectivity, Mobile Learning has demonstrated the potential to support learning activities both inside and outside of the classroom (Naismith, Lonsdale, Vavoula & Sharples, 2004; Nussbaum, 2004; Sharples et al., 2007; Pachler et al., 2009). Adventure Learning enhances the learning experiences by opening doors for students to interact in real time with an expedition team traveling to remote places (Veletsianos & Eliadou, 2009; Miller, 2010; Veletsianos, 2012). What are the educational potentials when Mobile Learning and Adventure Learning converge in the K-12 setting? This study combines both approaches in an Adventure Learning project that gives students—enabled by mobile technologies—the opportunity to participate as the expedition team. The research investigates how classroom instruction changes and student interest levels are impacted among high school students in an Adventure Learning project supported by mobile technologies.

Rationale

High school students have opportunities to take Advanced Placement (AP) courses and receive college credit before graduating. Students tend to focus on mastering the subject matter to meet the course requirements (Mehrens & Kaminski, 1989) and scoring high enough on the standardized tests to receive college credit for the coursework (Haladyna, Nolen, & Haas, 1991; Higgins, Miller, & Wegmann, 2006). Though they often follow a textbook's outline and content, teachers in some schools might choose whether to teach straight from the textbook content and outline, or enhance the course with additional content and hands-on activities. Determined by their own professional goals, teachers may also choose to what degree they create an appreciation for the subject and set up patterns that promote lifelong learning.

The purpose of this study is to evaluate an innovative teaching approach guided by blending Adventure Learning and Mobile Learning for AP Environmental Sciences in a high school setting. Subsection 112.37 of the 2012-2013 Texas Essential Knowledge and Skills (TEKS) for Science outlines the state requirements for this subject. Content requirements for AP Environmental Science are prescribed in the College Board Publication Advanced Placement Course Description: Environmental Science.

This study will inform AP Environmental Sciences high school teachers, researchers, and administrators of both the benefits and the challenges they may encounter when implementing ubiquitous mobile technologies combined with student-centered pedagogies in their classrooms. In addition, stakeholders will understand the potential impact of ubiquitous mobile technologies and Adventure Learning on education and instruction. Researchers will benefit as findings from this study address some of the gaps in existing literature on educational technology. This knowledge is important because an increasing amount of hands-on learning through mobile technologies is occurring in the K-12 environment. Additionally, a study like this should support their efforts at integrating technologies and technology-related pedagogy into their curriculum selection and lesson planning.

The foundational ideas for this study come from the research literature on mobile learning. Once thought to be the next step in, or replacement for, traditional

Educational technologies, mobile learning practitioners have found that this addition to educational technology is limited by device size, but provides new learning opportunities because of ubiquitous access to information and communication (Pachler, Bachmair & Cook, 2009). Some of the potential benefits include access to web-based information while making field observations, the ability to log information directly into a retrievable database, and the ability to collaborate in real time with experts or peers.

Identified Educational Challenges That the Intervention Intends to Solve.

This project intends to explore learning technology potentials through the design and development of an educational intervention. The Eastbury High School[1] is part of the Belton Independent School District situated in a relatively affluent section of a large Southwestern city in the United States. As recently as 2010, the district has sold bonds to support development of educational technology resources for the school system. At the start of the school year in Fall 2011, part of the bond sale funded the purchase of iPad tablets for all of 11th and 12th grade students. Provision of iPads will continue into lower grades within the next year. Students are expected to take the devices home at night and bring them to school each day for taking notes, accessing schedules, reading books, doing web searches, and producing and submitting assignments.

The major advantage of iPads over traditional laptops is portability. Newer generation tablets such as the iPad fit easily into a backpack, and can be used while standing. They also feature instant start-up, so the students can use the devices

[1] All person and place names used in this dissertation are pseudonyms.

immediately instead of waiting for them to boot. During the time of research, the manufacturer covered technical support for the devices, so there is no additional IT cost to the school other than developing a more robust Wi-Fi System. It should be noted that the tablet devices are not 3G or 4G enabled, so they need to be supported through a personal or public Wi-Fi network. Tablets are generally, though not universally, accepted as mobile learning devices (Orr, 2010a). For the purposes of this study, we will consider newer generation tablets, such as the iPad, as mobile learning devices.

Students Focus on Preparing for the Standardized Test

For 30 years, Justin Kollar had an extensive career with the Texas Parks and Wildlife Department and has been teaching high school for the past six years. He currently teaches the Environmental Sciences AP course to 187 high school seniors. Toward the end of the school year, his students will take a standardized AP test for Environmental Sciences. If the students pass the exam, they will receive college credit for the course.

Discussions with Mr. Kollar and Clayton Sagers (the district IT director) have uncovered some issues that require educational intervention: while students are motivated to pass the standardized tests, they are, in general, not interested in learning the subject beyond what is required in order to get a good score. An effective intervention, therefore, is one that yields increased interest in the subject matter, leading to improvements in learning outcomes for students.

Teacher Promotes Hands-On Science

Likewise, some students have had little or no experience using scientific methods to gather and analyze data. Following the current paths of instruction, they would continue to learn from lectures and textbooks, without hands-on experience with environmental sciences. In addition to developing a foundation for improved student outcomes, a hands-on approach enabling direct participation in scientific methods is designed to help students see the value of learning and making decisions about life choices based on environmental sciences.

Mobile Devices are used as a Laptop

Mobile technologies present new opportunities for teaching because of ubiquitous access to information and communication, but teachers still tend to teach with existing methods, not making use of these new tools. Based on descriptions from Justin Kollar, students are using the tablet devices similar to the way they would a laptop or a netbook: taking notes on class lectures, following a slide show with content outline, visiting related websites, and communicating through e-mail, document programs, and chat sessions. As a replacement to a personal laptop, these functions could be expected to some degree with tablets. New possibilities in education are not being leveraged, however, when tablet usage is limited to these functions.

Justin demonstrated some interactive technologies he used for the class that were specific to tablet devices. Among these are Leaf Snap, which is an electronic field guide designed to help mobile users identify plant species they encounter in the outdoors. The Leaf Snap application, however, was being used inside the classroom, because it requires connectivity to access the database of plant species. This is a start, but developments in ubiquitous technologies should lead to untethered learning outside as well as inside the classroom (Pachler et al., 2009). According to Clayton Sagers, Mr. Kollar is also considered to be at the forefront of leveraging ubiquitous technologies among his peers at the school. With his demonstrated interest, creativity, and flexibility with learning technologies, Mr. Kollar is a likely candidate to participate in a learning intervention leveraging ubiquitous technologies in an Adventure Learning project.

Research Informed by the Stated Educational Challenges

Research for this dissertation supports the academic goals for Advanced Placement Environmental Sciences at Eastbury High School through an intervention using ubiquitous mobile learning technologies to support students who act as the expeditionary team for an Adventure Learning project. The following chapter reviews literature related to this project in the areas of Adventure Learning, Mobile Learning, and Hands-On learning in the K-12 sciences. It also points out the existing gaps in the literature and how this research project addresses those areas. Chapter 3 begins with the research questions and lays out the research design and methods. The main research questions are:

1. How did a teacher leverage mobilized Adventure Learning to design learning activities?
2. How did active participation in a mobilized Adventure Learning project affect student interest in the subject of Environmental Science?

Chapter 3 also addresses the approach to instructional design, the study context, method, participants, data sources, approach to analysis, and how validity and reliability are supported through the research project.

Chapter 2: Review of Literature

This chapter covers related literature on Adventure Learning and Mobile Learning and explores how the existing body of academic literature relates to the learning intervention designed for this project. This section is followed by a discussion of the gaps in existing literature and how this project addresses some of the areas that have not been covered in prior research.

Adventure Learning Literature

Adventure Learning is an online and hybrid approach to education that provides students with authentic experiences through collaborative learning environments (Doering, Veletsianos, & Scharber, 2007). In many examples, a professional expedition team will travel to an area to explore subject matter through interviews and scientific observations. Often funded by sources such as the National Science Foundation, they connect their travel experiences, observations and interviews to students in classrooms through both synchronous and asynchronous methods. This creates a digitally enhanced learning environment where students can experience the research process through inquiry-based education (Veletsianos & Eliadou, 2009). Adventure Learning projects may also include both instructors and learners traveling outside the classroom to collect data and make observations (Miller, 2010). In this study, middle school students applied math and science while they were competing in a traditional Native American winter contest called “Snow Snakes.” This is an outdoor contest where students were required to test and improve the properties of a wooden gliding device over snow or ice in addition to improving the way that they launch it. They log the information in a database, sometimes collaborating with similar Adventure Learning teams to share and analyze the information they have collected (Veletsianos, 2012).

To date, the approach of Adventure Learning has been exemplified through seven projects: Arctic Transect 2004, GoNorth! Arctic National Wildlife Refuge 2006, GoNorth! Chukota 2007, GoNorth! Fennoscandia 2008, GoNorth! Nunavut 2009, and GoNorth! Greenland 2010. In several case studies (Doering & Veletsianos, 2008; Doering & Veletsianos, 2008b; Moos & Honkomp, 2011), Adventure Learning projects have been shown to increase motivation levels and engagement with the subject matter in K-12 students. In addition to increased motivation and subject interest, new ground for Adventure Learning was explored in a dissertation project by Miller (2010) in which students acted as the exploratory team in a social studies project for Native American children. Through this added dynamic, students participated in Adventure Learning by directly participating in the adventure in addition to watching and hearing from an external team.

An additional educational benefit of Adventure Learning has to do with student-centered outdoor learning activities. These include learning activities where students are involved in climbing, hiking, and obstacle courses. The Adventure Learning Center at University of Wisconsin and APLS at Iowa State provide some examples. Though learning via activities outside of the classroom creates some overlap, the primary focus of Adventure Learning as researched in this paper stems from the ideas founded by Doering, Veletsianos, & Scharber (2007), because the teacher intended to implement the elements of Adventure Learning on a smaller scale for outdoor learning activities.

Elements in Adventure Learning Projects

The main elements required in an Adventure Learning project are adventure-based education, a researched curriculum grounded in problem-solving that guides the progression and evolution of the Adventure Learning program, and exploration of the issues, environment, local population, culture, and additional relevant factors that provide an authentic narrative for students and teachers to follow (Doering et al., 2009; Veletsianos, 2009). Additional elements can include the identification of an issue and respective location of exploration; collaboration and interaction opportunities between students, experts, peers, explorers, and content; and design and utilization of an Internet-driven learning environment for curricular organization, collaboration, and media delivery. Adventure Learning projects often include direct access to experts, just-in-time scaffolding of educational resources, ongoing web-based dialogue among students, and both synchronous and asynchronous modalities (Doering & Veletsianos, 2008b; Veletsianos & Doering, 2010; Miller, 2010).

Existing Research Topics in Adventure Learning Projects

Research questions in studies of Adventure Learning cover a wide range of topics but tend to focus on student motivation. The existing research questions in the Adventure Learning literature address content delivery (Miller, Veletsianos & Doering, 2008), student content knowledge (Doering, Miller, & Veletsianos, 2008; Moos & Honkomp, 2011; Miller, 2010), student motivation and engagement with the event (Miller, 2010; Veletsianos & Doering, 2010; Moos & Honkomp, 2011), student interaction with technology (Doering & Veletsianos, 2008a; & Veletsianos, 2008c), student transformation in thinking and lifestyle choices (Doering & Veletsianos, 2008b; Veletsianos & Doering, 2010; Miller, 2010), teacher administrative issues (Doering & Veletsianos, 2008a), Adventure Learning as an educational model for design (Veletsianos & Eliadou, 2009), and the relationship between technology and pedagogy (Veletsianos & Doering, 2010).

Expanding Framework of Adventure Learning

The Adventure Learning literature focuses on students participating from the classroom and a professional expeditionary team exploring places and topics that are physically out of reach for the students. By leveraging communications technology, students are able to view and interact with the expeditionary team in real time, participate in the direction of the study, and collaborate on what they learn in the process. Miller's (2010) dissertation, however, begins to expand the framework for Adventure Learning by including students as participants in the expeditionary team. This was accomplished by blending a traditional Native American learning game with Science, Technology, Engineering and Math (STEM) subject matter. Instructional materials integrated STEM curriculum with a locally based traditional Native American learning game called "Snow Snakes," which involves skill-based contests in which participants craft and throw or glide a wooden shaft across a frozen body of water.

Miller's research asked, "What key experiences are involved in the development of science agency through a culturally based STEM curriculum context?" As a case study, the research involved qualitative methods, relying largely on interviews with students before, during, and after the learning intervention.

Findings were divided into three categories: science and STEM learning, agency, and community impact. This study focuses on findings in science and STEM learning. Among the findings of this study were students connecting STEM curriculum with experiences outside the classroom and students emerging as intrinsically motivated learners and leaders. Specifically, students were able to articulate content related STEM topics at grade level derived from their hands-on involvement with the Snow Snakes game. Each of the students that participated in the project commented on how the Adventure Learning project enhanced their engagement with the subject matter. Teachers commented on the fact that student focus on the project eliminated any need for disciplinary action.

Summary of Adventure Learning

Adventure Learning focuses on identifying issues for exploration and promotes collaboration with both peers and content experts. Adventure Learning makes use of both synchronous and asynchronous methods to connect students to first hand scientific research through the use of the Internet and communication technologies. Research on Adventure Learning has focused on levels of student engagement and increased motivation while participating in the project. There has also been research on content knowledge acquisition; interaction with technology, and to what extent involvement with an Adventure Learning project changes lifestyle habits related to interacting with the subject they studied.

Prior research lays the foundation for the study described in the following chapters. Due to the growing interest in Adventure Learning, the research context for this paper includes a description of how a teacher designs learning activities outside of the classroom by including the elements of Adventure Learning. This research helps to inform educators for possibilities of incorporating Adventure Learning principles in a local educational context.

Mobile Learning Literature

Mobile learning, sometimes referred to as "MLearning" or "handheld learning," has become a focal point for conversations about both the technical and pedagogical issues raised by instructional technology (Churchill & Churchill, 2008; Huang, Keo, Lin, & Cheng, 2008). Compared to Adventure Learning, mobile learning has a broader body of research and a broader scope of related learning approaches and underlying theories. The following section will define mobile learning, distinguishing it from traditional Educational technologies. It will also review the affordances and constraints of mobile learning and explain how the literature describes mobile learning deployed as a part of traditional Educational technologies or in addition to a live classroom. This section also reveals some of the gaps in the literature in addition to summarizing where current researchers are pointing for future study.

Earlier definitions of mobile learning tended to be based on the type of technology used, such as Savill-Smith (2005) who described it in terms of devices. Desktop and laptop computers were already well established in learning technology literature, so introduction of mobile devices, such as cell phones and PDA’s, was initially categorized as mobile learning. Perhaps the earliest definition, though simple, was offered by Quinn (2000) who said, “MLearning is the intersection of mobile computing and ELearning." Peters (2007) defined Elearning as "web-based delivery of content and learning management" and described Mlearning as a subset of that. These early descriptions of MLearning, however, are based on available technologies of the time, but do not not satisfy the possibility that mobile devices with limited communication functionality, such as audio recorders, digital cameras, or similar devices are included in mobile learning technologies as described by Son, Lee, & Park (2004). Additionally, mobile computing as a subset of Electrical Engineering focuses on a broader category of devices, not limited to consumer products considered in Quinn's (2000) definition.

The ELearning Guild defines mobile learning as "Any activity that allows individuals to be more productive when consuming, interacting with, or creating information, mediated through a compact digital portable device that the individual carries on a regular basis, has reliable connectivity, and fits in a pocket or purse" (Pulichino, 2006). Under this definition, tablets are not a perfect fit as mobile learning devices, since they depend on other devices to connect to the Internet. According to another definition of mobile learning widely accepted in Europe, however, Wi-Fi connected devices fit into an overall collection of mobile learning resources as they contribute to "the processes of coming to know through conversations across multiple contexts amongst people and personal interactive technologies" (Sharples, Taylor & Vavoula, 2007). Taking several of the definitions into consideration, this study will focus on the ELearning Guild (2006) definition for mobile learning, because students are using portable devices to consume, interact with and create content related to their class.

Pedagogy in Mobile Learning

Though a few calls have been issued for the development of a "mobile education theory" (Zurita & Nussbaum, 2004), mobile learning research tends to focus on exploring the relationship between existing educational theory and how it can be applied and observed in mobile learning (Sharples et al., 2007). Naismith, Lonsdale, Vavoula & Sharples (2004) indicate that Behaviorist theories from Skinner and Pavlov are relevant to mobile learning due to the quick feedback or reinforcement that mobile devices facilitate. As mobile devices enable immersive experiences in gaming environments or simulations beyond simply gaming within the local device, users work their way through these environments and construct their own knowledge base as proposed by Piaget, Bruner, and Papert (Naismith et al., 2004). Zurita & Nussbaum (2004) suggest that mobile learning also supports constructivist educational activities that emphasize collaboration among learning groups. Collaborative learners observe and can be observed by others; they can engage in group discussion and reflect on practice with faculty and other users (Franklin, Sexton, Lu & Ma, 2007).

Affordances of Mobile Learning

Starting with the various generations of correspondence education and moving to modern distance education, educational researchers have examined the strengths and weaknesses of learning where the teacher and learner are not in the same location (Moore & Kearsley, 2011). Challenges arise from lack of face-to-face interaction, technical issues, and learner isolation. Mobile learning inherits some of those strengths and weaknesses, but it is also distinct from traditional Educational technologies that makes use of a laptop or desktop computer. A number of studies (Traxler, 2007; Casey, 2005) have looked at the trade-offs involved with developing curricula for mobile devices. Ironically, both the positives and negatives of mobile learning have to do with the size of the device used. Small devices can be carried almost anywhere with minimal effort and can therefore be accessible to the user at all times, but small devices also have limited processing power and memory. Small size also makes text input cumbersome.

Ubiquitous Access to Information

Because mobile devices are small, they can be carried anywhere; access to the information that supports learning is available to the user at any place and any time (Churchill & Churchill, 2008; Chen et al., 2008; Naismith et al., 2004). Mobile learners have access to real-time or static data whenever and wherever they need it in addition to rapid access to applications for data-gathering, including note taking, imaging, audio recordings, videos, teacher lecture notes, reference books, simulations, worksheets, etc. (Lai, Yang, Chen, Ho & Chan, 2007; Ng & Nicholas, 2009; Savill-Smith, 2005).

Due to the ubiquity affordance of mobile learning, some studies have revealed a tendency for students to have a higher motivation, improved organizational skills, and an increased sense of responsibility (Savill-Smith, 2005). Ubiquitous access to communication has also been shown to deter motivation, as some studies have shown that motivation among students will drop off when they feel like they are not able to contribute in a valuable manner (Zurita & Nussbaum, 2004). Future development of research projects should ensure that collaboration through mobile devices does not turn into unhealthy competition.

Mobile Device as an Information Gathering Tool

In early research projects, such as Trifonova & Ronchetti (2003) and Naismith et al. (2004), mobile devices have been shown to support new kinds of learning activities as an information gathering tool. Earlier studies included taking pictures and making notes on the devices. As new functionalities are added to mobile devices, affordances should be evaluated for potential contributions to education. Some of the more recent developments that show potential for learning include location awareness and image-based searches.

Technoskepsi was a mobile learning project in Cypress that worked with 28 students between the ages of 10 and 12. According to Evagorou, Avraamidou, & Vrasidas (2008), this project was designed to help students develop their own scientific knowledge using mobile devices to gather and represent scientific ideas. Though Technoskepsi focused on mobile learning devices as representation tools, students used mobile devices to gather and log scientific data, such as photos, notes, and interview audio, to be uploaded to a shared drive when they returned to school. Wallace (2009) conducted research using a location-based mobile game among middle school students in Guam for locating potable groundwater. Though a game, students actually used mobile devices to locate something usable in their daily lives within their community. Pre- and post-course student evaluations revealed that they were motivated to learn more about the subject as a result of the project. Content assessments revealed that they were better able to both discuss hydrologic concepts and conduct their own scientific research compared to using other teaching methods.

Bannan, Peters & Martinez (2010) researched elementary and middle school students in the U.S. who used Google Earth® running on location-aware mobile devices. These students could observe and log information related to erosion in their local environment. Findings from the study indicated that using mobile devices as the primary instructional tool during the project promoted first-hand geological observation and reasoning. Students who participated in the intervention also demonstrated evidence of a shift in cultural practices based on what they observed first hand using mobile technologies as devices for gathering information.

A study of second graders in Singapore observed students leveraging the multiple approaches to education afforded by mobile learning, including using the mobile device as an information gathering and knowledge building tool (Looi et al., 2009). The context was English as a second language, and students used a mobile-based curriculum that was designed for them to collaborate with each other in English to complete assignments and to use the mobile device to gather information about the English language outside the classroom. Looi et al. (2009) observed four ways that learning is supported by mobile technologies, including allowing multiple entry points and learning pathways, supporting multi-modality in learning, enabling student improvisation in learning situations, and supporting the sharing of student-created artifacts on the move. They found the highest motivation point for the students was when they shared the language artifacts they had gathered with their mobile devices.

Mobile Device as a Knowledge Representation Tool

Since most mobile devices can connect to a projector through a wired or wireless connection, they can be used to write, hand in, or demonstrate homework. Students can gather, organize, and present information all from a mobile device that they carry on a regular basis. Collecting first-hand information was shown to be helpful for knowledge building as demonstrated in an elementary school science classroom case study (Evagorou et al., 2008). On a field trip, students were assigned to learn specific properties of various plants and both take an assessment and create a report when they got back to the classroom. An experimental group was given a mobile device for data gathering while a control group used paper and pencil. Though not conclusive, this study demonstrated that students with mobile devices could gather more data through photographs, audio input, and writing when compared to their counterparts. However, it was observed that students using paper and pen demonstrated more attention to detail. For instance, taking a photograph of a leaf requires less attention to detail than drawing it.

In a study designed to research both student motivation and content knowledge by comparing students with and without mobile learning treatment, Lai et al. (2007) determined that mobile devices enabled students to develop reports using text and images more efficiently and allowed a more thorough investigation of a larger number of specimens. Students using the handheld devices generally felt freer from their tools to explore the learning activity. In this study, two 5th grade science classes in Taiwan—taught by the same teacher—were given pre- and post-tests, a motivational survey, and an assignment to create a poster displaying their scientific observations. One class of 34 students was given mobile devices for taking photos and writing notes, while another class of 32 students completed the assignment with paper and pencil. There was no significant difference between the pre- and post- content tests, but the post-test results indicated increased learning among the students with mobile devices showing an increase of 3.62 (SD 1.04) compared to an increase of 2.88 (SD 1.01) in an 8 question test. Students took a five point Likert Scale motivational survey after the project, and those with the mobile device treatment reported 4.33 (SD 0.78), while the students using pen and paper reported 3.89 (SD 0.96). Though this effort observed a small group of students and did not consider the potential waning effects of interest in using a new technology, it indicates a potential for increased motivation and content knowledge connected to using mobile devices for gathering and representing knowledge.

In another study, taking photos rather than drawing sketches allowed students freedom to look more closely at the object of study but found that it could prevent them from concentrating on the effort of creating a diagram of what they are studying (Clough & Jones, 2008). By contrast, another case study found mobile devices helped accomplish some learning goals but were considered unnecessary or easily replaceable with a camera, digital recorder, or pen and paper (Song, 2005). It should be taken into consideration that mobile devices of this era did not have built-in cameras and required an external camera adapted to the device.

Mobile Device as a Communication Tool

Ubiquitous communication is an important affordance of mobile learning. As a discussion tool, the device makes it convenient to contact other people through various means (e.g., by voice, text). Though communication can be as instantaneous as a phone call, it can also involve posting the idea somewhere so other users can access it when it is convenient to them, whether in class or out of class (Evagorou, et al., 2008). Ubiquitous access to information and communication has been shown to enhance independent learning, but the main advantages support collaborative learning (Savill-Smith, 2005).

Framing Mobile Learning Affordances

Mobile technologies are shown to support both content knowledge and student motivation by the case studies mentioned. Are the supporting ideas and uses really affordances of mobile learning? Or can these types of learning activities be performed just as well through other means? If taking pictures is important, are mobile devices required, or will a stand-alone camera suffice on those few days when taking a photo is helpful? For audio recording, would a stand-alone digital recorder serve just as well or better than a mobile device? What affordances of mobile learning can be done as well, if not better, by a netbook or low end laptop? Though not as small or as quick to boot and make use of in a ubiquitous manner, netbooks and small laptops are portable, highly functional, and have a comparable initial cost when compared to a mobile device. Some leaders in distance education research say the affordances of mobile technologies have yet to be determined (Moore, 2008). According to Ryu & Parsons (2009), educators have not yet seen persuasive arguments for the affordances of mobile learning in terms of quantifiable outcomes.

The affordances of mobile learning open new possibilities for Adventure Learning projects because the ubiquity of mobile technologies enables students to participate as both learners and as the expedition team by connecting them with experts, knowledge bases, and with each other from the classroom to the outdoor learning project. While on an environmental sciences Adventure Learning project, students use features built into their mobile devices to gather first-hand scientific information through cameras, recorders, and data entry. They could then log the information in a database. When they return to the classroom, they can use the same mobile devices to analyze the data and organize it to be presented with their mobile devices as a knowledge representation tool.

Constraints of Mobile Learning

Some mobile learning constraints relate to a "mobile only" scenario where the teacher and students never meet in person. Constraints in these situations are similar to, and somewhat inherited from, issues with traditional Educational technologies. These constraints include lack of contact between students and teachers, isolation, and technical support problems (Fozdar, 2007). Many of these inherited constraints are not applicable when the learning situation is a blend of classroom and mobile learning. Related to this research, new issues arising from mobile learning include student distraction from trying to study while in motion (Dolittle, Lusk, Byrd & Mariano, 2009) and issues of information and personal security (Pachler et al., 2009).

Size Limitations of the Mobile Device

Though the main affordances of mobile learning have to do with ubiquity, which stems from the small size of the device, the primary constraints of mobile learning also stem from the device's small size: small display, slow text input, and short battery life (Churchill, 2008; Ryu & Parsons, 2009). Huang (2008) found that instructors could communicate with students in synchronous mobile learning contexts but could not ask for substantive feedback from students due to text input limitations.

Regarding constraints related to text input limitations, mobile technologies open the possibility of moving away from text-based representation altogether. It is possible to work around limitations by developing mobile-friendly web pages that can assess students by giving them numbered choices rather than requiring text input. Some cloud-based and native applications turn spoken words into text. The lack of convenient input tools pushes the research toward exploration of new forms of user interfaces, including sound or mobile scanning tools as input/output (Trifonova & Ronchetti, 2003). If search capabilities could be developed, video or audio projects could begin to replace text on paper as the main method of demonstrating knowledge for academic assignments.

Small screens are another size-related constraint. Mobile users cannot view content in the same format as a laptop, so new approaches to formatting, such as responsive web page technologies, are needed. Digital materials can be partially re-used, and formatted in CSS style sheets to appear in both computer browsers and mobile browsers. The best way to make the adaptation would be through automation and web standards that enable both mobile and standard screen size users to access the same pages (Trifonova & Ronchetti, 2003). Much of information on the Internet itself is designed for interaction with a larger screen and keyboard, so rethinking of how captured information stored and retrieved will be necessary for mobile learning and may even be driven by market forces in mobile use of technology ahead of mobile learning. Rather than focus on what needs to be done, educational researchers could focus on how to work with current and emerging trends in technology deployment (Kuiper, Volman & Terwel, 2005).

Connection Issues

One of the shared issues with other Educational technologies is that mobile learning requires connection with the Internet or a server. Due to the ubiquitous aspect of mobile learning, there could be times when there is limited or no connectivity, cutting off communication with the Internet and with other users. Some researchers have suggested engineering a pure connection and pure mobility mode for the mobile device so that it can download and store what is needed for most of the learning process and be able to function with minimal or no connection for long periods of time (Trifonova & Ronchetti, 2003). In this case, the mobile device turns into a small computer that can function for limited learning activities whether connected or not. At most university, corporate, or home office settings, users can access through Wi-Fi, but when disconnected, it is simply a small computing device. Since the iPads used for this research are not enabled for cellular communication, interactions that take place away from the school Wi-Fi need to be self-contained if mobile hot spots are not available.

Distracted Mobile Learners

One of the advantages of mobile learning is that learners have ubiquitous access to learning materials. Some researchers have begun to question whether ubiquitous access to information and communication actually provides the best context for quality learning. Is there a learning advantage to listening to a podcast or reviewing a slide show while riding a bus or walking across campus? Dolittle et al. (2009) examined the extent to which mobile learners could be distracted while trying to learn with their mobile devices while going about other tasks. The researchers conducted a comparison study using 76 students and compared their retention of content from different means. One group sat at a desk with a computer and went through the learning objects three times. Another group had a walking assignment while working with the same learning objects, the same amount of times, except through a mobile device while walking. The group that sat at a desk with a computer scored significantly higher on an assessment than the group that walked with a mobile device. Though they did not claim the study was conclusive, it did indicate how future studies could explore the extent to which multitasking distraction can disrupt the learning process.

Challenges for Developers

The physical constraints of mobile technologies are carried over into the development of mobile learning curricula. Churchill (2008) pointed out that instructional desingers could no longer afford to develop content that is targeted for use via a single access mechanism. They must develop courseware that enables their content or applications to be delivered through a variety of access mechanisms with a minimum of effort. This would include content that can be accessed through mobile devices, traditional computers, print, audio, video feed, and other media. Currently, some devices will play Flash files while others require a scripting code that can change with the device size or preferences. Though it would take more time, implementing a web site or an application with device independence in mind could potentially save costs and assist the authors in providing users with an improved user experience anytime, anywhere, and via any access mechanism.

Developers need to consider the fact that students want to keep their social networks as they are; they will add networks but not at the expense of their existing networks. They also need to allow students to have control over their personal technology, even though the learning objects are planned (Naismith et al., 2004).

Focus on Developing Student Interest

In addition to supporting constructivist educational activities, Zurita & Nussbaum (2004) suggest mobile learning also supports increased subject matter interest among students by prompting collaborative and interactive learning. According to that study, mobile learning enables control of the learning process for students and helps relate learning activities to the real world. Mobile learning should have the guidance and support to assist both ends of the educational spectrum, as well as enable users to access unplanned learning experiences and information. Researchers are suggesting that teachers should have adaptable programs that can adjust to the flow of the classroom (Trifonova & Ronchetti, 2003). This kind of approach would require a change in the traditional classroom model, but a broad study of 102 elementary school teachers using mobile devices in the classroom indicated that students learning to use a handheld for blended personal and classroom purposes were more interested in the subject than students using them only for required classroom purposes (Franklin, 2007). Based on teachers' responses, this study also found that adapting the classroom to the students' discoveries and interests added to student motivation in school.

Leveraging New Affordances in Learning

Whether or not the underlying curriculum changes when the learning activities are extended outside of the classroom, teachers will need to change the design of lesson plans, learning activities, and instructional design overall if they are to take advantage of the new possibilities provided by technology. Looi et al. (2009) notes that multi-modal access to learning activities and information requires teachers to consider making instruction fit individual student needs through personalized learning. In a qualitative study of science classes that use mobile devices for outdoor studies in Sri Lanka, Ekanayake (2011) observed that teachers developed a wide range of approaches to lesson planning, implementation, and methods of evaluating instruction. Without a cohesive plan for developing and evaluating instruction, it would be difficult to measure success in the instructional experience.

Norris & Soloway (2008) recommended allowing teachers the freedom to develop instruction for learning outside of the classroom supported by mobile technologies. It was suggested that teachers should then meet on a regular basis to share best practices through a discussion of what the students actually did during the learning activities and to what degree personalized learning took place.

An adaptation of the instructional design process was further developed by Zhang, Looi, Seow, Chia, Wong & Chen (2010) through observing the redesign of an existing science curriculum for elementary students. Researchers worked with a class of 39 students as the experimental group and five classes totaling 195 students as the control group. The control group learned the subject matter through the textbook and traditional classroom means, while the experimental group used mobile devices to gather and interpret information. Using an ACNOVA test, results showed a significant difference (41%), with the average score on a standardized test for the control group averaging 63.96% and the experimental group averaging 76.67%. The research suggested the following order for instructional design and evaluation: Deconstructing, Brainstorming, Composing, Reconstructing, Implementing, and Evaluating. While the results appear impressive, it should be noted that teachers taught the control group in their traditional manner while nine researchers were assigned to the experimental group and contributed as instructional designers. The researchers did not contribute any, let alone equal, information to the control group.

Additional literature resources inform this research, including the curriculum used in the current Advanced Placement Environmental Sciences class at Eastbury High School. The textbook is *Living in the Environment 2004 Edition* (Thompson, 2003). Justin Kollar plans to continue teaching from the same textbook used in previous years but adapts the design for instruction based on the possibility of leveraging mobile technologies in an Adventure Learning project. One of the new dynamics for his classroom is that the textbook is now available as an electronic resource, and students are no longer required to carry a large textbook to and from school. It is downloaded to their iPad and available as an eBook. Since mobile technologies are opening new possibilities for education, the research in this paper observes how Mr. Kollar leverages these technologies to design learning activities both inside and outside the classroom.

Hands-On Learning for K-12 Sciences

In a study of 14 undergraduate students, El-Bishouty, Ogata, Ayala & Yano (2010) showed that self-directed learners who participate in gathering first-hand scientific data have a higher level of subject matter interest compared to those who learn from classroom lectures or textbooks. Through qualitative research, Wallace (2009) found that eight upper elementary school students showed a higher degree of motivation and content knowledge after using mobile technologies to study environmental sciences in an outdoor setting. To support K-12 learning in the sciences, Dyson (2011) proposes a mobile learning portal hosting instructional content but mainly providing a space for mobile collaboration through wikis, blogs, messaging, and secure social networking.

Science instruction for the K-12 setting has been enhanced through inquiry-based learning with the main body of research focusing on changes in student motivation (Moos & Honkomp, 2010; Dyson & Litchfield, 2011). Additionally, self-esteem was increased as students learned to apply their knowledge to scientific research (Tinker, 1996). Some increases in learner outcomes have been identified (Kalloo & Mohan, 2011; Shih, Hwang, Chuang, & Cheng, 2010; Valk et al., 2010), but other studies were not able to isolate and quantify any increase in learning (Pollara & Broussard, 2011; Economides & Grousopoulou, 2010; Andrews, Smyth & Caladine, 2010).

The study at Eastbury High School looks at the role of the teacher in designing instruction that employs inquiry-based learning but also examines learner interest levels in the subject. This includes observations of how the teacher designs instruction along with student interest levels based on their feedback from interviews and surveys along with their involvement with the project.

Digital Divide

Outdoor science projects with ubiquitous communication and information gathering possibilities have become less cost-prohibitive. According to Valk et al. (2010), reduction in the gap between the haves and the have-nots is accelerating for K-12 learners due to the proliferation of mobile technologies among all social strata. An exploration project with Australian Indigenous learners in remote communities demonstrated that people who were previously disenfranchised from the educational system can have access to the same technologies and resources as other areas of the country for a low cost when mobile technologies are employed (Wallace, 2011). Since the entire student body of Eastbury High School is issued an iPad, the digital divide within the student population will not be a consideration. The digital divide does become an issue, however, when considering possibilities of expanding or generalizing discoveries made through this research project to the local region or across the nation. This study addresses areas of learning that are dependent on having the skills, resources, and knowledge to perform the required tasks along with identifying what resources would be necessary for starting a similar project with little or no technological infrastructure in place.

Learner Outcomes

Among the primary purposes of education or an educational intervention should be supporting higher learner outcomes. Does this intervention actually help students learn the material more thoroughly than the existing methods? Issues surrounding user experience and subject matter interest or motivation contribute to mastering the subject matter. Taking their limitations into consideration, the studies referenced earlier indicate that higher learner outcomes can be supported through mobile learning technologies (Lai et al., 2007; Zhang et al., 2010; Shih et al., 2010).

Middle school students participated in a location-based mobile game designed for locating potable groundwater where analysis of pre- and post-event open-ended assessments indicated that students not only enjoyed the field experiences but were better able to communicate hydrologic concepts than those utilizing other teaching methods (Wallace, 2009). Elementary and middle school students using Google Earth® on location-aware mobile devices gained geological knowledge and technical skills, as it enabled them to observe and log information in an automated fashion (Bannan, et al., 2010). Results from this study indicated that the activity enhanced student ability to give reason to geological observations compared to students who did not participate in the project. Learner outcomes from these projects indicate that first-hand student involvement in their subject of study supported by mobile technologies provides a more in-depth understanding of their subject compared to classroom and textbook exposure alone.

A study by Kalloo & Mohan (2011) was designed to reduce failure in mathematics among elementary school students in a Caribbean territory. The program was developed by MobileMath® and included a curriculum with game-based learning and allowed the individual student to customize some of the interactions. This study compared learner-directed with teacher-supported interventions and evaluated student performance correlated with usage of the application. The experimental design showed an increase from pre- to post-tests among users with the application, but it did not explore equal treatment of users with the same treatment that was not mobile.

In a secondary education experiment in Taiwan, local history was taught through a location-aware mobile application that asked questions and provided answers for each location. Though the study refers to the student activities as "investigation," it appears that the tool takes learners on something more like a guided tour. The results of the pre- and post-test show a positive learning effect on students' understanding of the history and geography of these locations. A usability test found positive reactions to the mobile learning system (Shih et al., 2010).

For learner outcomes, Valk et al. (2010) observed that mobile technologies facilitate increased access to resources, but much less evidence exists for how mobile technologies promote new learning. Holley & Oliver (2010) proposed a model for analysis that measures student engagement based on user control of technology, the overall educational experience, and expectations of managing their learning space. Other K-12 studies find similar increases in engagement, subject matter interest, motivation, and communication but are not able to quantify increases in outcomes through experimental design (Pollara & Broussard, 2011; Economides & Grousopoulou, 2010; Andrews et al., 2010).

Learner outcomes are a primary goal of AP courses at Eastbury High School and are measured by student test scores at the end of each school year. Measuring standardized test scores on a yearly basis over a period of several years would be ideal for evaluating teaching methods but is outside the scope of this project.

Global Lab

In the late 1980s, Global Lab was developed through a partnership with the Concord Consortium and the National Geographic Society's Kid's Network. Over 20,000 elementary school students participated as scientists in a worldwide effort to explore the acid rain problem (Tinker, 1996). Data on acid rain was collected and compiled in a global database that could be shared, referenced, and researched. This laid the foundation for Student-Scientist Partnerships (SSPs), which helped move instructional design for science education from static textbooks toward interactions with experts currently working in the field. This empowers students to support scientific observations in addition to monitoring their findings and collaborating with other students across the globe (Tinker, 1997).

Before mobile learning was a consideration, the new dynamics of instruction that emerged from the Global Lab were titled "Telecollaborative Inquiry" because students were engaged in a virtual learning community that conducted synchronized collaborative investigations (Berenfeld, 2010). During Global Lab 1.0, students collected data using analog kits and collaborated by contributing data to a globally shared database. Global Lab 2.0 took place in Russia and enhanced collaboration through the use of cloud computing. Learning continued to be open-ended, forcing the teachers to choose between curriculum goals and participating in a highly motivating project. The earlier phases of Global Lab enabled students to develop an integrated and more in-depth knowledge as a result of engaging in the practices of scientists for gathering, collaborating, and constructing their own knowledge base (Tinker, 2001). Global Lab

3.0 integrated the content and curriculum with learning outside the classroom (Berenfeld, 2010)

Earlier case studies of Global Lab projects reported the potential of inquiry-based learning to replace textbooks (Fine & Friedman, 1991), but the literature has moved toward supporting needed changes to the existing curriculum (Tinker, 1997). Likewise, optimism about student acquired knowledge feeding the data interests of existing scientists (Tinker, 1996) was challenged by Drayton & Falk (1997), who found that only a select few inquiries supported research by ecologists. The main benefit reported by professional scientists is the opportunity to work with students and share their enthusiasm with the next generation.

Berenfeld (2010) described a potential future for Global Lab 4.0 which focuses on building voice and video into the IP conferencing system to make collaborations easier and more conversational. The next phase of Global Lab is planned to include more on-demand resources that could be available to students while they are doing scientific research. It would also include formative assessments built into the mobile devices so that instructors could determine whether students have learned and are able to apply the skills necessary to continue. Both the learning resources and assessments would be cloud based so that the interactions can be compiled centrally. Cloud based resources would also allow interactions across a broader range of devices and eliminate the need to download and install applications.

Primary Source Shift for Global Lab Curriculum

The earliest Global Lab projects opened the door for the primary source of curriculum to shift away from textbooks toward first-hand scientific inquiry. One teacher said, "I'll never us a textbook again" (Fine & Friedman, 1991). Though this might be an overstatement, it points out the value teachers can draw from inquiry-based learning. Tinker (1997) points out that long-term studies related to the Global Lab project should build a curriculum based on the information and analysis that has been gathered and conducted worldwide, so that future inquiry can learn from and build on the existing knowledge base. He also does not envision inquiry-based learning as replacing the traditional curriculum but argues that the findings can become a driving force for needed change and heavily influence future curriculum design.

Pedagogy Developments from Global Lab

As a pedagogical strategy, inquiry allows students to focus on constructing their own knowledge base through hands-on investigation. Observations from the earliest phases of Global Lab indicated that students learned science content better through scientific inquiry than studying from books to prepare for the next exam (Tinker, 1997). Fine & Friedman (1991) pointed out that the Global Lab led to increased collaboration among students as they interacted with the information. This study also showed an increase in the integration of school subjects, such as geography, mathematics, and language arts, which all played an important role in students capturing, analyzing, and reporting their findings.

Berenfeld (2010) determined that "Cloud Pedagogy" played a large part in the Global Lab because students could immediately construct, share, and apply knowledge through cloud-based applications. By immediately logging, sharing, analyzing, and collaborating on information, students are gaining skills necessary in the modern workforce in addition to building their knowledge of course content. He also pointed out that immediate collaboration on information added value to the scientific inquiry because of the volume and geographical distribution of information.

Changing Instructional Design Roles for Teachers

The learning interactions and dynamics of the Global Lab projects are similar to Adventure Learning projects that leverage mobile technologies. The promotion of globally collaborative work at the point of inquiry, analysis, and reporting helps inform both the design and potential for the project being designed for this study.

Teacher as Designer

Teacher as designer is a teaching concept that shifts the emphasis for teachers away from distributing knowledge toward designing learning experiences for students (Ackerman, 1977). Since many curriculum designers or book writers are also teachers, to some extent, professional teachers have always been designers. Whether they actually develop the complete curriculum, or adapt their teaching plans to an existing curriculum, teachers today are enabled by technology to take on an increasing amount of learning design (Reinders, 2010; Mor & Craft, 2012).

Ackerman (1977) provides several steps that should be taken for “teachers as designers,” which include identifying the instructional objective and events, and then selecting the ideal media and materials. With opportunities afforded by educational technologies, Mor & Craft (2012) point out that teachers should perceive themselves and should be perceived by society as “techno-pedagogical designers.”

With a variety of content sources, educators may still provide information according to Loveless (2011), but they must now provide the environment for students to ask questions, explore answers, collaborate, synthesize and construct their knowledge from the sources that are not only available to teachers, but to students and the general public as well. Moving in this direction would require an alignment closer to design-based research in education, but Mor & Craft (2012) cite a lack of support for design practices and methods in research, and lack of design-based culture among teachers as the reason that teacher-as-designer has not yet become prevalent.

In a study focused on math teaching, Hjalmarson & Diefes-Dux (2008) researched teachers who designed problem-based learning activities that required students to work in teams for several days to solve. Teachers moved from a focus on teaching the concepts and processes of solving math problems with a high volume of homework to a model where students were presented with problems in the context of a real life situation and assigned to figure out solutions by teams. Teachers designed the real world problems, assigned them to student teams (groups ranging from three to eight in number with an assignment), and facilitated student presentations of their solutions. In this study, teachers worked together to design a template for assignments and a rubric for assessment. Though a different subject, the Environmental Science teacher in the research project for this paper has taken on the role of teacher as designer.

Citizen Science

The convergence of Adventure Learning and Mobile Learning for an Environmental Science class opens opportunities for students to participate as scientific researchers, rather than simply learning from scientific information that others have gathered, processed and synthesized. Public participation in scientific research has been called "Citizen Science" in recent years, a term coined by (Bonney & Dhondt, 1997), who also stated that Citizen Science was a main contributor to scientific research during the 18th and 19th centuries. According to the Center for Advancement of Informal Science Education (CAISE), Citizen Science often describes a type of scientific research that involves public participation for gathering information (Bonney, et al., 2009). In a chapter of the Handbook for Urban Informatics, Paulos, Hinicky & Hooker (2009) have refined the definition of Citizen Science in the following way:

> Citizen Science is a term used for projects or ongoing program of scientific work in which individual volunteers or networks of volunteers, many of whom may have no specific scientific training, perform or manage research- related tasks such as observation, measurement or computation. The use of citizen-science networks often allows scientists to accomplish research objectives more feasibly than would otherwise be possible. In addition, these projects aim to promote public engagement with the research, as well as with science in general. Some programs provide materials specifically for use by primary or secondary school students.

Bonney & Dhondt (1997) explain that only the term "Citizen Science" is new, citing researchers such as Descartes, Newton, Leibniz, Buffon, and Darwin as "amateurs" who based research decisions on scientific interest rather than "money-biased technical bureaucrats." Using "public participation" as a term, Coffey (1996) also referred to efforts from the 1850s to 1940s to transform school grounds into places where students could participate in doing their own scientific research. According to Paulos (et al., 2009), the longest running Citizen Science project still active today is the Audubon Society's Christmas Bird Count, which started in 1900.

With an emphasis on "People Power," Hand (2010) cites Citizen Science projects in astronomy and biochemistry where volumes of non-scientist contributions from the public helped to develop a folksonomy to categorize natural structures and patterns. Several environmental science applications are available for mobile devices, enabling the public to contribute to scientific data such as air or water quality, and also track wildlife species. In conjunction with the National Audubon Society, over 11,000 bird watchers have used eBird, a mobile Citizen Science application, to upload over 110 million records of bird sightings (Rosner, 2013).

It should be noted that data contributions through Citizen Science might not hold the same weight or depth compared to what is produced by professional researchers, but contributions from Citizen Science can add a breadth that is otherwise impossible without input from the public (Trumbull, Bonney, Bascom & Cabral, 2000; Paulos, Hinicky & Hooker 2009). With data quality issues considered, scientific contributions through public participation have value based on the impact they have on the participants as a result of the project.

Gaps in Existing Adventure Learning and Mobile Learning Literature

The literature surrounding Adventure Learning and mobile learning addresses several topics through case studies and quasi-experimental design. This section discusses some of the gaps in the Adventure Learning and mobile learning literature and set a foundation for the research design described in Chapter 3.

Adventure Learning literature explores collaboration between students and among students, explorers, and content experts. It also addresses student motivation and engagement with the learning content. Some of the questions in existing Adventure Learning literature investigate increases in content knowledge, but there are currently no examples of experimental design that quantify improvements in academic outcomes, such as comparing student test scores with those not participating in the intervention. Setting up a rigorous experiment with control and experimental groups would be challenging because the researcher would need to give equal treatment to each group. This would require setting up a non-Adventure Learning non-mobile learning alternative for the control group that still gets equal exposure to the information accessed by the experimental group.

The current Adventure Learning literature also lacks information on how individual teachers use Adventure Learning to create instructional projects, even though the literature shows that when teachers use Adventure Learning projects created by others, they integrate them into their classrooms in differing ways (Doering & Miller, 2008). Miller's (2010) literature review focuses on STEM curriculum, but his research questions focus on the experiences of students and the perception of such programs in the local community. What are some of the new challenges a teacher faces when designing a project where students act as the expeditionary team rather than relying on a professional expeditionary team? This issue will be addressed by examining how a teacher uses an Adventure Learning approach to design instruction in a science classroom.

Student participation in existing Adventure Learning projects has been shown to increase student motivation in school and enthusiasm about the subject at hand (Miller, 2010; Veletsianos & Doering, 2010; Moos & Honkomp, 2011), but engaging them as both expeditionary and local participants should provide some helpful information about their motivational level.

Mobile learning literature, though broader and covering a longer time period than Adventure Learning literature, highlights the need for research in motivation and to what extent mobile technologies influence academic outcomes. Lai et al. (2007) points to the need to explore the motivational influences of mobile technologies in education. Some of the earlier mobile learning research called for effective and standardized diagnostic tools to compare mobile with other types of learning experiences (Naismith et al., 2004), though media comparison studies are seen as inconclusive in our field. Information sent from mobile devices tends to have more accepted errors in spelling, grammar, and formatting. There is not much research on why students do not correct their mistakes (Lai et al., 2008). Regarding how information is collected, there is a distinction between expectations for note taking and expectations for formal written presentations. As some project requirements include elements such as web pages, classroom presentations, and videos, grading matrices have been adjusted to accommodate the various platforms of completed work.

Moore & Kearsley (1996) pointed to the need for instructional design that is different from classroom design in the earlier forms of distance education. They suggested that instructional designers avoid simply taking a classroom curriculum and dumping it onto an online learning platform. Ryu & Parsons (2009) suggest a similar distinction between mobile learning and traditional Educational technologies.

Mobile technologies make available new affordances for teaching because of ubiquitous access to information and communication, but teachers tend to teach with existing methods, not making use of the new affordances. From a practitioner standpoint, there is a lack of literature that would help experienced teachers transition from traditional classroom or existing course delivery using existing technologies into making use of mobile technologies in education.

Professional and real-time interaction is motivating to students, but only as recipients

If students are motivated by participating in real time interaction with an expedition team, researchers could consider what changes might take place should some of the students take the lead as the expedition team. In a scenario like this, there would still be a need for experts to provide specialized training, just-in-time information, and advice on how to conduct the environmental sciences research.

Measurement of Learning in Adventure Learning

Adventure Learning literature aims to evaluate the increase in content knowledge through traditional performance and evaluation studies (Doering, Miller, & Veletsianos, 2008). Moos & Honkomp (2011) observed 182 Minnesota students in 7^{th} grade during an Adventure Learning Social Studies class. Using a mixed methods approach involving interviews and self-disclosure through a motivational questionnaire, they measured motivation, attitude, and other parts of the learning process and its influence on building content knowledge. Similarly, Miller's (2010) dissertation, which focused on increasing STEM standards among Native American students involved in an Adventure Learning project, employed mixed methods through classroom observations, interviews and motivational questionnaires. In the interviews, students demonstrated an increase in content knowledge of STEM related subjects, but content assessments were not part of the research. As discussed earlier, the potential for unplanned variables in adventure and mobile learning experiences make it challenging to discover how the Adventure Learning project impacted student performance on standardized tests. Furthermore, a tremendous amount of time (several years) is required to measure such a change, and, as noted previously, it is difficult to design a study with appropriate controls to determine the influence on grades based on application of adventure and mobile learning technologies.

Since the current study took place within the period of a few months, the investigation focuses on student interest in the subject of Environmental Science as they participate in mobilized Adventure Learning projects. Results from content assessments are not part of the analysis.

Factoring the Novelty of New Technology

There has been a discussion in the field of educational technology about the degree to which the increased motivation levels that seem to result from using educational technology are dependent on novelty. Once the novelty wears off or a newer product becomes available, students lose their initial interest. Since the 1990s, a lot of people have debated whether technology is even necessary for valuable educational transactions (Tennyson, 1994; Jonassen, Campbell & Davidson, 1994; Kozma, 1994; Morrison, 1994; Ross, 1994; Shrock, 1994). Over time, much of the discussion has settled on good pedagogy being a necessary element in any educational endeavor, no matter how well equipped. For research at Eastbury High School, repeated reports from interactions and surveys of user opinions helped to determine student attitudes toward learning over a longer term.

Current Focus of Mobile Learning Literature

Similar to Adventure Learning, researchers have not focused on quantifying the advantages of mobile learning compared to teaching with existing technologies or classroom learning. A big reason for this oversight is that the literature has settled on mobile learning as an enhancement to an array of educational technology tools available to educators. Pachler et al. (2009) observed that trying to compare mobile learning to teaching with existing technologies or instructor led teaching is like comparing apples to oranges. The arrangements and dynamics of the diversified classroom are too broad to isolate elements in the learning process and study them in a comparative fashion. According to some researchers, mobile learning practices are not guided by theory but are driven by paradigms that focus on technology rather than pedagogy (Naismith et al., 2004; O'Malley, Vavoula, Glew, Taylor & Sharples, 2003).

This study helps fill this literature gap because mobile learning is guided by the theoretical framework of Adventure Learning, which focuses on inquiry-based learning, collaboration between students and experts, learning environments supported by the

Internet and other media, and adventure-based curriculum (Doering et al., 2008). Supported by mobile technologies, students can participate in an Adventure Learning project as the expeditionary team. The Adventure Learning framework provides a means through which student interactions and the learning process can be evaluated in terms of both motivation and content knowledge.

Mobile Device as an Information Collection Tool

With a few exceptions, tablets can be used for the same purposes as laptops. Students can type documents, do web searches, download and follow lecture presentations, and communicate via email and other means. The instant boot capability and small size add a level of convenience. Tablets open doors for even more uses in education, so a study with tablets as mobile learning devices should press the boundaries and take advantage of the new possibilities. Though many functions are shared with laptop computers, the versatility of a tablet releases these functions into the world outside of tabletops.

One of the most referenced new functionalities of mobile technologies in learning is the potential to use the devices as information gathering tools (Trifonova & Ronchetti, 2003; Naismith et al., 2004). Students can use them to write observations or record audio, video, or images. Tablets with GPS enable students to geo-tag information that is captured by the tablet and store the information with tags of location, time, temperature, and other relevant information. Instead of using the device to only gather information that other people have researched, tablets enable students to research some types of information first hand. Several recent case studies document student use of mobile devices to gather information (Evagorou et al., 2008; Wallace, 2009; Bannan et al., 2010; Looi et al., 2009) but have not addressed whether there is a change in academic outcomes associated with the use of mobile technologies in education.

Adventure Learning frameworks and mobile learning technologies have different effects on the learning environment. The research literature for both areas lack data on whether the interventions have any impact on learning outcomes. They are also lacking observations on how the teacher changes teaching plans and processes because of the implementation. Both address student motivation to some degree but leave room to refine the extent of motivational change among students. Adventure Learning literature will benefit from observing how students respond to participating as the expeditionary team, and mobile learning literature will benefit from observing how students use the mobile device as a first-hand information gathering tool. I will address these gaps in the following chapter on research design.

Chapter 3: Methods

The research potentials for a mobilized Adventure Learning project stem from the areas that are not currently covered by the existing body of research literature. Following the development and discussion of research questions, the following section will lay out the methodology as a theoretical framework for answering the research questions.

Research Questions

The research questions are designed to investigate answers to some of the gaps that appear in Adventure Learning and Mobile Learning literature. Suppose a teacher wishes to leverage available mobile technologies to create adventure in the teaching process and enhance learning activities both inside and outside the classroom. With the exception of Miller (2010), projects presented in Adventure Learning literature tend to be designed by research teams with access to funding and design expertise. Though these projects set an excellent example for Adventure Learning, individual teachers would need a lot of creativity, expertise, and resources to go beyond participating in an existing Adventure Learning project to create something that resembles these more elaborate projects. How might teachers with limited access to expertise in the Adventure Learning model design their own Adventure Learning projects? These gaps in the literature are addressed in the first research question, which focuses on the instructional design process from the perspective of the teacher. Existing literature in education also indicates that learner interest in a specific subject can be increased when students are engaged with hands-on learning in addition to traditional means of teaching a subject, such as textbooks and lectures (Abell & Roth, 1992; McBride & Bonnette, 1995; Brush & Saye, 2000). In this study, student interest is a psychological reference to students having an affective reaction and focused attention for particular subject content and a predisposition to re-engage ideas in that subject on an ongoing basis, even after course requirements are completed (Hilton, & Lee, 1988; Renninger & Hidi, 2002). What happens to student interest levels in Environmental Sciences when they take their mobile technologies outside of the classroom and learn in the Environment through an Adventure Learning project? To address this idea, the second research question focuses on student interest levels in relation to participating in the Adventure Learning project. The research questions are as follows:

1. How did a teacher leverage mobilized Adventure Learning to design learning activities?

2. How did active participation in a mobilized Adventure Learning project affect student interest in the subject of Environmental Science?

Leveraging Mobilized Adventure Learning to Design Learning Activities

In what ways will the teacher leverage mobile learning technologies to enhance learning opportunities in an Adventure Learning activity? Will he leverage most or just a few of the functions afforded by mobile technologies? Will he employ all or only part of the Adventure Learning principles? How will perceived success or failure in implementing these learning activities affect his willingness to continue mobilized Adventure Learning activities? Though ubiquitous access to information and communication opens new possibilities for teaching, would a teacher fall back on existing methods, not making use of the new affordances (Savill-Smith, 2005; Pachler et al., 2009)? The first research question is divided in several related questions to address these issues:

1. How did a teacher leverage mobilized Adventure Learning to design learning activities?

    a) What challenges did the teacher face when implementing the designed learning activities?

    b) What did the teacher think was the role of the mobile device for mobilized Adventure Learning?

    c) What was the teacher's understanding of Adventure Learning and its role in the educational process?

These questions can be answered by gathering artifacts, such as learning activity plans, conducting interviews with the teacher about his understanding of Adventure Learning, and by observations of learning transactions (Moore, 1987) that take place primarily outside of the classroom. As described in the Data Analysis section, the researcher analyzed the data by transcribing conversations, coding, developing and confirming themes, and then triangulating ideas using the Constant Comparative method (Charmaz, 2006; Glasser, 1965; Glasser & Strauss, 1967).

Student Interest in the Subject of Environmental Science

The second research question focuses on student interest in the subject of Environmental Science in relation to participating in a mobilized Adventure Learning project. An issue for teachers of advanced placement courses is that students tend to study to receive a high course grade in order to boost their grade point average. Those who go on to take the standardized advanced placement test focus on knowing the information they need to get a good test grade, but are not otherwise interested in the subject at hand (Popham, 2001; Menken, 2006).

Starting at early age, positive learner emotions lead to deeper attention, engagement, and absorption in learning a particular subject (Dewey, 1913, 1933; Krapp, 2000; Xu, Coats, & Davidson, 2012). In this study, Mr. Kollar, the Environmental Science teacher, has a particular focus on engaging students with hands-on involvement in the subject, intending to raise their interest level in the subject and result in career or lifestyle choices benefiting the natural environment. This is similar to Christidou (2011), who observed that student interest and attitudes toward science consequently affect their academic achievement, career choices, and lifestyle choices. Though, by age 16, 17, and 18, students have already gravitated to interest or disinterest of subjects, their ideas are still forming at this age and are open to positive influence (Krapp, 2000; Osborne, 2003; Maltese & Tai, 2010).

To understand the impact of the intervention toward addressing this problem, the researcher asks how active participation in a mobilized Adventure Learning project affects student interest in the subject of Environmental Science. Answering the second research question will require attention toward a number of influencing factors, such as the technology involved, location of learning, and activities involved in the learning process. The second research question is divided into several sub-questions to help address these issues:

2. How did active participation in a mobilized Adventure Learning project affect student interest in the subject of Environmental Science?

    a) How did the mobile device support learning Environmental Science?

    b) What was the relationship between the use of mobile technologies and student interest in Environmental Science?

    c) How did hands-on participation in mobilized Adventure Learning affect student interest in Environmental Science?

These questions will be answered by analyzing data collected from surveys (See Appendix C) administered by the teacher, learning activity observations, and focus group discussion. Data from opinion surveys, travel status, and interviews are presented and analyzed in the Results section of this paper.

Study Context

The research for this project was conducted at the Eastbury High School campus or on school outings, located in a large city in Texas. The school district has approximately 7,700 students at nine schools. According to the district profile for 2012, the self-disclosed ethnic distribution of the school district is African American 0.8%, Hispanic 12.5%, White 71.8%, Asian/Pacific Islander 10.7%, Native American 0.1%, and two or more 3.8%. The Eastbury High school has an average enrollment of approximately 2,500 students and is the only public high school in the district. It is one of over 50 public and private high schools in the greater metro area in which it is located. Standardized test scores are above average for both the State of Texas and for the nation. According to the district annual report for 2010 and 2011, the average SAT score is 1792, compared to a state average of 1446 and a national average of 1498. Similarly, the mean ACT score of the school is 27.0, compared to a state average of 20.8, and a national average of 21.0. Test scores for the 2011 TAKS Test in Reading were 66% compared to a state average of 47%. Scores for the 2011 TAKS Test in Math were 60% compared to a state average of 42%.

Project Description

The project included approximately 160 high school students from six Advanced Placement Environmental Science classes taught by Justin Kollar (a pseudonym). Throughout the school year, rotating groups of 30 students at a time travelled to a state park that was recently damaged by massive forest fires, to an environmentally friendly farm, and to a bird observation activity. Mr. Kollar planned for half of his students to have one opportunity to travel one time to the state park in the fall from October to November, and for the other half of his students to travel to the park in the spring semester from January to February. As the project was implemented, all of the activities took place between January and March, and half of the students participated in the travel teams while the remaining students participated from the school campus without traveling to the Adventure Learning projects.

Both from the school campus and onsite at the outdoor activity, students participated in an Adventure Learning project in Environmental Sciences arranged by their school. Students traveling to the research site and students participating from the school all used mobile technologies along with traditional tools, such as magnifying glasses, sample gathering instruments, computer databases, and office software for calculations and reporting. While traveling, students took samples from the environment, made environmental observations, such as logging frequencies of native, non-native, and invasive plant species, and participated in forestry replanting. Students who participated by staying at the school performed related laboratory work, reviewed photographs, and analyzed information reported by the students who traveled.

The ideal times for traveling were January to March. These times were based on the ideal seasons for outdoor activities, observing invasive plant species, and replanting of native forest in early spring. Based on class sizes, travel times, and logistical issues, Mr. Kollar decided which projects would occur at what times, so random selection for participation was not possible. He intended to include every student in traveling to at least one of the outdoor projects, but realized during implementation that uncontrollable circumstances such as weather, travel constraints, other school commitments, or absences would prevent some of his students from participating as part of the travel team for Adventure Learning.

According to Mr. Kollar's plan, the traveling classes acted as the Adventure Learning expedition team, and travelled to the state park and other observation sites for two main purposes. The expedition teams were to address the first purpose by investigating the condition of the burned forest by collecting samples and making observations about the environment while capturing data on their mobile devices. The second purpose is addressed through replanting native forest.

Students participating in the trip brought back any specimens to a laboratory at Eastbury High School to be shared with other students, who also participate in the project by analyzing the samples using school laboratory equipment. Students who stayed at the school were also given a related research assignment. The students traveling uploaded the information they captured on their mobile devices to a shared database. These practices allowed students who travelled at other times to collaborate by accessing and analyzing the data when they are not traveling. Students traveling as part of the expeditionary team primarily focused on gathering information with their iPads and replanting native forest species. After the opportunities to travel were completed, students then began to collaborate with each other and with students who stayed at the school on their findings by leveraging shared images, observations, lab results, and data to create reports in the form of documents, videos, and other formats as assigned by Mr. Kollar.

Adventure Learning Curriculum

Among the seven elements in Adventure Learning (Doering, Miller, & Veletsianos, 2008), planning for learning activities in this project focuses on the elements that address curriculum enhanced by media, and curriculum leveraged by technology. Other elements, such as inquiry based learning and collaboration, were evident in the delivery methods of the learning activities.

Until the 2012-2013 academic year in which this study took place, the main curriculum for the AP Environmental Sciences course at Eastbury High School had been from a hardcover textbook. The school had recently switched to an electronic version of Living in the Environment (17th Edition, Thompson, 2011). At the time of research, all of the students were using an eTextbook downloaded directly to their iPads. Though factors of cost and convenience of a book with zero weight were primary factors in deciding to use an electronic version of the textbook, this decision directly supports the Adventure Learning element of using a technology-based learning environment in addition to supporting the mobile learning element of ubiquitous access to information such as curriculum. As the focus for one of the Adventure Learning projects was analyzing forest conditions and replacing native plant species following a massive forest fire, students reviewed print and video media that reported the conditions causing, during, and resulting from the fire. Though some video reports were shown to the entire classroom with a projector, students also accessed web-based resources using their mobile devices either in class or as a homework assignment. Before traveling to the site, field experts taught the class about the massive forest fires in the area where their project was scheduled to take place. Some were through a live appearance in the classroom, but at least one of the meetings with a field expert was through videoconference to provide live question and answer before the students travel to the site. Field experts were also available through email for questions that students face later in the project.

Adventure Learning elements, such as Inquiry and Collaboration, were supported in learning activity design as students used their mobile devices to discover first-hand information at the project site while capturing it with their mobile devices to add to a database and create reports for grades and to collaborate with their classmates. An environment of Adventure-Based Education was also designed into the learning activities to emphasize that students are participating in the recovery process from a natural disaster.

Methodology

This study is a qualitatively driven mixed methods approach. It includes some quantitative data to provide deeper and fuller information, and reflect, challenge, or illuminate some of the qualitative findings (Johnson, Onwuegbuzie, & Turner, 2007). The researcher employed qualitative methods through interviews with the teacher, interviews with focus groups of students, learning activity observations, and artifacts, such as curriculum, current learning activity plans, and technologies used including hardware and mobile applications. He used quantitative methods to analyze statistical information reported through travel status and student responses to pre- and post-treatment opinion surveys. Data were compared by frequency distribution graphs and tested through statistical analysis tests described later.

As a mixed methods study, this research attempted to use both qualitative and quantitative methods to answer the research questions. As much as possible, the primary investigator avoided manipulating the environment while collecting data. Some degree of influence could not be ruled out, as there were pre and post intervention surveys, interview and focus group discussions, and direct observation of classroom and learning activities.

Teacher Background

Colleagues of Mr. Kollar recommended him to the primary investigator because of his hands-on approach to teaching, and because of his interest in learning with a sense of adventure. He is also known as an innovator, willing to try new learning technologies as they have the potential to help him teach more effectively. His background story is interesting, and helps to build a foundation for why his classes were selected to participate in this study.

Because the first research question focuses on the teacher himself, the primary investigator drew most of the data from three formal interviews with Mr. Kollar, along with classroom and Adventure Learning project observations. The interviews were scheduled in advance with Mr. Kollar with some of the main topics and questions e-mailed to him in advance. A list of the interview questions can be found in Appendix D.

Additional information about the teacher's background was gained from an extended conversation during half-day trip on a Saturday to investigate a potential natural habitat where students might go to a future Adventure Learning project. This setting provided a more informal atmosphere for discussing how Mr. Kollar became interested in environmental sciences and what led him to his pedagogical practices.

Questions for the basis of this discussion are under the General Questions section of Appendix D. The primary investigator also observed classroom settings, participated in three Adventure Learning projects with an average of 30 students each trip. He traveled in the same school bus with the students to and from each of the trips. This provided an opportunity to observe how students interacted during both traveling and at the location for their Adventure Learning projects.

Justin Kollar grew up in rural Louisiana, and recalled that his parents would take him to vacation in a cabin next to a lake during the summers. They would spend several weeks, or more than a month, in the cabin relaxing and enjoying the summer, doing outdoor activities such as fishing and swimming. As he was growing up, Justin describes the summers as the high point of his year. While staying at the family summer cabin, he would spend the daytime swimming or fishing, and he would spend the nights tracking and pursuing animal wildlife. He learned a lot about how animals live and move, and he also observed a lot about their habitats. During those summers, he learned how to identify species and identify evidence of specific animal. This evidence might include things like animal markings, tracks, droppings or other evidence of animals feeding or marking their territory.

First-Hand Observation of Wildlife

During those summers of his growing up years, Justin describes an appreciation that he gained from fishing and observing wildlife. He also learned to identify various species of plants. He started to learn what plants are necessary for animal survival, including what plants are necessary for their food or their shelter. He observed how rainfall and sunshine or lack of resources for plants affected not only plant life but also the animals that depended on these plants. From his early years, Justin began to understand the influence of humans on the natural environment. He became aware of his own influence on the environment through his interactions, and attempted to minimize any influence on the natural environment.

A large part of Justin's experience during those summers resulted in learning different species of birds. Using books from the library and science classroom, he would collect all of the information that he could during his school year regarding birdlife. He would look at encyclopedias, nature publications, and other printed data, and created his own notebooks in order to learn to identify species and better understand their habitat.

As a teacher today, Mr. Kollar draws from his experience as a young person. From those early years, he developed an appreciation for environmental sciences through his first-hand observations by spending time in the natural environment. As a teacher, he hopes to convey the appreciation that he developed for the natural environment to students who are now the same age he was when he developed that appreciation. Much of his own experience, with books and other resource media, was self-directed learning.

Through his own personal interests, he would go to libraries and classrooms and read through printed materials that help to inform him of plants and animals that he observed in the natural environment. He was internally motivated to research this subject, and used his own time to gain information about the natural environment that he was observing. His responsibilities now include requiring students to read and learn and make observations, but those students may or may not have a comparable internal motivation to learn the subject. Through classroom observation and interviews, it became apparent that Mr. Kollar insists that all of the students develop a foundation for Environmental Sciences through reading and use of other media available before venturing into the natural environment to learn from first-hand observations. Following the foundational information, he expects that students would use their own hands to learn about environmental science through their own observations in the natural environment.

Path to Environmental Science Major

After his teen years, Mr. Kollar took several education courses in his undergraduate studies. In fact, he originally started his undergraduate career as an education major. He was hopeful that he could convey his love for the natural sciences to the next generation of young people when they were in the same range that he was when he developed his own appreciation for the subject.

He describes this as a brief period of time when he took education courses, but eventually became frustrated and said “No way." He described the experiences that he had as leaving him somewhat disillusioned about education. At that time, he had a lot of respect for teachers, but he thought, “If this is what I have to go through to become a teacher, I don't want any part of it.” From his perception of the way the college courses were conveyed, he found that the college professors were neither motivational nor inspirational. Had the teachers been more interesting, and had they made the subject more interesting, Mr. Kollar expects that he would have remained an education major and started his career as a teacher.

During his college years, Mr. Kollar changed his major to Environmental Sciences, and ended up pursuing a career with the state of Texas Parks and Wildlife Commission, where he spent 27 years before retiring. Though Mr. Kollar's career path was working directly in the environment with the Texas Parks and Wildlife Commission, he was also involved in teaching or education during that career. Mr. Kollar described several occasions when he was asked to visit classrooms and talk about wildlife, environmental sciences, or environmental issues in the state of Texas. Classes would take field trips to various state parks where Mr. Kollar would sometimes give an on-site lecture or demonstration of the natural science issues related to that location. He admits that he was not concerned about pedagogy or about educational objectives when making brief presentations. He also did not give grades or have to deal with contacting students or parents or follow-up on any kinds of student responsibilities. He was not involved in any of the bureaucracy of education or of the work that is involved with classroom management. But he was able to convey his environmental science interests to students anywhere from elementary school through high school. During his years in that career, he also taught adult groups who visited the state parks or asked him to come and be a special speaker at some of their meetings. Many of these meetings were involved with bird watching groups, of which Mr. Kollar continues as a member.

Engagement with Education

While participating as an informal educator, Mr. Kollar worked with a lot of people who were directly involved as formal educators. When he worked with the Department of Parks and Wildlife, he also served as a board member of the Texas Environmental Education Advisory Committee (TEEAC), advising the Texas Commissioner on Education about the need for environmental education. In that part of his job, he also worked with a lot of teachers who were directly involved with formal education who also served on that committee. As both an informal and formal participant, Mr. Kollar was involved with education during his career with Texas Parks and Wildlife Commission.

After working 27 years at the Texas Parks and Wildlife Commission, Mr. Kollar was planning to work a few more years at the Commission and then retire. He describes going to a social event and sitting down for a dinner. The lady sitting to his left was asking about his current career and his satisfaction in his work. Though he described that he was very happy in his work, another guest suggested that he might be very happy teaching in K-12. Mr. Kollar described his background and interest and involvement with education, but also said that he was happy in his current work role. She asked, "When would you be eligible to retire?" He answered, "Well, I was eligible to retire last year sometime." She said, "Well, good! You need to retire and become a teacher." She went on to describe how happy she was as a teacher during her 36 years of career in teaching experience. She was now retired but she and her sister were currently conducting an alternative course for teaching certification in the state of Texas.

Her sister happened to be sitting on the other side of Mr. Kollar. And she chimed in, “Yes! That's a great idea!” She was also a retired teacher, and she had taught in a large urban area. They were both, at that time, teaching alternative certification. One of them said, “My class starts tomorrow night. Just come and go to it. Just come and visit, and if you like it, you can stay and you can register and pay us later.” So, Mr. Kollar went to the course and ended up completing the alternative certification. During the course, the instructor said that they should be already applying for positions at schools even though they were still earning their teaching certification. Less than two weeks later, Mr. Kollar had a job offer at Eastbury High School. He thought the application and interview was just a practice required for the course, but it actually ended up getting him a position at a high school. After Mr. Kollar accepted the offer, he sent in his notice of retirement with Texas Parks and Wildlife, and in a few months he was in the school teaching environmental science.

Looking at his academic and professional background provides information for not only how Mr. Kollar became a teacher of Environmental Sciences, the story demonstrates how he developed an appreciation for the subject, and why he prefers to teach through constructivist methods. It also provides some insight regarding his unconventional approach to education, leveraging new technologies, and taking learning outside of the classroom.

Student Participants

Based on prior class-size limitations of close to 160 students, Mr. Kollar estimated that he would be teaching Advanced Placement Environmental Sciences to a total of approximately 160 students in the 11th and 12th grades at Eastbury High School during the 2012-2013 academic year. In the course of that year, Mr. Kollar preferred an approach to designing outdoor mobilized learning activities that would take place in cycles, each building on what was learned in previous cycles, and allowing each student to participate in various types of Adventure Learning experiences at different times during the school year. The different types of learning experience include traveling as an Adventure Learning expeditionary team member to gather information or replant forestry in a state park, or in several school-based roles such as laboratory work, data analysis, and various methods of producing reports on their findings.

Though students are required to complete all of the class assignments, only those with written parental agreement and student agreement were included research data, including data from surveys and focus group discussions. Students who did not wish to participate in the research were not included in survey data and they did not participate in focus groups. During learning activity observations, the PI took general notes, but did not relate specific observations to specific students. Before analyzing any survey data, each participating student name was replaced with an anonymous number to protect privacy in the research process. The primary investigator did not note student names of students who participated in the focus group discussions, but only noted gender of the participants. For the class assignments, students participated in different ways at different times of the school year due to seasonal changes in the natural environment and the logistical issues associated with transporting students for off-campus activities.

Mr. Kollar required all of the participating students to fill out a survey on their interest level toward Environmental Sciences (see Appendix B). Students took the survey two times during the school year; once before participating in the intervention and a second time after participating in the intervention. The primary investigator requested a total of six focus group meetings, and planned to meet two times with three groups of six to eight students each. One meeting was planned before and one after these students had participated in a mobilized Adventure Learning project. The teacher was responsible for selecting students among those willing, and with parental permission, to participate as a focus group. These students met for focus groups during Environmental Science class, during free time, or while traveling to or from a learning project to discuss how participating in the mobilized Adventure Learning project affects their interest in the subject of Environmental Sciences (see Appendix C). Because of student schedules, not all of the students interviewed in the first round of focus group meetings participated in the mobilized Adventure Learning projects. The follow-up focus group meetings tended to have fewer students.

Another participant in the study was the teacher himself. Mr. Kollar was retired from wildlife management at the Texas Parks and Wildlife Department (TPWD) and had been teaching Environmental Sciences at Eastbury High School for six years. Though teaching was not his primary career prior to working at Eastbury High School, Mr. Kollar had often taught K-12 children while he worked at TPWD, visiting schools as a special speaker or guiding groups of students as they took field trips to natural settings in Texas parks. One of Mr. Kollar's primary interests in teaching high school students has been conveying his appreciation for preserving and maintaining the natural environment through proper management.

For the six Environmental Sciences classes at Eastbury High School, Mr. Kollar was responsible for teaching the content students needed to know in order to perform well on the standardized test for Advanced Placement so that they could receive college credit for taking the course. During the travel times for the mobilized Adventure Learning project, other faculty from the school were involved to some extent as field trip supervisors and for technical support. Teachers of other subjects were also involved, as some of the analysis and reporting tasks for students participating in the Adventure Learning projects involved subjects such as Language Arts, Mathematics, Computer Sciences, and Media Studies. Though the current scope of this study does not cover how the Adventure Learning project impacts subjects other than the primary focus, the additional academic subjects are mentioned here because of the need for coordination to make the Adventure Learning projects take place.

The researcher participated by observing and interviewing the teacher and the students. He also negotiated with the school to get the necessary permissions for observing the Adventure Learning projects and to facilitate focus group discussions with students.

Starting April 2012, the researcher has consulted to the teacher about maximizing mobile technologies in education and introduced the concept of Adventure Learning. Though the purpose of these discussions focused on creating a research environment for instructional technologies, any influences resulting from this relationship must be acknowledged at this point. Participating in the research project, the role of the PI changed to interviewer and observer. The researcher interviewed the teacher, but did not provide expertise or ideas to support Adventure Learning or Mobile Learning. While intending to assign use of a specific mobile learning application, there was an occasion when Mr. Kollar asked for feedback on the affordances of either application. The PI talked about the affordances for two applications, but refrained from making any recommendations.

During classroom or Adventure Learning activities, the PI participated as an interviewer or observer. He did not take on any roles of a teacher or facilitator, but followed and watched the students, switching from one group to another to gain a broader sense of how students were integrating mobile learning technologies. One of the Adventure Learning activities was an effort to reforest a burned area by planting seedlings. It was a cold day, and the event organizer handed a shovel to the PI and said, “The best way to stay warm is to plant some trees.” So, in that case, the PI participated in the same events as the students, but continued to observe without interacting with them.

Data Acquisition

Data acquisition sources include information gathered through interviews with the teacher, interviews with focus groups of students, learning activity observations, subject interest surveys, and artifacts, such as curriculum, learning activity plans, and technologies used including hardware and mobile applications.

The first source of data included interviewing the teacher three times. One interview took place before Adventure Learning projects begin traveling, one during, and one after all of the travel was completed. Since Mr. Kollar has a unique background, the research was enriched by a thick description (Geertz, 1973; Glesne, 2005) of his career path toward the teaching profession in addition to discussing his teaching methods. The series of interviews and observations also helped describe how Mr. Kollar designed learning activities on a regular basis, and how he incorporated mobilized Adventure Learning into planning of future learning activities.

Interviewing students in a focus group setting provided feedback on their experiences in Adventure Learning projects and helped students recall and explore in depth how both positive and negative experiences contributed to their learning process. There were a total of two interviews with each focus group, one before and one after the intervention. Though not participating as a teacher, the researcher visited learning activities to observe student interactions and use of technology. The role of the PI was to observe the teacher and students in their outdoor learning activity.

The teacher administered a survey of student interest based on the Science Motivation Questionnaire (Glynn, Taasoobshirazi & Brickman, 2009) seen in Appendix B, which draws its categorization from the broader Motivated Strategies for Learning Questionnaire or MSLQ (Pintrich, Smith, Garcia, & McKeachie, 1991). The surveys were administered by the teacher to all students in Environmental Sciences, once before the intervention and once after all of them have participated. Though the surveys given before and after the learning projects were identical, they explored the intervention effect on student interest in Environmental Sciences before and after the Adventure

Learning project. The Science Motivation Questionnaire has been modified to focus on student interest for the subject in terms of personal, academic, and professional goals. The survey helped triangulate other research data by providing quantitative data measuring student interest both before and after participation in the mobilized Adventure Learning project.

In addition to survey materials, nine days are allocated to the researcher for classroom and learning activity observations. These time allocations include time for classroom, outdoor learning activity, and focus group data collection. Notes taken from the researcher's observations were coded to explore themes and ideas as they emerge.

The primary investigator employed observation and interview techniques. The observations took place during classroom sessions and Adventure Learning activities where both mobile learning and Adventure Learning were employed. Interviews took place with the teacher. Some of the interviews took place over the phone, others took place in the classroom at the end of the school day, and yet others took place while doing pre-investigations at outdoor locations where Adventure Learning activities would take place in the future. Data that provided answers to this question were mainly divided into two categories: adaptation and planning.

Week of	1/7	1/14	1/21	1/28	2/4	2/11	2/18	2/25	3/3	3/10	3/17	3/24	4/3
Student Opinion Survey (1)	X												
Student Opinion Survey (2)													X
Student Team A Focus Group (1)		X											
Student Team A Intervention			X										
Student Team A Focus Group (2)							X						
Student Team B Focus Group (1)			X										
Student Team B Intervention				X									
Student Team B Focus Group (2)								X					
Student Team C Focus Group (1)				X									
Student Team C Intervention					X								
Student Team C Focus Group (2)									X				
Teacher Interview (1)	X												
Teacher Interview (2)					X								
Teacher Interview (3)											X		
Weekly Classroom Observations	X	X				X	X	X	X				

Table 1: Data Gathering Schedule

Data Analysis

Categorization for coding started as the research questions were designed. Information based from the literature review indicated gaps in current research that could be addressed through further first-hand research. As that information was considered for building the research questions, the PI created broad categories that the codes would fall under. These major categories included Elements of Adventure Learning, Mobile Learning Affordances, Technology Challenges, Factors in Student Interest, and Teacher Pedagogy.

After all of the interview and observation data were gathered, the PI added a total of 855 statements into a spreadsheet. Next to each statement, several columns were added to identify the related speaker or observer, the related research question, and whatever codes applied. Speakers might include the teacher, Boy 1, 2, 3, etc., or Girl 1, 2, 3, etc. The Observer was categorized as the PI. Each statement was tagged to one or more research questions or sub questions where were addressed in some way by the statement. As the PI read through the statements, he began to create codes that were sometimes merged into a fewer number of codes or other times split into more codes when required for specificity.

After determining the codes to use in the study, the PI de-identified the content and placed three conversations in an online survey, then provided access to two peer reviewers. One conversation was an interview with the teacher, and two were focus group discussions with students. For two of the conversations, each statement had an area where the reviewer could choose from a list of existing codes provided by the PI or provide their own ideas in a text entry box. The third and final conversation provided only text entry boxes next to the conversation. Based on feedback from peer reviewers, the PI tagged additional codes that were not previously considered for some statements, and added new code categories, including: Self Efficacy, Equality, and Authentic Learning. A final list of codes is provided in the Appendix section (See Appendix G).

The researcher used the Constant Comparative method (Glasser, 1965; Glasser & Strauss, 1967; Charmaz, 2006) for analyzing the data gathered through interviews with teachers and students, review of artifacts, and observation of learning activities. The Constant Comparative method allows for multiple exposures to ideas or topics that are transcribed, coded and formed into hypotheses (Glasser, 1965). Once repeated comparisons of interviews or focus groups produce no new categories or concepts, Boeije (2002) recommends the researcher determine that the topic is “saturated” and move on to comparison between concepts.

Appendix C contains a series of focus group questions for asking students before and after their participation the intervention. The entire recording of each discussion was transcribed, and then topics that were coded by the researcher. Two assistants to the researcher coded two discussions each, for a total of four discussions that were compared to the researcher's results to determine coding similarities or differences (Glesne, 2005). According to Boeije (2002), researchers can triangulate ideas and themes within a single interview, within the same group, but separate interviews, and between different groups with the same set of interview questions. The researcher analyzed focus group feedback from three different groups of students, each participating in pre and post intervention focus groups. Data within the same groups was analyzed between pre and post to discover progression of themes or ideas. Data from different groups was compared to triangulate emerging themes and ideas.

A series of questions was designed for interviewing the teacher before, during, and following the intervention (See Appendices D, E, and F). Interview conversations were transcribed and coded. Similar to focus group discussions, each interview was transcribed, and then the researcher coded each of the topics. Two assistants to the researcher also coded the transcription of one interview each. These codes were compared to those of the researcher. The researcher incorporated peer-coding ideas, analyzed data from the pre, during, and post intervention interviews to discover progression of themes or ideas.

Classroom and outdoor learning activity observations were coded as well. The researcher used member checking (Huberman & Miles, 1983; Pogrebin, 2002) to develop ideas and theories as they were related from coding of both the discussions and observations. Where differences arose, member checking through following observations provided clarification on the issues.

Data from the pre and post intervention student opinion surveys was analyzed through a simple T test to explore any changes in student opinions regarding the subject of Environmental Sciences or the supporting technologies. Though this is a qualitative study, quantitative data from the surveys is used to support the findings.

Validity and Reliability

Comparison of data between different subjects or within the same set of subjects gathered at different times is a means of ensuring validity and reliability within the Constant Comparative method (Holloway & Jefferson, 2000; Beoije, 2002). Data from student focus groups and teacher interviews are similar in that the discussions are a series, and allow the researcher to follow up by clarifying apparent similarities or differences that appear from earlier discussions. The teacher is only one subject, but was interviewed three times, allowing for a longer span of time and more interviews to gather and clarify data. Since three groups of students participated in focus groups, additional validity can be supported for focus groups through comparison of themes and ideas that arise between different groups. In later interviews, the PI asked follow-up questions when students elaborated on their use of mobile devices for school or frustrations they encountered. This practice helped to ensure reliability of the information and to clarify what students expressed.

Two peer reviewers also coded transcriptions of two student focus group discussions and one teacher interview each. Coding by peer reviewers was compared to that of the principal investigator to determine reliability in the analysis of the data collected. This process helped to split some of the code categories, and added three codes based on their text entry feedback. See Appendix G for code scheme.

Throughout the process, the PI noted items that were contrary to a line of thinking that he was following. Whether this is due to researcher bias or misinterpretation of the data, Glesne (2005) recommends paying more attention to negative cases, as they may not confirm all of the researcher's opinions, but support the trustworthiness of the findings.

Though this research project is qualitative by design, quantitative data contributes to information that can be used to support and triangulate ideas. Student opinion surveys administered by the teacher before and after the mobilized Adventure Learning intervention provide data for quantitative analysis. The researcher used ANOVA and Chi-Square tests to provide measurement on any trends or correlations of student interest in Environmental Science as it relates to the student experience with Adventure Learning supported by mobile technologies.

Triangulation of ideas helps to increase the validity of the findings as they describe commonalities and differences in behavior, reasoning, and attitudes (Beoije, 2002). Once the sampling of qualitative data has been collected, Glaser & Strauss (1965) have demonstrated that researchers can begin to build a base for generalizing concepts and relations between them.

Limitations

For conducting a primarily qualitative research project as described here, a number of limitations of the research should be discussed. The sample group of all the students in Mr. Kollar's classes was narrowed to 104 though he had 160 students. Mr. Koller distributed consent and assent forms to students, and provided digital copies of the responses to the PI. The 104 students whose survey responses were incorporated into the research were taken from students in AP Environmental Sciences at Eastbury High School who provided consent forms signed by their parents and assent forms that the students signed. Other than self-reporting within that group, no data were gathered from other classes, other schools, or activities outside of school. Most of the research questions were answered through self-reporting, either by survey or interview, though the PI conducted classroom and learning activity observations.

One of the measures used to collect data included a survey with 15 questions taken from the Science Motivation Questionnaire (Glynn, 2009). Though focused on K-12 interest in the subject of science, the survey by itself does not address all of the variables that impact student interest in a subject, especially when the students are a few months away from high school graduation. This point in the life of high school students includes a series of major life transitions, so graduating seniors might have their focus on future chapters in life. Additionally, at the completion of twelve years of public schooling, one would have to question whether three months of leveraging mobile tools for adventure-based learning will be able to change interest levels or learning preferences.

Finally, limitations of the researcher include limited access to the sample group and longitudinal effects. The PI was able to conduct interviews and observe classroom or Adventure Learning activities on a weekly basis during a nine-week period of the school year. Aside from self-reporting, no observations were conducted outside of school activities. Moreover, no direct observations took place outside of Environmental Sciences classes, so the only external information available was through self-reporting. Limited to a nine-week observation period, the PI could not observe trends over the period of a school year, or from one school year to the next.

Chapter 4: Results

Research questions for this study set the stage to investigate the processes involved for the teacher and the responses by the students when implementing and participating in a mobilized Adventure Learning project. The research questions and sub-questions for this study are as follows:

1. How did a teacher leverage mobilized Adventure Learning to design learning activities?
    a) What challenges did the teacher face when implementing the designed learning activities?
    b) What did the teacher think was the role of the mobile device for mobilized Adventure Learning?
    c) What was the teacher's understanding of Adventure Learning and its role in the educational process?

2. How did active participation in a mobilized Adventure Learning project affect student interest in the subject of Environmental Science?
    a) How did the mobile device support learning Environmental Science?
    b) What was the relationship between the use of mobile technologies and student interest in Environmental Science?
    c) How did hands-on participation in mobilized Adventure Learning affect student interest in Environmental Science?

Informing the Research Questions

Several sources of data were gathered to answer the research questions. The first source of data came from three interviews with Mr. Kollar as the teacher of the Environmental Science class. To set up the research, several conversations took place in advance, but the interviews took place over a scheduled 1-hour time slot, centering on specific questions (see Appendix D) to provide information for the research questions. Interviews 2 and 3 built on the topics and ideas discussed in the previous interview (Appendices E and F). The interviews were transcribed and data were coded and distributed to answer specific research questions and sub-questions.

The second source of data came from interviewing students through focus groups. Depending on class schedule and availability, Mr. Kollar arranged for three groups, ranging from six to eight students each, to meet with the primary investigator for focus groups and answer questions found in Appendix C. The design was for the same groups of students to meet and discuss the same topics once before and once after participating in the mobilized Adventure Learning projects. Due to participation rates in the projects and other scheduling issues, the follow-up meetings had fewer students. This enabled more depth of questions and answers, but prevented follow-up among students who did not travel. Data from the student focus groups were transcribed and coded, then added to the report as the data supported answers to specific research questions and sub-questions.

Another source of data was first-hand observation of classroom and learning intervention activities. The primary investigator made six visits to the high school during regular class days observed a total of 10 Environmental Science classes taught by Mr. Kolllar. The PI also traveled with the students to three mobilized Adventure

Learning projects that started from the school, but took place at an outdoor location away from the school campus. Data from first-hand observation was compiled, coded, and distributed among topics that answer the research questions and sub-questions.

The teacher administered an online survey that was developed by the primary investigator. The survey questions were based on the Science Motivation Questionnaire (Glynn, 2009) and additional topics to answer specific research questions. The survey questions are contained in Appendix B. All of Mr. Kollar's 160 students were required to take the survey both before and after the learning interventions, even if the students did not travel. A total of 156 students completed the survey before and after. Due to limitations of consent/assent, along with matching names for the pre and post surveys, the number of survey responses matched and used for data was 104. Students answered these questions from options based on a 5-point Likert Scale from Strongly Disagree to Strongly Agree (See Appendices K and L). The scores were analyzed using several statistical tests, which include a 2-Way ANOVA, and Chi-Square. Mr. Kollar also provided a list of students who participated in any of the three mobilized Adventure Learning projects, and this information was combined with the survey data as another point of analysis. Data from the surveys was compiled and imported into SPSS for statistical analysis. This data mainly informed the second research question which focuses on student interest in Environmental Sciences in relation to their participation in the mobilized Adventure Learning project.

Finally, learning artifacts were gathered to inform the research questions. These included class and learning activity items such as curriculum, learning activity plans, and technologies used including hardware and mobile applications.

Data from all of these sources was compiled, coded, and organized by how they informed research questions or sub-questions. This approach attempts to describe characteristics of the learning activities being observed, and uses classroom and learning activity observations, interviews, and artifacts to describe the teacher and students participating in the mobilized Adventure Learning project.

How did a teacher leverage mobilized Adventure Learning to design learning activities?

The literature review on both Mobile Learning and Adventure Learning indicated a gap in research regarding how a teacher could design learning activities to leverage mobile technologies in an Adventure Learning context. The following section takes a close look at how the teacher in this study took a constructivist approach to learning by pointing students to knowledge. He also taught students to gather first-hand information related to the subject. A description of how he adapted curriculum and schedule to incorporate mobile technologies and Adventure Learning is also included.

Pointing Students to the Knowledge

Mr. Kollar adapted his teaching style to allow students the flexibility and the time to look up information that helped them complete an assignment. He described this as the opportunity to present more authentic information. During a class observation, the primary investigator noticed that students were presenting on various species of plants. The teacher gave them the opportunity to look up their information ahead of time online and make presentations for what they found. Mr. Kollar himself also looked up some information, and he presented supplemental websites and video presentations that helped to fill in the gaps that some of the students left out. This provided a more thorough treatment of the subject and enabled the students to gain information that would be helpful on their course examination. After the class, Mr. Kollar explained that he had looked up the information ahead of time and bookmarked some of the resources in case the students did not address certain areas. He had some things prepared, and other pieces of information he gained, according to his words, “on the fly.” During that particular day, Mr. Kollar had already downloaded a video of a high-speed falcon chase so that it would be ready for the students to watch in relation to their curriculum for that day. Though students presented information on the same bird, none of them came across that video. Having the chance to see it, however, appeared to engage the students.

Students Gather First-Hand Knowledge

In an outdoor Adventure Learning activity that focused on bird watching, the students were assigned to work in groups of 4 to 5 students each. Two of the students on each team used a mobile application, titled iNaturalist®, that helped them identify species of birds that were observed by the team. This application provided information on which bird species they were observing, how to identify them, and information about habitat, including where those species most often live. Two other students used another application, titled BirdLog®, to log the observations that students made during the trip. This application enabled students to identify time location and weather settings even if they did not have connectivity to the Internet or a functioning GPS. At least one student on each team had either a pair of binoculars or a spotting scope to view birds that were some distance away. Mr. Kollar downloaded and tested several applications before deciding which ones would contribute the most to the Adventure Learning experience and designed the teams around how students would use the applications.

Mr. Kollar also adapted to the mobile affordances available while planning and traveling on an Adventure Learning project. While in the field, teams of students would log information based on their observations using a mobile application. They log this information into a shared database that was primarily shared by classmates taking Environmental Sciences. They have the ability to make this data available to the public, but for their current work, they are keeping it a private database. The BirdLog® application in particular requires a connection, and works best with GPS functionality. The students, however, were able to connect through a Wi-Fi hotspot. Since a GPS was not available for automatically including geolocation, students were able to select the location based on a map tool that is also part of the application.

Adapting Curriculum Schedule to Adventure Learning Activities

Based on the Adventure Learning projects and the schedule of outdoor learning activities, Mr. Kollar rearranged the topics for the class based on the opportunities that were available to conduct outdoor learning activities. He explained that several units were addressed in a different order compared to the order in the textbook. “But that's okay. There is no magic to the order of the textbook outline,” according to Mr. Kollar. Changing the order ended up changing classroom dynamics somewhat. The teacher described that it changes the things the classroom is able to focus on, because the teacher wanted to focus on the things that the students will be actively involved with. He even reordered some of the plans that he had for presenting lessons. The textbook has an outline, but the outline is not set in a specific order. The final test for the students does not require that one lesson necessarily builds on any of the previous lessons. Each unit being self-contained, they can be moved around within the school year, with the teacher still covering each of the subjects at some point during the school year.

Mr. Kollar explained that at one point he was originally going to work on a topic of land management, but he decided to do that as a subunit to another topic because it was related to a major outdoor learning activity that students were going to be involved with at a later point in the year. So in this case, every Adventure Learning activity could coincide with what the students are learning in the class at that time. Each Adventure Learning project or field trip presented an opportunity for the teacher to make sure that the lesson plans were adapted or were scheduled to coincide with the learning activity and achieve the maximum possible learning benefit for the students.

Mr. Kollar admits that there were some trade-offs with rescheduling or emphasizing one part of the subject over another. Because he spent more time in one area that was related to an outdoor learning activity, some other subjects had to be addressed within a shorter period of time, resulting in less in-depth treatment in terms of information. He described, “That's okay. Because they're going to retain that information a lot better. And because of the depth of experience on the field, they're going to experience something that they could not have experienced through the textbook and lectures.”

Providing a Framework for Knowledge Searches

Adapting to the Adventure Learning projects also afforded students the opportunity to build their own knowledge based on questions or assignments that they received from the teacher. This relates directly to the inquiry-based learning element of Adventure Learning, and will be addressed in more detail later in this section. Mr. Kollar provided students with the best suggested websites for getting information about environmental sciences and then allow the students to go to those places and look for answers to questions that he had given them ahead of time. He preferred that the students build their own knowledge rather than passively sit in their seats and receive information that he is presenting to them, but he also realized that web searches do not necessarily point them to the most reliable information. He would ask them to look up answers to questions, and would observe them finding the answers, coaching them to use reputable websites. Later, the students would present that information to their peers and get feedback based on the perception of other students.

These activities supported Mr. Kollar's long-term goals to convey self-reliance in learning for the students. He would gear his own presentation toward what the students are bringing to the discussion based on their own research. He had to keep his presentation flexible so that he could adjust to what the students were presenting or add to what they were not presenting to make sure that all of the students received a thorough picture of the subject that was being taught.

Mr. Kollar described how the planning for mobilized Adventure Learning projects had to be flexible in order to incorporate all of the learning materials in addition to covering any possible need for contingency plans. When outside of the classroom, the teacher has no control over the weather, wildlife movements, and a lot of what students might encounter or do while they are on the trip. For this reason, he emphasized the possibility of learning about things from various perspectives, including testing what they had read in books, making first-hand observations, and logging them through recording on their mobile devices. This content could be captured in the form of writing, recording, or taking pictures with their mobile devices. Students also reflected on findings through verbal feedback, and conversations with experts in the field.

Researching before Forestry Project

For one of the Adventure Learning trips, the students traveled to a state park that had been burned a year earlier as a result of severe wildfires. Before traveling, the students were required to read PDFs that were distributed by the teacher. They were also required to do their own searches on media accounts of the forest fire that devastated the area that they were going to research. The students were also assigned to read the textbook section on management of public and private land. Though it only briefly mentioned forest fires, this section of the textbook talked about land management both in preventing forest fires and in recovering from a forest fire. Before attending the Adventure Learning trip, all of the students were required to participate in groups that presented an account of the fire, the extent of the damage, fire intensity maps, news accounts, and also links to websites that they used for their resources. Each student was able to see various photographs, videos, and accounts of people who went through the fire, gaining an understanding of the extent of the damage.

Damage from this particular fire took place on both private and public land, but the students were traveling to public land in order to investigate and begin re-forestation that would not occur naturally. Students not only studied fires for this particular area, but also looked at fires in grasslands and other areas, and were able to learn from written texts and media about the environmental impact of wildfires, whether they occur in the forest or in grasslands. Some areas recovered naturally. As the students learned though, the area that they were about to visit could not recover through natural means. The forest that existed in that area for thousands of years was completely burnt. The intensity of the fire was so hot that it sterilized the ground and prevented re-forestation through natural means. In order for the forest to recover its natural state before the fire, human intervention was required to replant after life returned to the soil and it began to recover.

Researching before Bird Observation Project

For another Adventure Learning project, Mr. Kollar prepared the students for watching and observing bird species in the natural environment. For this learning activity, he assigned the students different bird species and asked them to research and present to the class what they found based on Internet searches and textbooks. The groups that were formed to research and make these presentations continued into the Adventure Learning project, as students went out and made first-hand observations in the natural environment. The groups were required to carry information about bird species in order to identify them on their iPad devices. This interaction took place through iNaturalist®, an application that works much like an encyclopedia but does not require connectivity once it is downloaded. Students were able to access this application and find identifying features and habitats of species so that they could make sure that they have correctly identified the birds. Other students on their team would log the findings in BirdLog®, which is another online application that works best when students are connected to the Internet. This application can also work offline, but students must upload their findings at a later point after they restore connection.

Various kinds of Adventure Learning activities require different kinds of planning and preparation. Mr. Kollar described preparation and assignments in different ways because the designs for each of these projects were very different. In each project, however, students had work to do ahead of time where they were required to search and find information and present it to the rest of the class. Following their foundational search for information, students were required to go into the natural environment and obtain first-hand information that related to their environmental science assignment for each of the Adventure Learning projects.

Scheduling Flexibility

Mr. Kollar also needed to create some contingency plans in case weather or travel issues prevented students from reaching the original plan for Adventure Learning activities. During one learning activity, students were planning to visit an organic farm and observe how vegetables and animals were raised for the organic food market. If there had been rain within the last several days before or during the day of the trip, students would not be able to visit that farm because it would be muddy. Mr. Kollar prepared for a later date for outdoor learning activity as a backup plan, in case weather conditions prevented them from visiting the farm.

During a previous year, Mr. Kollar had to cancel a trip to the same farm because it had rained on the day prior to the trip. During the current year, he made contingency plans in case there was rain or for other reasons that would prevent them from traveling to the farm. He planned an earlier date for the bird watching learning activity in case of rain, but this created a new problem. If the class went on an earlier date to the bird watching activity, the students would not be prepared as adequately as if they had gone at the planned time. Though bird watching can be done with or without rain, Mr. Kollar preferred to have the students prepared for the bird watching activity before they went. In order to deal with this contingency, Mr. Kollar had students download the applications ahead of time for bird watching, and he had some prerequisite reading scheduled in case they had to make changes to their plans. If they needed to go bird watching instead of visiting the farm, students would have assignments to read on their way to the bird watching adventure learning activity. If this was the case, students would not have as thorough an introduction to bird watching as they would if things went as scheduled, but they would have foundational support for that topic.

The teacher also had to create contingency plans because chaperones, bus drivers, and student schedules made it difficult to postpone an Adventure Learning project for two or three days or into the next month. So whenever a learning activity trip was planned, the teacher felt it was important to go on some kind of learning activity, even if it was not the originally planned location or activity. This way, the teacher could make use of the time, bus reservations, and everyone's schedule, in order to accomplish some kind of learning activity.

What challenges did the teacher face when implementing the designed learning activities?

Mr. Kollar reported several areas that were challenges when implementing the designed learning activities to include mobilized Adventure Learning. One of the challenges related to schedules. At first, he tried to plan everything with a firm schedule, expecting that all of the dates would fall in place according to his original schedule. But events beyond his control, like school activities, weather, sickness, and other issues, all contributed to the need to be a lot more flexible when planning Adventure Learning activities like this.

Keeping Records of the Learning Activities

Documenting the learning activities so that all students could see what happened was a challenge to the teacher. In planning for all three of the Adventure Learning activities that were conducted in the spring semester, Mr. Kollar determined in retrospect that it would be helpful to plan more videography to give comprehensive coverage of all of the outdoor activities in addition to what students captured through the video recording feature of their iPads. Though videography was not part of the original plan, one event had an outside videographer that the Mr. Kollar felt contributed a lot to the learning experience for the students who did not attend the on-site activities. The students who went to the on-site activities took short video clips with their iPads as well as photographs, but the videographer provided a more professional, objective, and high-resolution perspective of the event.

In preparing for the trip, Mr. Kollar looked for mobile applications that would enable students to create their own information or allow them to capture their own information to be shared with members the class who did not travel. He preferred mobile apps that give them the opportunity to go out and get the information above those designed for only searching for the information on the Internet or downloading some kind of an article. Rather than giving them a paper and pen assignment or asking them to take content that he gives to them, Mr. Kollar prefers to find applications that enable students to go out and collect information, and put it together in a way that is meaningful to them. In looking for these kinds of applications, Mr. Kollar and encountered a few problems with applications that failed or were difficult to use. For the Adventure Learning trips that took place during the spring semester, students were able to use applications that were either part of the native operating system, or were approved by the school and caused minimal technical problems.

Mobile Device Limitations

The type of mobile devices used by the students created a challenge for learning while out in the field. The larger screens of an iPad are convenient for viewing searching, and reading, but the size of the device creates a problem for students who need to handle something, such as a measuring or excavation tool, with one or both hands. In one of the Adventure Learning projects, students were busy shoveling and planting trees. While they were participating in the learning activity, they were not able to use their mobile devices because they were using both hands and most of the mobile devices were stored in the bus. A few of the students carried their iPads in their backpacks, and were able to take pictures or videos of other students and use FaceTime to communicate with their classmates who were back at the school. Mr. Kollar suggested that he would like to integrate various mobile devices on the next trip where students would be working with their hands. He suggested that some students having a dedicated GPS would be helpful to log exactly where they are whether or not they had connectivity to the Internet. He would also like to see some students using personal cell phones rather than an iPad, as they could be easier to carry and access during an event where they are working with both of their hands. At least the device could be available to them whenever they needed to take a photo, capture a video, record something, or communicate with someone. He would also like to see more students carry mobile hotspots. The hotspots might be cell phones that are enabled as hotspots, or they could be dedicated hotspots that would enable all of the students to use their iPads to connect to the Internet even while they are out in the field.

Effort in selecting the best mobile applications

One of the challenges that Mr. Kollar faced while working with mobilized Adventure Learning was anticipating which applications and learning formats the students would prefer. For instance, he described a situation where he found a video that the students could watch and learn from. Before he was using mobile devices, he would just show it to the students during class time. But now that the students are enabled by ubiquitous access to information, Mr. Kollar decided to make the link to the video available through one of the applications that the students like to use. He found that the students watched it and talked about it more than they would have if he had shown it to them in the class. He even saw them watching it during times that they were not required to be working on their schoolwork. But he also said that sometimes he would try something and it simply failed. He would try some new kind of application that he thought the students would like, but found out that they did not like it or that there were technical problems that students could not get past.

In addition to mobile applications that would sometimes cause a problem, Mr. Kollar encountered problems during previous school years because there was no mobile supportive learning management system within the school. Eventually, the school was able to purchase an appropriate learning management system, and the user experience improved overnight. Mr. Kollar described it this way: “Now, it's so easy, you don't even notice it.” The previous way of exchanging homework assignments and teacher handouts was very cumbersome and often failed. But with a mobile supporting learning management system, both the teacher and the students have a much better user experience.

Sometimes, up-to-date information on the Internet became a challenge for both the teacher and students. When the students arrived on site for replanting burnt forest, they were able to access Google Earth® and look at the location where they arrived. The map information was several months old, so the satellite view had an older picture of the area where they were replanting trees. In some ways, this turned out to be an advantage, because the students were able to see the forest the way it looked before the fire. With their eyes, they were able to see the forest after the fire. Even though Google Earth® had older pictures, they were able to imagine their goal for what the forest could look like in 50 years if they were successful in replanting it.

During that same trip, students were able to take pictures of the burnt forest, and take pictures and videos of their replanting efforts. They uploaded those to a database so that future students participating in future projects could see what they have done already.

On a trip to an organic farm, Mr. Kollar expected the students to access information about farming or about marketing agricultural products. He also wanted students to take notes during the project that they could go back to the class and share with their classmates. As it turned out, many of the students watched as the farmer explained and demonstrated some of the agricultural techniques, but only a few the students actually took notes or pictures or uploaded any information to share with others. Having live animals that could be touched or held turned out to be more interesting to most students than capturing or looking up information.

Mr. Kollar was able to support his constructivist approach to education by leveraging mobile technologies in a way that enabled students to gather their own information through web searches, and eventually gathering first-hand information in the field. He also adapted the curriculum schedule so that subjects were taught during a time that students would be able to observe them first-hand in the environment. He also found that it would be helpful to have a more structured system for recording the student activities to share with the current students who did not participate in the travel activity, and for future classes. He found it important to spend time testing to determine the best mobile applications to assign the students to download and use for an assignment. Some of the mobile technologies, such as battery life and device size, also became a challenge.

Challenges with Adventure Learning elements

From the start, Mr. Kollar encountered several challenges in aligning the learning activities with the elements that are included in Adventure Learning projects. Though these were initially challenges to him, aligning the learning projects with the elements of Adventure Learning helped him to clarify learning objectives and make more use of the opportunities involved in an outdoor learning activity.

Challenges Related to Specific Elements of Adventure Learning

Adventure Learning elements are not automatic, and the teacher in this study was intentional about incorporating each of the elements resulting in varying levels of implementation.

Leveraging Technology

One of the elements for Adventure Learning projects is having a planned curriculum that leverages technology (Doering, Veletsianos, & Scharber, 2007). Mr. Kollar described his plans for integrating the class textbook, outside articles and videos, and visits from specialists in the area that they were studying for the Adventure Learning activities. Before the trips, students had assignments to search the web and find information about the subject that related to their outdoor learning activity. The students gathered their resources together and presented their reports in front of the rest of the class. Materials from textbooks and from student presentations were included on classroom assessments that took place before students went on the trip.

During some of these presentations, the primary investigator was able to observe that students had searched the Internet with the guidance of the teacher, and found photographs, video, and other resources that they could share with other students. In some ways, students became experts in small areas of the Adventure Learning topic, and as a team, were able to present a full picture of the entire topic.

Inquiry-Based Learning

Another challenge with aligning learning activities with the elements of Adventure Learning is the focus on student inquiry. One of the pre-activity learning assignments for students was to look at the issues and damage to environment as a result of overfishing. This was an earlier assignment, and Mr. Kollar did not provide parameters for ideal search websites or where they could find the most relevant information. Students, then, performed general Internet searches and found a lot of information on overfishing, but most of the hits or returns were from outside of the United States. Mr. Kollar does not know whether students shared resources, but all of the student presentations on overfishing contained information about overfishing problems in and around Australia. None of the presentations contained any information about overfishing in the coastlands of the United States or in fresh waters or in the state of Texas. Though this presented a challenge to the teacher, he was able to learn from experience to give some guidance and some framework for the students in terms of where to search and also in terms of what is acceptable material to report on. For instance, is the question about worldwide or local issues? Is it about nationwide issues? Is it about state issues? Or, could it be about specific areas within the state? So, Mr. Kollar began to create more specific questions, with a focus on something such as freshwater vs. salt-water issues.

Adventure-Based Learning Activities

In terms of managing an outdoor learning activity, probably the most challenging element of Adventure Learning for the teacher was managing the learning activity once they left the school grounds. Because there are a lot of opportunities and competing stimulation when outside the classroom, students found it difficult to focus on their assignments while they were in a natural environment. On one bird watching learning activity, students were next to a lake and had specific instructions to log bird wildlife observations in this setting. The primary investigator noticed that only one out of four students were actually looking for birds or noting bird species that were observed. The rest of the students were near the water, and essentially playing by throwing stones or splashing or threatening to push each other into the lake. This kind of activity is to be expected, and it helps for a teacher to be prepared and hold students accountable for the information that they produce during a trip of this sort.

Dangers While Learning Outside of the Classroom

Another challenge stemming from the adventure-based learning was related to danger while working in the natural environment. In the tree planting exercise, some of the students had to be careful about where they stepped because of exposed roots, loose ground, or something they might trip over. Some students complained about soreness or blisters on their hands because the work was not normally part of their daily routine. Planting trees is somewhat strenuous and requires certain types of tasks that many people do not perform on a daily basis. Because of erosion, there was a lot of loose soil and slippage was an issue for all to beware of. Because of the sheer volume of dead trees, branches and entire trees would fall to the ground from time to time. The forestry employees only allow non-employees to work in safe zones where there was no chance of dead trees or branches falling on the volunteers. Every participant, however, was required to wear a hard hat for his or her own protection.

During a bird-watching trip, one of the students was running past a parked bus and bumped her head against a side-view mirror. She fell to the ground, and the teacher spent the next hour focusing on treating her injury. The potential of dangers, such as this one, point to the need for additional staffing or chaperones to ensure safety, and the ability to address needs of individual students while continuing the learning project.

Synchronized Learning Activities

Synchronized learning activities presented another adventure-based challenge for Mr. Kollar. While on a tree planting project, the teacher and students used FaceTime to communicate with the substitute teacher and classes who were still meeting back at the school. Students on the expedition team were able to update their classmates with live information about the number of trees planted and issues that they encountered during the Adventure Learning trip. One of the challenges related to synchronized learning activities is that a strong battery life and a reliable connection are very important in order to stay in contact with classes throughout the day. For instance, it was very easy to stay in contact with the class from the first hour and the class from the second hour. But later in the day, the teacher's cell phone began to run out of battery power because it was being used as a Wi-Fi hotspot to enable the iPads to communicate back to the classroom. Mr. Kollar described a more ideal situation in the future where he would request dedicated Wi-Fi hotspots with battery power to last an entire day and to provide a reliable connection to the Internet. Ensuring connection would provide a better likelihood of synchronized learning activities.

Collaborative Learning

The Adventure Learning element of collaboration is closely related to the synchronized learning experience. Collaboration provided the opportunity for students on the expedition team to share with more than 100 students who stayed back in the classroom. Some of this collaboration took place in real time as students communicated via cell phone or FaceTime. Some of the collaboration would take place later, as students brought back soil and root samples for the laboratory, and would share their notes, images, and videos with classmates. In addition to the need to establish a more reliable method of communication, Mr. Kollar would like to have more specific roles for students on each team. Since a majority of the students participated by staying in the classroom, Mr. Kollar would prefer that they work on laboratory experiments based on physical samples that students on the expedition team bring back from the Adventure Learning trip. He would also like to see more specific questions presented in real time from the students who stayed at the school to be investigated and answered during the class time by the students who are part of the expeditionary team. These questions might be required as part of an assignment. This kind of synchronous and asynchronous collaboration would help to reinforce learning and more thoroughly involve all of the students whether they participate by staying at the school or by traveling with the expeditionary team.

Technology Challenges While in the Field

There were several challenges that the teacher faced which became frustrations, both for the teacher and the students. The major frustration for the outdoor learning activities was the problem with connectivity. As described earlier, the iPads issued to the students connect to Wi-Fi but do not connect to a cellular network. If a mobile Wi-Fi hotspot is within range, students can connect to the Internet through that Wi-Fi hotspot. This kind of setup provides ubiquitous access to the Internet and communication so that students can be completely mobile during their learning activity.

Issues with Connectivity

For the first Adventure Learning trip, the teacher wanted to provide demonstrations for all seven of his classrooms that were back at the school administered by a substitute teacher. He was able to make a presentation to the first two classes, but the rest of the day he was not able to connect with his classrooms because of connectivity problems. Most of the connectivity problems were due to limited battery power while out in the field. Another issue was that mobile Wi-Fi hotspots are usually limited to a small number of participants. If connecting from a cell phone, a mobile Wi-Fi hotspot might provide five or six connections. A dedicated mobile Wi-Fi hotspot may allow several more connections, so Mr. Kollar is interested in pursuing this for the next series of Adventure Learning projects.

The primary investigator observed that one of the applications purchased by the school specifically for bird watching helped to alleviate the connectivity problem. Once downloaded, this mobile application provided mobile encyclopedia type information about bird species and helped students to identify them. The application does not require an Internet connection to work, though some features only work when it is connected. Students were able to use this application while out in the field, whether or not they were connected to the Internet. They used it to identify species of birds that they observed.

Limited Storage Capacity

Another technology related frustration is the low storage capacity of the iPads that were distributed to the teacher and students. In addition to lacking a cellular connection, budget restraints required that students and teachers receive an iPad with a low memory capacity. Since Mr. Kollar often tests various mobile applications, he was often removing applications in order to have space to load more applications.

Tablet Form Factor Not Portable Enough

In some ways the mobile device that students used was not portable enough. Especially during the tree planting project, students were not able to perform their assigned duties while carrying their iPads. Most of them left their iPads on the bus while planting trees. Students were also given assignments to take pictures of what they were doing and log their experiences using their mobile devices. Mr. Kollar suggested that smart phones might be more useful on a project like that. Students can wear the phone while they are using their hands to perform other tasks. When they need to access the Internet or take a photo or create a recording, they can take out the phone and use it as needed. Mr. Kollar also described the day as unusually cold. He experienced difficulty using his hands-on the touch screen because he was wearing gloves. The entire tree planting trip was hindered somewhat because of the cold weather. Many of the students preferred to stay in the bus rather than participate outside. The teacher has no control over the weather conditions, but has learned to plan around the circumstances.

Engaging Students back at the School

One of the frustrations related to the Adventure Learning activity was continuing to keep students back in the classroom engaged with the learning project. Mr. Kollar connected with the students back in the classroom by using FaceTime. As mentioned earlier, he was only able to connect with the first two of seven classes during the day. Even when he did connect with them, he expected that they would have more questions for the students who were participating as part of the expeditionary team. They only had a few questions about weather and the number of trees being planted. They were not asking questions related to environmental science such as observations about soil, erosion, and plant life that is currently recovering from the fire. Mr. Kollar used what he learned from this challenge to design learning activities where students had more structured assignments whether participating as the expeditionary team or staying in the classroom during the trip. The issue of student engagement is nothing new to education. Student engagement is a challenge to traditional distance learning when the student and teacher are not in the same place and sometimes not involved in the class at the same time. Student engagement can also be an issue for a live classroom. When teachers are meeting face-to-face with students, students will sometimes not be engaged with learning activities.

Even though there were several challenges and a number of frustrations with the Adventure Learning projects, Mr. Kollar said, "I think there are a lot more successes than failures."

What did the teacher think was the role of a mobile device for instruction?

Citizen Science is a term coined by Bonney and Dhondt (1997), which refers to the practice of science and collection of scientific data by non-professional science enthusiasts. Others such as Rosner (2013) and Trumbull, Bonney, Bascom and Cabral (2000) have referred to the term as well. Having been a fan of Citizen Science for many years before mobile applications were available, Mr. Kollar believes that mobile technologies support Citizen Science in ways that it could not be supported earlier. For the Adventure Learning trip where students replanted a forest that had been burned, students were assigned to take photographs or video field notes and log all of that information into a database with geolocation tags of where they replanted trees. Students originally kept the data private, so that they could update the information and share it for class assignments. Eventually, the intention is to make their information public and share it with other people who are contributing to the same effort. In doing so, they would be contributing to public information about the environment, and the scientific community in particular.

On the Adventure Learning project where students were observing bird wildlife, students were assigned to take photographs log field notes, and upload their information to a private database so that they could share that information with other students in their class. Since this database is part of a mobile application, the teacher will eventually review the content and change the settings of their database so that the research the students conducted could be shared with the general public. The teacher will first review and de-identify any information that was shared before making it available to the public.

Mobility Brings New Possibilities for Education

Mr. Kollar stated that participating in Citizen Science to this extent was not possible before mobile tools were available to students and allowed them to log and to collect first-hand scientific information to be shared with the public at large. Based on student reaction and demonstration of interest in the classroom, he also thinks that students are more interested in the subject of environmental science when they feel like they participate as citizen scientists and contribute to the body of scientific knowledge. During a class observation, the teacher demonstrated collecting physical samples from a lake nearby their school. Students often go to this lake for recreational purposes, and they are very interested in the types of organisms that live in the water there. When they saw the types of organisms that the teacher collected from the lake, they displayed interest by standing up, looking closely, and asking whether they were natural organisms, or whether pollutants or lack of care contributed to what organisms are in the lake. They also asked questions about the level of safety due to any exposure to the organisms.

Rather than present a 50 min. lecture based solely on the textbook, Mr. Kollar explained that he could present up-to-date information that is relevant to students based on information that he found in places that they like to go. He also finds that students want to take their mobile devices to the same place and perform follow-up studies based on samples that they collect. So, the dual benefit is that students are empowered to contribute to scientific knowledge using their mobile tools, and they are more interested in finding a local and practical application for the subject of environmental science.

Ubiquitous Contact between Student and Teacher

Mr. Kollar also expressed his support for mobile devices in education because it enables students to stay in contact with him whether they are in his class, in a study hall, at a sporting event, at home, on their way to school, or at a number of other locations or activities. Ubiquitous access to communication allows students to ask questions, submit assignments, or download learning resources whenever they need to or at whatever location they are. Traveling to one of the Adventure Learning activities, the primary investigator observed that students had two applications opened. While riding on the bus, the teacher asked them to open the application that helps them identify birds. He used the example of one of the birds that they might see, and walked the students through the steps to narrowing their identification of that bird. Each step in the identification process returned fewer and fewer results until the students had narrowed down the selection to two or three species. After an orientation to a mobile application for that trip, the students were now prepared to make their own observations and narrow the possible species to a few based on what they saw.

Since they were required to log observations about bird wildlife, students opened one application, titled iNaturalist®, which helped them identify the types of birds they were observing. They also opened a second application, BirdLog®, where they were able to log the types and numbers of bird species they observed and include geolocation information as well. With ubiquitous access to information provided by a Wi-Fi hotspot, students were able to receive the just in time information about bird species, and were able to upload their observations to a database in real time if they were connected. Mr. Kollar was able to monitor their findings as they were logged by viewing reports from the shared database.

First-Hand Gathering of Information Supporting Constructivist Approach

Mr. Kollar also saw a great strength of mobile devices because of their ability to capture first-hand scientific observations. Students in his class were assigned to take pictures, create audio files, and capture video of their interaction with the natural environment. With a group of high school students, this activity could lend itself to playing games in addition to collecting data that is helpful to their assignment. Since their information was originally for classroom use only, Mr. Kollar decided not to make an issue of clowning in front of the camera and provided assignments for them to clean up the information later.

Mr. Kollar also pointed to elements of the constructivist approach to education that are supported by mobile learning. In an interview, he said, "If you're going to read something, you'll remember a certain percentage of it. But if you read something and have to create something from what you've read, brain research tells us you're going to remember a higher percentage of it." In his opinion, if the students were required to learn from only textbooks and lectures, they might be expected to recall the information for a test. Using a mobile device to go out and perform their own scientific research, Mr. Kollar insists, students would be participating in a higher level of learning. Though it might not be obvious, he expected that working with the information first-hand will help the knowledge to become more stable in their minds and more likely to create a change in life patterns.

Integration with Other School Subjects

Because students at Eastbury High School were required to use their iPads for all of their subjects, using a mobile device in education also opened doors for integrating several subjects into one learning activity. In the project for visiting an organic farm, Mr. Kollar identified integrating classes on government policy, economics, biological systems, and statistics. During this Adventure Learning activity, students were evaluating the financial cost of putting chemical fertilizers on the ground, in addition to the long-term environmental cost of the effects that this kind of fertilization has on the land and ecosystems.

Because trips to the organic farm have taken place and evolved over the years of Mr. Kollar's teaching, he planned to ask the teachers of government classes to work with him on integrating how government decisions affect the food that we eat. He planned for future Adventure Learning projects such as this one to find out how students could collaborate based on what they learn about government policy. Though politics economics, and statistics can be related to environmental studies in some ways, they were not a major section of study for environmental sciences in high school at the time of this research. Mr. Kollar believed, though, that mobile learning could play a part at integrating various courses through mobile and adventure learning projects and strengthen both the knowledge that students build and the skills they develop in the learning project.

As one teacher, though, Mr. Kollar did not think it was feasible for him to lead a project that integrates several teaching disciplines into one major project. Additionally, not all of the students were taking the same classes at the same time. He suggested that having someone dedicated to the task of organization and integration with other subjects could help involve teachers from various academic disciplines, and customize the learner experiences based on their current course load.

Adventure-Based Learning Activities

Learning with a sense of adventure is one of the main elements for Adventure Learning projects. The primary investigator observed that when students got out of the bus for a project to observe bird species, they took out binoculars and spotting scopes to see if there were any birds that were further away from what they could see with their eyes. Communicating with each other and with classmates back in school by phone and FaceTime, they shared their observations of various birds that they spotted near a lake.

Students initially worked with their iPads, binocular's, cell phones, and some other tools to make their observations. Some of them continued during the entire trip to stay on the learning task. After some observations were made, and after some of the birds were scared away, most of the students focused on the social event of being away from the school for the day. As Mr. Kollar evaluated this later on, he thought that future trips could support a better learning experience with more staff or volunteers providing assistance to guide student learning in addition to a fuller structure of tasks and requirements for the students.

Though some of the mobile technology was a source of frustration for both teacher and students, Mr. Kollar sees the evolution of mobile technologies as an ever-improving resource for learning tools that can add to student interest in learning and a sense of adventure as they participate in learning activities. He described some early applications that were difficult to use or failed, but also how they are replaced by updates or new applications that perform better and provide more support for the Adventure Learning activities.

What was the teacher's understanding of Adventure Learning and its role in the educational process?

Through interviews with teacher and observations of classroom and Adventure Learning activities, the primary investigator uncovered some of the teachers understanding of Adventure Learning and its role in education both in his theory and his practices. During an interview, Mr. Kollar explained that providing hands-on learning experiences for students was more valuable than only learning from lecture and textbooks. When asked how he arrived at his opinion, he returned with a question by asking, "Would you rather read about the list of birds or go and watch birds? Would you rather read an article about a farmer even watch a video about a farmer or go to the farm and walk through the fields, touch the animals, and talk to the farmer?" These questions to the primary investigator indicated his assumptions that students would find it more interesting to learn from first-hand experiences rather than from traditional classroom or homework activities.

Based on observations of both in-classroom and Adventure Learning activities, students showed interest when they were given hands-on projects. These observations support Mr. Kollar's assumptions about student learning preferences. Their survey answers regarding learning preferences both before and after the Adventure Learning projects, however, demonstrated something different. In both surveys, students favored book learning at a 2:1 ratio. Though several of the students changed preferences, the ratio remained about the same in contrast to Mr. Kollar's assumptions. It should be noted that their interest for hands-on learning vs. book learning should be considered alongside their prior learning experiences, and that the surveys were taken within months of high school graduation.

Mr. Kollar explained that seasoned professionals or field scientists might not spend as much time collecting data and will not make as many mistakes. He expected that the students will take a while and will make mistakes because they are trying things for the first time. He anticipated this would be due to the fact that they might have various distractions or be focusing on other subjects or socializing. Considering both the lower level of data collection and distractions, Mr. Kollar anticipated a lot of value in students participating in a real world experience where they can leverage the concepts in the vocabulary and concepts that they learned in class and apply them to a real life situation.

According to Mr. Kollar, Adventure Learning, supported by mobile technologies, created opportunities for students to participate as citizen scientists. Even though the quality and quantity could not match those of professional scientists, Mr. Kollar believed that student participation in scientific gathering of information would be valid both for their own learning experience and that the data they collected would be helpful for the scientific community at large. One of the benefits he pointed out arising from Citizen Science was the volume of data that can be accessed because of nonprofessionals contributing what they find.

Mr. Kollar also identified lifelong learning as a value gained through Adventure Learning projects. He stated "the connection to their lives is the most important thing to me as a teacher." Even though their contribution to science might be very small compared to the larger picture, the way that their individual lives have changed and their learning can be challenged would be significant contribution stemming from Adventure Learning. Student responses to the survey tended to support his ideas. According to survey responses to the statement “Learning Environmental Science is relevant to my life,” the overall class increased from 3.39 to 3.41. Students who traveled showed a significant increase from 3.31 in January to 3.43 in April.

After the Adventure Learning project where students visited an organic farm, several students reported back to Mr. Kollar in the following weeks that their parents began shopping for organic groceries, and even purchasing products at a local market directly from the farm that they visited. Another teacher who drove the school bus for that activity also purchased food products directly from the organic farm that they visited. Responses to test questions may or may not be improved through these efforts, student interest in the subject of Environmental Science may or may not rise, but Mr. Kollar believed that the most important test would be a change in practice that benefits the environment. He was pleased with signs of these changes among students based on his early observations.

While reviewing all three of the Adventure Learning activities, Mr. Kollar summarized them by saying that the re-planting of trees on the first trip allowed the students to experience environmental activism. On the second trip, students visited an organic farm, and were able to reflect on how their personal actions impact the environment. On the final trip, students watch the birds and by logging what they found into a scientific database, they were able to contribute to scientific knowledge. These were all aligned with his personal goals as a teacher, and with the stated goals of the class curriculum.

To what extent did the teacher provide an environment where students could experience the seven principles of Adventure Learning discussed in the literature review? These principles include inquiry-based learning, collaboration, technology-based learning, curriculum enhanced by media, synchronized learning opportunities, planned curriculum leveraging technology, and adventure-based education (Doering, Veletsianos, & Scharber, 2007).

Inquiry-Based Learning

In preparation for the first Adventure Learning project, students were given assignments to research the damage incurred by forest fires. Teams of students collected information from their textbook and the Internet and then presented it to the rest of the class. When the students arrived on site at the burned forest, a park ranger presented a 20-minute description of what happened to 6,200 acres of forest tree because of a forest fire. He explained that not only the plant life was killed in the fire, but that the fire was so hot that the ground was sterilized and would not support germination of new seeds so that they could naturally take root. The sub-species of trees that burned were unique to that forest, and were significantly diminished in their changes for survival. They would not grow back naturally without human intervention.

The original question for students was to look into the causes and effects of large forest fires. But when they arrived on site, their new question was to investigate what kinds of plant life were beginning to grow back naturally several months after a major forest fire. Students took pictures and made notes using their mobile devices and found that only a small percentage of the unique native forest street was growing back. Even these small numbers, however, were being outpaced by other plant species that were neither unique nor original to the forest.

The students wanted to learn what microorganisms had returned to the soil several months after the fire. Mr. Kollar brought along sample gathering tools so that the students could use to collect samples and take them back to the school laboratory to learn more about the condition of the soil. By visual observation, students observed that the topsoil had been washed downhill and that most of the area where they were taking samples and planting new trees was very rocky as a result. The soil in the valleys and ravines appeared to be a more ideal area to plant trees, however, the park rangers directed the students to plant in both rich soil and rocky soil alike.

Mr. Kollar admitted that preparing students for inquiry-based education took a lot more time than preparing a lecture or a textbook assignment. On a later trip, students were observing bird species in the natural environment that was next to a lake. Their assignments were to identify a bird species and log their numbers and any information they gather through observation. Thinking through what they could gather and report on, and what applications could be used took a lot of Mr. Kollar's time. Students also took both soil and water samples, and carried them back to the school for further analysis. They were interested in how the water quality and soil quality supported wildlife. They also observed which birds stayed in grassy areas, which birds stayed in the brush, which birds stayed in high trees, and which birds stayed in or near the water. Students consulted their bird identification resources in their mobile application to determine whether the birds were in those locations for food, shelter, or both. Planning, preparing, and deploying all of these activities took extra time. According to Mr. Kollar, the benefits outweighed the efforts.

Mr. Kollar believes that much of inquiry-based learning was transferable between academic subjects. Learning by starting with the question challenged students to look for answers through their ubiquitous access to information, but also challenged them to collect their own information and compare the answers they found with answers from a broader body of knowledge. No matter what subject they will major in at college, Mr. Kollar this experience as one that will overlap with other subjects and will help students learn better at whatever subject they are studying. Though students in Mr. Kollar's classes at Eastbury High School tended to prefer book learning, their participation in Adventure Learning projects and survey responses to life-related questions supported their interest in the subject as it relates to their lives.

Collaboration-Supported Learning

The design for the Adventure Learning activities included the requirement for collaboration among students. Some of the students travelled to the outdoor learning activity as part of the expedition team, while other students stayed in the school and were required to do research about the subject and would perform lab work when students came back with samples. Another form of collaboration took place within teams that traveled. During the first outdoor learning activity, students worked in teams of three to replant forest trees that had been burned earlier. The learning activity was designed for one student to dig the hole, one student to plant the tree, and another student to document any plant species they observed and the work they did. Once the students learned the routine of planting trees, there was not much additional knowledge collection other than observations about invasive plant species that could prevent the desired types of trees from taking root or flourishing. Working in teams of three, students collaborated in observation and in the work they were performed. They also collaborated among tasks, trading roles because digging was more tiring than either of the other roles.

Some competition entered into the tree planting has some of the student teams were trying to plant more than others. In these cases, students collaborated to determine best practices, finding the most efficient method for planting trees and arranged their teams accordingly.

Mr. Kollar noticed that students staying at the school worked together on their reports based on information that was sent back to them by students who were traveling to the outdoor learning activity. By reading their reports, he could determine the degree to which the students collaborated as they worked together on their reports. Before batteries ran out, the primary investigator observed that students on the tree-planting trip were using FaceTime and cell phone contact to talk with their classmates with whom they would work collaboratively writing a report.

The week following the trip, students who traveled and students who stayed at the school presented their reports together. Mr. Kollar noted that the students who stayed at the school contributed information based on their Internet research and laboratory work, while students who traveled to the learning activity contributed information based on their observations in the field. Through student collaboration, both sets of information were combined into each team's report.

Mr. Kollar also thought that sharing of knowledge among students lent itself to a constructivist approach to learning. With only a few exceptions, students focused on responsibilities for their contribution to the academic success of their team. When asked about collaboration, Mr. Kollar pointed to a handful of objectives posted on his whiteboard at the front of the class. Among those is “Collaboration,” which he intended to make a part of every learning activity, whether in the classroom or in an outdoor learning assignment. He observed that a collaborative environment, supported by working in teams to complete assignments, provided students with transferable skills that they can use in other classes and will most likely use in whatever profession they enter. He suggested a lot of situations in the professional world where people have to collaborate within organizations to make something happen that is larger than a task one person could complete on his or her own. He recalled the importance of collaboration in the professional world and in education. From his experience, he described several ways that collaboration is very important between government agencies and nonprofit organizations.

In class, the primary investigator noted that presentations about an upcoming outdoor learning activity were very similar. With limited exposure to the subject, students collaborated to secure information they could find from their textbook and the Internet. They also collaborated by sharing assignments or research as well as presentation. In this case, collaboration presented some limitations to their knowledge gathering, because they shared their resources between teams, and lacked broader sources of information.

Through field observation, the primary investigator observed that students went through different phases of collaborating during the outdoor learning activity. At first, students started off by enjoying the adventure of being outside of the class. Once they got into a routine of planting trees and making field notes, they began to focus more on what they were learning and gathering from the process. Toward the end of their day in the field, teams of students that had planted the highest number of trees seemed to be focusing more on the competitive side of the event, trying to plant more than any of the other teams.

Following the outdoor learning activity, students prepared a final report and posted their photographs, notes, and other observations to a shared database. Now that some of the team had first-hand observations, students were able to collaborate and build a more thorough presentation of fire damage, invasive species problems, and re-forestation efforts.

On a bird watching outdoor learning activity, students worked in teams of five. This activity differed from the tree planting activity largely because there were fewer hands-on assignments for students. The team of five was broken into a recommended structure where two students used a mobile application to research and identify bird species. Another pair of students was assigned to log the species finding in a different application. The remaining student had the role of a spotter. His or her assignment was to use binoculars or a spotting device on a tripod to find bird species for the rest of the team to identify and log. The primary investigator observed that the students often traded roles within their team, but in each case, each player in the team relied on the others in order to complete their assigned task.

Mr. Kollar explained that using collaboration in an outdoor learning project required a lot of organization in advance. Having small teams that collaborate within the teams and throughout the larger class, each person having a specific role, created a need to depend on each other to complete the task. In reflecting after the first trip, Mr. Kollar said that it took the students a while to begin focusing on their required tasks. They started off clowning around and were not focused on the learning tasks, but eventually settled in and focused on what was required. He also noticed that some students were stronger at going to Internet resources and finding quality information about a subject as part of their assignment. Some students appeared to learn well by listening to an expert talk about the subject, and some of them appeared to learn best by going out and discovering their own information. He expected that including as many learning styles as possible should be an advantage to students depending on their preference, and would also help to reinforce their knowledge. Adding an element of collaboration allowed students who learn best in one area to support their team based on the type of learning activities that were most helpful to them individually.

In general, Mr. Kollar observed that some students were more motivated than other students. The difference in interest level was observed in all phases of the project, including research that they conducted online, how they presented to the rest of the class, how they participated in the outdoor learning activity, their conduct in the laboratory, and when they worked together on a project as a team. Though he noticed some students excelling at one phase of the project or another, he also observed that students who are generally motivated tended to work well in most if not all steps of the project.

Mr. Kollar used the mobile devices available to the students to support collaboration during these learning activities. In some assignments, students used their mobile devices to do Internet research on a particular part of Environmental Science. In other assignments, students worked together to prepare a presentation for the rest of the class. Students also used their mobile devices to capture field data through note taking, audio recording, and photographs and then shared the information with their classmates. Some teams were broken up so that students could collaborate with students from other groups to complete an assignment. That way, some students could access information about bird species, while others log the information to a database that is shared among the students.

Technology-Based Learning Environment

From start to finish during the adventure learning activities, the teacher incorporated technologies that helped to enhance learning. While students were making presentations based on research they did for an upcoming trip, Mr. Kollar noted some areas where Internet-based research from the students was lacking, so he placed additional resources about bird species as they were needed into the learning management system. Students used their mobile devices to access the resources and to do research on bird species while they were in the classroom. They worked together and also connected their mobile devices to the classroom projector to share their information visually in every port to other students. After all of the presentations were finished, Mr. Kollar switched the presentation back to his desktop computer so that he could display information from his resources, such as videos that he thought would be helpful for the learning experience.

In a presentation related to visiting the organic farm, the teacher presented some online resources that were specific to one of the classroom discussions. Students did their own searches and found a lot of general information, but Mr. Kollar wanted to present specific information regarding the tension between endangered species and industrialized agriculture. His design was for students to learn from textbook resources which were downloaded to their mobile devices, finding their own information using the Internet, watching or reading learning resources that he placed in the LMS, and from doing first-hand learning experiences during the Adventure Learning project. He wanted to leverage technology by making sure that students have the best technology available to enhance their education. As much as possible, he aimed to avoid needing to learn new technology. He accomplished this by finding applications that are intuitive for users to begin using without a lot of training.

Before participating in an Adventure Learning project where they visited an organic farm, students were given an assignment to view the local area through Google Earth®, and look at the agricultural impact on the environment near the organic farm. They were able to use existing technologies to make observations in the classroom about farmed areas, wooded areas, rocky areas, and freshwater resources. When they went on their Adventure Learning trip, they took soil samples, collected first-hand observations through photographs and field notes, and asked questions directly from the people who worked on the farm.

Before participating in a bird watching learning activity, students were required to use the Internet to gather and report on resources related to their Adventure Learning project. In addition to research about bird species and migration patterns, students were also required to explore the Internet and find information regarding the quality of freshwater and its relation to supporting bird wildlife. Though not utilizing mobile technologies, students used laboratory technologies when they brought back samples of water and soil to analyze in the laboratory at the school. Once they retrieved information contained in the samples, they entered their findings into a database using their mobile devices.

Mr. Kollar demonstrated to them how scientists can look at satellite imagery and determine some things about the terrain of the ground they are observing. He also showed them how to set up and organize data tables and how they can store and sort and interpret the data that they find. The classroom used a lot of Internet resources to help prepare for the trip. When they brought back their data at the end of the trip, they also used online resources to discover the best ways to analyze and interpret the data, along with learning what they could do with it.

According to Mr. Kollar, while working with technologies used on an environmental science project, students gain some skills that they can use in their private or academic or professional life. Learning both the digital and analog resources required to measure soil and water quality provided students with the skills to do research on environmental quality at places they go for recreational purposes. This was one of the benefits the teacher refers to as a lifelong learning benefit from what they learned in the environmental science class.

Curriculum Enhanced by Media

All three of the Adventure Learning projects that took place during the spring semester involved curriculum that was enhanced by media, though some of the activities required more use of media than others. In each of the Adventure Learning projects, Mr. Kollar encouraged students to use their mobile devices to access the Internet and research the main topics of any upcoming learning activities. Some of the resources that students found were text-based while others were video-based. Mr. Kollar also provided access to specific educational videos, which he showed to the class, or provided a link and assigned watching a video as homework. During each of the Adventure Learning projects, Mr. Kollar used FaceTime to communicate with the students who were back in the classroom in real time. This provided a low-resolution video feed so that he could see the students in the class and they could see him and his surroundings. He not only talked with the students, but he also turned his iPad toward other students, so the students who were back in the class could see what the students who traveled were doing. This connection enabled students back in the school to see what was happening in the outdoor learning activity. Students participating in the outdoor learning activity also used their iPads for FaceTime and to capture images and videos to take back and prepare a presentation based on findings from their trip.

Among three projects, one of the projects specifically got more media attention than the others. When students participated in replanting forestry that had been burned by a fire, a professional videographer attended the project and created a video that he published on a non-profit website and sent back to the class. Looking at the videos in high definition inspired some of the students to bring dedicated video equipment on future Adventure Learning projects, because of the value of having longer video clips of higher resolution and sound quality. A news article appeared in a local newspaper that featured the students participating in this learning project.

After completing three Adventure Learning activities, Mr. Kollar reflected on what took place and thought about some potential uses for media in future projects. He thought it would be helpful to preserve the images, videos, and field notes for classes to view in the future. He planned for future classes to review media files created by earlier classes so that they could build on the knowledge created by their predecessors. He intended for them to track data year-over-year so that they can increase the depth of their knowledge in a particular area or broaden the scope of their knowledge into more areas. Depth of knowledge could be enhanced as different students return to the same place over a period of several years. Their observations could build on what was observed earlier, and the results of their interventions could be tracked over a longer period of time. Reviewing the current year's information in future school years could also provide benefit from a broader exposure as students might move to another area, or other schools might be interested in following up on something started by Eastbury High School.

Mr. Kollar expressed that the use of media to enhance curriculum is sometimes more successful in certain projects than it is in others. In a project where the students are very active and if the project is high profile, he observed that there is more likelihood that the video recording and production will be successful. Helping to replant a burned forest lent itself to media enhancement of the curriculum. Before the project, there were several news broadcasts that could inform the student about the situation. It was also easy for students to make video recordings of their activities because the activities involved a lot of movement. Digging holes, moving fallen down branches, and planting new trees are activities that are easy to capture by imagery or video. Students walking around and observing farm animals or birds can capture first-hand information through photographs as well as video, but student involvement in the project was less appealing to a camera compared to replanting burned forest.

Probably the biggest challenge to enhancement of curriculum through media was related to the extent to which they could connect to the Internet while on a field project. In the projects observed during the spring semester, students had limited access to communicating with classmates back at the school using FaceTime. Part of this was due to battery issues, and the other part was due to connectivity. In this case, they still had connectivity for a cell phone call, but they were not able to share video in real time with any regularity. They were able to capture and store video, images and audio recording on their iPads, and upload their data to a shared folder in the school learning management system after connection was restored. So these resources provided a workaround to continue using media to enhance curriculum even though the connectivity was not reliable.

Synchronized Learning Activities

In order to coordinate three Adventure Learning activities, Mr. Kollar had to make all of the of transportation arrangements, safety arrangements, academic schedule arrangements, food, and a number of other details. Even though it added to his work, he said, "I think it's really worth it. Spending the money on buses and substitute teacher and everything else really pays off." Though he was not sure about the returns in terms of student grades, he believed that it pays off in terms of the richness of the educational experience and life choices going forward.

Most of the responsibility for synchronizing the learning activities rested on Mr. Kollar as the teacher. He had to organize with students, parents, other classes, school activities, safety, and transportation. Some elements of the trip cost money and came out of his budget. Even though it involved a lot of work, he felt like it was worth all of the effort and resources because of the subject interest that was built in the students. According to Mr. Kollar’s observations, the interest in the learning activity as well as the subject of environmental sciences builds from the day he announced any upcoming Adventure Learning activities. “Those students are interested in something different from sitting in a classroom and listening to lectures. Their interest in the subject grows as they start to work on their assignments that build up to the day that they are going to travel.” All of this took place over the period of a year, but Mr. Kollar noticed that student interest in the activity grew at a steady pace, as time approached for any of the outdoor learning activity events.

While students were traveling on a learning activity, the teacher connected to the classroom back to the school using FaceTime in order to synchronize learning activities with students who did not travel. Originally, he talked while looking directly at the iPad and communicated with students about the project allowing students back at the school to ask questions about the project. Eventually, he turned the iPad toward some of the places where students were digging and planting new trees so that the students back of the classroom could get to see their classmates using shovels and the digging tools. Students back in the classroom watched their classmates drop seedlings into the soil and begin to replant the forest in real time. During a quick glance at the iPad, the primary investigator observed that students back in the classroom were looking intently toward the screen so they could see what their classmates were doing. In a few situations, students working out in the field were communicating through FaceTime with students back in the classroom, telling them about what they were doing. Though not all of the communication was serious, they were able to talk in real time with the students and synchronize their learning experience by showing them what they were observing and doing.

When students returned from the learning activities, they shared some of their data with the students who stayed at the school. Synchronizing their efforts, they collaborated to build a presentation based on resources they found in the Internet and resources they found first-hand in the Adventure Learning activities.

Mr. Kollar planned and taught under the assumption that students learn more by doing environmental science through hands-on activities rather than learning about environmental science through a lecture or book. He also believed that students learn more by doing after they have built a foundation of knowledge for the project that they are preparing to participate in. In advance, he planned learning activities for classroom and homework that help to scaffold the knowledge base students have when they enter the outdoor learning activity.

Planned Curriculum Leveraging Technology

Adventure learning projects supported by mobile technologies lend themselves to curriculum that leverages technologies. Starting with the textbook, students used a downloaded version of the textbook required for their class so that they could have ubiquitous access to the information in their textbook that related to their outdoor learning activity. While preparing for the trip, they were able to go to the Internet and link to videos, webpages, and other resources on the web that related to the subject of their investigation. The mobile device also served as a first-hand information-gathering tool, so that while students were out in the field, they could collect data through notes, images, and video. The mobile device also supported a curriculum leveraged by technology as it served as the communication tool for students to communicate with their classmates in real time while in the outdoor learning activity. Finally, students used the mobile device to collaborate, assemble, and prepare and present the report based on their initial research and their field research.

Students who did not travel to the outdoor learning activity but stayed at school were required to write an additional paper based on information they gathered from Internet research and information that their classmates brought back from the trip. For the tree-replanting project, they could report on forest fires in general, the specific forest fire related to their classmates' project, replanting efforts, invasive plant species, or other topics as cleared and assigned by the teacher. Though not traveling to the intervention site, they were able to use mobile technologies for each step in this learning project.

During the bird watching project, students were required to log a certain number of bird species that they observed during their trip. This assignment was given to them a week before they participated in the trip. This way, students were able to use technology to research the types of birds they might encounter before participating in an Adventure Learning project. While on the field, they were able to access a mobile application that helped them identify bird species that they saw. They also used another application to log their findings in a shared file.

Mr. Kollar found it helpful to narrow down some of the best places where students would find information on the Internet. Based on earlier experience, he found that students would sometimes find and use information that was not relevant or perhaps not reliable. He directed them to use Google Scholar rather than the regular Google search engine if they were looking for academic articles. He also directed them to state and national agencies that deal with the environment and provide resources to the public.

Learning Projects With a Sense of Adventure

Mr. Kollar entered the science of environmental studies because he found studying the subject to be an adventure. His primary interest for teaching was to convey his appreciation, interest, and sense of adventure related to the subject of environmental sciences to future generations. During one of the classes when students were preparing for an Adventure Learning trip where they would observe bird species, students presented slideshows of some of the birds that were on their watch list. They included images, descriptions, videos, and a few audio recordings. The audio recordings included some of the birdcalls that students might need to identify birds that they observe. Mr. Kollar would sometimes add videos or links to online resources that helped to fill in gaps of areas that students did not report on. During one presentation, Mr. Kollar demonstrated a turkey mating call using his own voice. Students laughed, but many of them tried it on their own.

When Mr. Kollar talked about upcoming Adventure Learning projects, he tied the current information presented by the students to future activities where they would gather first-hand information using their mobile devices and some other tools. The primary investigator observed that students started to show interest and talked with each other about what kind of information they hope to find when they went on the Adventure Learning project. This conversation uncovered a sense of adventure among the students even though they had not yet traveled. When they arrived at their learning activity, the same sense of adventure continued and heightened as they used their mobile devices to go out and add to their current body of knowledge about the subject they were studying.

During the tree planting learning activity, the forest ranger talked about the damage incurred by the fire, gave a safety demonstration, then proceeded to hand out digging tools and young tree saplings for planting. When students received the digging tools, safety equipment, and saplings, they sprinted toward the area where they would start planting trees. The primary investigator observed from their reactions that the students were doing their schoolwork with a sense of adventure.

During an Adventure Learning project where students took water samples, Mr. Kollar used a microscope to demonstrate what kinds of microscopic life were living in the water. Since the students might drink from the water or swim in the water, they were interested in getting samples and learning what forms of life are living in the water where they participated in these activities. In a later interview, Mr. Kollar expressed that he had studied aquatic ecosystems for 11 years of his life. He said, "I really want to share that with them, because it is exciting whether you are a novice or a professional."

When students visited the organic farm, they listened to the people who worked on the farm, observed some of the habitats for the farm animals, and looked at the fields where food was grown for the animals. An atmosphere of adventure was created when students were given the opportunity to look at the biological systems under tilled earth, feed some of the animals, handle some of the animals, and move some of the livestock from one location to another. They not only got their hands involved in the project, they also got their hands dirty. This activity provided for a lot of conversation about smells, but also caused a lot of students to get in line as the next person to feed or handle an animal. Before the trip, Mr. Kollar planned these events and expressed his hope that students would find it interesting that these animals were being raised in a humane manner, and in a way that contrasts to most of the industrial methods under which most of the US food is produced.

Mr. Kollar also anticipated that pulling plants out of the ground and showing students some of the life that takes place immediately under the surface would create a sense of adventure among students. When the farmer actually demonstrated this process, he made it clear that industrial style farms did not have the same complexity of life structure under the surface due to constant plowing, use of herbicides, and over fertilization. The primary investigator observed that some students found it interesting to look at bugs and worms under the roots of plants, but that several students looked away. Whether intriguing or repulsive, observing forms of life in their natural habitat provided a sense of adventure for all students, and generated some emotional response to the topic they were learning.

In preparing for the trip to the organic farm, Mr. Kollar showed a video of industrial style farming, and how animals were treated standing shoulder to shoulder their entire lives without the chance to live in a free-range environment. The students expressed sadness and anger after observing this kind of treatment of animals, so Mr. Kollar expected that observing free-range animals would give them a sense of adventure as they realize that it is possible to raise animals in a humane way and take the product to market harvested for the general public. During the learning activity, the primary investigator could not determine any specific reaction from the students as they observed animals being raised in a free-range environment. Students appeared to be interested in the animals because they wanted to hold them or pet them. In a later interview, Mr. Kollar described how several students encouraged their parents to purchase some of their meets from the farmers market where the organic farm marketed their products. Even the bus driver for the trip talked about purchasing meets directly from this farmer at the local market. So, whether the students considered specific farming techniques a sense of adventure, some of them definitely changed their shopping patterns based on what they learned.

Some of the challenges to using mobile technologies for adventure learning projects included addressing each of the Adventure Learning elements in depth. Though they provided a good framework, trying to make sure all of the elements were addressed was a challenge the first time he tried it. Technology challenges included connection issues, battery life, and size of the device. Also, it was challenging to engage students who were part of the Adventure Learning project, but were not part of the traveling team. New possibilities for education through use of mobile devices included ubiquitous access to communication and information, integrating a science project with other courses, and untethering students from the classroom setting and giving them a sense of adventure in the learning activity. Mr. Kollar anticipated building on these affordances in future projects.

How did active participation in a mobilized Adventure Learning project affect student interest in the subject of Environmental Science?

To answer the second research question, the primary investigator conducted a pre and post intervention survey, observed classroom and Adventure Learning activities, interviewed the teacher, and interviewed students in three focus group settings. For the focus groups, a request was sent to the teacher to select random groups of 8 to 10 students who would be willing to participate in a focus group to discuss questions related to their experience with mobile and Adventure Learning projects. A list of questions asked in the focus groups can be found in Appendix C. The primary investigator also attended a series of classroom settings to observe how the students interacted with each other, participated in planning for Adventure Learning projects, and how they employed mobile tools in the educational process. He also attended three Adventure Learning projects, traveling with the students on the school bus, and observing their participation as the exploration team for the Adventure Learning projects. Each of these projects averaged 30 students in attendance with Mr. Kollar, a bus driver, and one or two parents who came as chaperones. Some feedback from teacher interviews was also incorporated into the data that helped answer this research question.

The primary investigator provided a survey to the teacher who sent it to students at the beginning of the spring semester. A copy of the survey is located in Appendix B. The survey asks questions about student usage of mobile devices for learning, student interest in the subject of environmental science, and also investigates learning preferences of the students. After participating in three Adventure Learning projects, students took the same survey at the end of the spring semester. The results of the survey were compared before and after to determine whether changes have taken place among the students. Data from the surveys was used to compare with or support data that was gathered through interviews and observations.

In an attempt to determine the effect on student interest for environmental science in relation to their participating in a mobilized Adventure Learning project, the primary investigator used data from interviews with the teacher, interviews with students in focus groups, classroom observations, outdoor learning activity observations, and data from surveys administered to the students before and after the Adventure Learning projects. Data were gathered from each of these research efforts and combined into the following section.

Despite the relatively short amount of time for students to engage in the science-based Adventure Learning activities, it was included in the study to determine the possibility of the highly interactive and engaging activities might have some impact on student interest. As these students were approaching the end of 12 years of public education and transitioning into a new academic career in college, it should be noted that expectations in changing learning styles or academic interest would be limited, if any changes occurred at all. Even with those qualifications, attempts to help students engage in learning activities through multiple means and create first-hand knowledge through their efforts seemed worthwhile, and helped provide a potential framework for learning in college or other settings after graduating from high school.

Mr. Kollar's goals, though, incorporated something beyond their interest in the class that he teaches. Certainly, he hoped that students will perform well on the standardized test, would enjoy his course, and that some students would major in the subject when they go to college. His primary intentions, though, were to create a life-long appreciation for the subject, and that students would consider what they had learned in class for life choices that they make in the future.

Responses to the Survey

Two identical surveys about student interest level in environmental science were administered to the students before and after the intervention. One survey took place at the beginning of the semester in January, and the other survey took place later in the semester during April. The first survey was administered before any of the three outdoor Adventure Learning projects took place, and the second survey took place after all of the Adventure Learning projects were completed. Among the 160 students in Mr. Kollar's class, 156 students took the surveys. Among the 156 students who took the survey, the primary investigator could only determine that results from 104 students matched before and after. Loss of data came because 32 students either did not return consent forms signed by their parents, or did not give their own assent. The remaining students could not be matched with certainty by before and after survey name entries. The primary investigator did not use a closed set of names for students to choose from, so the students wrote in their first and last names in a text entry box. Some name differences were easy to match, such as a shortened form of the same name or upper and lower case use. In total, 52 survey returns could not be used. The primary investigator used the data from the 104 before and after surveys that could be matched.

The survey was 21 questions long, and students could select from multiple answers. Out of the 21 questions, 15 were taken from the Science Motivation Questionnaire (Glynn, 2009). These questions could be divided into two categories based on personal goal interest and academic or career interest. The primary investigator added six questions based on research interest (See Appendix B). Some questions allowed students to write in additional information. The purpose of administering the surveys was to support data that the primary investigator was retrieving through classroom and learning activity observation, and interviews with the teacher and students.

Administering the same survey before and after student participation in the Adventure Learning projects was designed to observe any changes in student interest before and after their involvement in the learning projects. The chart below shows the overall means changes in student interest before and after participating in the Adventure Learning projects. See Appendix L for a more detailed chart of student responses with standard deviations and division among students who traveled and students who did not travel. Students were given an option to Strongly Disagree, Disagree, Neutral, Agree, or Strongly Agree, rendered as a scale of 1 to 5. It should be noted that about one-third of the students traveled to the Adventure Learning trips that took place between the surveys in January and April. Both groups of students are included in the table below.

Questions divided by category	January	April	Change
Responses based on personal interest (Overall Average)	3.20	3.15	-0.04
I enjoy learning Environmental Science	3.71	3.59	-0.12
I find learning Environmental Science interesting	3.63	3.60	-0.03
I like Environmental Science assignments that challenge me	2.87	2.85	-0.02
Learning Environmental Science content is more important to me than the grade I receive	2.62	2.62	0.00
Learning Environmental Science has practical value for me	3.28	3.21	-0.07
Learning Environmental Science is relevant to my life	3.39	3.41	0.02
Learning Environmental Science relates to my personal goals	2.70	2.68	-0.02
Understanding Environmental Science gives me a sense of accomplishment	3.37	3.27	-0.10
Responses based on academic interest (Overall Average)	3.58	3.57	-0.01
Earning a good Environmental Science grade is important to me	4.20	4.17	-0.03
I expect to do as well as or better than other students in the Environmental Science course	3.80	3.89	0.09
I expect to use the Environmental Science I learn	3.03	3.03	0.00
I prefer course material that arouses my curiosity, even if it is difficult to learn	3.77	3.63	-0.14
I think about how my Environmental Science grade will affect my overall grade point average	4.07	4.15	0.08
I think I will be able to use what I learn in Environmental Science in other courses	3.21	3.11	-0.10
I think that learning Environmental Science can help me get a good job	2.99	3.02	0.03

Table 2: Means Change in Survey

A table with more detailed information, including standard deviation, is contained in Appendix L. Some qualifications must be made for this body of data. Not every factor was considered, especially issues relating to all of the priorities surrounding students preparing to graduate from high school and move into their college career.

Taking other issues into consideration, there was not much change before and after the intervention.

In the table above, student responses average to the positive side of neutral in both in January and in April. It is helpful to note that students had a slight preference toward academic and professional goals rather than personal interest goals in relation to taking environmental science class.

Testing for Differences

The figure below provides a reference for the means and standard deviation among responses to the survey questions in both January and April, divided by whether the students traveled to the Adventure Learning activities between the surveys.

A 2-Way ANOVA test was run to examine the influence of time and travel status (independent variables) on responses to 15 survey questions (dependent variable). The purpose of the 2-Way ANOVA was to determine the main effect of contributions from each independent variable and identify whether any significant interaction took place between the independent variables.

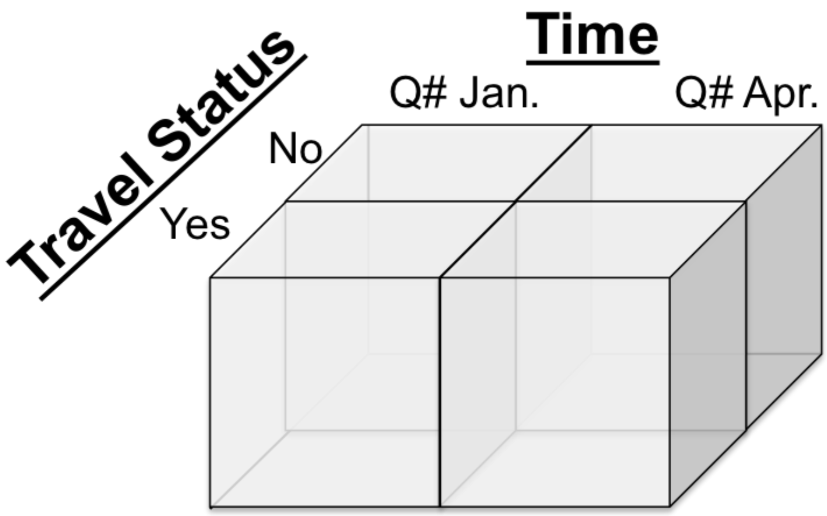


Figure 1: 2-Way ANOVA

DEPENDENT VARIABLE (15 separate items):

- Responses to each of 15 items from the Motivation Questionnaire

INDEPENDENT VARIABLES:

- Time – January vs. April within subject
- Travel Status

Frequency distribution varied among the 15 survey items (See Appendix K), but only one survey question produced significant results in the 2-Way ANOVA. In both January and April surveys, students agreed with the statement, "I prefer course material that arouses my curiosity, even if it is difficult to learn." With 3.0 being neutral, the mean of January responses was 3.77 and the mean in April was 3.63. Though still toward agreement, this was the largest decrease in agreement among the 15 survey questions taken from the Science Motivation Questionnaire (Glynn, 2009).

When responses are divided among students who traveled and did not travel, it should be noted that students who did not travel only showed a decrease of 0.01, whereas students who traveled showed a decrease of 0.31. The table below displays the mean and standard deviation for this question. See Appendix L for a list of mean and standard deviation for all survey questions.

	Travel		No Travel	
	Jan	Apr	Jan	Apr
I prefer course material that arouses my curiosity, even if it is difficult to learn.	Mean: 3.93 SD: 0.92	Mean: 3.62 SD: 1.03	Mean: 3.66 SD: 0.83	Mean: 3.65 SD: 0.81

Table 3: Mean Difference by Travel Status

The 2-Way ANOVA showed that the results were statistically significant, specifically, that the independent variable of time had an effect on student responses to this particular statement, but time and the travel by time interaction effects were not significant.

Effect	F	p
Travel Status	3.985	0.049
Time	3.235	0.075
Travel x Time	0.586	0.446

Table 4: Results of 2-Way ANOVA

The table below shows the frequency distribution for this item, where shift from agreement to neutral is evident among students who traveled to Adventure Learning projects compared to their peers who did not travel. The shift could indicate a change in preference due to the experience of traveling to the Adventure Learning projects, which may have included more work than simply traveling away from the school campus for a day of activity.

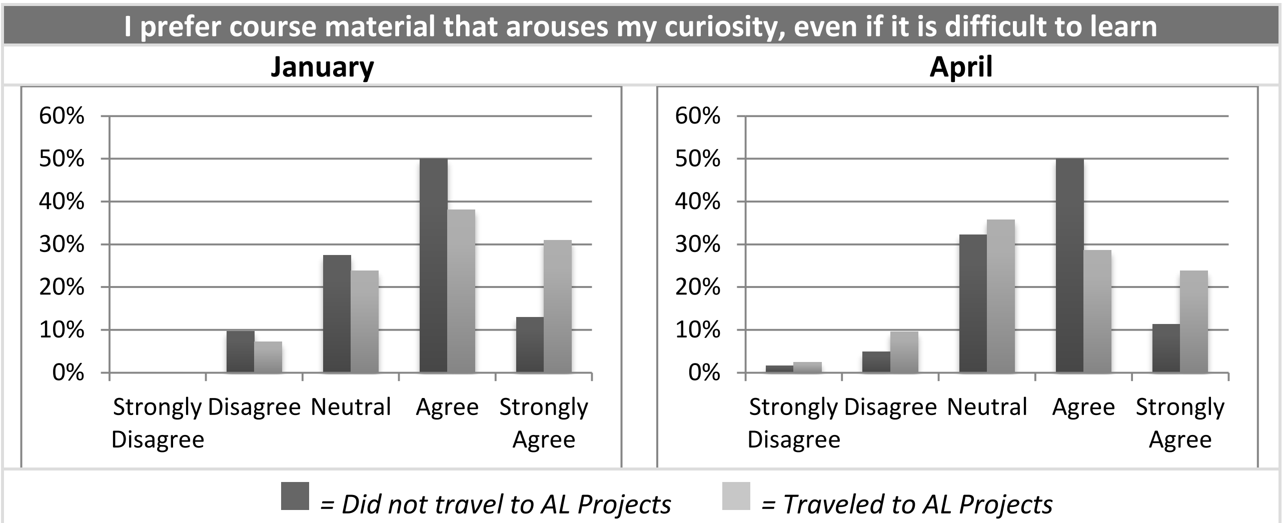


Figure 2: Frequency Distribution for Course Material

Chance and Observed Distribution

One of the questions developed by the primary investigator asked about student preference for learning. It asked, "Which way do you prefer to learn?" Students had two options for answering this question. The first option was, "Give me the information and answers I need through a lecture or book." The second option was, "Point me to an environment where I have to explore and find my own answers." To divide students based on either of these choices, the primary investigator labeled the two groups Book Learners (B), and Hands-On learners (H). Both January and April surveys revealed that the 104 students in this sample group preferred book and lecture learning to exploration learning at a 2:1 ratio. From January to April, there was a 3% increase in Hands-On learning preference that can be noted in the table below.

Learning Preference	January	April
Book Learner	72	69
Hands-On Learner	32	35

Table 5: Learning Preferences

It appeared, at first, that the numbers had stayed nearly the same, with only three converts moving from book learning to hands-on learning, increasing the hands-on learners from 32 in January to 35 in April. A deeper investigation into the responses, however, revealed that several students changed their minds in both directions between January and April. Descriptive analysis revealed that 55 students identified themselves as book learners in both January and April, 17 identified themselves as book learners in January but switched to hands-on learners in April, 14 had switched from hands-on learners to book learners, and 18 selected hands-on learning preference in both January and April.

Learning Preferences

Book; Book (BB) 55

Book; Hands-On (BH) 17

Hands-On; Book (HB) 14

Hands-On; Hands-On (HH) 18

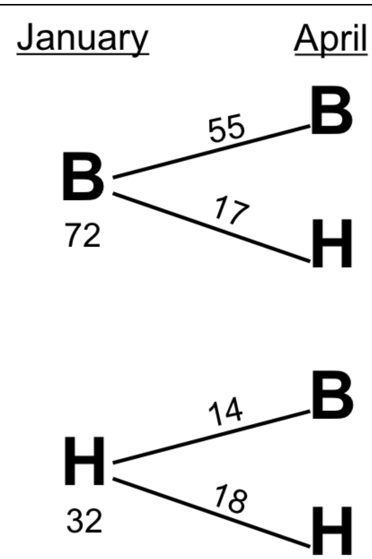


Figure 3: Learning Preferences Over Time

In terms of learning preference before and after participating in the Adventure Learning project, the movement of students moving in both directions lead to the question of whether travel status was influencing these preferences.

Comparing whether or not students in each of these categories traveled to an Adventure Learning project exposed some additional information. Among a sample group of 104 students, 40% traveled to one or more of the Adventure Learning projects between January and April. Student preferences for learning modes are described in the figure below by percentage (above the columns) among the number who traveled (below the columns) rather than the numbers themselves, so that tendencies can be more evident.

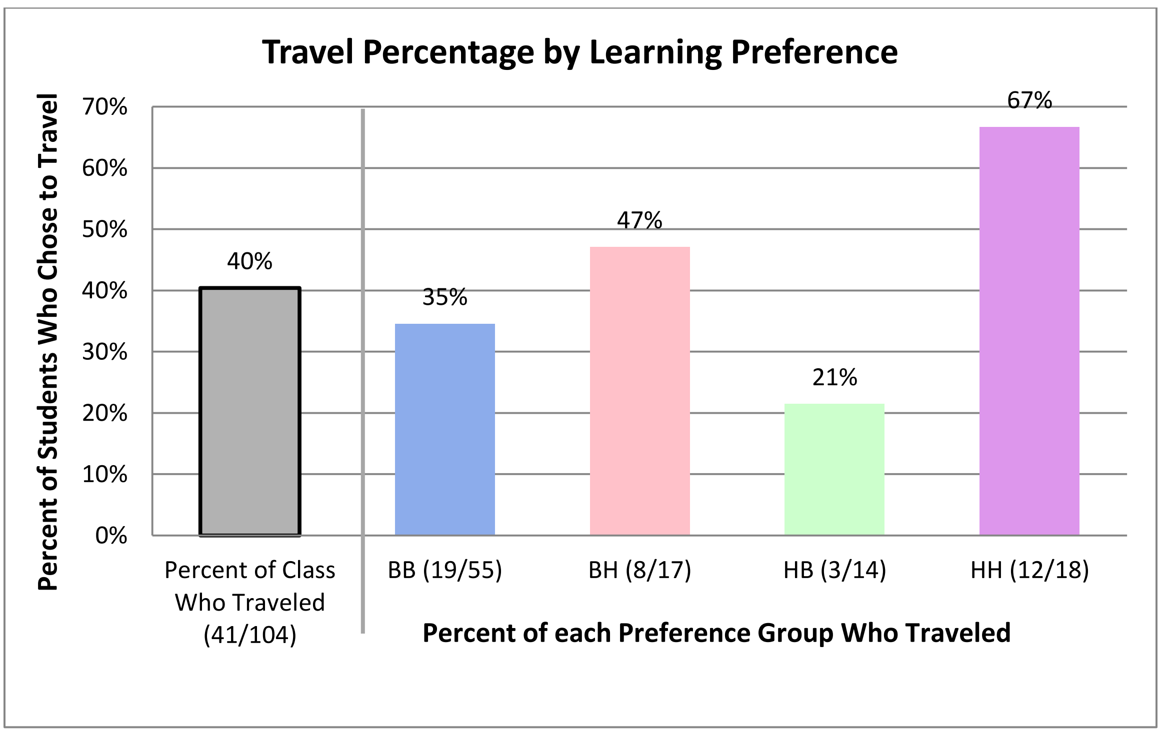


Figure 4: Travel Percentage by Learning Preference

To explore any significance of travel in relation to learning mode, a Chi-Square test compared changes in student preferences for learning style with whether or not they had traveled. Results show a significant influence of travel for learning preference in the second survey.

Trips-N1-Y2 * Style Change Cross tabulation						
		Style Change				Total
		BB	BH	HB	HH	
Trips-N1-Y2	Not Travel	36	9	11	6	62
	Travel	19	8	3	12	42
Total		55	17	14	18	104

Table 6: Change in Learning Preferences

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.347[a]	3	.039
Likelihood Ratio	8.429	3	.038
N of Valid Cases	104		
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 5.65.			

Table 7: Chi-Square Results for Learning Preferences

The Chi-Square chart below provides helpful information for exploring the significance between the changes in learning preferences compared with whether or not each student traveled to an Adventure Learning project.

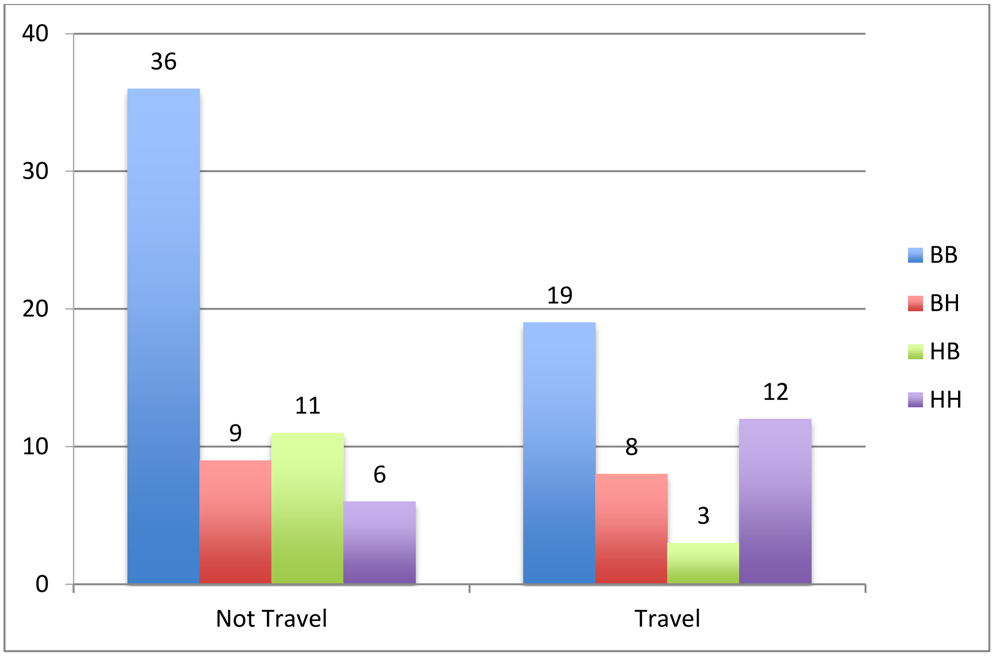


Figure 5: Chi-Square Chart

Among Mr. Kollar's classes, 40% of students traveled to the Adventure Learning projects. Students who transitioned from a preference for hands-on to book learning (HB) had the lowest percentage of travel at 17%, followed by students who preferred book learning in both January and April (BB) who traveled at 35%. Students who changed preferences from book to hands-on learning (BH) were slightly above class average for travel at 47%. Students who had the highest travel ratio were those who chose hands-on learning in both January and April (HH) at 67%. The Chi-Square test supports depth in the relationship between travel and learning preference. Travel reinforced the hands-on preference by reducing the proportion of students who remained with a book learning preference.

General Responses to Survey Questions

When asked why students might take his class, Mr. Kollar explained that he knew exactly why most students took his course. "They take my class because it's an easy A." In response to that question specifically, students were able to select all that applied to the following question, "Why did you take the environmental sciences advanced placement class?" Student responses are displayed in the table below, which supports the grade motivation in addition to some other reasons.

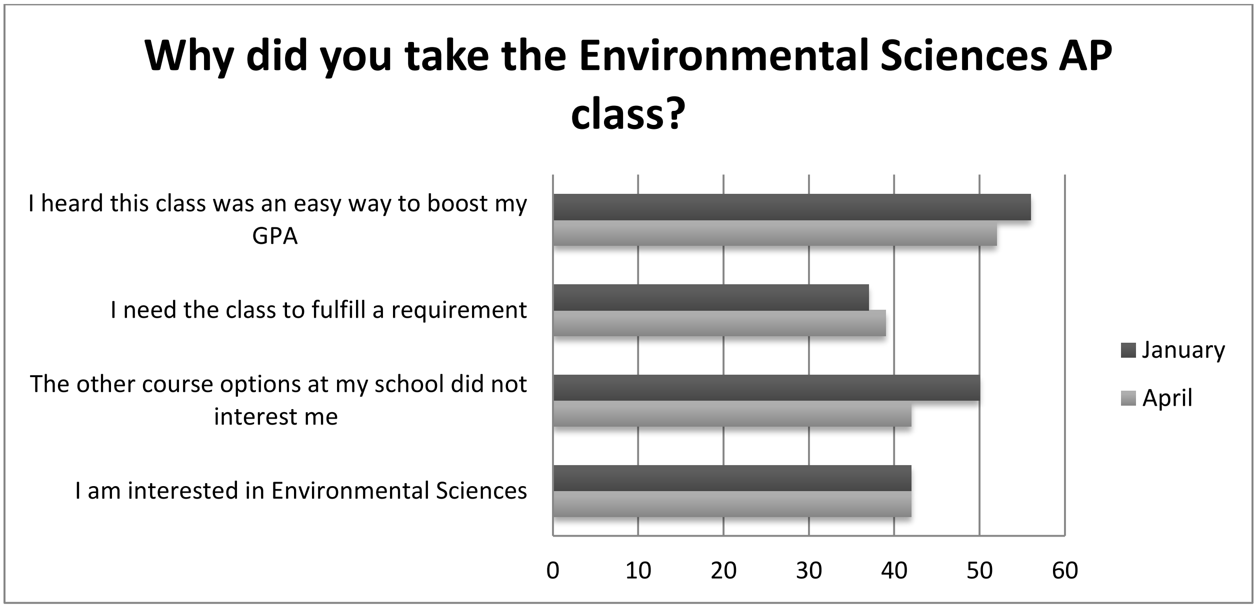


Figure 6: Reasons for taking Environmental Sciences class

Six students included write-in answers, stating: “Had a class before with the teacher and enjoyed being in his class;” “I wanted to take another science and my counselor told me a lot of people enjoyed this class;” “If I took this class this year, I wouldn't have to take a science my senior year;” “I want to take as many science classes as I can in high school, because I want to major in science;” “Knew the teacher and was interested and what the class would be like;” “Kollar is the man!”

Displayed in the figure below, students were also asked what their grade expectations were for environmental sciences. Most of them expected to get a high B or an A in the course at the beginning of the semester. By the end of the semester, students could see how their grades were shaping up, and there was a slight shift toward grade expectations that were higher. The changes could be attributed to students having more grade reporting sections and being closer to finishing the academic year by the time they took the second survey.

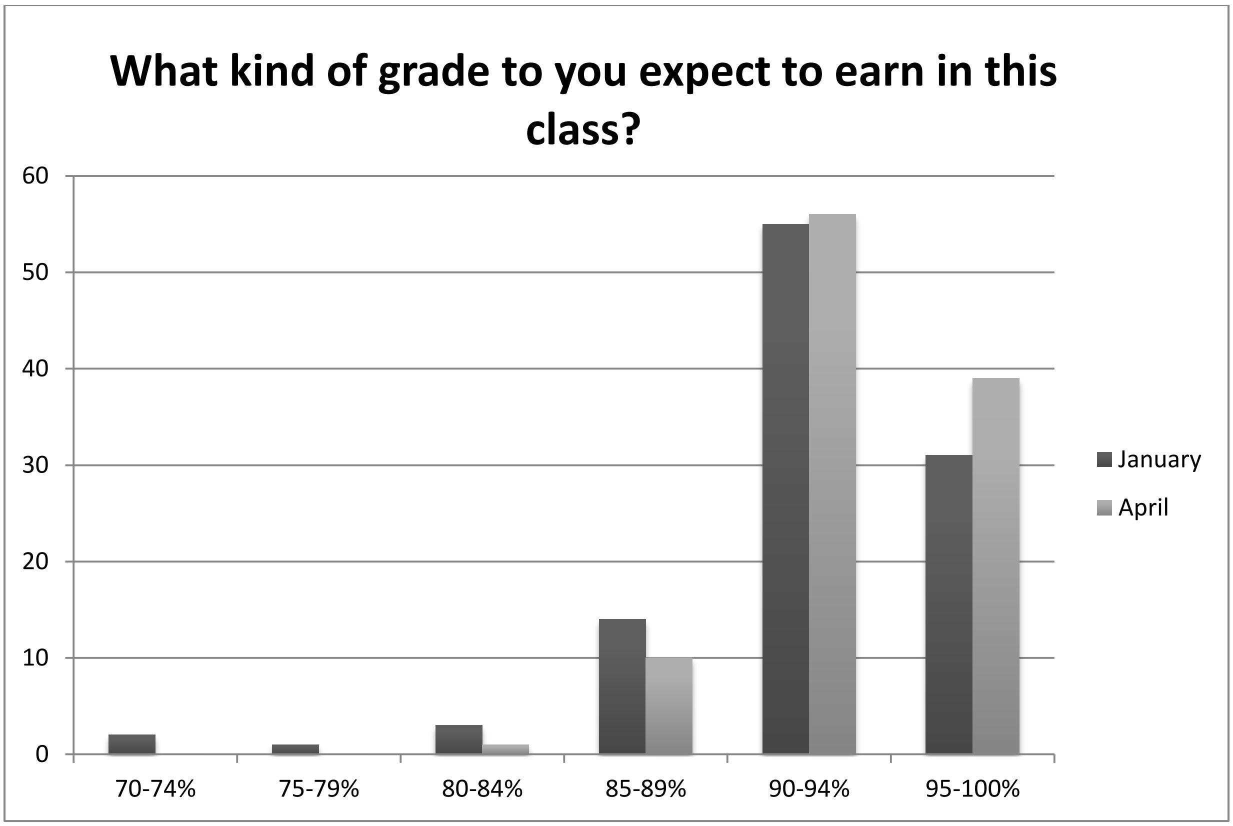


Figure 7: Grade Expectations

When asked to compare Environmental Sciences to other classes they were taking, students gave the following expectation for environmental science as reflected in the before and after survey. As seen in Table 5, there were only slight and mixed changes between the survey results in January and the results in April, so according to the self-disclosure of students, there was no significant change in the difficulty level in comparison to other classes.

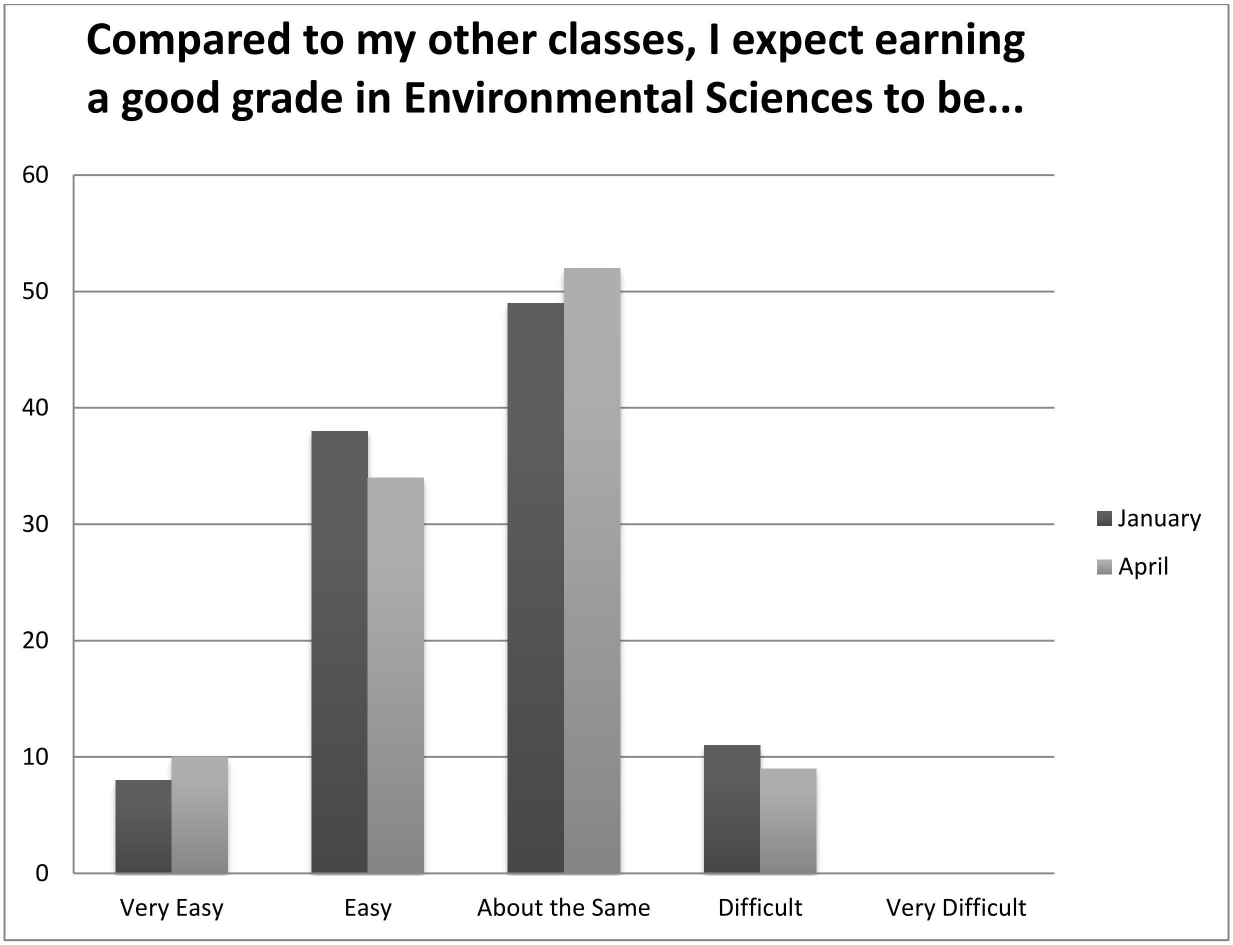


Figure 8: Grade Expectations

When asked whether they would take the standardized test for college credit in environmental sciences, students' opinions were more varied. Many of them moved from not decided to either yes or no. There was a decline in the number who answered "Yes" between January and April, and there was a significant increase in students who said "No" between January and April. Another large change between January and April was the number of students who were undecided about taking the standardized test. That number dropped from 40 to 12 over the time period.

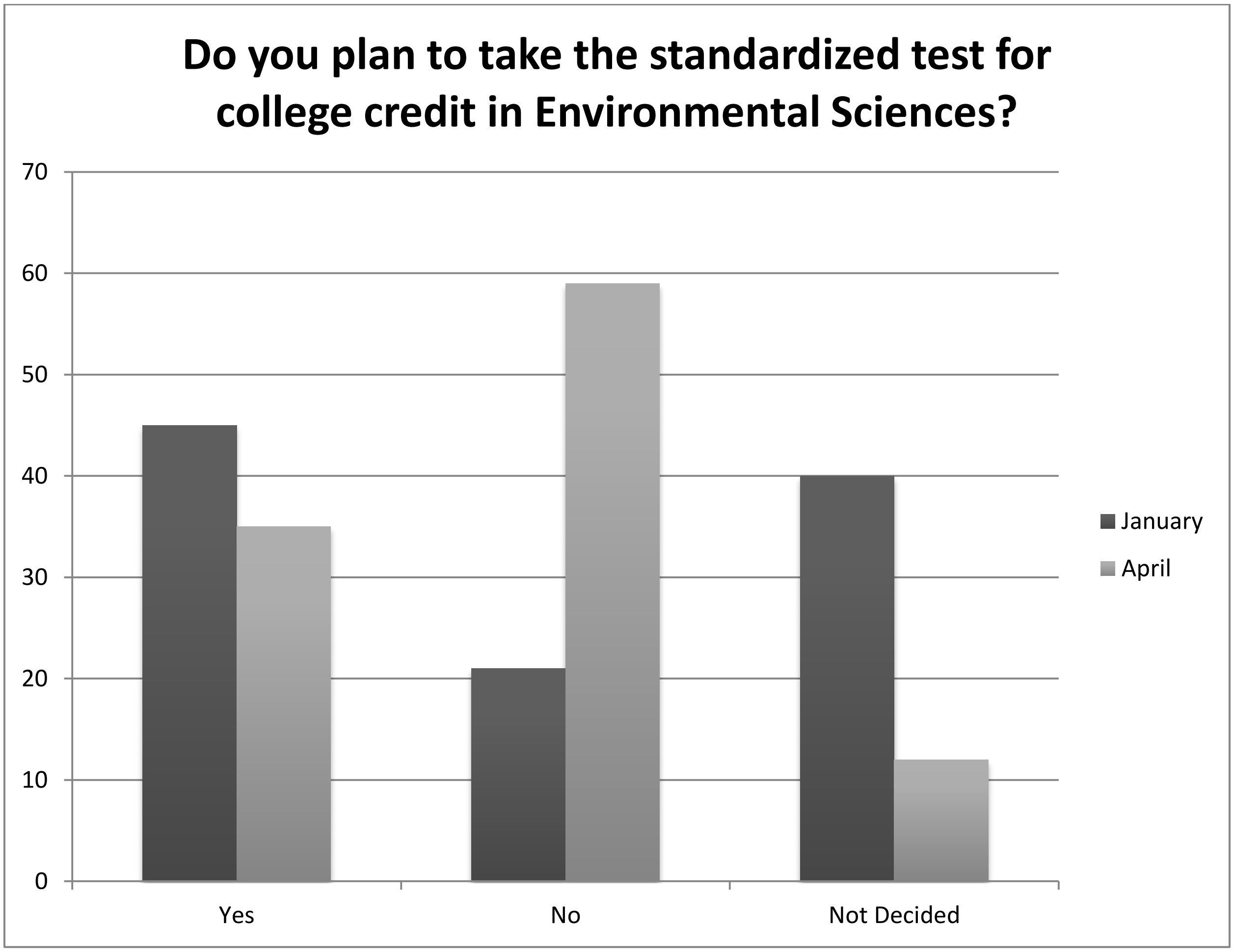


Figure 9: Plans for taking the standardized test for college credit in Environmental Science

When asked whether any of the students would major in environmental sciences when they attended college, Mr. Kollar said that one student entered the school year planning to major in environmental science, and had been accepted at the college of her choice during the school year. When describing that student, Mr. Kollar said, "I have a student now who never thought she would be a scientist, she is accepted at a major state university to major in environmental sciences. And that's what she wants to be. She wants to study environmental science as it relates to aquatic issues." The survey results seemed to bear this out both before and after the intervention. Students' responses of "Likely" increased, as is displayed in the figure below.

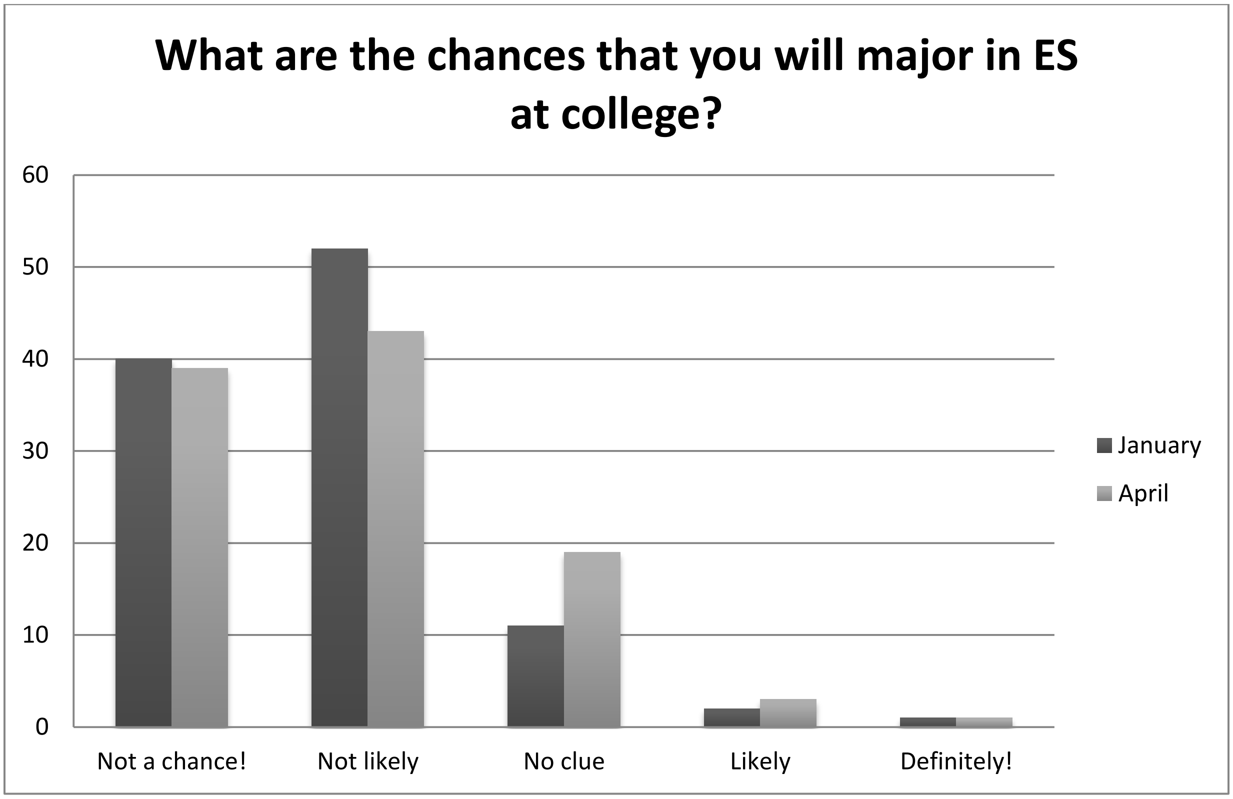


Figure 10: Chances that students will major in Environmental Science when they go to college

Ideas from the Teacher

During an interview, Mr. Kollar expressed that his method of gauging student interest in the subject of environmental science was mainly gathered through the amount of attention they showed to a particular topic, and the kinds of questions and comments that they make in class. He described that the ideal situation is when he can work with students in small groups, because students speak more openly and more casually, and he is able to determine their interests. Sometimes students will raise a question in class, and depending on the follow-up discussion, Mr. Kollar is able to judge the interest level that students have for that particular topic.

During a classroom observation, the primary investigator observed that Mr. Kollar listened to a presentation that students were making about bird species, and he noticed the kind of interaction they got from their peers. In his follow-up discussion, Mr. Kollar added some information to the discussion by going to a website and presenting it on the screen in front of the class. Some of the students asked for further information, so he posted a link to the learning management system so that all of the students could access it. Since many of the students spend recreational time at a local lake, Mr. Kollar brought aquatic life samples from the lake so that the students could analyze them and build their own knowledge about their local surroundings. He later explained that this helps students connect the subject of environmental sciences to their recreational activities, promoting student interest in the subject.

Mr. Kollar is also aware of student motivation and interest issues, and that most of the students at the school are very focused on grades and college preparation. When asked why students might take his course, Mr. Kollar replied, “Oh, I can tell you exactly why they take my course. It’s an easy A.”

In addition to helping students in their academic careers, Mr. Kollar is also interested in lifelong learning, and helping students to see how their choices in issues that relate to environmental science impact both their personal lives and the world around them. He described how their textbook sections on farming and water conservation prompted a lot of discussions about daily decisions that people make an impact those have on the environment. During one of the Adventure Learning trips, students were able to observe organic farming, and listened to a farmer explain the processes of sustainable farming as opposed to industrial style farming. In the few weeks following the trip, Mr. Kollar heard that students began changing their eating habits and were educating their parents on the subject. During another one of Adventure Learning trips, students observed some of the water systems and what happens as a result of poor water conservation. Mr. Kollar expects that changes in their lives will also occur as a result of their first-hand observations.

In the table below, results from both the January and April question: "Learning Environmental Science is relevant to my life" had an overall gain, which is one of the stated goals of the teacher. Student responses in January peaked at "Neutral" while their April responses peaked at "Agree." On a scale from 1-5, the January mean was 3.39 and the April mean was 3.42.

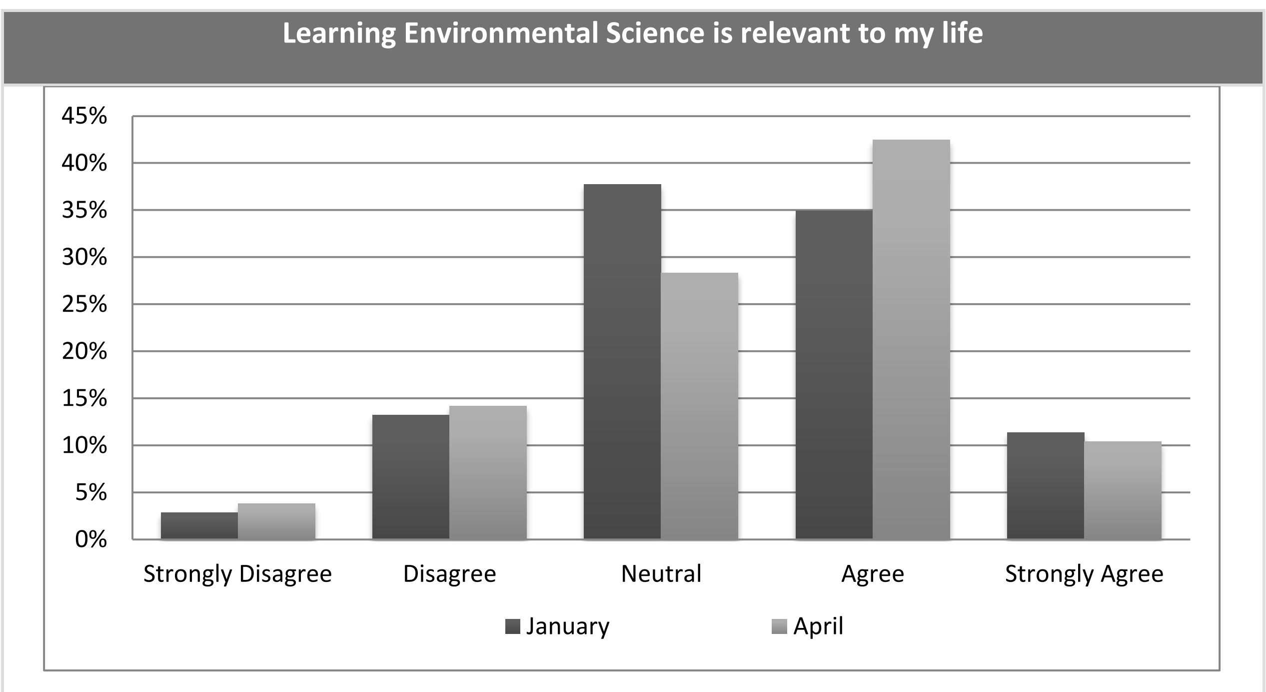


Figure 11: Relevance of Environmental Science to personal life

When the results of the survey are divided among book learners vs. hands-on learners, the hands-on learners tend to be more positive both in January and April. The chart below divides January and April responses to the same question. This is typical, as most of the 15 questions from the Science Motivation Questionnaire (Glyn, 2009), demonstrating hands-on learners with slightly more positive responses.

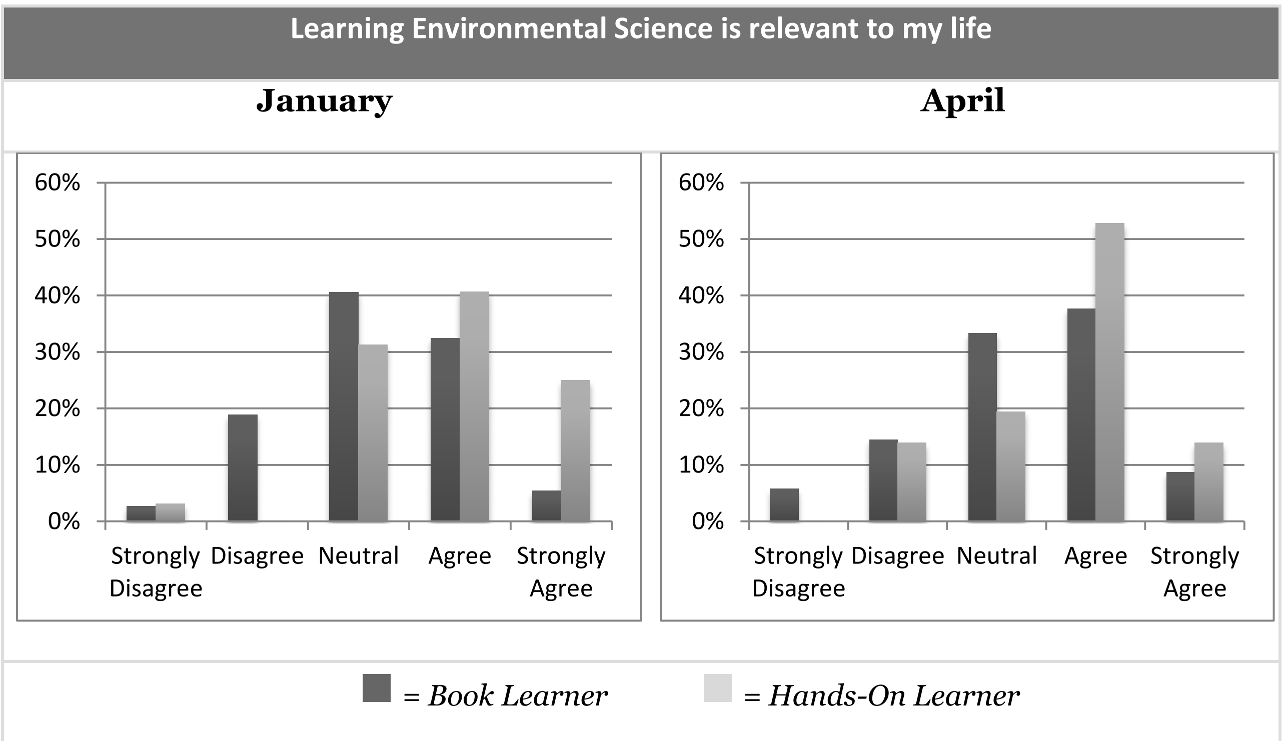


Figure 12: Relevance of Environmental Science and Learning Preference

Analysis of the Science Motivation Questionnaire

Questions from the science motivation questionnaire (Glyn, 2009) were divided by students who traveled to one or more of the Adventure Learning projects compared to students who did not travel at all. Among the 104 students who were included in the analysis of both January and April surveys, 42 traveled to Adventure Learning projects and 62 did not travel. Among the 42 students who traveled, 15 went on one trip only, 12 went on two trips, and 15 went on all three trips. The teacher's original design was for every student to have an opportunity to travel to at least one Adventure Learning trip, but the reality of travel constraints, resources, and scheduling only allowed for 42 students to travel.

Though traveling students were not analyzed by categories based on the number of trips taken, a decision was made to only consider whether or not the students traveled to any Adventure Learning trip. Students were given fifteen statements and could select among five choices ranging from Strongly Disagree to Strongly Agree. The following charts show the beginning and end of semester identification broken down by percentages among the students who traveled on Adventure Learning projects and those who did not travel.

Summary of issues related to student interest

Based on interviews and observations by the primary investigator, Mr. Kollar adapts his approach to teaching based on feedback he gathers from working with students in small groups. He also understands that students in 11th and 12th grade taking advanced placement courses have a focus on their grades and future academic opportunities. A hands-on learner himself, Mr. Kollar incorporates as much activity-based learning as possible to engage students through more than lecture and book knowledge. Though he would like to see more students enter a major of Environmental Sciences, he hopes to promote a love for the lifelong appreciation of the subject, and changes in life choices that have an impact on the environment.

Student responses on surveys had a mix of supporting and not supporting the ideals expressed by Mr. Kollar. The strongest response among reasons for taking the course was that they wanted to get an easy A. It should be noted, however, that responses went from 56% in January to 52% in April, and that 42% said they were genuinely interested in the subject in both January and April.

Student responses to book vs. hands-on learning question revealed a difference in what the teacher perceived as the ideal way to learn and what the students expressed as a learning preference on a survey. Though there were significant shifts among students between January and April, both surveys revealed approximately 2 to 1 in favor of book to hands-on learning. The Chi-Square test revealed a significant statistical relationship between travel to the Adventure Learning projects and student learning preferences.

Some of the students in focus groups expressed a wish that the Environmental Science class could have more structure in support of the overall survey responses. It should be noted that most of the students were graduating seniors, and within a few months of taking the next step in their academic careers toward college. This would call into question the likelihood of major changes in learning preferences at this point in their academic careers.

While building a personal interest in Environmental Science is a goal of the teacher, students tended to be less interested in the subject toward the end of the school year. An exception to this was the question on whether Environmental Science is relevant to their personal lives, which increased. Increasingly positive responses to questions related to academic goals supported student interests in getting a good grade for their academic records.

In most survey questions, students who traveled on the Adventure Learning trips responded more positively (or less negatively) than the students who did not travel. Some of this is likely due to the more enriched learning experiences, though initial interest of the students to volunteer for the trips must be factored in as well.

How did the mobile device support learning in Environmental Science?

To answer how the mobile device supports the learning experience, the primary investigator drew from interview, observation, and survey data. The data obtained from interviews mainly came from student feedback during the focus group discussions. During the focus groups, students would answer questions that are provided in Appendix C. When a particular question would spark further discussion, the primary investigator might add a follow-up question for purposes of clarification. Data obtained from observations took place in classroom settings and Adventure Learning activities. Survey data that helps to reinforce or challenge any of the findings is also included in this section.

Ubiquitous Access to Information

During classroom observations, students worked in groups and presented information related to upcoming Adventure Learning activities such as observing bird species. This was in preparation for the Adventure Learning trip where students would go to an outdoor environment and log observations of bird species. At classroom or homework settings, students used their mobile device to conduct research on the Internet and pulled their information together into a slideshow that they presented to the rest of the class. Some of the slideshows contained more than pictures and words, including audio files of bird sounds and videos of birds in their natural habitat.

When asked about this, one student responded about how quickly he can pull information from the Internet and arrange it for presentation on his iPad. "I like using Keynote on my iPad. Like, if I just need to make a slideshow, I can just create it instead of starting up my laptop." Another student described the time when she had to create little characters in a mobile application and they had to speak a foreign language to each other. Students used a mobile application to develop both the animation and the audio for this kind of a learning project. The mobile device provided their lesson plan, a recording instrument, a development tool, and a presentation device.

Another student remarked on how easy it is to use a mobile device and access course materials, read through the materials, compose or put together any homework, and turn it in. Prior to their interview, students had to use their mobile devices in a setting where they did not have a mobile friendly learning management system. There were several complaints about the earlier situation, but just as many positive comments about how well the current learning management system helps them receive, track, and turn in their work. One student commented, "I like to have, like, all of my books on the iPad, instead of, like, carrying them all around. I think I only have one (hardcopy) book that I keep at home."

While participating in an outdoor Adventure Learning project, ubiquitous access to information was limited by battery and connectivity issues. When power and connection were available, students were able to access the Internet to look up or log information. The iNaturalist® application provided access to the information they needed, though it was purchased and downloaded when students were connected.

Ubiquitous Access to Networking and Learning Resources

Students commented about the ubiquitous nature of communicating and networking with mobile learning. Not only are they using the device for so many of their learning tasks, the device can also access the school learning management system from anywhere that the students have a connection. The iPads do not connect directly through a data plan, so they need a home or institutional Wi-Fi in order to connect. While in school, students connect through the school Wi-Fi that can be accessed wherever they are on campus. Students can access the Internet through their Wi-Fi at home or at a public Wi-Fi. Some students use their personal cell phone as point of access hotspot.

Students have become accustomed to finding and sharing answers at their fingertips. Some students described how they use Internet search engines to look up and share information while they are listening to a lecture on the same topic. Sometimes there may be a term or something they don't understand, and they do a quick search to make up for any information gaps they have during the class.

One student commented, "I like having Internet access so quickly, and when I want to look up something, I just look it up and get my answer." Another student commented, "If you are sick or whenever you are at home, you can just login to the learning management system and find your assignments. Everything is online, so you can still do your homework whether you're at home sick, or gone on a trip. It's not like when you come back and you have a ton of makeup work." She went on to describe how being in band requires her to be away from the school campus during certain times of the year. She is able to keep up with homework and reading assignments because everything is on one device and she can access the school learning management system as long as she has her iPad and some connection to the Internet.

Organizational Benefit of a Single Device

Students also commented on the organizational benefit of having one mobile device for taking notes, reading, doing homework, and turning it in. Before using an iPad, one student commented that he used to use his smart phone for doing web searches in class. Now that he has the iPad to use in class, he feels like he can view the web content better because of the larger screen size. Several students mentioned that they use the iPad as their alarm clock, both for waking up in the morning and for daily schedule. One student commented, "I can't organize things to save my life, but on my iPad it's like, all in one folder and easy to organize. And I don't have to organize or do anything to stay organized." Several students commented about the convenience of having all of their notes and books and assignments in one place. A student who participates in the school choir said that he keeps all of his music on the iPad. He described how earlier choir experience required carrying sheet music in thick binders, but now it is in a folder along with the rest of his course materials.

Students discussed the convenience of having everyone use the same operating system. This enabled both teachers and students to prepare or present materials that could be accessed by anyone else in the school. One student commented on how this was a source of equality for all of the students. "Yeah, it like levels out the playing field. With everybody having an iPad, it like makes it really fair for everyone."

Student Use of Mobile Device for Learning

The use mobile technologies for learning by the students varied from use as a computer for tasks such as reading, writing, or searching the Web to gathering information through photographs and audio or video recording. Mr. Kollar assigns first-hand information gathering activities with the iPad including photography, geolocation, field observations, and FaceTime communication with their peers. Before participating in Adventure Learning projects supported by mobile devices, students in environmental sciences were assigned an information-gathering project on the school campus. Their assignment was to gather information about plant species on the school campus by matching leaves from the plant's with a plan database on the Internet. Students described activities where they took photos of leaves and loaded them onto a database.

Students also compared their photographs with online resources so that they could identify each of the species. They collaborated and refined their research, and then turned in their projects to be graded by Mr. Kollar. The Adventure Learning activities expanded on this exercise as students took an entire day to gather information with their iPad and load that information to a shared database that they would analyze later.

In classroom observation, the primary investigator observed less than half of the students in the environmental sciences class were using the iPad for on-task work. Some were shopping, some were social networking, some were playing games, and others were reading assignments for other classes.

The need to use or put away the mobile device could change depending on the current learning activity. After a classroom lecture, Mr. Kollar showed the students where they could go to download the notes from the lecture to review on their iPads. Later in the class, during a discussion, Mr. Kollar told the students to put away their iPads so they would engage more in the discussion.

Relying on a Single Mobile Device

Using a single device helps with design and organization, but not every experience with using a mobile device for learning was a positive one. Some of the negative experiences stem from device limitations while others stem from technology issues. Along with the benefit of using a single device there is the risk of a single point of failure. The benefit of using an interesting device come with the risk of technology distraction, either for entertainment purposes or because students have to learn to manage the technology in order to learn their course materials.

Tablet Limitations for Typing

One of the main frustrations that students have with using a mobile device is that the virtual keyboard is slow for typing. The primary investigator observed one student in the class who was using a laptop instead of in iPad. In a focus group, the student described that he prefers a laptop when he needs to do a lot of typing. He is still able to access the same materials, but has different applications that can work on his laptop. As with all of the students, he has a school assigned iPad that he also carries but only uses it when it's convenient or when he's required to use it. It should be noted that a student using a laptop in place of a more mobile device could be limited from some information gathering activities such as capturing images or video. Another student purchased a Bluetooth keyboard that connects to his iPad so that he can type more quickly while not losing the portability benefits of the mobile device.

Low Storage and Battery Capacity

Another negative experience for the students with using a mobile device is the lack of capacity. Some of the iPads fill up with mobile applications and students are not able to add more applications or more data. Without an expansion slot, students need to remove some of their applications or upgrade to a device with more capacity. The battery capacity also leads to some frustration. Most students agreed that if they charged their iPad overnight it would hold a charge throughout the day as long as they weren't using it constantly through the day. Most students carry their charger in case the device loses its charge during the day. But the charger creates a second device that the students need to carry and keep track of. One student said, "I've had to go back to several classes to unplug my iPad from the wall." Other students described a nightmare when they come to class but left their chargers at home. They have to borrow somebody else's charger, and that can be a problem. One student commented, "if your juice runs out and you don't have a charger you're really, like, screwed for the rest of the day. Because you really need a charger."

Device Crashing

Students discussed some of the negative experiences they've had with mobile devices for learning that center around the device crashing or freezing. Though only a few of the students described this problem, those who described it said that it happened on several occasions. One student commented, "Mine freezes a lot. It's kind of bad when I'm in class and it freezes. The teacher is, like, teaching something and the iPad freezes up. She's talking and, like, giving us notes, and I can't type anything. And sometimes it takes a couple of minutes for it to, like, go back to where you can use it."

One student described how a particular app would not open correctly. She needed that application to access a particular book for class. The staff on campus that help troubleshoot IT issues were not able to help her. She had to call the publisher help desk and was still not able to correct the problem. She had to delete the application and download it again to make it start working. In that process, she had to completely delete all of the files related to the book so that the application could be reinstalled and working again. She was thankful that only one of the textbooks required this application.

Off-Task Distractions

One of the challenges for students using a mobile device in the classroom is that it can be a distraction from the learning task. Ubiquitous access to information enables students to access social media, gaming, and other information aside from the topic of the classroom. During classroom observations, the primary investigator observed about half of the students using their iPad's for on task purposes. One student was playing plant vs. zombies until the teacher walked to the back of the class. Another student was reading a textbook from another class as one student was reviewing notes for another class. One student was using her iPad to shop online, while a student in front of her was reading unrelated news. Several students were playing 2-D or 3-D games. Though Mr. Kollar is a proponent of using mobile devices in the classroom, he asked the students to put away their iPads if they're going to be playing on them while other students were making presentations.

Students also identified distraction as a problem for having mobile devices in the classroom. One student commented, "It's like when I start up my iPad. Should I open my class notes? Or should I get caught up with my friends on Facebook? Or should I play a game?" Some students described it as an issue of responsibility, and don't feel distracted by off task applications on the mobile device. One student said, "I have a lot of free time later, so games don't bother me." Another student described a fear of getting too far behind, so she doesn't want to feel overwhelmed because of playing games or going online for social networking while in school.

Lack of IT Support

Students expressed difficulty with the mobile device based on a lack of IT support. There are staff on campus to help answer questions or troubleshoot iPads, but students said that there are limited hours when they are available and sometimes students are not able to reach them until the next day. One student described, "so it's like, it might just be a simple solution, but if there's no one to answer your question, there's nothing you can do about it." Even the staff who are dedicated to help with troubleshooting are not always able to resolve IT issues with the mobile device. One student had to call the App Store and was then referred to the company that made the application. Waiting on hold was not very easy because the student was missing another school activity trying to troubleshoot her mobile device. She talked further about this issue, "Sometimes you want to ask your teacher about a problem, but they don't always know. And you can e-mail the IT people, but sometimes that takes longer than just going downstairs and finding them. But they are not always there."

Students are accustomed to using computers and mobile devices. Some of them are more at ease than others when they encounter an IT problem. One student said, "If you're not very good at technology, it's like hard to use." Another student was happy that the technology was new and difficult to some people. She said, “My mom doesn't touch my iPad. Like, she does not know even how to turn it on and stuff. Yeah, it's a different system."

Though the students have adapted to mobile technologies, they had some difficulty in the first few weeks of using their mobile devices. Some of the students thought they had an IT problem, but it was mainly learning the process of logging in to the school network and the learning management system. On some occasions, the learning management system is not accessible, and students have to wait until it is functioning again. There is no consistent messaging or broadcast to the students so that they can no whether they have a device problem or if there is a system-wide problem.

The students expressed frustration with the learning curve of the learning management system. Now that they are familiar with it, they find it very easy to use. When they were first learning, they encountered a lot of problems, because each time they tried something they needed to do, it was the first time they were exposed to that function. They wished that there was a tutorial so that they could start using it with basic knowledge. One of the students said, "And like when we first started using the E backpack, a lot of students did not know how to work it at all. And like teachers would be expecting them to turn in their assignments. And they wouldn't know how and some teachers were more patient than other teachers. Some teachers weren't patient at all. But once we got that up and running, it was a lot easier." One student said that her classmates were able to learn how to use the learning management system in about one week but that it took her two weeks, so her experience was different from her classmates.

One student described a situation where her application closed without saving a document she was working on. It was an application that she was using to create a document, so when it closed on a number of occasions, she would lose the progress that she was making on her document. She tried restarting her iPad, but it didn't help the situation. She said, "One time I was working on a whole bunch of documents with this app and then the app stopped working. So I figured, okay I'll just delete it and then re-download and install it and I can start it up again." But when she restarted the application, all of her progress was lost.

Students who are accustomed to a different method of saving documents find some of the mobile methods frustrating. Since the mobile device automatically saves the documents while students are working on them, students don't always know when it was last saved or whether it was saved at all. They would prefer having a manual save feature so that they can have control over where and how often the document is saved.

Single Point of Failure

One of the greatest strengths of everyone having the same type of mobile device for learning activities is the convenience of being able to organize all of the learning resources through one device. That greatest strength can also be the greatest source of frustration, because if that single device is not working, it results in a single point of failure. One student had trouble logging in to the school network, and was unable to get any work done. Since the account wasn't working, nothing was working. One student described the situation where she was trying to restart her iPad and took about 5 minutes troubleshooting a technology problem, and ended up missing 5 minutes of note taking in the class. In the environmental sciences class, one of the students was not able to access her textbook during the time that there was an in class reading assignment. After spending several minutes trying to access the textbook, she asked the teacher and he handed her an old paper textbook. One student said, "If I don't bring my iPad to school, I'd probably be lost. Because I'm, like, using it, like, every day for math and music. I take notes with it and do my stats on it. I've been turning in, like, all of my assignments on my iPad. So if I don't have it, I'm, like, screwed."

Use of the mobile device is seen to support the educational experience for the students because they have ubiquitous access to information and communication with each other and the teacher. They are also able to organize their notes, assignments, and textbooks on a single device. Students can use the mobile device to capture information, and the same device to demonstrate what they have found with the teacher or other students. Students also described limitations to using a tablet, which include low storage and battery capacity, along with occasional crashes. Having a single device for several school tasks is a benefit to students, but also creates a problem if the device is not working. If the mobile device fails, the student is not able to participate in many of the school assignments.

What was the relationship between the use of mobile technologies and student interest in Environmental Science?

Though the relationship between the use of mobilized Adventure Learning actives and student interest in environmental science was difficult to determine, data gathered from interviews, artifacts, and observations of learning activities provided helpful information. Students showed evidence of using mobile learning technologies to capture firsthand scientific data and engage with the subject of Environmental Science beyond the requirements of the course. This kind of activity supports one of Mr. Kollar's stated goals of starting a lifelong appreciation and learning experience in that subject. Additionally, Mr. Kollar rearranged and adapted the course schedule and crafted learning activities around opportunities to create mobilized learning activities that took place outside the classroom.

Mobile Learning Technologies Support Lifelong Appreciation for Environmental Science

During a focus group interview, one student expressed the importance of environmental sciences and lifelong appreciation for Environmental Science. He said, "I know it's more like a life lesson class, because you can always use it at any point in life." Another student described how well the mobile technologies are integrated in the environmental sciences class compared to other classes. He said that other classes would often have some paper-based assignments and some electronically based assignments, but that environmental sciences assignments were always electronic-based.

The students at Eastbury High School are in an academically competitive environment. Many of their interests focus around earning good grades and getting as much college credit as possible so that they can get into the best colleges. Looking at the reasons why students take the environmental sciences class, the highest return was so that the students could boost their GPA. This is in agreement with what Mr. Kollar said was the main reason that students take his class. During focus group interviews, students did not tend to rank environmental sciences at the top of their class favorite list. Some said psychology, some said music, some talked about creative design classes, and some talked about health career classes, but none of the students in the focus groups identified environmental science as their favorite class.

Several students expressed how they liked Mr. Kollar as a teacher, and appreciated the opportunities he gave them to use mobile technologies to explore the subject through first-hand observation. One student commented, "It's just interesting to me, because environmental science is something I can use when I'm young and when I got older. I think it might help me in my job, but it can help me and a lot of other ways too."

Students expressed appreciation for how Mr. Kollar helps them connect the subject to their everyday lives. Enabled with mobile devices on an Adventure Learning project, Mr. Kollar is able to take students even more closely to the subject they are studying. One student said, "Things we learn and touch in environmental sciences, we can use every day." Another student said, “I like learning about what's, like, going on in the actual world around me." Students also talked about how passionate Mr. Kollar is about but he teaches and that he often has real-life stories that he can share related to the subject that he is teaching.

There is evidence that student interest in Environmental Science has increased as a result of taking this class, but there are a number of contributing factors, including Mr. Kollar’s approach to teaching and his passion about the subject. The relationship of mobile technologies and student interest was more difficult to determine. Prior to attending the Adventure Learning activities, students downloaded and began using mobile applications for tracking bird species. While traveling to the activities, they used the mobile applications to complete their assignments, whether it was logging observations about the environment in a specified application, or simply recording audio, video, or taking photos. After traveling to the activities, students were observed in the classroom accessing their collected information, but the degree of ongoing use of the applications could not be determined. There is evidence of potential lifelong appreciation for Environmental Science based on their comments about life choices and interests that are based on what they learned in Environmental Science. Tools that could potentially support ongoing interest are provided through mobile technologies, but a direct relationship between the mobile technologies and student interest in Environmental Science was not observed.

Adapting Course Structure to Leverage Mobile Learning Technologies

Mr. Kollar designed his classes to leverage mobile technologies in education, providing opportunities for students to access existing information while training them to build their own knowledge base. Though students expressed and displayed a great appreciation for Mr. Kollar as their teacher and they found environmental sciences less intense than some of their other classes in general, some of them preferred a more straightforward method of teaching. They did not always know what the course expectations were. Compared to the other classes, one student said, "I think environmental science is a slower paced class, definitely, but it's partly because of the material and partly because of the way it's taught. Sometimes, we are very confused about what were supposed to do...what's required." This might stem from the teacher's orientation to teach in a more constructivist approach, while students were more oriented to learning by textbook and lecture.

One of the focus group interviews took place on the bus while traveling to an Adventure Learning project. It should be noted that the students in this group volunteered to be part of the Adventure Learning project, so it was an interview among students who would rather spend a day using their hands for an environmental science project instead of attending other classes. One of these students described his appreciation for environmental sciences class because he could actually do this science with the resources that he had. These resources included his own knowledge, his ability to drive himself wherever he needed to go, and his iPad, which gave him access to existing knowledge in the Internet and the ability to collect his own information from the natural environment.

How did hands-on participation in mobilized Adventure Learning affect student interest in Environmental Science?

Based on responses to student surveys before and after participation in Adventure Learning projects, evidence suggests that student interest in Environmental Science either stayed the same or was slightly negatively impacted. Other factors, such as finishing the school year and approaching graduation, would need to be considered for their influence on student interest in any subject.

Continuing Formal Study of Environmental Science

In an interview, Mr. Kollar said that he knew of one of his 160 students indicated that she intended to major in environmental sciences when she attends college. The following chart shows how the students answered about majoring in environmental sciences before and after participating in the Adventure Learning projects related to environmental science.

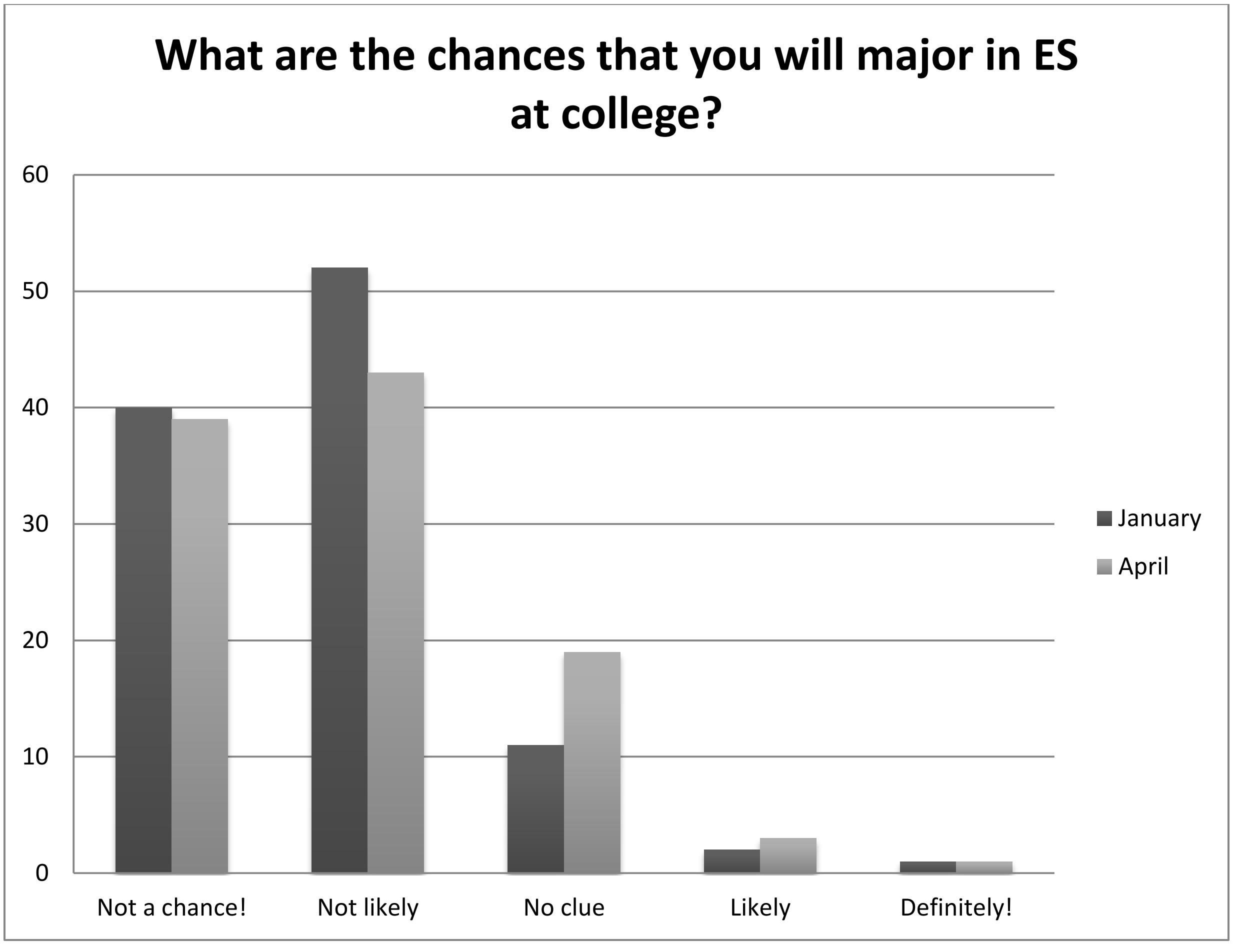


Figure 13: Chances that students will major in Environmental Science when they go to college

One of the survey questions asked, "What are the chances that you will major in Environmental Science at college?" Students were given five options ranging from "Not a chance!" to "Definitely!" In both January and April, most students answered "Not a chance!" or "Not Likely." In both surveys, one student answered "Definitely." In January, two students answered, "Likely," which changed to three students in April.

The low number of students planning to major in Environmental Science is not necessarily an indication that Mr. Kollar is not reaching his goals in developing a lifelong appreciation for the subject and changing decisions that impact the environment. One student said, "I don't think I'm going to major in anything that has anything to do with Environmental Science, because, I can just go outside and it's, like there. It's nature. I like learning it, because it's more relatable than other sciences." Another student said, "This class has helped me be more aware of a lot of things, and I think it's going to help me be more aware of my surroundings as I get older. It will help me, like, conserve and everything." Students also expressed an appreciation in the adventure-based learning model that Mr. Kollar has adapted for his classes. "It's something I can observe with my eyes. It's more interesting to me than just learning about what's inside something because I can go out and observe how it really works."

Issues that students are facing during their last semester of high school would be expected to play a large part in their interest levels in all subjects, especially as they are receiving notification of acceptance to universities and are changing their focus from high school to college. It is worth noting that according to the science motivation questionnaire (Glynn, 2009), students were more strongly inclined to favor environmental science for academic reasons rather than personal reasons.

Out of 160 students, one student expressed to the teacher a determined interest to major in environmental science in college. The same result showed up in the before and after survey of students regarding their plan for college.

Though not planning to major in environmental science, or any science at all for that matter, one student said, "I know I'm not going to do anything with science later on. Like, when I go to college and in my career I'm not going to do anything with science. So I might as well take a science class that I really enjoy." When asked what students enjoy about their environmental science class, they commented about the teacher's experience and passion that he is able to relate to topics that they are learning. They also talk about outdoor activities such as the Adventure Learning projects.

Some of the students talked about doing location aware exercises where they are using maps to log environmental science information that they find when they are in the field. When they used their mobile devices in the field, the primary investigator observed that they would use the iPad to capture pictures and take notes and log the information. Though some of the outdoor activities required more hands-on work than others, students generally started out working on their assignment before completely engaging in a hands-on project like planting trees.

Summary

This section addressed the two main research questions, which asked: How did the teacher leverage mobilized Adventure Learning to design learning activities? How did active participation in a mobilized Adventure Learning project affect student interest in the subject of Environmental Science?

The teacher drew from his own experience of learning from first-hand environmental observation to leverage mobile technologies in the creation of Adventure Learning activities. These provided opportunities for students to learn Environmental Science through hands-on activities in the natural environment. The teacher also adapted the course schedule so that topics could coincide with Adventure Learning activities. In addition to preparing learning activities, the teacher researched and tested mobile applications in order to choose the most useful and user-friendly software for student participation. Technology issues, such as battery capacity, connectivity, and portability hindered some of the teacher's original plans. Considering the limitations, Mr. Kollar found methods to work with what he had, and was overall positive about the experiences.

Identical surveys about student interest level in environmental science were administered to the students before and after the intervention. The survey was 21 questions long, and students could select from multiple answers. Out of the 21 questions, 15 were taken from the Science Motivation Questionnaire (Glynn, 2009). Student interest in Environmental Science had very little overall change, however a Chi-Square test revealed that student participation in the outdoor Adventure Learning activities was a significant factor in preference for hands-on learning compared to book and lecture learning. Since participation was not randomized, student choice must be factored in.

Chapter 5: Discussion

This section of the dissertation restates the research problem and reviews the major methods used in previous chapters. It also summarizes the results and discusses their implications. The first section provides an overview of the problem that is addressed in this study. This is followed by a summary of results that highlight the teacher's pedagogy, and challenges he faced with managing the Adventure Learning projects. A brief review of the benefits and constraints encountered using mobile learning technologies summarizes technology issues encountered by the subjects. This is followed by a summary of student responses to surveys and focus group discussions. The next section discusses interpretation of the findings, which relate to student interest in the subject of Environmental Science and student learning preferences. The final section provides recommendations for educators and researchers who intend to learn from or build on the findings.

Statement of the Problem

As described in previous chapters, the purpose of this study was to evaluate innovative teaching approaches guided by blending both Adventure Learning and Mobile Learning in the context of a high school Advanced Placement Environmental Sciences course. The research was designed to inform high school teachers, researchers, and administrators of challenges as well as benefits they might encounter while implementing ubiquitous mobile technologies combined with student-centered pedagogies in the classroom. For research purposes, names of people or places were replaced with pseudonyms.

Eastbury High School is described as an academically competitive school, with a combination of 11th and 12th graders taking AP Environmental Science. With a high rate of acceptance into higher education, students nearing graduation are focused on the next steps in their academic careers. At the time of this study, the school had already issued iPads to all students from 9th to 12th grade, and teachers were encouraged to implement mobile technologies in the classrooms. Much of the required readings were distributed through eBooks, followed by the initiation of a mobile-friendly learning management system. Different levels of mobile technology implementation were reported, with some teachers using tablets the same way they used laptops, while other teachers attempted using the tablets in ways that made further use of ubiquitous access to learning technologies, such as a tool for gathering first-hand information.

Justin Kollar, the AP Environmental Sciences teacher, is described as an innovative teacher with a hands-on approach to learning. In other words, his focus is to instill a lifelong appreciation for the subject by enabling students to practice in an authentic environment. According to both Mr. Kollar and student responses on surveys, students are primarily interested in Mr. Kollar's class to earn a high grade in the course, and to prepare for AP credit through taking the standardized test. As a teacher, Mr. Kollar wanted students to learn by doing Environmental Science in the environment. They could then collaborate with students back in the classroom by sharing their captured information in real time and by sharing larger files when they returned to the school.

As described in Chapter 2, Adventure Learning (AL) is described as an online and hybrid approach to education that provides students with authentic experiences through the use of collaborative learning environments (Doering, Veletsianos, & Scharber, 2007). With AL research focusing on Social Sciences or Science, Technology, Engineering and Math (STEM) curriculum, the earliest and largest of the studies involved a funded and professional expedition teams that traveled to remote parts of the earth and communicated in real time with students who were in their classrooms. Since the launch of AL mainly focused on major productions with outside funding, one of the knowledge gaps was low budget local integration, with students acting as the expeditionary team. Miller (2010) implemented an AL research project where students participated as the expeditionary team. His work demonstrated that students could collaborate in learning both as expeditionary and classroom-based team members.

Several recent mobile learning case studies document student use of mobile devices to gather information (Evagorou et al., 2008; Wallace, 2009; Bannan et al., 2010; Looi et al., 2009). The research for this dissertation is a case study built on the idea of students participating as the expeditionary team in an AL project, but added elements of mobile technology, as students used their tablets to gather first-hand environmental science information to share with their classmates back at the school in real time.

Review of Methodology

The research questions for this dissertation are designed to help address some of the knowledge gaps described in the educational setting and review of literature investigating the processes involved for the teacher and the responses by the students when implementing and participating in a mobilized Adventure Learning project. The research questions and sub-questions for this study are as follows:

1. How did a teacher leverage mobilized Adventure Learning to design learning activities?
    a) What challenges did the teacher face when implementing the designed learning activities?
    b) What did the teacher think was the role of the mobile device for mobilized Adventure Learning?
    c) What was the teacher's understanding of Adventure Learning and its role in the educational process?

2. How did active participation in a mobilized Adventure Learning project affect student interest in the subject of Environmental Science?
    a) How did the mobile device support learning Environmental Science?
    b) What was the relationship between the use of mobile technologies and student interest in Environmental Science?
    c) How did hands-on participation in mobilized Adventure Learning affect student interest in Environmental Science?

The participants in this study included the Environmental Science teacher and 160 students who elected to take the AP Environmental Science class during the 2012 to 2013 school year. Completed and returned forms of consent/assent narrowed the student group to 104. The PI approached this study as a qualitatively driven mixed methods approach as described by Johnson, Onwuegbuzie, & Turner (2007). The PI employed qualitative methods through interviews, learning activity observations, artifacts and technologies. He used quantitative methods to analyze statistical information based on student responses to pre- and post-treatment opinion surveys. Though the PI avoided manipulating the environment while collecting data, some degree of influence could not be ruled out, as there were pre and post intervention surveys, interview and focus group discussions, and direct observation of classroom and learning activities.

Data were gathered through interviews with the teacher, interviews with focus groups of students, classroom observations, learning activity observations, subject interest surveys, and artifacts, such as curriculum, learning activity plans, and technologies used including hardware and mobile applications.

Transcriptions of interview and focus group content were de-identified and coded by the primary investigator. See Appendices C, D, E, and F to reference focus group and teacher interview questions. Sections of the transcriptions were made available to three peer reviewers to provide a comparison of coding, resulting in some changes and additional code categories. See Appendix G for final code scheme.

The student interest surveys were given pre and post AL project intervention, and were partially based on topics related to student interest in the subject, and partially on the Science Motivation Questionnaire (Glynn, 2009). See Appendix B for the survey questions. The teacher administered the same survey to students once before the AL activities began and once after they were concluded.

The researcher used the Constant Comparative method (Glasser, 1965; Glasser & Strauss, 1967; Charmaz, 2006) for analyzing the data gathered through interviews with teachers and students, review of artifacts, and observation of learning activities. Survey data were de-identified, and responses before and after the intervention were compared. The researcher used ANOVA and Chi-Square tests to provide measurement on any trends or correlations of student interest in Environmental Science as it relates to the student experience with Adventure Learning supported by mobile technologies.

Summary of Results

This section summarizes the results of the study, highlighting the Pedagogy, Adventure Management, Benefits and Challenges to Mobile Learning, and Student Responses. Refer to Chapter 4 to read the full report of the results. Additional survey information is available in Appendices G, H, I, J, K, and L.

Pedagogy

Interviews with Mr. Kollar revealed a very rich background in hands-on practice and learning of Environmental Science. During his formative years and professional life, Mr. Kollar has been a practitioner of Environmental Sciences, and this has carried over to his Constructivist pedagogy as a teacher. His goals for the students include academic success, but are also aimed at building a foundation for lifelong learning and lifelong practices that support environmental sustainability. Even without the latest technologies, Mr. Kollar would prefer to have the students out in the environment practicing as student scientists. He observes that mobile technologies help create new opportunities for learning outside the classroom by providing a framework for communication between teacher and students, and for collaboration between students. Ubiquitous access to cloud technologies also allows students to contribute to scientific knowledge as they gather it in a hands-on setting. Integration of Environmental Science with other subjects was also within his plan, but coordination with teachers of other subjects was only in planning stages at the time of the research. Since he did adjust the lesson plans so that the learning projects could leverage the available technologies, Mr. Kollar could be considered a "techno-pedagogical designer" according to Mor & Craft (2012).

Mr. Kollar found that the elements of Adventure Learning fit naturally into outdoor Environmental Science learning projects, as they emphasize use of technology, inquiry-based learning, collaboration, and learning with a sense of adventure.

Adventure Management

From classroom and learning activity observation, it appeared that managing 30 hands-on mobile learners was a challenge for one teacher. Technology glitches, safety issues, and the physical distance between groups of students highlighted the need for additional staff or volunteers during the Adventure Learning activities involving this number of students. Additionally, Mr. Kollar had to play several roles during the trips, including teacher, subject matter expert, logistics coordinator, technology specialist, and nurse. Though his plan was for all students to travel to the activities at some point during the school year, the all-day events needed to be optional to allow for student schedules. As it turned out, about one-third of the students traveled to one or more of the Adventure Learning activities.

Mobile Learning Benefits and Challenges

Students talked about their appreciation for tablet technology, largely for organization and convenience. They are able to have their alarm clock, calendar, notebook, file cabinet, and several textbooks in one device. Everything is always in one place, and they enjoy carrying fewer materials to, from, and around school. They did point out issues that were frustrating, such as software bugs, limitations of typing on a virtual keyboard, off-task distractions, and battery or storage limitations. The largest point of frustration for students was the single point of failure that can occur when so many schoolwork tasks center around one device. If that device fails, they cannot function. In former days, students could borrow a pencil, get an extra textbook from the shelf, or ask for a sheet of paper to take notes. If their iPad freezes or the battery runs out, borrowing someone else's iPad is not a viable solution.

During classroom observations, students tended to use tablets the same way they use laptops for tasks like taking notes, going to web sites, and transferring assignments. Several off-task activities were observed when students were given time to work on activities. Some students worked on the assignments, some were playing games, social networking, or shopping. Some were studying notes for another class.

For the Adventure Learning trips, Mr. Kollar assigned a number of first-hand information gathering activities with the iPad including photography, geolocation, field observations, and FaceTime communication with their peers. Early mobile learning research (Trifonova & Ronchetti, 2003; Evagorou, Avraamidou, & Vrasidas, 2008), determined that mobile technologies went beyond making use of existing educational technologies more convenient because of ubiquitous access to information. Mobile learning opened new frontiers for education through the ability of mobile devices to work as a first-hand information-gathering tool. In the research for this study, students were observed using tablets to capture images, video, sound recordings, time, temperature, and geolocation. They also input text through a virtual keyboard. If students had been using earlier technologies such as a laptop, most of these tasks would require additional tools, such as a camera, audio recorder, dedicated GPS, and other devices. They commented about the convenience of using mobile technologies, but also demonstrated the benefits of using the mobile devices to capture first-hand information that would be shared with other learners.

During the trips, limitations of the mobile technologies used became more apparent compared to their use in the classroom. Though students had battery and software issues while at the school, working from outside the proximity of power outlets and school Wi-Fi limited use of the devices even more. In some cases, students could connect to the Internet through their personal cellphone hotspot. Mr. Kollar also allowed several students to connect through his cellphone hotspot, and he planned to work with cellular providers to carry dedicated hotspots for future classes, so that everyone could connect.

Student Responses

Two identical surveys about student interest level in environmental science were administered to the students before and after the intervention. One survey took place at the beginning of the semester in January, and the other survey took place later in the semester during April. The first survey was administered before any of the three outdoor Adventure Learning projects took place, and the second survey took place after all of the Adventure Learning projects were completed. Among the 160 students in Mr. Kollar's class, 156 students took the surveys. Among the 156 students who took the survey, the primary investigator could only use results from 104 students who provided consent/assent forms and whose names matched in both surveys. The results of the surveys can be found in Appendix K for Frequency Distribution, and in Appendix L for Survey Questions by Means and Standard Deviations. The results are categorized by whether or not students traveled on Adventure Learning projects.

With a few exceptions, students tended toward a lower rate of interest in Environmental Science over time. The largest drop in interest was the agreement with the statement: "I prefer course material that arouses my curiosity, even if it is difficult to learn." With a 3.0 being neutral, the overall mean in January was 3.778 and in April was 3.63. Although most of the survey questions did not reveal a statistically significant change, a Two-Way ANOVA for this item revealed a significant difference (0.049) between students who traveled and students who did not travel. The students who traveled dropped from a mean of 3.93 to 3.62 and students who did not travel stayed almost the same at 3.66 and 3.65. Though still positive overall, the factor of travel played a significant role in changes over time regarding student interest in course materials that arouse their curiosity, even if it is difficult to learn. During focus group interviews, some students expressed some frustration over assignments that were not always clearly outlined in a course schedule or syllabus. Some students were “surprised” when given a writing assignment while on the ride home from an Adventure Learning trip. Toward the beginning or middle of the school year, challenges in learning assignments might be easier for students to handle. The more compressed timeline toward the end of the school year, coupled with traveling for learning activities, could have contributed to the students who traveled to show less interest in challenging academic exercises.

Responding to the statement, “Earning a good Environmental Science grade is important to me,” students who did not travel to any Adventure Learning projects showed a slight increase (0.06) while students who traveled showed a decrease (-0.18). Though not statistically significant, the divergence between students who traveled and those who did not is worth noting. It is possible that the sacrifices of time and extra work involved with traveling to Adventure Learning projects, while other students are able to earn course grades by staying at the school, may, as noted previously, have led to a drop in interest.

One of the questions developed by the primary investigator asked about student preference or learning style. It asked about learning preferences and gave two options:

Which way do you prefer to learn?

- Give me the information and answers I need through a lecture or book.
- Point me to an environment where I have to explore and find my own answers.

To divide students based on either of these choices, the primary investigator labeled the two groups Book Learners (B), and Hands-On learners (H). Both January and April surveys revealed that the 104 students in this sample group prefer book and lecture learning over exploration learning at nearly a 2:1 ratio.

Learning Preference	January	April
Book Learner	72	69
Hands-On Learner	32	35

Table 8: Learning Preferences

Through answers to interview questions and information gathered from classroom observations, Mr. Kollar's preference for teaching is based on more of a Constructivist approach, pointing students toward an environment where they can learn and enabling them to capture and create their own knowledge. He describes his interests as long term, and focuses on developing an appreciation for the subject and laying a foundation for lifelong learning in the subject. His preference for teaching contrasts to the students' learning preferences, possibly because of where they are in their academic careers—nearing the end of high school and transitioning into college.

It appeared, at first, that the learning preferences stayed nearly the same from January to April, with three converts moving from book learning to hands-on learning. This resulted with an increase in hands-on learners from 32 in January to 35 in April. A deeper investigation revealed that the groups were very mixed. Some students preferred book learning during the first survey, and hands-on learning during the second. Some went in the other direction, and some stayed with either book or hands-on learning preferences for both surveys. A Chi-Square test compared changes in student preferences for learning style with whether or not they traveled. Results showed significance in learning preference toward hands-on among students who traveled to Adventure Learning projects compared to those who did not travel (See Figure 4, p. 142).

Between January and April, 40 of Mr. Kollar's students traveled to the Adventure Learning projects. Students who transitioned from Hands-On to Book (HB) had the lowest percentage of travel at 17%, followed by students who preferred book learning in both January and April (BB), who traveled at 35%. Students who changed preferences from book to hands-on (BH) were slightly above class average for travel at 47%. Students who had the highest travel ratio were those who chose Hands-On in both January and April (HH) at 67%. The Chi-Square test supports depth in the relationship between travel and learning preference. Travel reinforced the hands-on preference by reducing the proportion of students who remained with a book learning preference.

During both surveys, the larger portion of student responses to learning preferences favored book and lecture over hands-on. This learning preference would support more book and lecture teaching, but would not prevent hands-on learning specifically or mobile learning in a broader sense. Previous research (Sharples, 2007), described an approach to teaching with mobile technologies that highlighted the relationship between Behaviorist pedagogy and the instant feedback available through mobile learning technologies. The smaller portion of student responses showed a preference for hands-on learning, which is also favored by the teacher, and described by

Naismith et al. (2004), and Zurita & Nussbaum (2004). These studies emphasized discovery of knowledge and collaboration as supported by mobile technologies.

Interpretation of the Findings

On the basis of this study alone, it is not possible to determine a cause and effect relationship between learning activities and student interest in a particular subject. As a descriptive case study, some trends are worth analyzing and merit further research.

Learning Preferences

Issues related to pedagogy cannot be underestimated in this research. Earlier studies of mobile learning identified learning tasks that could be supported by Behaviorist learning theories (Naismith, Lonsdale, Vavoula & Sharples, 2004). These observations were based on interactions with mobile learning courseware that provided feedback depending on user input. Immediate and informative feedback provided reinforcement of knowledge.

Mr. Kollar's approach was more Constructivist with an emphasis on collaboration, providing tools to students for gathering information and collaborating to develop their own knowledge base. On the bird-watching trip, as an example, he provided two mobile applications, and trained the students how to use them. One application helped students identify bird species, and the other application enabled students to log any sightings or evidence of birds. Students had to work in groups to complete their assignments, so collaboration was a requirement.

Inquiry-Based Learning and Collaborative Learning are among the seven elements of Adventure Learning. Zurita & Nussbaum (2004) suggested that mobile learning also supports Constructivist educational activities that emphasize collaboration among learning groups. Another study includes students developing their own scientific knowledge using mobile devices to gather and represent scientific ideas Evagorou, Avraamidou, & Vrasidas (2008).

Instructors who can adapt to multiple modes of learning possibilities are able to enhance the learning process using ubiquitous mobile technologies. In order to move learning outside of the classroom, Mr. Kollar had to determine how students would learn while in the field. Their knowledge came from some information they read before going, information stored on their devices, information they found, and information shared by their classmates. An earlier study of mobile learning technologies described how gathering information by audio and photographs enabled students to make more observations because they were not spending as much time writing their descriptions Lai et al. (2007). These findings are in line with those identified by Looi et al. (2009) who also found that student improvisation and creation of knowledge artifacts is supported by mobile learning.

Student Interest in the Subject

During the focus groups and classroom observations, students indicated or demonstrated a positive attitude and general interest in Environmental Sciences. Using the Science Motivation Questionnaire (Glynn, 2009), students responded with an overall slightly positive interest level both before and after participating in mobilized

Adventure Learning projects. On a scale of 1 to 5, with a 3 being neutral, student interest in Environmental Science for personal interest questions had a mean of 3.20 in January and a mean of 3.15 in April. Questions based on academic interest in environmental science, students had a mean of 3.58 in January and a mean of 3.57 in April.

The largest drop in student interest was in response to "I prefer course material that arouses my curiosity, even if it is difficult to learn," which went from 3.77 to 3.63, a drop of 0.14. It should be noted that responses remained above average (3.63) in terms of student interest. A Two-Way ANOVA for this item revealed a significant difference (0.049) between students who traveled and students who did not travel. The students who traveled dropped from a mean of 3.93 to 3.62 and students who did not travel stayed almost the same at 3.66 and 3.65.

Earlier research pointed to an increase in student interest in a subject when they were able to practice it while supported by mobile technologies. Savill-Smith (2005) observed that students had a tendency toward a higher motivation, improved organizational skills, and an increased sense of responsibility. Other studies showed an increase in motivation when students felt like they were contributing to a knowledge base in a valuable manner (Zurita & Nussbaum, 2004). When students were able to connect their mobile learning activities to something that impacted their daily lives, their interest and participating in the subject increased as a result (Wallace, 2009). Another study by El-Bishouty, Ogata, Ayala & Yano (2010) indicated that self-directed learners who participate in gathering first-hand scientific data have a higher level of subject matter interest compared to those who learn from classroom lectures or textbooks. Since earlier findings seem different from findings in the current research, it would be helpful to look into influences for student learning preferences.

Future research could investigate why students who traveled lost interest in assignments that may be more difficult. For now, we could ask whether the Adventure Learning projects required more work than the students expected. Was it because the assignments associated with traveling on the projects were actually more difficult? Or could it be that they were more difficult than anticipated? Looking into students' expectations about the difficulty level of a "field trip" merits research. They might have expectations of a free day for travel and social activity, when it turned out to be a lot of work before, during, and after. It would also be helpful to learn how much of an influence transitioning through high school graduation into entering a university would influence how much effort students are willing to invest in high school learning activities.

This idea is also supported by the two survey questions with the highest before and after responses, both of which are related to earning a good grade, and the influence the class would have on their overall grade point average. In another part of the survey, students were asked to select among four options why they took Environmental Sciences, the most chosen answer before and after the intervention was "I heard this class was an easy way to boost my GPA." The least selected answer before and after was "I am interested in Environmental Sciences." From the start of this study, interest in the subject was not highly ranked by the students.

Relation of Participation and Interest

In addition to helping student preform well on the standardized test, and creating a lifelong learning approach and appreciation for Environmental Sciences, Mr. Kollar expressed an interest in helping students modify their behavior in a way that would be more beneficial to the natural environment.

Among the personal interest questions, the strongest overall increase was responding to "Learning Environmental Science is relevant to my life." Although not statistically significant, it is interesting to note that students who did not travel showed a 0.05 decrease in their mean, while students who traveled showed an increase from a mean of 3.31 in January to a mean of 3.43 in April. Though this study did not separate out factors such as student choice in participating in the Adventure Learning projects, their participation in traveling correlates to a shift in how they intend to implement what they have learned into their life choices. This is similar to a study by Bannan, Peters & Martinez (2010), which showed that students who participated in the intervention also demonstrated evidence of a shift in learning practices based on what they observed first hand using mobile technologies as devices for gathering information.

Recommendations for Educators

While no single case study can provide a sound basis for the designing and practicing mobilized Adventure Learning projects, this study would suggest highlighting the importance of the relationship between a Constructivist approach to teaching and developing a life-long appreciation for a subject by participating in hands-on projects. Educators should also pay close attention to logistical issues when education takes place outside of the classroom, and allow for flexibility in designing learning activities.

Participation of Students

Students tended to be more engaged, interested, and motivated when they participated by traveling to the mobilized Adventure Learning projects. In an ideal world, all of the students could participate and enjoy the same benefit. In the real world of final semester of students' final year of high school, it was not possible to insist that all of the students take one or more days away from regular school activities to participate. With students at this level in their careers, it might be helpful to have more frequent, but shorter, options from which students could select to participate. This could allow students to miss only one class period while participating in a learning project instead of missing a whole day of classes.

Logistical Issues

While investing in ever-improving technologies will help to overcome some of the logistical issues, such as connectivity and software issues, some logistical issues will need to be addressed directly. The main affordances of mobile learning have to do with ubiquity, based on the small size of the device. A tablet has functionality partway between a laptop and a cell phone, containing some of the best and worst features of each device. Tablet computers are easy to carry and quick starting. They function well for taking pictures, videos, or recording sounds. They also have a fairly large screen. But, they share some of the same constraints as a cell phone, such as battery life issues, are not ideal for text input (Churchill, 2008; Ryu & Parsons, 2009). Tablets are large enough that they cannot be carried or used like a cell phone, so the trade off must be a consideration.

Aside from technology, other logistical issues include the planning and resources needed to create and carry out a mobilized Adventure Learning project. With the teacher acting as teacher, subject matter expert, logistics coordinator, technology specialist, and nurse, an emergency in one of these roles prevented him from maintaining the others. Since Adventure Learning started as a larger event with a professional expeditionary team, it would be advisable to staff the activities with experts, organizers, and volunteers who can help a dispersed group of students to remain safe and remain on task.

A teacher must first consider whether the learning activity may lend itself to mobilized Adventure Learning. Environmental Sciences is a subject that can be learned and practiced outside the classroom, but it had its challenges. Language learning could be another subject, given a community that uses the language is within proximity. Could this approach to learning be used for any subject?

Use of Adventure Learning in Other Courses

Environmental Science is a subject that is conducive to outdoor activities, but how would a U.S. History teacher create and conduct mobilized Adventure Learning projects? Perhaps students could research historical sites as preparation for trips to those locations. With mobile-supported Adventure Learning, they could construct their own brochures and become their own tour guides. They could use global positioning to reenact travels of historic figures. Second language learners could use mobile devices to gather first-hand information from native speakers of the languages they are studying, and bring the language back to the classroom.

With extra planning and project management, several subjects could leverage mobile technologies into a collaborative Meta Adventure Learning project. Combined courses would contribute toward a common project, such as a goal of moving their community toward better awareness and management of water supply. History, Geography, Environmental Science, other sciences, Math, Economics, Civics, Writing, Media, and other subjects could combine their efforts toward a larger project while creating opportunities for hands-on application of all of these and other subjects.

Flexibility in Designing Learning Activities

The teacher in this study had a wide range of options for tailoring learning activities to fit into the Adventure Learning model. He used the class textbook which student could access from their iPads as an eBook. Students were also given pre-trip assignments by doing web searches on related topics and making a presentation to the class using their iPads. He was also able to provide mobile applications that helped students complete learning tasks while in the field in addition to built-in applications such as FaceTime and presentation tools. The teacher was able to implement these tools, but also designed learning activities based on the schedule and the type of activities in which students would participate. A similar study in Sri Lanka, Ekanayake (2011) observed that teachers developed a wide range of approaches to lesson planning, implementation, and methods of evaluating instruction. Norris & Soloway (2008) recommended allowing teachers the freedom to develop instruction for learning outside of the classroom supported by mobile technologies. Research by Zhang, Looi, Seow, Chia, Wong & Chen (2010) recommended the following order for instructional design and evaluation: Deconstructing, Brainstorming, Composing, Reconstructing, Implementing, and Evaluating.

Suggestions for Future Research

Additional research would be helpful to flesh out deeper information in some areas of this study. There are also some new questions that are raised and could be pursued from a different direction.

Drop in Curiosity When Assignments are Challenging

The largest drop among students between the January and April surveys was in response to "I prefer course material that arouses my curiosity, even if it is difficult to learn." As stated earlier, the major drop for this question was among students who traveled to the learning projects. Since prior research pointed to an increase in student interest (Savill-Smith, 2005) and motivation (Zurita & Nussbaum, 2004) in a subject when they were able to practice it while supported by mobile technologies, it would be helpful to further research the causes of decline in interest among students who traveled to mobilized Adventure Learning projects in the current study.

Learning Preferences

The Chi-Square indicated a significant relationship between traveling and learning preferences, but it would be helpful to interview students based on their preferences to determine whether other factors were involved in their choices before and after. Future research could also observe an environment where all of the students in the class participate by traveling to the learning activities. This could help clarify the relationship between the activities and student interest in the subject.

Expand the Student Survey

In this study, students answered 21 questions with 15 of the questions used from the Science Motivation Questionnaire (Glynn, 2009), and 6 questions developed by the primary investigator. Since travel status was a contributing factor in some of the statistical analysis, it would be helpful to ask a few more questions in the survey to determine what influences students in their decision to travel. Some students might have academic or extracurricular activities that would not allow for taking an entire day trip for one subject. Asking questions about what factors in to student decisions to travel or not presumes that future travel to learning activities is optional and not required. In the latter case, questions about decision factors would be irrelevant.

Longitudinal Studies

Future research could examine the same variables with the same teacher and course over time to determine whether there are variations between school years. Working with the same teacher teaching the same class with a different group of students over time would provide opportunities to explore some of the same issues through similar methods, including student focus groups, classroom and learning activity observations, and surveys before and after the intervention. Investigation could compare results year after year, and take a more in depth look at issues that were generated during earlier research. For instance, follow up studies would allow students to elaborate on why they changed or stayed the same in their learning preferences. A different set of students might respond differently, however, other factors, such as weather, could influence the outcomes.

Other Subjects and Places

Creating similar research questions, surveys, interviews, observations, and focus groups would be helpful for other teachers within the same school that are implementing mobile technologies and intending to create a sense of adventure in learning. Mr. Kollar reported that the interview questions made him think more intentionally about the instructional purposes of Adventure Learning activities, and other teachers could benefit in a similar way. Future research could benefit from investigating different instructors, different subjects, and different in students.

Conclusion

With the rapid growth of secondary students with their own personal device, as well as the growing number of schools with one-to-one initiatives, it is clear that there are unprecedented opportunities for students to use these digital devices for learning activities outside of the classroom. Continued research is needed to better understand the most effective ways to use the devices for this new set of purposes and how the power of this new generation of digital devices can be harnessed to improve student engagement and learning.

It is hoped that this study not only has provided some preliminary insights, raised important questions and also offered some suggestions for future studies that may contribute to our knowledge of how better to integrate these devices into more authentic, out-of-classroom learning processes.

Appendices

Appendix A – Research Matrix

RQ #1	Data Sources	Specific data to answer this question	Analysis Required	What will this allow me to say?
How did a teacher leverage mobilized Adventure Learning to design learning activities?	Interviews with teacher (Appendix D) Learning activity plans Observations of teaching and learning activities	Teacher's: Philosophy of teaching Understanding of AL Understanding of ML Changes in plans for learning activities with use of mobilized AL How the design appears in teaching (Map observation data to AL principles and ML affordances)	Qualitative - Constant Comparative Frequencies of AL or ML activities vs. traditional lecture or textbook content Methods of integrating the AL project and ML practices and technologies for teaching	Teacher's appreciation for technology in education, Environmental Sciences, and constructivist learning supports leveraging mobilized AL to design learning activities With intro of mobilized AL, teacher uses more hands-on activities and mobile devices as info gathering tools for both AL and non-AL activities
What challenges did the teacher face when implementing the designed learning activities?	Interviews with teacher Observations of teaching and learning activities	Legacy technology expectations and teaching habits Observed roadblocks or frustrations with new technology and legacy teaching paradigms	Qualitative – constant comparative Frequencies, coding, and grouping of challenges Methods of planned and unplanned solutions for challenges	- Challenges for the teacher. - He implemented solutions for A and B, but had to accept C as an obstacle. - He used solution X as a work-around. - He slipped back into old methods for delivering Y to the students - He was frustrated with connectivity while off campus, but compensated by relying on native applications.
What did the teacher think was the role of the mobile device for mobilized Adventure Learning?	Interviews with teacher Observations of teaching and learning activities	Teacher description of functions required for mobile device as part of the educational process. Observed frequencies of teacher leveraging ML affordances for learning activities.	Qualitative – constant comparative Triangulate teacher's stated ideas for role of ML with implementation frequencies of leveraging ML affordances	During the 3 months of planning and carry out of the intervention, the teacher added X, Y, and Z mobile learning practices Teacher affirms B as a role of mobile device, but uses the ipad for B in the same way that he uses X. The ipad serves purpose C, D, and E as described by the teacher.
What was the teacher's understanding of AL and its role in the educational process?	Interviews with teacher Observations of teaching and learning activities	How the teacher's practices and ideas line up with principles of AL Observed use of AL principles in design and implementation of learning activities.	Qualitative – constant comparative Triangulate Principles of AL with teacher's stated ideas for role of AL and implementation frequencies of AL practices	Teacher understands AL to cover X, Y, and Z, but was only able to implement X and Y. However, he came up with Q, which may be considered part of AL in the future. He also did not use U and V of AL.
RQ #2	**Data Sources**	**Specific data to answer this question**	**Analysis Required**	**What will this allow me to say?**

How did active participation in a mobilized Adventure Learning project affect student interest in the subject of Environmental Science?	Student focus groups (Appendix C) Opinion Survey (Appendix B)	Whether students interest levels toward Environmental Sciences change after involvement in a mobilized AL project	Qualitative – constant comparative Compare interest levels of pre- and post-mobilized AL project.	Students describe a greater interest in Environmental Sciences when they participate in a mobilized AL project, and 3 are considering it as a college major as a result of the project. Surveys reported a 10% increased interest in the subject of Environmental Sciences when students participated in a mobilized AL project
How did the mobile device support learning Environmental Science?	Student focus groups Before, during, and after learning activity observations	Student feedback on how the mobile device supports the learning experience Frequency that students leverage ML affordances for learning activities.	Qualitative – constant comparative Track increase or decrease in students' usage of iPad for ML affordances during learning activities	Students described how their usage of the tablet changed as a result of the project Students said that using the ipad allowed them to do XYZ. Students increased using mobile device for ML affordances in the classroom by 20%, such as: On average, students increased from 3 to 8 first-hand gathered items
What was the relationship between the use of mobile technologies and student interest in Environmental Science?	Student focus groups Learning Activity observations	Student descriptions of using mobile technologies in a learning project How often, and for what reasons, do students encounter technology problems?	Qualitative – constant comparative Frequencies, coding, and grouping for technology-related problems	Students reported frustrations with connectivity while in the field, and recommended an app that can be used offline. Two major show-stopping issues: connectivity (90%) and too many apps to learn (60%) should be addressed before next project
How did participating in a mobilized AL project affect student interest in Environmental Sciences?	Pre and Post Opinion Surveys Student focus groups Learning Activity observations	Difference in student interest levels based on pre and post project surveys Student descriptions of how AL influences their interest in ES. Frequency of learning activities that enabled students to participate in the seven principles of AL	Compare interest levels of pre- and post-mobilized AL project. Frequencies, coding, and grouping participation in AL principles related to student interest levels	Pre and post surveys reported a 10% increase of interest in the subject after participating in an AL project. Students would like all of their science topics to be taught through AL projects. Students described new ways they learned through AL: such as participating in science research instead of learning through text and lecture

Appendix B – Subject Interest Questionnaire

Subject Interest Questionnaire

(Administered both Pre and Post Intervention)
This survey is based on the Science Motivation Questionnaire (Glynn, 2009) and the MSLQ (Pintrich, 1991).
The survey is divided into three factors, two of which are used in this study:

- Factor 1: Personal Goal Interest (1, 2, 7, 8, 9, 12, 14, 15)
- Factor 2: Academic and Career Interest (3, 4, 6, 11, 13)

Please respond to each of the following statements with your opinions. Options: Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree.

1. I enjoy learning Environmental Science.
2. Learning Environmental Science relates to my personal goals.
3. Earning a good Environmental Science grade is important to me.
4. I think that learning Environmental Science can help me get a good job.
5. I prefer course material that arouses my curiosity, even if it is difficult to learn. (MLSQ)
6. I think about how my Environmental Science grade will affect my overall grade point average.
7. Learning Environmental Science content is more important to me than the grade I receive.
8. I expect to use the Environmental Science I learn.
9. I find learning Environmental Science interesting.
10. Learning Environmental Science is relevant to my life.
11. I think I will be able to use what I learn in Environmental Science in other courses.
12. Learning Environmental Science has practical value for me.
13. I expect to do as well as or better than other students in the Environmental Science course.
14. I like Environmental Science assignments that challenge me.
15. Understanding Environmental Science gives me a sense of accomplishment.

Additional Questions for Student Surveys
(Administered both Pre and Post Intervention)

- Why did you take the Environmental Sciences AP class? (You may select more than one answer.)
  a) I am interested in Environmental Sciences
  b) The other course options at my school did not interest me
  c) I need the class to fulfill a requirement
  d) I heard this class was an easy way to boost my GPA
  e) Other ____
- What kind of a grade do you expect to earn?
  a) 70-74%
  b) 75-79%
  c) 80-84%
  d) 85-89%
  e) 90-94%
  f) 95-100%
- Compared to my other classes, I expect earning a good grade in Environmental Sciences to be...
  a) Very easy
  b) Easy
  c) About the same
  d) Difficult
  e) Very difficult
- Do you plan to take the standardized test for college credit in Environmental Sciences?
  a) Yes
  b) No
  c) Not Decided
- What are the chances that you will major in Environmental Sciences when you get to college?
  a) Not a chance!
  b) Not likely
  c) No clue
  d) Likely
  e) Definitely!
- Which way do you prefer to learn?
  a) Give me the information and answers I need through a lecture or a book
  b) Point me to an environment where I have to explore and find my own answers

Appendix C – Questions for Student Focus Groups

Student Interest

- What are some things that interest you about school?
- What are some of your most interesting classes?
- Among all of your subjects, where would you rank Environmental Science in terms of subject interest?

Mobile Technologies Questions

- How do you use your iPad in school?
- What do you like the most about using your iPad?
- In what ways was the iPad helpful in your _____________ (lesson/adventure name)
- During your Adventure Learning project, what activities might you miss if you didn't have the iPad?
- Was there anything special about using the iPad versus other devices?
- What technology problems did you encounter during the AL project? (Post Only)

Appendix D – Teacher Interview 1

Teacher Interview 1: Before the Intervention

General Questions:

- When you were in high school, what activities contributed to your interest in the environment?
- How did you become interested in Environmental Sciences as a profession?
- Describe your involvement in education before becoming a HS teacher.
- What motivated you to become a HS teacher?

Adventure Learning Questions:

- What do you expect Adventure Learning to bring to your class?
- How will incorporating Adventure Learning change the way you prepare lessons?

Adventure Learning Questions based on the 7-Principles of AL

1. (Inquiry) How will you plan for students to "discover" their own knowledge during an Adventure Learning project?
2. (Collaboration) Describe some ways that you think students are will learn from each other.
3. (Technology-based learning environment) How do you see technology contributing to the AL project when students are inside or outside the classroom?
4. (Curriculum enhanced by media) How will students access information supporting their AL project before they get started? (Web pages, documents, videos, online conferences?)
5. (Synchronized learning opportunities) How do you anticipate that students will access the same learning materials across all six of your ES classes?
6. (Planned curriculum leveraging technology) How will you guide students to ensure their safety and that they access quality information?
7. (Adventure-based education) What parts of the AL projects do you think students will consider an "adventure"?

Mobile Learning Questions

- How do you expect students to leverage mobile technologies in the learning activities?

- How will access to mobile technologies change the way you plan lessons?

Appendix E – Teacher Interview 2

Teacher Interview 2: During the Intervention

Adventure Learning

- What are some of the Adventure Learning principles that you are finding easy to implement in the class project?
- What principles of Adventure Learning are you finding get left behind or are difficult to implement in the class project?

Mobile Technologies

- What are some unexpected ways mobile technologies are working for your class?
- What are some ways you expected mobile technologies to help but they did not?

Appendix F – Teacher Interview 3

Teacher Interview 3: After the Intervention

General Questions:

- As a teacher, how would you determine whether a student is interested in Environmental Sciences?
- How might an AL intervention support student interest in the subject?
- In the future, how will your lesson planning change based on your experience with AL?
- For your class, what has changed as a result of Adventure Learning?
- How did students leverage mobile technologies in the learning activities?
- What are some of the challenges you have had with mobile learning?

Appendix G – Code Scheme

Coding Scheme Major Categories	Codes
Elements of Adventure Learning	
	Adapt to AL project
	AL - Adventure Based Learning
	AL - Collaborative Learning
	AL - Curriculum Enhanced by Media
	AL - Inquiry-Based Learning
	AL - Planned Curriculum Leveraging Technology
	AL - Technology-Based Learning
	AL - Synchronized Learning Activities
Afforded by Mobile Technologies	
	Adapt to Mobile Affordances
	Collaboration
	Constructivism
	Hands-on, Citizen Science
	Integration
	Convenience
	* Self Efficacy
	* Equality
	Lifelong Learning
	ML - Capture Data
	Mobile-Supporting LMS
	Organization
	Ubiquitous
Technology Challenges	
	Frustration - Access to Help
	Frustration - Complicated
	Frustration - Connectivity Issues
	Frustration - Crash
	Frustration - Distraction
	Frustration - Freezes
	Frustration - Legacy Distance Ed
	Frustration - Login
	Frustration - Lost Data
	Frustration - Not Portable Enough
	Frustration - Saving Docs
	Frustration - single point of failure
	Frustration - Slow Typing
	Frustration – Low Capacity
Factors in Student Interest	
	College/Career Interest
	Interest Level in ES
	Interesting HS Courses
	Compare to other teachers
	* Authentic Learning
Teacher Pedagogy	
	Teacher frame of reference
	Teacher as Designer

** Denotes category added after feedback by peer reviewers.*

Appendix H – Between-Subject Relevance

Tests of Between-Subjects Effects					
Learning Environment Sciences is Relevant to My Life Dependent Variable: Q10_Diff					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Model	11.972[a]	8	1.497	2.393	.021
TripsN1Y2	1.465	1	1.465	2.342	.129
Book1Explore2Mar	.798	1	.798	1.276	.262
Book1Explore2Jan	.974	1	.974	1.558	.215
TripsN1Y2 * Book1Explore2Mar	.435	1	.435	.696	.406
TripsN1Y2 * Book1Explore2Jan	2.026	1	2.026	3.240	.075
Book1Explore2Mar * Book1Explore2Jan	3.996	1	3.996	6.391	.013
TripsN1Y2 * Book1Explore2Mar * Book1Explore2Jan	1.246	1	1.246	1.993	.161
Error	60.028	96	.625		
Total	72.000	104			
a. R Squared = .166 (Adjusted R Squared = .097)					

Appendix I – Repeated Measures

I prefer course material that arouses my curiosity, even if it is difficult to learn

Repeated Measures, Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
TravelStatus	Pillai's Trace	.038	3.985[b]	1.000	102.000	.049
	Wilks' Lambda	.962	3.985[b]	1.000	102.000	.049
	Hotelling's Trace	.039	3.985[b]	1.000	102.000	.049
	Roy's Largest Root	.039	3.985[b]	1.000	102.000	.049
TravelStatus * TripsN1Y2	Pillai's Trace	.031	3.235[b]	1.000	102.000	.075
	Wilks' Lambda	.969	3.235[b]	1.000	102.000	.075
	Hotelling's Trace	.032	3.235[b]	1.000	102.000	.075
	Roy's Largest Root	.032	3.235[b]	1.000	102.000	.075

a. Design: Intercept + TripsN1Y2

Within Subjects Design: TravelStatus

b. Exact statistic

Appendix J – Between Subjects Course Preference

I prefer course material that arouses my curiosity, even if it is difficult to learn

Tests of Between-Subjects Effects

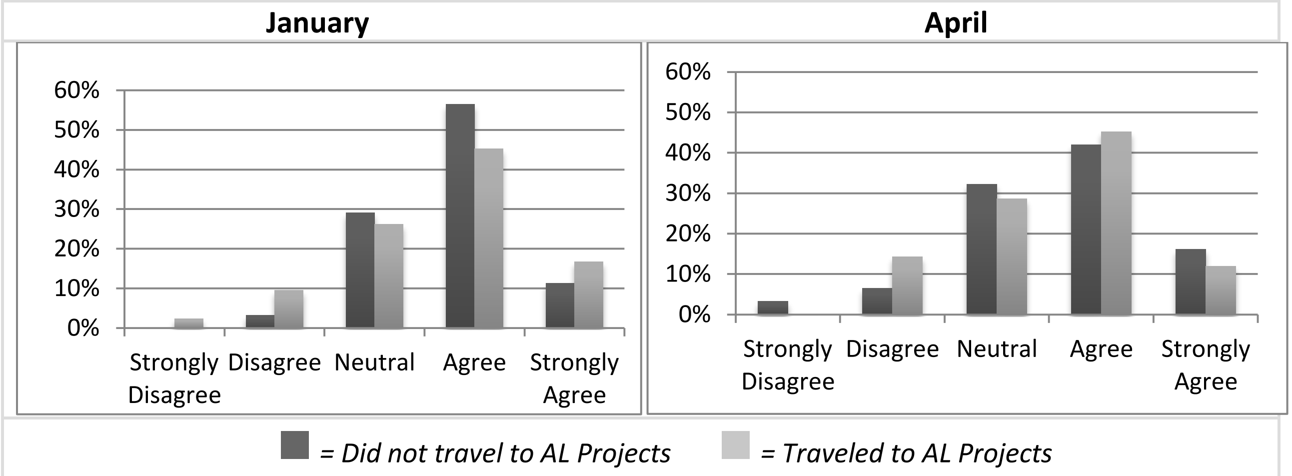
Dependent Variable:

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Model	7.876[a]	8	.984	1.474	.177
TripsN1Y2	3.102	1	3.102	4.643	.034
Book1Explore2Mar	.104	1	.104	.155	.695
Book1Explore2Jan	.340	1	.340	.509	.477
TripsN1Y2 * Book1Explore2Mar	.906	1	.906	1.356	.247
TripsN1Y2 * Book1Explore2Jan	1.686	1	1.686	2.524	.115
Book1Explore2Mar * Book1Explore2Jan	.373	1	.373	.559	.457
TripsN1Y2 * Book1Explore2Mar * Book1Explore2Jan	1.217	1	1.217	1.822	.180
Error	64.124	96	.668		
Total	72.000	104			

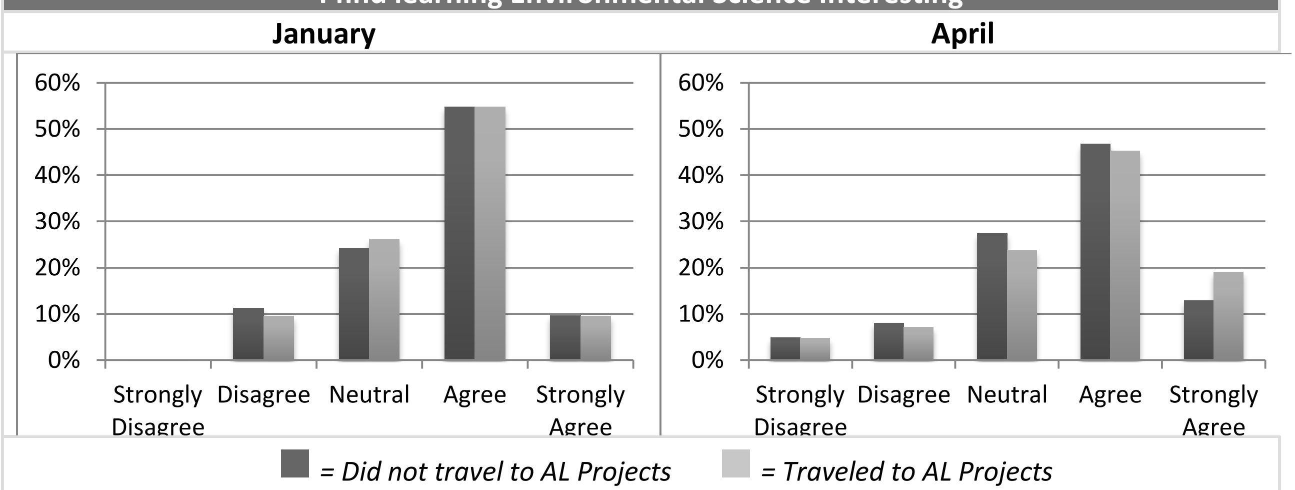
a. R Squared = .109 (Adjusted R Squared = .035)

Appendix K – Frequency Distribution

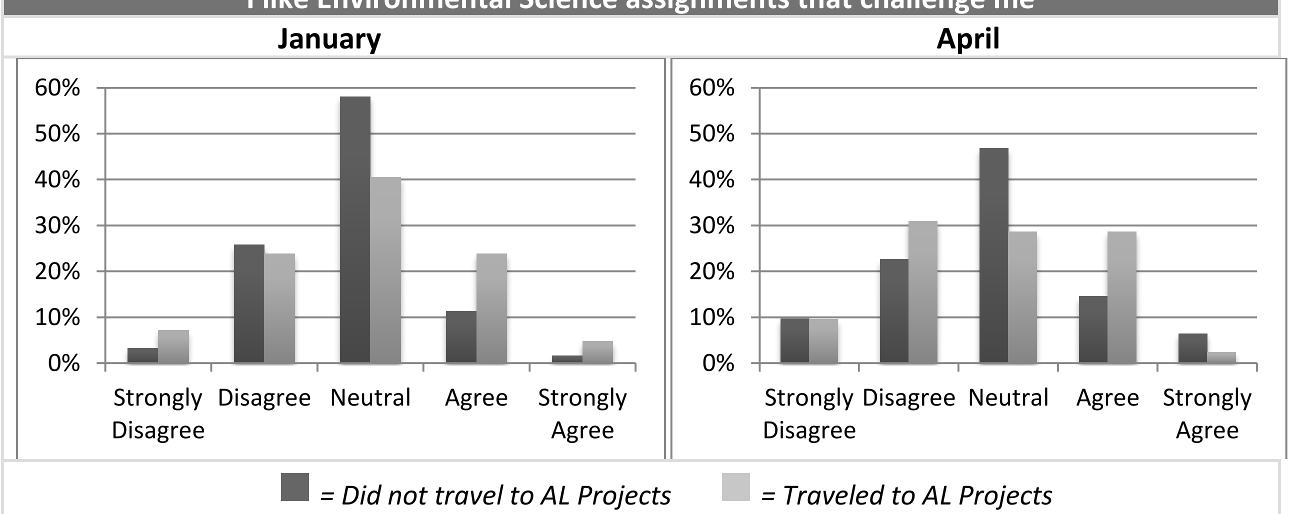
I enjoy learning Environmental Science

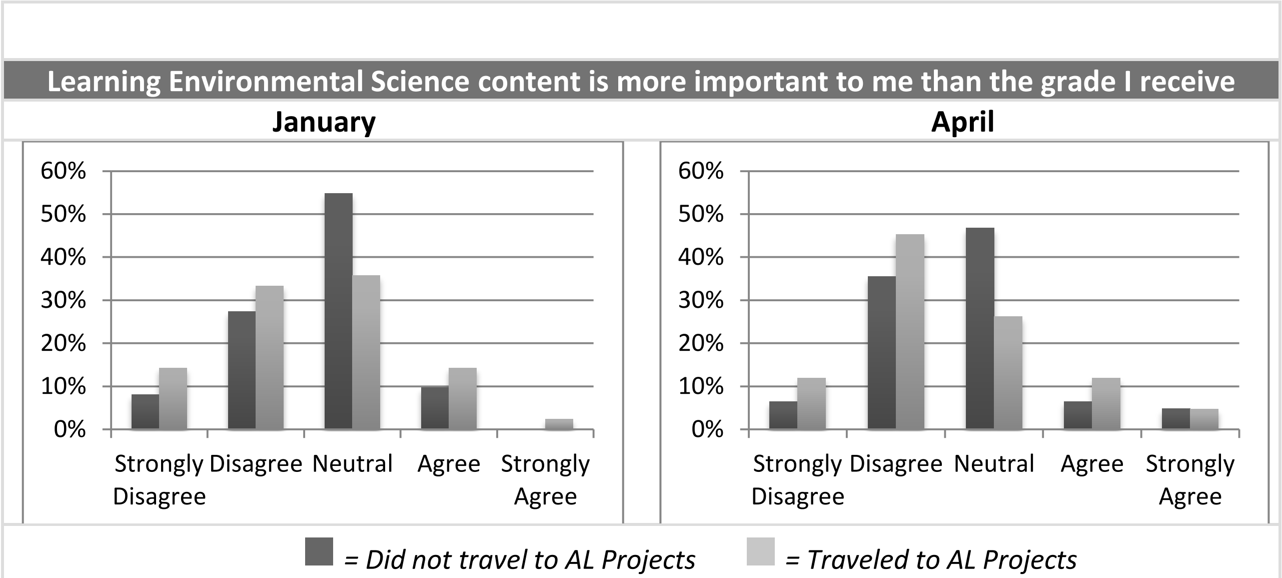


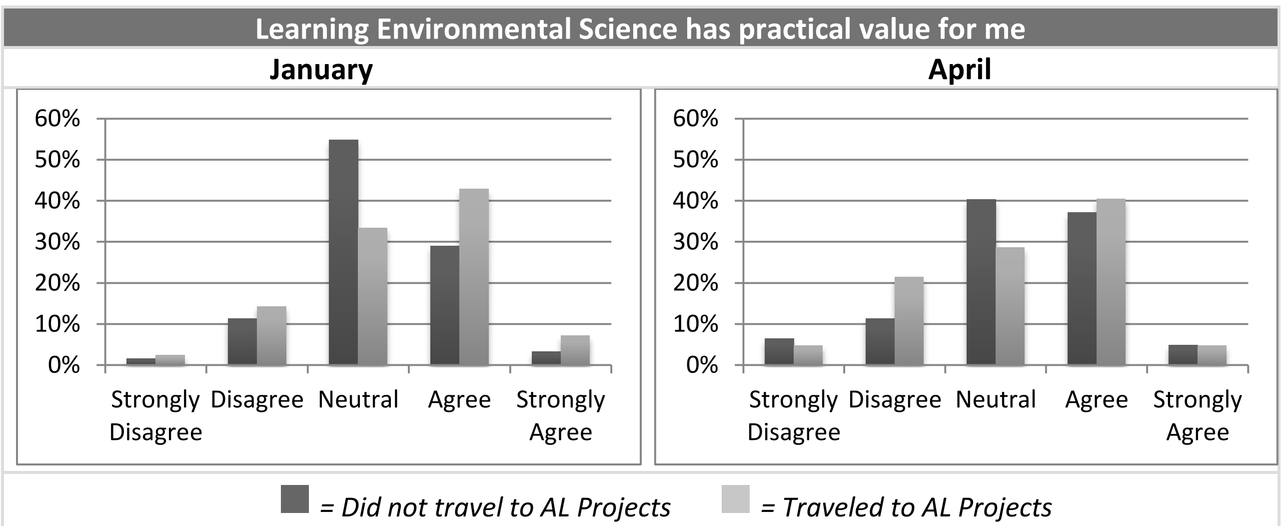
I find learning Environmental Science Interesting

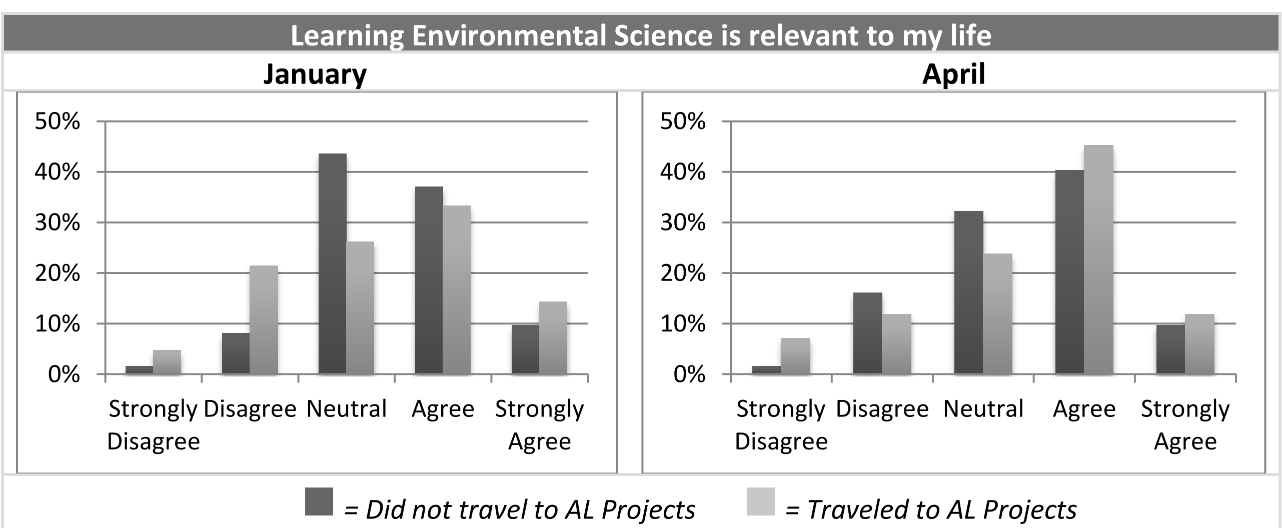


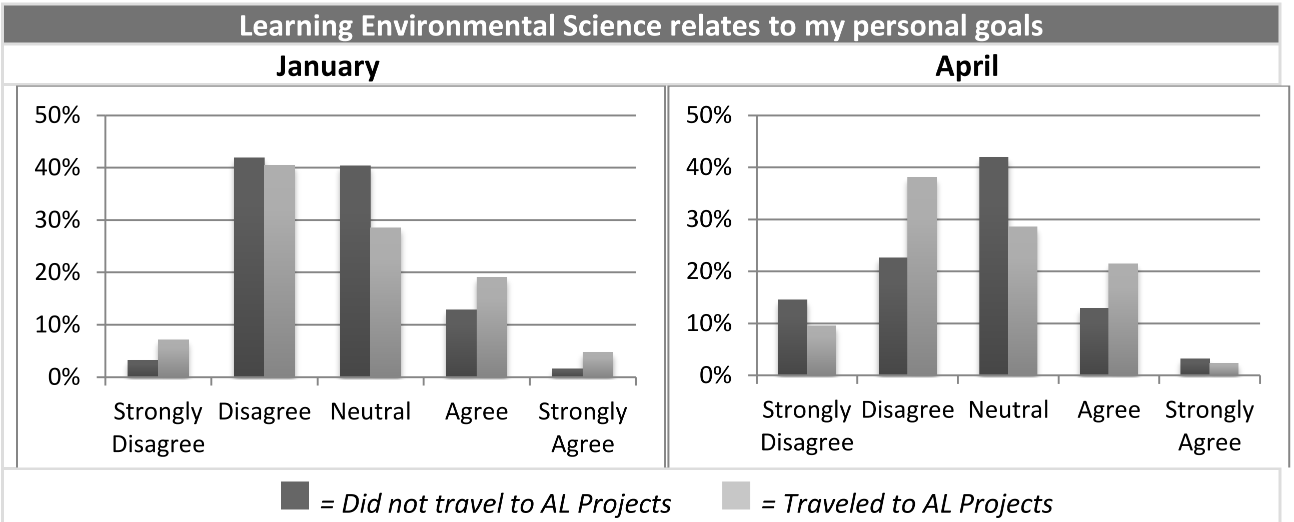
I like Environmental Science assignments that challenge me

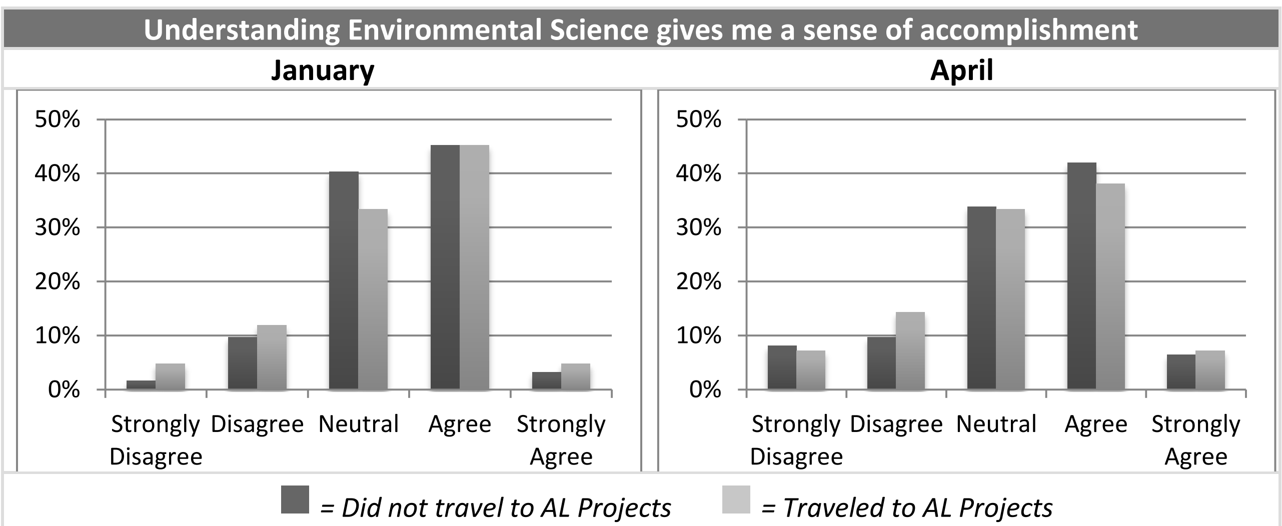


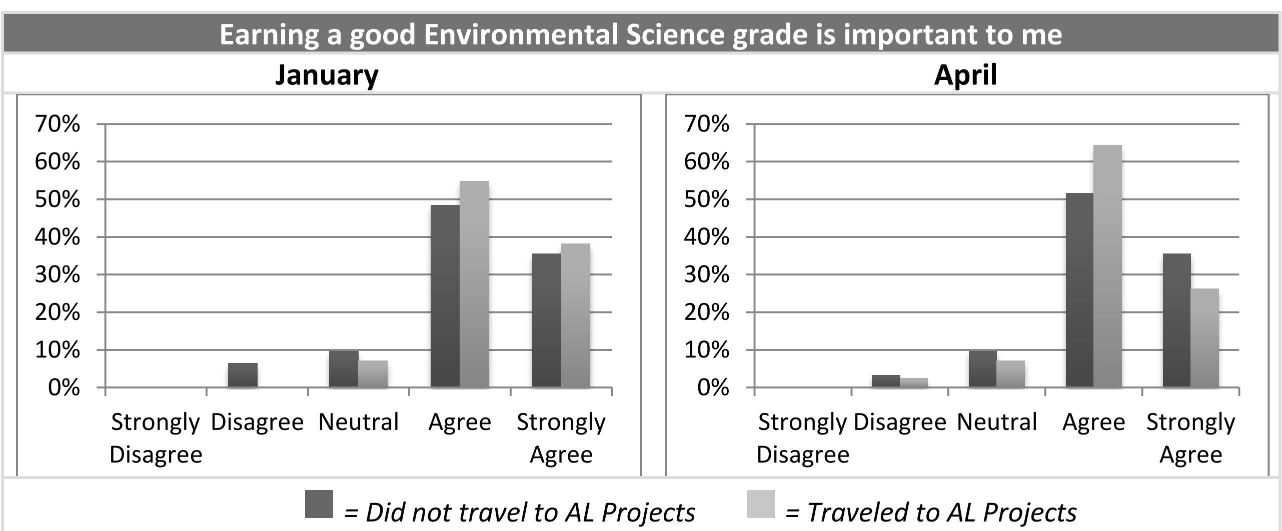

Learning Environmental Science content is more important to me than the grade I receive
January
April
60%
50%
40%
30%
20%
10%
0%
Strongly Disagree
Disagree
Neutral
Agree
Strongly Agree
= Did not travel to AL Projects
= Traveled to AL Projects

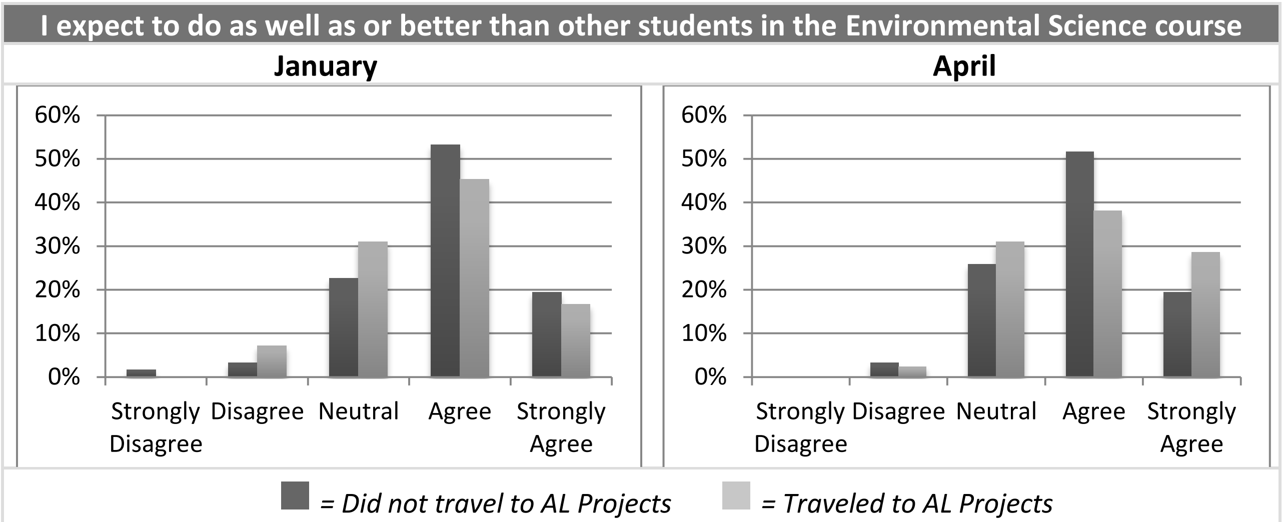

Learning Environmental Science has practical value for me
January
April
60%
50%
40%
30%
20%
10%
0%
Strongly Disagree
Disagree
Neutral
Agree
Strongly Agree
= Did not travel to AL Projects
= Traveled to AL Projects

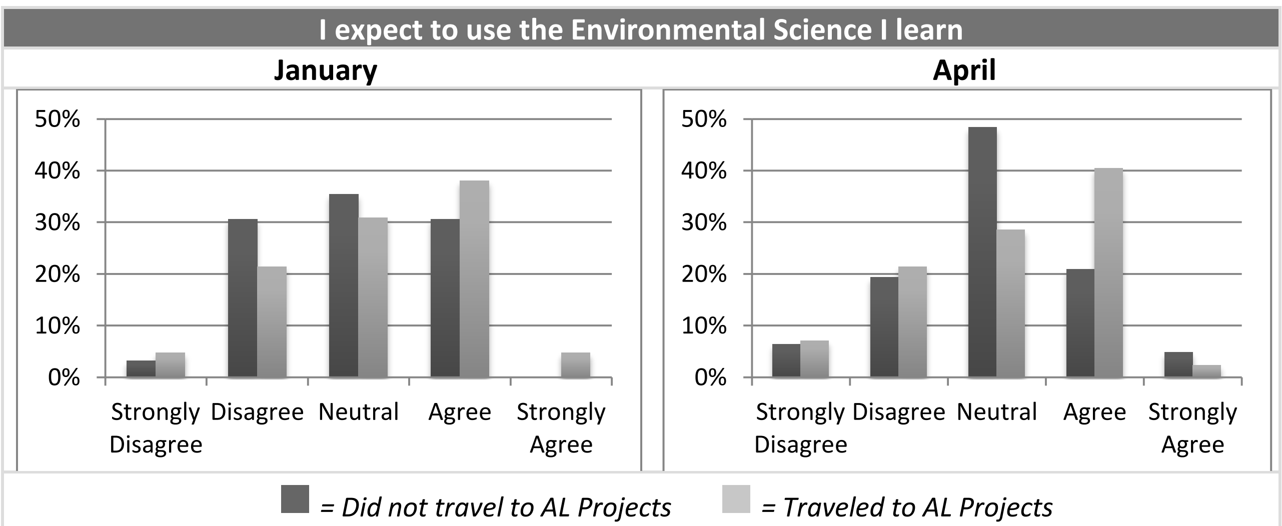

Learning Environmental Science is relevant to my life
January
April
50%
40%
30%
20%
10%
0%
Strongly Disagree
Disagree
Neutral
Agree
Strongly Agree
= Did not travel to AL Projects
= Traveled to AL Projects

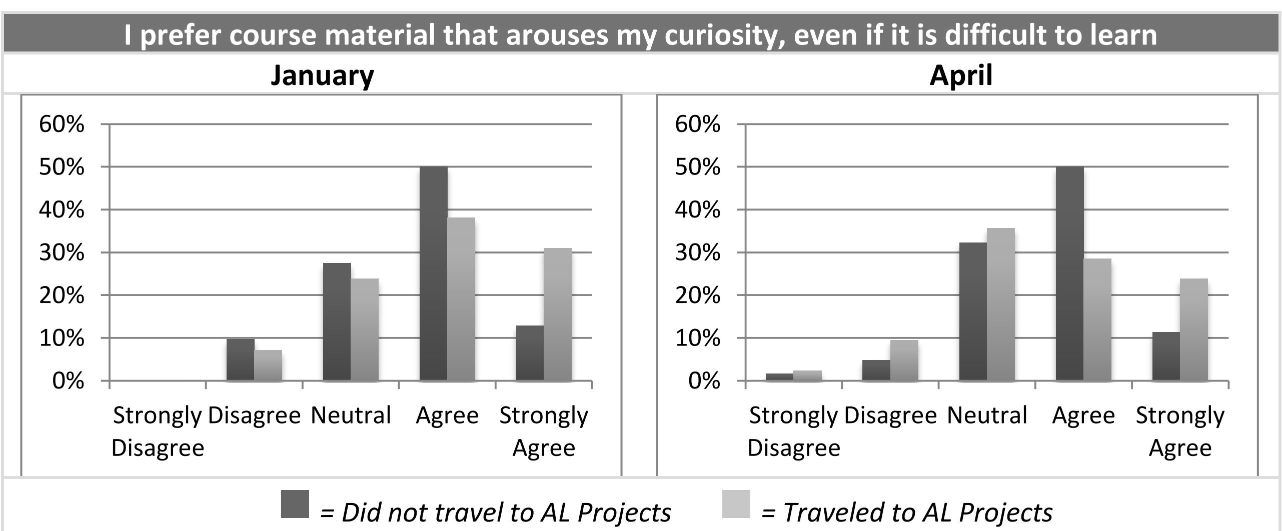

Learning Environmental Science relates to my personal goals
January
April
50%
40%
30%
20%
10%
0%
Strongly Disagree
Disagree
Neutral
Agree
Strongly Agree
= Did not travel to AL Projects
= Traveled to AL Projects


Understanding Environmental Science gives me a sense of accomplishment
January
April
50%
40%
30%
20%
10%
0%
Strongly Disagree
Disagree
Neutral
Agree
Strongly Agree
= Did not travel to AL Projects
= Traveled to AL Projects

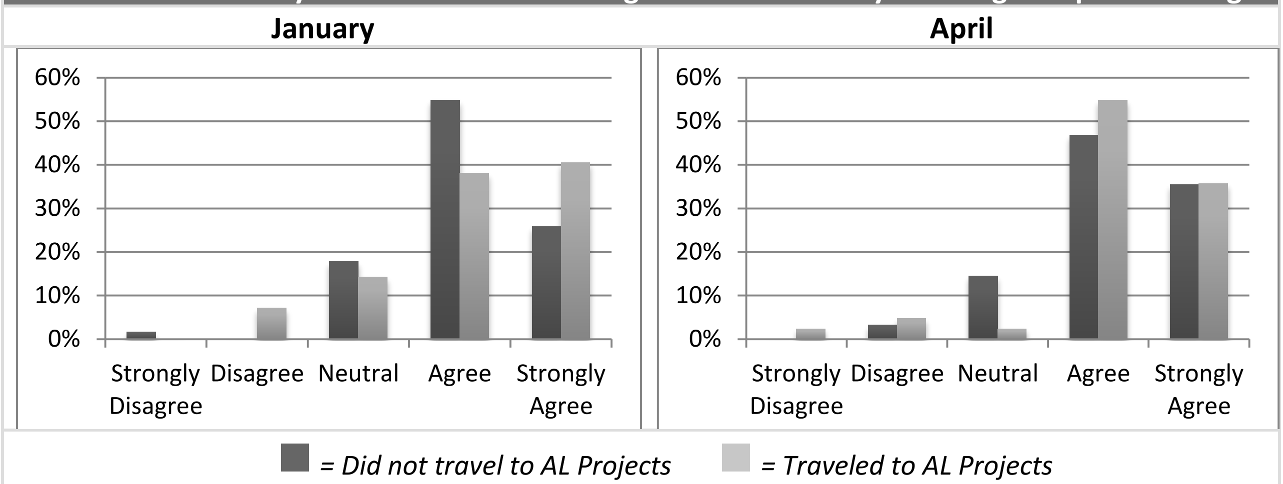

Earning a good Environmental Science grade is important to me
January
April
70%
60%
50%
40%
30%
20%
10%
0%
Strongly Disagree
Disagree
Neutral
Agree
Strongly Agree
= Did not travel to AL Projects
= Traveled to AL Projects


I expect to do as well as or better than other students in the Environmental Science course
January
April
60%
50%
40%
30%
20%
10%
0%
Strongly Disagree
Disagree
Neutral
Agree
Strongly Agree
= Did not travel to AL Projects
= Traveled to AL Projects

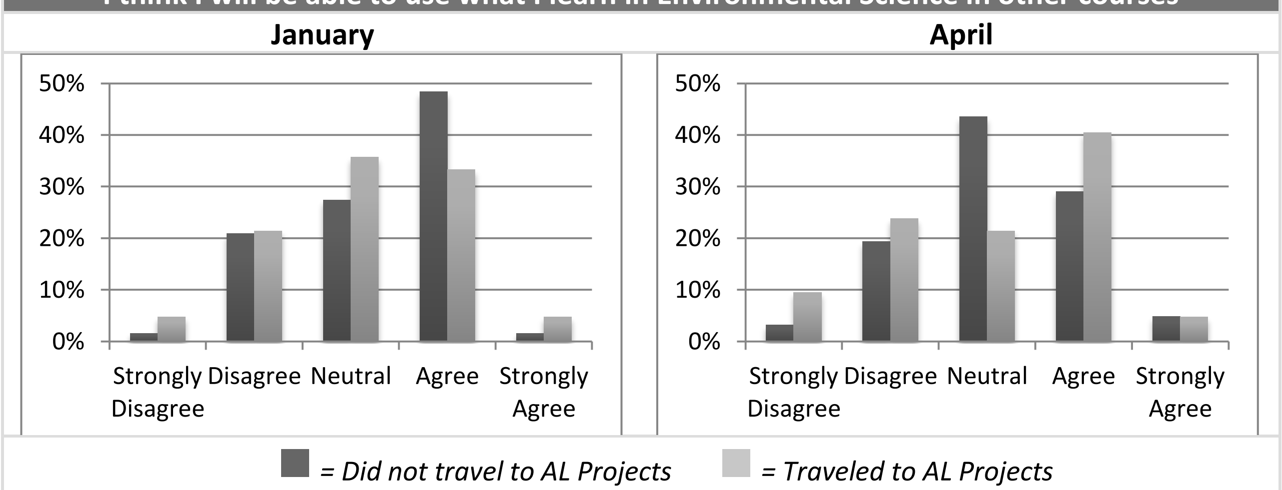

I expect to use the Environmental Science I learn
January
April
50%
40%
30%
20%
10%
0%
Strongly Disagree
Disagree
Neutral
Agree
Strongly Agree
= Did not travel to AL Projects
= Traveled to AL Projects


I prefer course material that arouses my curiosity, even if it is difficult to learn
January
April
60%
50%
40%
30%
20%
10%
0%
Strongly Disagree
Disagree
Neutral
Agree
Strongly Agree
= Did not travel to AL Projects
= Traveled to AL Projects

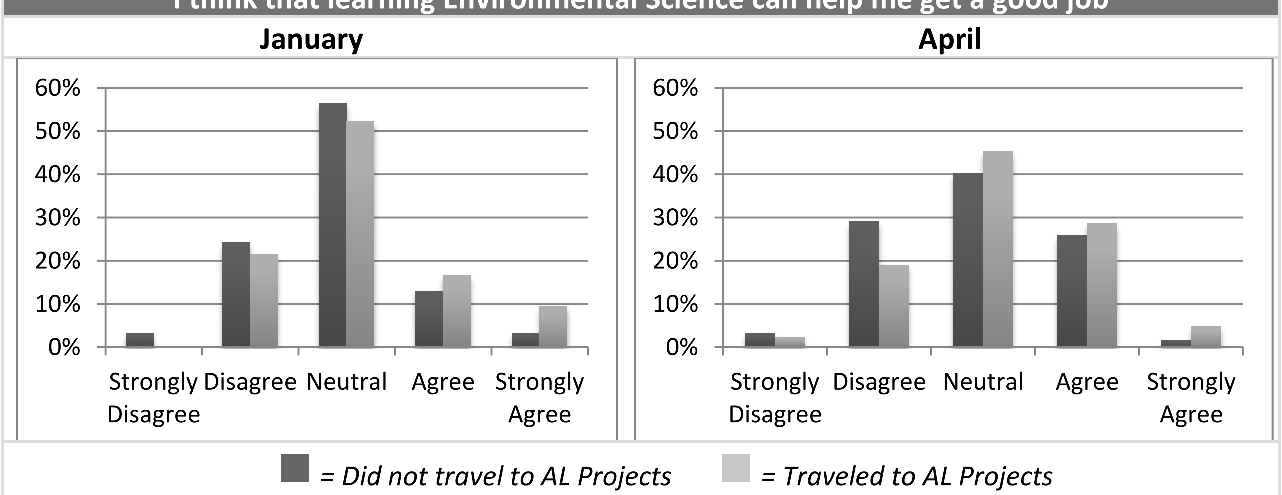
I think about how my Environmental Science grade will affect my overall grade point average



I think I will be able to use what I learn in Environmental Science in other courses



I think that learning Environmental Science can help me get a good job



Appendix L – Survey Questions Means and Standard Deviation

Questions divided by category	Travel		No Travel	
Responses based on personal interest	**Jan**	**Apr**	**Jan**	**Apr**
I enjoy learning Environmental Science	Mean: 3.64 SD: 0.958	Mean: 3.55 SD: 0.889	Mean: 3.76 SD: 0.694	Mean: 3.61 SD: 0.947
I find learning Environmental Science interesting	Mean: 3.64 SD: 0.814	Mean: 3.67 SD: 1.028	Mean: 3.63 SD: 0.814	Mean: 3.55 SD: 0.986
I like Environmental Science assignments that challenge me	Mean: 2.95 SD: 0.987	Mean: 2.83 SD: 1.034	Mean: 2.82 SD: 0.736	Mean: 2.85 SD: 1.006
Learning Environmental Science content is more important to me than the grade I	Mean: 2.57 SD: 0.991	Mean: 2.52 SD: 1.018	Mean: 2.66 SD: 0.991	Mean: 2.68 SD: 1.018
Learning Environmental Science has practical value for me	Mean: 3.38 SD: 0.909	Mean: 3.19 SD: 0.994	Mean: 3.21 SD: 0.750	Mean: 3.23 SD: 0.948
Learning Environmental Science is relevant to my life	Mean: 3.31 SD: 1.115	Mean: 3.43 SD: 1.085	Mean: 3.45 SD: 0.843	Mean: 3.40 SD: 0.941
Learning Environmental Science relates to my personal goals	Mean: 2.74 SD: 1.014	Mean: 2.69 SD: 1.000	Mean: 2.68 SD: 0.805	Mean: 2.68 SD: 0.988
Understanding Environmental Science gives me a sense of accomplishment	Mean: 3.33 SD: 0.928	Mean: 3.24 SD: 1.031	Mean: 3.39 SD: 0.776	Mean: 3.29 SD: 1.014
Responses based on academic interest	**Jan**	**Apr**	**Jan**	**Apr**
Earning a good Environmental Science grade is important to me	Mean: 4.31 SD: 0.604	Mean: 4.13 SD: 0.647	Mean: 4.13 SD: 0.839	Mean: 4.19 SD: 0.743
I expect to do as well as or better than other students in the course	Mean: 3.71 SD: 0.385	Mean: 3.93 SD: 0.838	Mean: 3.85 SD: 0.827	Mean: 3.87 SD: 0.757
I expect to use the Environmental Science I learn	Mean: 3.17 SD: 0.986	Mean: 3.10 SD: 1.008	Mean: 2.94 SD: 0.866	Mean: 2.98 SD: 0.932
I prefer course material that arouses my curiosity, even if it is difficult to learn	Mean: 3.93 SD: 0.921	Mean: 3.62 SD: 1.035	Mean: 3.66 SD: 0.829	Mean: 3.65 SD: 0.812
I think about how my Environmental Science grade will affect my overall grade	Mean: 4.12 SD: 0.916	Mean: 4.17 SD: 0.881	Mean: 4.03 SD: 0.768	Mean: 4.15 SD: 0.786
I think I will be able to use what I learn in Environmental Science in other courses	Mean: 3.12 SD: 0.968	Mean: 3.07 SD: 1.113	Mean: 3.27 SD: 0.872	Mean: 3.13 SD: 0.896
I think that learning Environmental Science can help me get a good job	Mean: 3.14 SD: 0.872	Mean: 3.14 SD: 0.872	Mean: 2.89 SD: 0.791	Mean: 2.94 SD: 0.866

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