AN EVALUATION OF AN ENVIRONMENTAL EDUCATION EXPERIENCE FOR ALL 6TH GRADE STUDENTS IN PRINCE WILLIAM COUNTY PUBLIC SCHOOLS, VIRGINIA

by

Robert Johnson
A Thesis
Submitted to the
Graduate Faculty
of
George Mason University
in Partial Fulfillment of
The Requirements for the Degree
of
Master of Science
Environmental Science and Policy

Committee:

	Dr. Dann Sklarew, Thesis Director
Cindy Smith	Dr. Cindy Smith, Committee Member
	Ms. Joy Greene, Committee Member
	Dr. Albert P. Torzilli, Graduate Program Director
	Dr. Robert B. Jonas, Department Chairperson
	Dr. Timothy L. Born, Associate Dean for Student and Academic Affairs, College of Science
	Dr. Vikas Chandhoke, Dean, College of Science
Date: November 28, 2011	Fall 2011 George Mason University Fairfax, VA

An Evaluation of an Environmental Education Experience
For All 6^{th} Graders in Prince William County Public Schools, Virginia

A Thesis submitted in partial fulfillment of the requirements for the degree of Master of Science at George Mason University

By

Robert Johnson
Bachelors of Science
United States Naval Academy, 1996

Director: Dann Sklarew, Professor
Environmental Science and Policy

Fall Semester 2011
George Mason University
Fairfax, VA

DEDICATION

This thesis is dedicated to my wife, Rupal Pujara, and our daughters, Sophia and Rayna.

I hope that their life journey is filled with joy,
a sense of wonder at the natural world,
an ever-present stillness to contemplate the beauty in the world,
and peace.

"Let children walk with nature, let them see the beautiful blendings and communions of death and life, their joyous inseparable unity, as taught in woods and meadows, plains and mountains and streams of our blessed star, and they will learn that death is stingless indeed, and as beautiful as life, and that the grave has no victory, for it never fights. All is divine harmony." (John Muir)

ACKNOWLEDGEMENTS

The completion of this thesis would not have been possible without the support I received from a raft of people.

The research and project development would not have been possible without a grant awarded from NOAA's BWET program, the support of Prince William County Public Schools, and the materials and sites provided by the National Wildlife Refuge System and the National Park Service. I am also grateful to George Mason University Creative Services Senior Photographer Evan Cantwell who provided a valuable collection of student pictures, some of which are included here.

I am happy to thank my adviser, Dr. Dann Sklarew, for guiding and advising me in the process of completing this research, for being my committee chair and keeping me on track, for understanding the "work hours" of a part-time student and father of 2 children under 5, for including me in the grant writing and curriculum development process to implement this project, and for occasionally paying me to help him complete other environmental science related projects over the last 4 years. I will be forever indebted.

I also wish to thank the other members of my committee, Dr. Cindy Smith and Mrs. Joy Greene, for their mentoring and advice, for showing me how much fun environmental education can be, and for repeatedly reminding me why I pursued environmental education as a research topic and potential new career.

I am grateful for the advice and support offered by my peers and friends along the way, including all the members of Dr. Sklarew's graduate lab, and Mrs. Lenna Storm, GMU's Sustainability Manager, for her counsel, guidance, periodic employment opportunities, and sympathetic ear.

I would be remiss if I failed to thank my parents for instilling a love of education early on and, when I was young, for making and letting me play outside until the sun went down and sending me to classes on the river and at camp even when I said I didn't want to go. Without your guidance and unending love and support, I wouldn't be where I am today.

And finally, to my wife, Rupal, and daughters, Sophia and Rayna. Without your support and encouragement, this would not have been possible. There are not enough words for me to say thank you for your love and patience.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS AND SYMBOLS

AP	Advanced Placement
BWET	Bay Watershed Education and Training
CWA	Clean Water Act
E.A.G.L.E.S.	Eastern Area Grounds for Learning Environmental Science
EE	Environmental Education
EEP	Environmental Education Program
EPA	Environmental Protection Agency
FWS	US Fish and Wildlife Service
GMU	George Mason University
IB	International Baccalaureate
JRA	James River Association
MWEE	Meaningful Watershed Education Experience
NAAEE	North American Association for Environmental Education
NCLB	No Child Left Behind
NOAA	National Oceanographic and Atmospheric Administration
OB NWR	Occoquan Bay National Wildlife Refuge
OEE	Outdoor Environmental Education
PLC	Professional (or Peer) Learning Community
PWCS	Prince William County Schools
SOL(s)	Standard(s) of Learning
SPSS	Statistical Package for the Social Sciences
TMDL	Total Maximum Daily Load
UNESCO	United Nations Educational, Scientific and Cultural Organization
VA BOE	Virginia Board of Education
VA DEQ	Virginia Department of Environmental Quality
VRUEC	Virginia Resource Use Education Council

ABSTRACT

AN EVALUATION OF AN ENVIRONMENTAL EDUCATION EXPERIENCE FOR ALL 6TH GRADERS IN PRINCE WILLIAM COUNTY PUBLIC SCHOOLS, VIRGINIA

Robert A. Johnson, M.S.

George Mason University, 2011

Thesis Director: Dr. Dann Sklarew

Appreciation of the natural environment is a vital step on the way to environmental sustainability. Environmental education in K-12 education plays an important role in developing ecologically literate and environmentally responsible citizens. Outdoor environmental education experiences in primary and secondary education (grades K-12) provide opportunities to generate this appreciation during the early stages of knowledge development (Sobel, 2004 and 2008).

Today, many school systems struggle to achieve federal and state-mandated education goals while, by and large, US education efforts are diverging from an "ecologically literate and culturally critical citizenry" (Gruenewald and Manteaw, 2007). As the global population continues to increase, it is important for people to understand the impact of their choices on the environment. Integrating environmental education and sustainability principles into the curricula of grades K-12 can help to foster understanding

and consideration of human environmental impact throughout students' lifetimes (Kozicki, 2010b).

Incorporating outdoor environmental education experiences improves students' knowledge and sows the seeds for environmental sustainability. Sixth grade students participating in a meaningful watershed educational experience (MWEE) (CBP, 2010) with an outdoor education component increase their watershed knowledge. This would indicate that student learning would benefit by including an outdoor education component (Hungerford and Volk, 1990; Sebba, 1991; Yerkes and Haras, 1997; Dillon, Rickinson, Teamey, Morris, Choi, Sanders, and Benefield, 2006; UNESCO, 2008).

This thesis examined the literature surrounding K-12 environmental education; indicated barriers to implementing outdoor activities in existing curricula; and showed the impact of incorporating outdoor education experiences into a 6th grade watershed curriculum. A recently implemented watershed education program in Prince William County, Virginia, provided context to examine a collaborative development process and describe and test a methodology to determine teacher and student improvement in watershed knowledge. By analyzing teacher workshop questionnaires and pre- and post-experience student surveys, this thesis evaluated the first year of a recently implemented 6th grade watershed education program in Prince William County, Virginia, to determine students' watershed knowledge. This evaluation indicates that a teacher workshop improves teachers' confidence and intentions in teaching about watersheds and the OEE improves students' knowledge of watersheds, familiarity with watershed issues, and ability to accurately assess the health of the Chesapeake Bay.

1 – INTRODUCTION

If the thinking that guides education reform does not take account of how the cultural beliefs and practices passed on through schooling relate to the deepening ecological crisis, then these efforts may actually strengthen the cultural orientation that is undermining the sustaining capacities of natural systems upon which all life depends.
- C.A. Bowers, 1993

"The ultimate *aim* of education is shaping human behavior," according to Hungerford and Volk (1990). Environmental education, in its many forms, designs to educate people about their place in, reliance and impact on the environment, with the vision to shape and inspire citizens' responsible behavior towards the environment. Any mandate for protecting and restoring our environmental commons requires citizens who value nature and the services it provides, absence of which may be cataclysmic (Orr, 1994; Hoelscher, 2009).

Despite this, across the United States school polices nationwide are overwhelmed by the mandates and standards of the No Child Left Behind Act and are silent about environmental education (Gruenewald and Manteaw, 2007). Environmental education in K-12 grades plays a critical role in instilling in future voters and decision makers a connection to and understanding of the natural environment and fostering environmentally responsible behavior in citizens (Hungerford and Volk, 1990). Though difficult to assess the long-term impacts of incorporating outdoor environmental education into K-12 education curricula, disparate experts and school systems have reported positive, short-term results (Lieberman and Hoody, 1998; Culen, 1998; Franklin, 2004; Dillon, Rickinson, Teamey, Morris, Choi, Sanders, and Benefield, 2006; Smith-Sebasto and Cavern, 2006).

Unfortunately, multiple factors – diminished and declining budgets; relegating outdoor environmental education experiences to an extracurricular activity; and federal, state, and local efforts to improve K-12 students' academic performance – make it difficult for teachers to incorporate additional objectives or outdoor lessons into their curricula. There are multiple competing activities and issues that act as barriers to finding time and space for outdoor educational experiences in a K-12 curriculum (Kirk, Wilke, and Ruske, 1993; Ernst, 2007; Kraemer, Zint, and Kirwan, 2007). Limiting these experiences might impact students', and future citizens', appreciation of the environment.

Because the extensive academic curricula is already full – with little time left for what might be considered extracurricular efforts – school districts, schools and especially teachers need outside help to develop, implement, and integrate outdoor environmental education experiences (Peacock, 2009). By teaming with environmental agencies, non-governmental organizations, and/or higher education institutions, K-12 schools can create and integrate outdoor environmental education lessons to enhance the existing curriculum (Archie, 2001; Thomashow and Witham, 2008; Wheeler and Conley, 2009; Kozicki, 2010a; Underwood, 2010). Here, evaluation of a recently implemented middle school watershed education curriculum will demonstrate the value of one such cooperatively developed program, along with students' improved watershed knowledge as a result of the outdoor environmental education component.

This research evaluated the effectiveness of the first year of a 6th grade watershed education curriculum in Prince William County, Virginia, by assessing students' improvement in watershed knowledge and summarizing teacher questionnaires of a preparatory training workshop. A prefatory literature review summarizes various aspects of environmental education – including its goals, some barriers to implementation, and evaluation methods. This thesis then summarizes the recently implemented watershed curriculum in Prince William County, Virginia, which is the basis for this research and describes the study methods, research questions, and hypotheses. Finally, this thesis presents the analysis results, briefly discusses the assumptions and limitations of this research, and points out the implications of this research and potential for follow-on research.

2 – LITERATURE REVIEW

Goals and Objectives of Outdoor Environmental Education (OEE)

"Environmental education must be systematically constructed and theoretically valid to achieve its goals" (Ramsey, Hungerford, and Volk, 1992).

A number of researchers describe and define the goals of environmental education (Ramsey et al., 1992; Orr, 1996; Culen, 1998; Palmer, 1998; Simmons et al., 2010). Ultimately, Stapps' (1969) definition still holds up well: environmental education intends to develop citizens that know about their "biophysical environment," are aware of its issues, and can work towards solutions. Strategically, environmental education can foster the responsible behavior of citizens (Hungerford and Volk, 1990).

Environmental education practitioners largely recognize that it is important to develop environmentally literate citizens in order to produce environmentally responsible behavior (Yerkes and Haras, 1997; Bonnett, 1999; Archie, 2001; Chawling and Cushing, 2007; Monroe, 2010). The complexity and variety of factors that influence any type of behavior change make it difficult to establish a singular teaching method for environmental education, especially as providers have a wide variety of perspectives and experience levels. While the pieces of environmental education include science-based knowledge and understanding of the human influence on their environment, eliciting a specific *behavior* is difficult. Today's ongoing environmental problems - climate change, biodiversity loss, and environmental degradation – indicate that environmental education is not fostering sufficient responsible behavior or a change in citizens' attitudes (Saylan and Blumstein, 2011).

Environmental education lends itself to curricula and practice that promote student engagement in hands-on, cross-curricular, problem solving activities. Today's curricula are typically focused on specific academic subjects, to the exclusion of environment-specific material, and use conceptual problems as examples (Palmer, 1998). In 1998, Culen noted the historical evidence that environmental education was not being integrated into school curricula (Culen, 1998). And in a slightly more recent report, Archie indicates that "not enough teachers" integrate environmental education into their curricula (2001). More recent resources, such as NAAEE's *Excellence in Environmental Education: Guidelines for Learning (K-12)* by Simmons et al. (2010), can assist education providers in systematically incorporating environmental education into their curricula.

There is myriad interrelated research regarding "nature study," "educating for sustainable development," "environmental education," "conservation education," and "outdoor education" (Robottom, 1987; Jacobson, 1987; Bonnett, 1999; Hopkins and McKeown, 1999; Smith, 1999; Gilbertson, Bates, McLaughlin, and Ewert, 2005; Kohlstedt, 2005; Venkataraman, 2009; Bailie, 2010; Strife, 2010). In its variety of forms, the literature describes how to create meaningful environmental lessons and experiences that ultimately influence responsible environmental behavior while maintaining or improving academic achievement.

Environmental education objectives for doing so build upon the Belgrade Charter (1976) and the Tblisi Declaration (1978). Their goals are to develop a global awareness of the environment and its problems, build the expertise and motivation to address and prevent current and future problems, cultivate awareness of urban and rural ecological dependencies and interdependencies, and influence society's responsible environmental behavior (Simmons et al., 2010). These two documents still provide the foundation for 21st century environmental education (Simmons et al., 2010).

Importance of Delivering K-12 Environmental Education Outdoors

Outdoor environmental education (OEE) experiences in primary education (K-12) play a critical role in instilling in future voters and decision-makers a connection to and understanding of the natural environment and, as noted above, developing environmentally responsible behavior (Orr, 1994; Lieberman and Hoody, 1998; Sobel, 2004 and 2008; UNESCO, 2008; Kozicki, 2010b). While it is difficult to assess the long-term impacts of incorporating OEE into primary education curricula, disparate experts and school systems report positive, short-term results in many areas, both academic and non-academic – reading, math, science, critical thinking and problem solving, leadership and character skills (Ernst, 2007, Kozicki, 2010)). Additionally, in studies of secondary school students and others who express environmental interests or concerns, "from half to more than 80% of the respondents identify childhood experiences of nature as a significant experience, such as free play, hiking, camping, fishing and berry picking"

(Chawla and Cushing, 2007). It is important to get children outdoors to help instill an ecological ethic.

For instance, one study of an environmental education program (EEP) in Mexico quantitatively and qualitatively indicated that the EEP students had more "ecological knowledge" than their peers. This program included outdoor lessons ("fieldtrips [and] practical field-based exercises"), lectures and group workshops." The authors suggested that a cooperative development approach in planning and evaluating the EEP enhanced "students' ecological knowledge assimilation and awareness of local environmental conditions." (Ruiz-Mallen, Barraza, Bodenhorn, and Reyes-Garcia, 2009).

In the USA, a recent independent evaluation of the NOAA Bay Watershed Education and Training (BWET) program-funded Meaningful Watershed Educational Experiences (MWEEs) corroborated the Mexican findings (Kraemer, Zint, and Kirwan, 2007). The Chesapeake Bay Program (CBP) defines a MWEE as "an investigative or experimental project that engages students in thinking critically about the Bay watershed. MWEEs are not intended to be quick, one-day activities; rather, they are extensive projects that allow students to gain a deep understanding of the issue or topic being presented" (CBP, 2010). Political leaders signing the Chesapeake 2000 Agreement – Virginia, Maryland, Pennsylvania, the District of Columbia, the Environmental Protection Agency (EPA), and the Chesapeake Bay Commission – declared the need for *all* students in the watershed to experience a MWEE before their high school graduation. The signatories aimed to foster environmental literacy and watershed stewardship through meaningful activities. To accomplish this, outdoor experiences provide students hands-on experiences in their local watersheds.

Program evaluators indicated that meaningful watershed experiences improved K-12 students' environmental stewardship qualities, their watershed knowledge, and their awareness of watershed problems. Third grade students who participated in the MWEEs showed improvement on the Science Investigation category of the 2004-2005 school year Virginia Standards of Learning (SOLs) Assessment science test (Kraemer, Zint, and Kirwan, 2007).

Environmental education experiences provide opportunities to sow the seeds for environmental sustainability. The examples above support the idea that a meaningful environmental education experience can benefit environmental awareness, ecological knowledge, and directly connect young citizens and future decision-makers to the natural environment. Unfortunately, federal, state, and local education agencies' efforts to improve K-12 students' performance have often crowded out time and space for outdoor environmental education experiences in the curriculum or during the school day (Culen, 1998; Kraemer et al., 2007).

Barriers to Implementing Outdoor Environmental Education

In 1993, Kirk, Wilke, and Ruske expressed their concern about the disjointed nature of many efforts attempting to integrate environmental education into formal curricula. As the 2010 NAAEE guidelines indicate, many educators recognized the need to integrate environmental education into their curricula since at least 1993. The major difficulty for administrators and teachers is deciphering how to implement environmental education in an era of diminished (and declining) budgets and required adherence to state-mandated standards of learning, often more compatible with a teach-to-the-test approach than a fully integrative experience. Marginalizing environmental education lessons, failing to integrate them with a curriculum, or treating them as extracurricular, might impact students', and future citizens', awareness of the environment as an integrating context.

Because of the increasing focus on accountability, state and federal standards, and successfully testing students, individual subjects are often hyper-focused on the textbook material, to the exclusion of other subjects, and programs deemed "nice-to-have" are abandoned as "extracurricular despite their valuable learning opportunities" (Ernst, 2007). Unfortunately, as Gruenewald and Manteaw lament, "The direction of education in the United States continues to move away from the ecologically literate and culturally critical citizenry" (2007). Without citizens who value nature and the services it provides, any mandate for protecting and restoring our environmental commons will be non-existent, and its absence may have cataclysmic implications (Orr, 1994, Hoelscher, 2009).

In the context of academic achievement and difficulty in integrating these experiences, NOAA's own BWET evaluation indicates that teachers do not commit class time to MWEEs because they "are not directly part of the tested standards" (Kraemer et al., 2007). The NCLB Act limits teachers to "teach to the tests" and implicitly incentivizes teachers to focus on the subjects to be tested. This decreases the amount of class time that can be used for environmental education, because, as some authors claim, "it is not a subject that the architects of the NCLB Act care much about" (Saylan and Blumstein, 2011).

Similarly, many environmental education programs suffer from lack of clear direction or curriculum development goals. Any goals that attempt to foster responsible environmental behavior are deemed too complicated to incorporate into curriculum development (Culen, 1998). Moreover, it is difficult for teachers to incorporate environmental education, especially *outdoor* environmental education, into their curriculum because of "lack of planning time, administrative support, transportation, and funding" (Ernst, 2007). The absence of clearly defined curricular goals and strategies, treating outdoor educational experiences as extracurricular activities and not fully-integrative lessons, and limited time to develop integrative lessons are factors that make it difficult for teachers and administrators to justify including outdoor environmental education in their curricula. Schools and school districts need help in developing and implementing outdoor environmental educational experiences (Peacock, 2009) By teaming with environmental agencies and organizations (federal, state, public, private, and non-profit) or higher education institutions, they can create outdoor environmental educational experiences that supplement the existing curriculum. In Virginia, especially "in many underserved communities, the establishment and continuation of MWEE programs appeared to be linked to the presence of a viable community partner, such as a local museum, 4-H Cooperative Extension Agent or Soil and Water Conservation District" (Underwood, 2010).

Another barrier to implementing programs with outdoor environmental education components is a lack of funding. School budgets tend to (rightly) focus on areas directly related to achieving state or federally mandated standards. Because integrating environmental education into existing curricula is perceived as a "nice-to-have," any effort to achieve this integration is often laid aside due to limited funding. Teachers and environmental educators must seek out and apply for grant monies to support these perceived extracurricular activities. At the same time, programs funded by grants often place an administrative burden on the teachers and cloud the grant's intentions. Time and money are wasted on programs that "have little practical importance or impact." To counter this and for environmental education programs to have a measurable impact, "the development and funding process must change." Scarce funding should be used to sustain programs that are objectively evaluated as successful rather than those that receive subjective evaluations. Because subjective evaluations tend to be biased (with the evaluator as part of the grant or getting paid by the grantee), some programs are perpetuated not because they demonstrate quantifiable success "but because they have momentum or precedent." This is a cycle that needs to be broken to ensure the delivery of quality environmental education programs that generate long-term improvement in ecological literacy among future citizens (Saylan and Blumstein, 2011).

Models of Environmental Education

For the last 40 years, many U.S. teachers have attempted to integrate environmental issues into their curricula. Elementary students learn about "endangered species or the benefits of recycling." Integrative, cross-subject environmental lessons are often introduced in middle school. "Many high school teachers are using a new Advanced-Placement environmental studies course that links science to social studies; and on college campuses, majors in environmental studies have become increasingly popular" (Smith, 2000). Despite the efforts of these teachers, students may become overwhelmed by the enormity and quantity of the environmental problems and thus distance themselves from generating new and innovative solutions because the problems are perceived as "too hard" to solve or, individually, the student feels futile. "There is some speculation that overemphasizing environmental problems, especially for children in the early stages of development, may create a kind of disassociation" (Saylan and Blumstein, 2011).

Regardless of this disparity – an inclusion of environmental issues versus a potential feeling of futility, this research found no clear consensus on a single "model" for environmental education. This research indicated that, generally, environmental education can be binned into two "models" – a *service provider* model or an *integrated* model. In the *service provider* model, a provider outside of the formal education develops and provides an environmental education experience as a service to a variety of groups, including K-12 students. There are many examples of this type of model across the United States.

In Virginia, one example of a *service-provider* model is the James River Association (JRA). The JRA provides multiple "education and outreach" services and programs to connect local youth to experiences and lessons on and about the James River (JRA, 2011). Generally designed to create hands-on nature experiences, some programs are explicitly connected to the Virginia Standards of Learning (SOLs) and thus offer teachers or administrators a ready resource to supplement their lessons. This requires teachers to know about and seek out the programs or an organizational representative to actively market their services to educators.

As exhibited by the JRA, a *service-provider* model either requires the provider to seek out opportunities to provide environmental education experiences or educators to know about the service. Such a model also requires the experience provider to continually seek out funding to remain in business. Alternatively, it requires educators to find a funding source if they want to provide such an experience to their students. This situation is not ideal in either case as funding sources are hard to come by and as school budget dollars are, as above, quickly redirected away from what may appear to be "nice-to-have" activities.

In an *integrative model*, environmental education experiences are integrated with and/or collaboratively developed by a school system using a committee-type approach. As Volk indicates, this committee is made up of a "core team and a support team" that includes teachers, especially those with environmental education experience; administrators; curriculum development specialists; and outside environmental educators and/or scientists. Because of the resident knowledge of such a committee, environmental experiences can be developed to explicitly support the curriculum. Regardless of the subject, "the core team [has] the major responsibility for curriculum development" and is supported by the support team (Volk, 1993). Motivated teachers or administrators can develop a program that enhances the students' learning process with environmental experiences. This model requires an interested, and motivated, educator (teacher or school administrator) to want to develop a program and enlist appropriate assistance and, as previously discussed, may be severely limited by the time, material, and budget constraints at a particular school or in a particular school system. Such a model is the subject of this research.

In 2008, under a NOAA BWET grant, Prince William County Public Schools (PWCS) and George Mason University (GMU) developed a watershed curriculum that integrates field experience lessons with classroom activities (Greene, Smith, Sklarew, Jones, and Johnson, 2009). By leveraging the 6th grade science curriculum knowledge of the PWCS administrator with the hands-on ecological knowledge of two university professors, this curriculum provides teachers a set of integrative lessons that both conform to the Virginia curriculum guidelines (Standards of Learning (SOLs)) and can be used to actively engage students in environmental problem solving and knowledge development. Furthermore, a curriculum development approach using an *integrative model* is supported by some results that indicate that "a viable community partner," in this case a public university, can help sustain an environmental education program (Underwood 2010). The effectiveness of this program will be discussed in Chapters 5 and 6.

As Saylan and Blumstein (2011) point out, "Without proper evaluation, it is difficult to assert that a particular environmental education program…is effective." The next section will briefly discuss some evaluation methods and tools available to assess environmental education programs, and the effectiveness of either of these models.

Assessing Environmental Education (EE) Programs

Attempting to evaluate EE program impacts on long-term behavior change is difficult. While numerous environmental education materials exist to develop programs and curricular integration is progressing, there is a scarcity of quality research or methods that support evaluating the utility of environmental education in influencing citizenship behavior (Hungerford, 1998; Heimlich and Ardoin, 2008; Carleton-Hug and Hug, 2010; Keene and Blumstein, 2010).

Given that the goals of most environmental education programs include developing environmentally responsible citizens, quantifying this change requires a formative evaluation – either continuous, longitudinal studies of students or periodic evaluation and revisiting of the same cohort – which would need "long-term involvement of an evaluator and stakeholder buy-in." Because of the difficulty of accomplishing this long-term effort, environmental education programs often use "descriptive summative evaluations" to qualitatively assess a program's effectiveness. Despite the inclusion of an evaluator as a stipulation of many grant-funded projects, these "descriptive summative evaluations" may miss the mark in assessing the larger impact of an environmental education program (Saylan and Blumstein, 2011). At the same time, there are a wide variety of methods and tools to evaluate environmental education programs (Stokking, van Aert, Meijberg, and Kaskens, 1999; Zint and Montgomery, 2004; Ernst, Monroe, and Simmons, 2009).

In the research reviewed, little provision is made for long-term, formative evaluation of EE programs, especially those developed outside of a formal curriculum or which include a service-oriented approach in some EE components. Evaluating a program is often delayed until the end of the program's life which then reduces the funds available to conduct the evaluation or may reduce the quality of the evaluation. In either case, without stakeholder involvement in the evaluation process and without a concerted effort to institute a formative evaluation process, program assessment is often overlooked (Saylan and Blumstein, 2011).

While highlighting two models of environmental education and conducting a formative evaluation of an *integrated model*, this report does not recommend a particular environmental education model, it only points out that alternate approaches may be worth considering when developing environmental education experiences. Future research could quantify the advantages of each educational model.

Literature Review Summary

Environmental education is largely designed to develop ecologically literate citizens. The literature reviewed above indicates that developing environmental stewardship and influencing environmentally responsible behavior is impeded by implicit and explicit barriers to implementing meaningful environmental education programs or curricula. Whether through curricular integration or provided by an outside source, environmental education programs should be implemented early in the education process, targeted to reach the largest number of students and improve their environmental stewardship. These programs may also benefit students' overall academic achievement, not just in the science curriculum. Outdoor environmental education experiences help to foster this responsible environmental behavior and offer students hands-on opportunities to apply their classroom lessons "in the field." To successfully evaluate these programs and justify their continuation, a variety of formative and summative evaluation methods and tools should be integrated into the program from its inception.

With this as context, the study hereafter examines and evaluates the initial year of a BWET-supported MWEE project for all middle school students in Prince William County, Virginia. Using a recently implemented, collaboratively developed 6th grade watershed education curriculum, this research will assess the improvement in students' watershed knowledge as a result of an outdoor environmental education experience. Results add to the growing body of research on the benefit of outdoor environmental education programs and curricular components to students' environmental awareness in grades K-12. Evaluation of the program's first year will also support sustaining the program in continuing its aim of “[providing] Meaningful Watershed Educational Experiences (MWEE) for over 16,000 middle school and high school students across 27 schools in Prince William County” and “[delivering] professional development and technical assistance to enhance capacity of 50 teachers of 6^{th} grade, high school earth science and environmental science” (Sklarew, 2010).

3 – PROGRAM DESCRIPTION

The Chesapeake Bay Watershed, Figure 1, is the largest estuary in the United States (Federal Leadership Committee for the Chesapeake Bay, 2010). In 2009, the EPA was sued for failing "to take adequate measures to protect and restore the Chesapeake Bay" (EPA, 2010). Recognizing that water quality in the Chesapeake Bay consistently failed to meet Clean Water Act (CWA) standards, President Obama issued Executive Order 13,508 directing cooperation among federal, state, and local agencies and organizations to improve the Bay's water quality (Executive Order No. 13,508, 2009). Shortly thereafter, the EPA developed Total Maximum Daily Load (TMDL) pollution limits for the Chesapeake Bay, a CWA requirement for impaired waters. This resulted in establishment of a nutrient pollution limit, or "cap," for the Bay (US EPA, 2010). Achieving and maintaining this cap will require active participation of

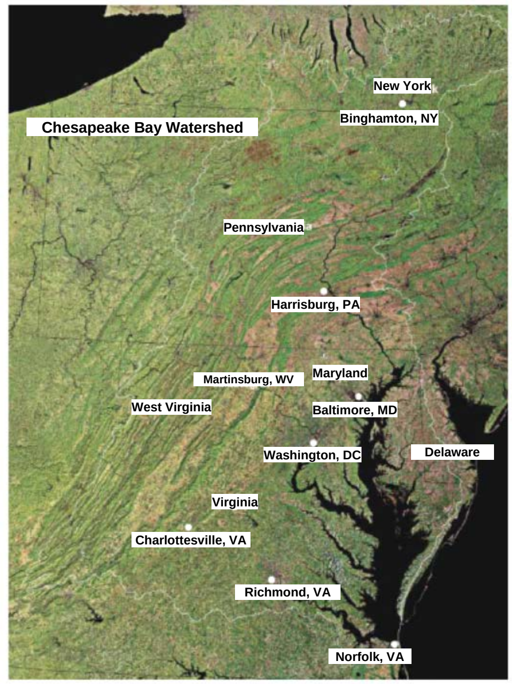

Figure 1 – Chesapeake Bay Watershed
(Adapted from Federal Leadership Committee for the Chesapeake Bay, 2010)

diverse stakeholders and stewardship-minded citizens across the Bay basin states, in both current and future generations.

In Virginia, the Potomac River, one of the main tributaries in the Chesapeake Bay watershed, forms the eastern border of Prince William County. Inspired by the Chesapeake 2000 Agreement and issues raised by the Executive Order and TMDL plans, George Mason University and Prince William County Public Schools (PWCS), the second largest school system in Virginia, developed a district-wide environmental education project, "From the Mountains to the Estuary, From the Schoolyard to the Bay," to enhance teachers' watershed knowledge, update them on the Bay's TMDL requirements, and integrate MWEEs into all public secondary schools' curricula. With a grant from NOAA's Bay Watershed Education and Training (BWET) program, the joint project was a three-year effort designed to provide meaningful watershed educational experiences (MWEEs) to all Prince William County secondary school students, "fostering their environmental stewardship and promoting their educational achievement" (Sklarew, 2010).

Per the proponents' 2008 project proposal, the goals for the first academic year (June 2009 to May 2010) were to create a 6th grade curriculum aligned to Virginia Standards of Learning (SOLs) with field experiences, meaningful watershed experiences, and hands-on lessons for 5,400, 6th graders per year, train 6th grade teachers through a pre-learning workshop, and institute teacher Peer Learning Communities (PLCs) to allow teachers to exchange best practices and relay program improvement feedback and lessons (Sklarew, 2010). Prior to development of this program, Prince William County Public

Schools' budget was limited. The district only sent about half of 6th graders on a yearly "water quality field trip" which did not constitute a valid MWEE experience, as defined by the Chesapeake Bay Program, and the student field work was not linked to curricular (SOLs, AP, or IB) objectives (Sklarew and Jones, 2008, CBP, 2010).

For teachers, the program included a 3-day teacher training workshop held in August, 2009, prior to the beginning of the school year and 2 peer-to-peer professional learning communities (PLCs) (teacher participation was required in order to receive a modest stipend). The workshop for the 2009-2010 school year was delivered in August 2009 to 17 PWCS sixth grade science teachers and three observers. Three more PWCS teachers received one-on-one training as they were unable to attend the workshop (Sklarew, 2010). These three teachers were not included in the workshop evaluation as their learning was individualized, thus distinct from the in-person workshop experience. Ultimately, a total of 20 teachers were trained to deliver a set of 6th grade watershed classroom and field-investigation lessons, both adapted and developed from scratch by project faculty (Greene et al., 2009). The 3-day workshop included demonstrations of the equipment to be used in each lesson; explanation of the web-based resources and how to input data; discussions of proposed schoolyard stewardship projects; and formative assessment of teachers' concerns about implementing these lessons.

Two PLC meetings were held during the academic year – in January (19 teachers) and June 2010 (16 teachers). In addition to an overview of the workshop, the PLCs included a review of lessons learned by teachers involved in the workshop and the watershed MWEEs held to date and brainstorming sessions on possible schoolyard stewardship projects. Based on participants' questionnaires (Appendices D and E), the workshop and two PLCs in 2009-2010 were largely a success (Sklarew, 2010). This study includes a formative evaluation of the teacher workshop but does not evaluate the PLCs.

For students, the program includes a total of 29 lesson plans. A majority of these lessons are designed for classroom-use and include practical activities for students to complete to learn about watersheds. Students received a subset of these lessons at one of two outdoor field sites in the County. These field experiences provided hands-on lessons to amplify their watershed education for one school day. These lessons were guided by field interpreters – a cadre of GMU students (both undergraduate and graduate), retired teachers, and volunteers – delivered the field lessons from the curriculum as outdoor experiences. The program's coordinators vetted the field interpreters to ensure that the 6th grade students were engaged with motivated and scientifically literate educators. The program coordinators also provided a one-day training workshop for new interpreters to demonstrate the watershed lessons they would be presenting during the outdoor experience.

The modules and lessons developed by PWCS and GMU satisfy all MWEE criteria and were linked to 6th grade SOLs (Appendix A). To facilitate its utility, the curriculum (Greene et al., 2009) is freely available on-line via a university web site (http://water.gmu.edu). The site also includes links to an on-line repository of watershed information (http://livebinders.com/play/play/1925), pedagogical tools, and lesson plans that relate the classroom lessons to what the students experienced on the field trip and provides hands-on activities to amplify the students' academic knowledge (Sklarew and Jones, 2008). Teachers can use these materials as their classroom lessons and prepare the students for their field experience.

Figure 2 – Field Experience and School Locations

The outdoor environmental educational (OEE) component of the watershed curriculum consisted of five lesson plans delivered at two locations in Prince William County, Virginia – Occoquan Bay National Wildlife Refuge in Woodbridge, VA ("Occoquan"), and Manassas National Battlefield Park in Manassas, VA ("Manassas") (Figure 2). Because each location had unique features and access, lessons were implemented slightly differently and the experience itineraries were slightly different (Appendix B). The curriculum included information for teachers to use in the classroom to prepare the students and enhance their field experience were linked to Virginia 6th Grade Science Standards of Learning, as presented in Appendix A (VA BOE, 2003).

Occoquan Bay National Wildlife Refuge is located in the eastern portion of the County at the junction of the Potomac and Occoquan Rivers. It includes "grasslands and marshes [that] attract songbirds, raptors, waterfowl and butterflies that depend on meadows and open water for their food, nesting sites, and a place to rest" (U.S. Fish and Wildlife Service, 2004). The Refuge is near the school district's Eastern Area Grounds for Learning Environmental Science (E.A.G.L.E.S.) Center, a PWCS facility specifically implemented to enhance environmental education in the County (PWCS, 2010). At this East county location, interpreters used four stations at two locations. One location was adjacent to a pond within the Refuge and the other included the E.A.G.L.E.S. watershed classroom and an adjacent field. The Occoquan field experience required bussing students between these two locations – a factor limiting total instruction time. Over approximately three hours, between 60 and 80 students rotated between four stations (specific number of students depended on the individual school). The lesson plans for the Occoquan location were (with page numbers from Greene et al., 2009):

1. Water Quality – "How's the Water?" (62)
2. Macroinvertebrates – "Who Lives Here?" (66)
3. Watershed Management – "Where Has All the Water Gone?" (78)
4. Watershed Investigation / Human Interactions / Topographic Maps – "Where's My Watershed?" and "Runoff Race" (33)

The West county location, Manassas National Battlefield Park (Stuart's Hill Tract and Brownsville Picnic Area) includes approximately 45 acres of wetlands as well as forested and herbaceous areas (Smithsonian NASM, 2004 and Sutton, Cucurullo, Brown, and Gorsira, 2003). At this location the interpreters used two parallel circuits of three learning stations adjacent to a creek, a pond, and in an open field. Over approximately two and a half hours, between 90 and 120 students rotated between three stations (specific number of students depended on the individual school). The lesson plans for the Manassas location were:

1. Water Quality – “How’s the Water?” (62)
2. Macroinvertebrates – “Who Lives Here?” (66)
3. Wetlands Challenge / Human Interactions / Wetland Metaphors – “Wetlands Lesson” and “Wetland Metaphors” – (75 and 68)

The Water Quality and Macroinvertebrate lessons were identical at each location while the other three were unique to each site. Prior to arriving at each location, students were divided into several groups of 15-20 students each – four groups at Occoquan, six groups at Manassas. Each group included two to three chaperones or teachers (approximately one per ten students). Upon arrival at the OEE location, each group was paired with an interpreter who led them to their first station. Interpreters spent approximately forty (40) minutes delivering the lesson and then the group went to the next station.

The following section summarizes each field lesson.

Field Lesson Descriptions

Water Quality – the Water Quality lesson was delivered at both locations, either on the banks of a creek or a pond. The field interpreter described ways to assess water quality – by testing water chemistry or identifying macroinvertebrates. Students were then led through hands-on activities to determine water quality. They observed the surrounding area to determine the indicators of water quality (e.g., erosion, run-off, impervious surfaces, ground cover). Students used a LaMotte Green Water Monitoring Kit to examine the chemical composition of the water – dissolved oxygen (DO), pH, nitrates, phosphate, and turbidity. Students also used thermometers to measure the water temperature. Finally, the interpreter modeled the use of a Secchi disk, a device researchers use to determine water clarity, and explained its inaccuracy in this case because of the shallow water. After recording all data on their individual data sheets (Appendix C – Student Data Sheet), students then developed and discussed conclusions about the water quality.

Figure 3 – Macroinvertebrate Collection (Cantwell, 2009)

Macroinvertebrates – Interpreters delivered the macroinvertebrate lesson at both locations. Using field guides, identification cards, buckets, magnifying viewers, and Brock magiscopes, students identified organisms they collected using dip nets from a pond or creek. As in the water quality lesson, the interpreter discussed ways to determine water quality, helped understand how to students identify organisms that were pollution tolerant, sensitive, or intolerant, and demonstrated how to collect and identify macroinvertebrates. Students then collected organisms, identified them (Figure 3), recorded what they found on their data sheets (Appendix C), and made conclusions about water quality based on what they knew so far (some students previously completed the water quality station).

Watershed Management – Interpreters delivered the Watershed Management lesson at Occoquan in the E.A.G.L.E.S. center classroom and in a nearby field. Prior to student arrival, the interpreters created an obstacle course with chairs, wooden planks, and rope. They also tied twenty pieces of one-foot string around two rubber bands large enough to fit around a large coffee can (10 strings per rubber band) and put each rubber band around a large coffee can (Figure 4). During this lesson, the interpreters divided the students into two groups and had the students identify water uses within a watershed – e. g., drinking, sewer, habitat, recreating, bathing. As students identified each water use, the interpreter gave each student a card that listed that use. Then, after filling the coffee can with water, students held the string corresponding to the use they identified and, without touching the rubber band or the coffee can, attempted to carry the coffee can through the obstacle course. This helped the students understand the difficulty of fulfilling all desired water uses in a watershed and the potential scarcity of water.

Figure 4 – Where does my water go? (Cantwell, 2009)

*Watershed Investigation, Human Interaction, and Topographic Map*s – Interpreters delivered the Watershed Investigation, Human Interaction, and Topographic Maps lessons at Occoquan as a single activity. These lessons were taught in the watershed classroom at the E.A.G. L.E.S. Center. The interpreter asked students to define the term *watershed* and identify their own watershed, discussed the impact of human activities on a watershed, and demonstrated the role of topography in a watershed. This lesson included the concepts of erosion, run-off, point and non-point source pollution, impervious surfaces, absorption, and establishing buffers. Students used magnifying lenses to investigate and identify the features of a local topographic map (Figure 5). They also compared aerial photos of the local area with the topographic maps. The interpreter assisted them in identifying their location on the topographic map and in the aerial photos. The interpreter also discussed the flow of water in the watershed based on the identified map features and contours. After separating into teams of three or four, the students used pans, a variety of substrates (pebbles, sand, soil, clay, pieces of artificial turf), sponges, netting, plastic plants, cement & wooden blocks to construct a watershed model. By elevating one end and pouring water into their model, students observed the watershed features that impact water quality, flow direction, mixing, absorption, erosion, and run-off. With an eye dropper, students collected water samples from the bottom of their model, and the interpreter used these samples to compare the

Figure 5 – Topographic Maps (Cantwell, 2009)

impacts of different watershed features on water quality. After cleaning up, students reported on the factors that affected their watershed models. These lessons helped students understand the impact their activities can have on their watershed and how varying topography impacts the watershed.

Figure 6 – Manassas Battlefield Park

Wetlands Challenge, Human Interaction, and Wetland Metaphors – Finally, the interpreters delivered the Wetlands Challenge, Human Interaction, and Wetland Metaphors lessons at Manassas as a single activity. These lessons used three group activities and a collection of everyday objects to demonstrate the services wetlands provide and the difficulties of cooperation in wetland restoration. Because of its historical significance, Manassas National Battlefield Park offered a unique opportunity for the interpreter to discuss the role of a variety of stakeholders in restoring the location as a protected wetland. Figure 6, the sign at the Park, describes the wetland mitigation and restoration process and the historical context of the Park. The restoration of this area to its 1862 condition and restoration of the wetlands required the cooperation of both public and private stakeholders – the U.S. Congress, the Virginia Department of Transportation, the Smithsonian Institution, Environmental Quality Resources, L.L.C, Parsons Brinckerhoff Construction Services, and URS Corporation (Smithsonian NASM, 2004 and Sutton et al., 2003). This provided the interpreter the opportunity to start this lesson with the students gathered around the sign and a discussion of the historical and environmental interests and goals of the different groups involved in the restoration process. Then, students returned to field where they completed three group activities: a "yurt circle," "All Tied Up," and a "migration challenge."

Figure 7 – "Yurt Circle"

First, in the "yurt circle," Figure 7, the students stood in one large circle, counted by twos, and, while holding hands and at the interpreters direction, one group (e.g., the "1s") leaned forward while the other group leaned backward. The interpreter then used a stopwatch and timed how long it took until the circle broke and then related this to the interconnectedness of a wetland and the importance of the individual pieces in maintaining its functionality without "breaking." Second, in "All Tied Up," students separated into groups of less than seven (preferably even numbers) and, with their right hand, grasped the right hand of a student not adjacent to them. Then, with their left hand, they grasped the left hand of a different student. Once they were "tied up," they attempted to untangle themselves into a circle – without injuring themselves. Regardless of success, the students appreciated the cooperation and patience necessary to solve problems – especially if the pieces are interconnected, as in wetlands.

Figure 8 – "Migration Challenge"

Third, in the "migration challenge," Figure 8, the interpreter laid two lengths of rope approximately 60 feet apart to represent the start and finish of a migratory bird path – e.g., North and South America. Then, with three wooden planks approximately seven feet long and making only three, one-way trips, students determined how to get the whole group ("flock") from start to finish, using the boards as the migratory path. They needed to stay on the boards between the lengths of rope, otherwise they were "killed" by hunters or pollution and the whole "flock" started over. This challenge demonstrated the difficulty animals have along their migration paths, especially as they traverse wetlands, and the potential role of human activities in enabling or inhibiting their migration.

After the group activities were complete, the interpreter then delivered the Wetlands Metaphor lesson. Using everyday objects – pillow case, sponge, small pillow or picture of bed, egg beater, empty jar of baby food, coffee filter, soap, antacid tablets, a can of tuna fish – the interpreter removed each object from the pillow case and asked the students to identify the wetland services represented by the object. Some examples of these metaphors were:

- Pillow or bed picture: A resting place for migratory birds
- Sponge: Absorbs excess water caused by runoff; retains moisture for a time during droughts even if standing water has dried up (sponge stays wet even after it has absorbed a spill)
- Egg beater: Mixes nutrients and oxygen in the water
- Baby bottle or jar: Provides a nursery that shelters, protects, and feeds young wildlife
- Coffee filter: Filters smaller impurities from water (excess nutrients, toxins)
- Soap: Helps clean the environment
- Antacid: Neutralizes toxic substances
- Can of tuna: Provides nutrient-rich foods for wildlife and humans

This lesson helped students understand the importance of wetland services in sustaining life.

Program Summary

Each of these five lessons used a variety of pedagogical tools and methods to engage and immerse the students in learning about watersheds. While interpreters may have delivered the lessons differently based on their experience, knowledge of the topic, and comfort in delivering the lesson, the lesson plans and the one-day interpreter workshops standardized the issues and content to be covered. This provided a common structure to successfully deliver the OEE and ensured the students received similar experiences at each site.

4 – METHODS

This study evaluates the effectiveness of a watershed curriculum designed to impart a meaningful watershed educational experience (MWEE) to all 6th grade students enrolled in public schools in Prince William County, Virginia. The curriculum included a 3-day teacher workshop implemented before the school-year and a follow-up pair of one-day professional learning communities (PLCs) delivered in the middle and at the end of the academic year. Participating teachers completed questionnaires before and after the workshop and again during the PLCs to provide feedback about lesson implementation and utility of the curriculum (Appendices D and E). Students completed a survey before and after the outdoor environmental education component (Appendix F). While designed slightly differently, portions of this evaluation method directly follow methods of, and thus results can be compared to, the evaluation by the Kraemer et al. (2007) evaluation of the entire NOAA BWET MWEE program.

Research Questions and Hypotheses

This evaluation addresses the following questions:

1. What is the impact of a teachers' pre-learning workshop in improving:
   a. confidence in teaching about watersheds; and
   b. ability to incorporate outdoor lessons into classroom curricula?

2. What is the impact of an outdoor environmental education (OEE) experience on 6^{th} grade students' watershed knowledge?

3. What is the impact of an OEE experience on 6^{th} grade students' ability to identify:
   a. impervious surfaces;
   b. sources of watershed pollution;
   c. pollution mitigation activities; and
   d. their own watershed?

4. What is the impact of an OEE experience on 6^{th} grade students' ability to accurately assess the overall health of the Chesapeake Bay?

Associated with these questions and informed by the above literature review are the following hypotheses:

Hypothesis 1: A multi-day teacher workshop will improve teachers' confidence in teaching about watersheds and intentions to incorporate outdoor lessons into their classroom.

Hypothesis 2: An outdoor environmental education experience investigating watersheds improves 6th grade students' watershed knowledge, as defined by the students' ability to correctly define *watershed* and *macroinvertebrate*.

Hypothesis 3: An outdoor environmental education experience investigating watersheds improves 6th grade students' ability to identify watershed components and issues (including major pollutants and pollution prevention methods) and improves their ability to identify their own watershed.

Hypothesis 4: An outdoor environmental education experience about watersheds improves 6th grade students' ability to accurately assess the health of the Chesapeake Bay.

Study Design and Survey Description

This research used both formative and summative evaluation methods to assess the impact of the first year (2009-2010) of the PWCS-GMU BWET project. Teachers completed a questionnaire before and after the 3-day workshop (Appendices D and E, respectively). Students completed a survey before and after their OEE (Appendix F).

Table 1 – Teacher Workshop Variables

Category	Questions	Variable Name	Likert Response Scale
Independent Variable	Workshop attendance	AtdWorkshop	
CONFIDENCE	Teach students about watershed / C Bay	ConfTeach	1-4 1 = Not at all confident 4 = Extremely Confident
	Integrate local watershed into curriculum	ConfInt	
	Use outdoors to teach about local watershed or Bay	ConfOutd	
	Research an environmental issue w/ students	ConfRsrch	
	Collect watershed / Bay field data	ConfCollect	
	Analyze watershed / Bay field data	ConfAnalyze	
	Guide students through action project to address local watershed / Bay issue	ConfGuide	
INTENTIONS	Teach about local watershed or Chesapeake Bay	IntTeach	1-6 1 = Extremely unlikely 6 = Extremely Likely
	Use outdoors when teaching about local watershed / Chesapeake Bay	IntOutd	
	Research an environmental issue with students	IntRsrch	
	Guide students thru taking action on environmental issue	IntGuide	

The teacher questionnaires (Appendices D and E) used a combination of Likert-scale and free-text responses to evaluate teachers' initial knowledge of watersheds; time spent delivering watershed lessons during the school year; comfort in providing watershed information to students; general confidence in teaching about watersheds; and impediments in providing meaningful watershed lessons. Pre- and post-workshop questionnaires were completed voluntarily by 15 of the 17 attending teachers.

Given the small sample size, SPSS was used to conduct a Kendall's tau-b test to determine if these teachers' confidence and intentions improved with respect to teaching watershed lessons. Assumptions and implications of this non-parametric statistical test will be discussed in the Data Analysis portion below. Table 1 list the ordinal variables used to assess teacher confidence and intentions. Comparing the descriptive statistics from the questionnaire responses provide an indicator of the utility of the workshop and its delivery by the program providers. Finally, because of the small sample size, the free text responses were summarized and qualitatively compared based on a key-word analysis to determine whether these teachers received an appropriate amount of information and materials to successfully deliver these watershed lessons.

The main portion of this study was comprised of students' pre- and post-experience surveys. The student survey (Appendix F) was designed to address the three focus areas of the MWEE lessons – watershed identification, the state of the watershed, and how to improve water quality in the watershed. Survey questions included both multiple choice and free-text responses and intended to quantify the impact of the OEE.

Students completed the same survey once in the classroom (before the OEE) and again after completing the OEE. The survey consisted of both multiple-choice and free-text responses. Teachers administered the surveys on behalf of the program coordinators and then returned the completed surveys to the program coordinators. To get the data into a form appropriate for statistical analysis, a group of interns entered the data into two Microsoft Excel-based workbooks – one for pre-OEE surveys, and the other for post-OEE surveys. Each workbook contained identical worksheets to capture the responses.

A student-created identification number was used to code each survey response. This code was based on the last two digits of the student's zip code and the last four digits of their phone number. Conceptually, this would allow the grouping of responses by school and, ideally, would allow determining individual student improvement pre- and post-OEE. In reality, and unfortunately, not all students included an identification number on their survey, some students did not include all six digits, and it was not clear whether students uniformly followed the instructions to create the number.

Regardless of whether the students correctly created an identification number, they consistently identified whether they completed the survey before or after their OEE. Ultimately, identifying whether the student attended the field experience was the key component for this study design. As long as the student indicated (circled) whether they had attended the field experience, this study only used the identification number to segregate individual responses (i.e., it was used as the data entry code for the survey responses). If the student did not complete the identification code, a random, 6 digit number was used to enter that student's response. If the student did not indicate whether they had attended the field experience, the survey was deemed as an invalid response.

All teachers who attended the OEEs with the students received surveys for every student to complete pre- and post-OEE. In the 2009-2010 academic year, 4,868 6th graders attended one of the OEE experiences (Sklarew, 2010). Teachers returned 2,385 surveys (24% of total attendees) to the program coordinators. Forty six surveys (0.5%) were invalid because the students did not indicate whether they attended the OEE. This resulted in 954 valid, pre-OEE survey responses (20% of student attendees) and 1,385 valid, post-OEE survey responses (28% of student attendees) used for subsequent analysis below.

Table 2 – Student Survey Variables

SPSS Variable Name	Translation	Data Type
AtdOEE	Attended OEE	Nominal (Independent)
Landareaanddrang	Watershed is "Land area and drainage"	Nominal
Macro	Correctly define "macroinvertebrate"	Nominal
CorrectID3Pltnts	Correctly identify 3 pollutants	Nominal
Impervious	Correctly identify impervious surfaces	Nominal
pkuptrsh	Identify ways to prevent pollution - pick up trash	Nominal
rccle	Identify ways to prevent pollution - recycle	Nominal
buffer	Identify ways to prevent pollution - build a buffer / barrier	Nominal
chem	Identify ways to prevent pollution - use less chemicals / fertilizer	Nominal
AnyChesPotOccAtl	Identify where drainage / sewer goes - (Chesapeake, Potomac, Occoquan, Atlantic)	Nominal
WshedID	Correctly identify *your* watershed	Nominal
CBGrade	Grade health of Chesapeake Bay	Interval (Numerical)

Data was entered based on the student identification codes, with the caveats mentioned above, and responses were coded into 10 nominal (dichotomous) variables and 1 interval variable. Free-text responses were entered verbatim directly into the Excel workbooks and spelling mistakes were corrected to aid data analysis. A keyword analysis determined the commonality of responses; if a free-text response contained a specific word or combination of words it was counted as a "1", otherwise it was a "0". Multiple choice responses were counted as correct ("1") or incorrect ("0"). For multiple choice questions with multiple response options, the answer was only counted as correct if all correct responses were marked (and only if there were no other choices marked). The Chesapeake Bay grade (CBGrade) was entered as an interval variable based on a 4.0 grading scale. The students' attendance of the OEE was entered as a nominal (dichotomous) variable – has attended the OEE ("1") or has not attended the OEE ("0").

These variables, listed in Table 2, could then be used in SPSS to conduct statistical testing and examine the relationships between variables with respect to Hypotheses 2, 3, and 4.

Data Analysis

Table 3 – Statistical Tests

Research Question (RQ) / Hypothesis		**SPSS Variables**	**Statistical Test**
Hypothesis # 1: Teachers' Confidence and Intentions	• Confidence in teaching about watersheds	– ConfTeach – ConfInt – ConfOutd – ConfRsrch – ConfCollect – ConfAnalyze – ConfGuide	Kendall tau-b Test
	• Ability (intentions) to incorporate outdoor lessons into classroom curriculum	– IntTeach – IntOutd – IntRsrch – IntGuide	
Hypothesis #2: Students' Watershed knowledge	• Correctly define a watershed	Landareaanddrang	Pearson's Chi-Square Test
	• Correctly define macroinvertebrate	Macro	
Hypothesis #3: Students' ability to identify watershed components and issues	• Correctly identify top three pollutants in a watershed	CorrectID3Pltnts	Pearson's Chi-Square Test
	• Correctly identify impervious surfaces	Impervious	
	• Identify ways to prevent pollution	pkuptrsh	
		rccle	
		buffer	
		chem	
	• Correctly identify their watershed	AnyChesPotOccAtl	
		WshedID	
Hypothesis #4: Students' ability to accurately assess the health of the Chesapeake Bay	• Health grade for the Chesapeake Bay	CBGrade	Independent samples t-test

The variables used to assess Hypothesis 1 are ordinal. The variables used to assess Hypotheses 2 and 3 are nominal (dichotomous) (responses were categorized as correct or incorrect). Thus, in the context of each of these Research Questions, non-parametric statistical tests were used to examine the impacts of the teacher workshop on teacher confidence and intentions as well as the impacts of OEE on students' watershed knowledge at a p-value less than or equal to 0.05.

As the Chesapeake Bay grade (CBGrade) is a continuous variable, a parametric test was used to evaluate evidence regarding Hypothesis 4, again at a p-value less than or equal to 0.05. Table 3 indicates the survey components and variables associated with each of the hypotheses and the statistical tests used to examine their significance.

For Hypothesis 1, the Kendall tau-b test is a non-parametric statistical test used to examine ordinal data that fails the assumptions for an independent samples t-test, i.e., that the variables follow a normal distribution, and has a small sample size. The sample size of the teacher workshop is too small to determine whether the results follow a normal distribution. While, the small sample size may limit the ability to identify any statistically significant impact of the teacher workshop (Norusis, 2009), Kendall's tau-b mitigates this because "it does not make assumptions about the number of expected frequencies" (Berman, 2007).

For Hypotheses 2 and 3, Pearson's Chi-Square test, a non-parametric test, was used to examine the nominal (dichotomous) data. The data satisfies the three assumptions for the Chi-Square test: the variables are nominal (or categorical), the pre- and post-observations are independent, and there are more than five observations in each sample (Berman, 2007).

Table 4 – Levene's Test for Equality of Variances (CBGrade)

		F	Sig.
CBGrade	Equal variances assumed	131.194	.000
	Equal variances not assumed		

For Hypothesis 4, an independent samples t-test is a parametric test used to determine if the means in two populations are statistically different. As both the pre- and post-sample size is large (greater than 40), the Chesapeake Bay grade variable can be assumed to be normally distributed within the sample. This satisfies one assumption of the independent samples t-test. As Table 4 indicates, the variances in the two populations are different (in this case, the null hypothesis (H_0) – that the variances are the same – is rejected because the significance of the Levene test is less than 0.05) (Norusis, 2009).

5 – RESULTS

Descriptive Statistics

Fifteen of the attending teachers completed questionnaires before and after the pre-learning teacher workshop held in August 2009. Before the workshop, six (40%) indicated they did not provide students a personal connection to the Chesapeake Bay. On average, these teachers spent fifteen hours per year teaching about watershed ecology.

Table 5 – Teacher Questionnaire Responses

Category	Questions	Likert Response Scale	After Workshop	Before Workshop
CONFIDENCE	Teach students about watershed / C Bay	1-4 1 = Not at all confident 4 = Extremely Confident	**2.8**	**3.8**
	Integrate local watershed into curriculum		**2.7**	**3.7**
	Use outdoors to teach about local watershed or Bay		**2.4**	**3.8**
	Research an environmental issue w/ students		**2.7**	**3.6**
	Collect watershed / Bay field data		**2.4**	**3.8**
	Analyze watershed / Bay field data		**2.6**	**3.6**
	Guide students through action project to address local watershed / Bay issue		**2.4**	**3.4**
INTENTIONS	Teach about local watershed or Chesapeake Bay	1-6 1 = Extremely unlikely 6 = Extremely Likely	**5.6**	**5.9**
	Use outdoors when teaching about local watershed / Chesapeake Bay		**4.7**	**5.9**
	Research an environmental issue with students		**4.6**	**5.4**
	Guide students thru taking action on environmental issue		**4.5**	**5.4**

As a result of the workshop, teachers' confidence and intentions appear to improve, Table 5. Of the four free-text responses to challenges in teaching about the Chesapeake Bay, "lack of time" was the most mentioned. Other responses included "lack of experience with field data collection and analysis" or difficulty in making the lessons meaningful. Notably, one positive comment from a teacher who is extremely likely to do all of these things was "principal & science [department] has made a commitment to hands-on application of teaching watersheds." Teachers requested help in developing schoolyard stewardship projects, designing computer-based activities, and developing memory aids.

Table 6 – Student Survey Responses

Research Question (RQ) / Hypothesis		**SPSS Variables**	**Pre-OEE**	**Post-OEE**
Research Question #2 / Hypothesis #2: Students' Watershed knowledge	• Correctly define a *watershed* as land area <u>and</u> drainage	Landareaanddrang	0.6%	7.4%
	• Correctly define a *watershed* as land area <u>or</u> drainage	Landareaanddrang	9.1%	31.2%
	• Correctly define *macroinverterbrate*	Macro	42%	65.4%
Research Question #3 / Hypothesis #3: Students' ability to identify watershed components and issues	• Correctly identify top three pollutants in a watershed	CorrectID3Pltnts	0.4%	19.9%
	• Correctly identify impervious surfaces	Impervious	18.6%	34.2%
	• Identify ways to prevent pollution	pkuptrsh	57.9%	47.1%
		rccle	14.3%	11.1%
		buffer	4.7%	11.3%
		chem	3.6%	9.3%
	• Correctly identify their watershed	AnyChesPotOccAtl	38.8%	50.7%
		WshedID	51.7%	68.5%
Research Question #4 / Hypothesis #4: Students' ability to accurately assess the health of the Chesapeake Bay	• Health grade for the Chesapeake Bay	CBGrade	1.80	1.58
		A	2%	4%
		B	17%	19%
		C	46%	32%
		D	21%	16%
		F	10%	26%

In the 2009-2010 school year, 85% (4,868) of the 6th grade students attended one of the OEE experiences (Sklarew, 2010, and PWCS Office of Accountability, 2011). As discussed above, students completed 954 valid, pre-OEE surveys and 1,385 valid post-OEE surveys. Table 6 summarizes the students' survey responses. Of note, half of the students correctly identified their watershed pre-OEE, and this rose to nearly two-thirds of students correctly identifying their watershed post-OEE. Similarly, post-OEE, half of the students correctly identified where their water drains – an alternate means of asking them to identify their watershed. Alternatively, even post-OEE, only 7% of the students correctly <u>defined</u> watershed using "land area" and "drainage" in their definition (a free-text response) (post-OEE, 31% defined watershed using "land area" *or* "drainage"). With regard to pollutants, post-OEE only one-fifth of the students correctly identified <u>all three</u> of the top 3 watershed pollutants (phosphorous, sediment, nitrogen). Finally, these results indicate a potential negative impact of the OEE on the students' ability to *accurately* assess the health of the Chesapeake Bay. Pre-OEE, less than half of the students gave it a C, and this decreased to one-third of the students post-OEE. The most recent report cards for this timeframe gave it a C (Chesapeake Ecocheck, 2010) and a D+ (Chesapeake Bay Foundation, 2010). Notably, A and B responses did not change significantly, C and D responses decreased, and F responses increased.

Research Questions

Research Question 1: What is the impact of a teacher's pre-learning workshop in improving the teachers':

a. confidence in teaching about watersheds; and
b. ability to incorporate outdoor lessons into classroom curriculums?

Table 7 – Kendall's tau-b Test Results Regarding Teacher Confidence

	ConfTeach	ConfInt	ConfOutd	ConfRsrch	ConfCollect	ConfAnalyze	ConfGuide
Correlation Coefficient	0.55	0.539	0.696	0.527	0.659	0.544	0.474
Sig. (2-tailed)	0.001	0.001	0.000	0.001	0.000	0.001	0.003

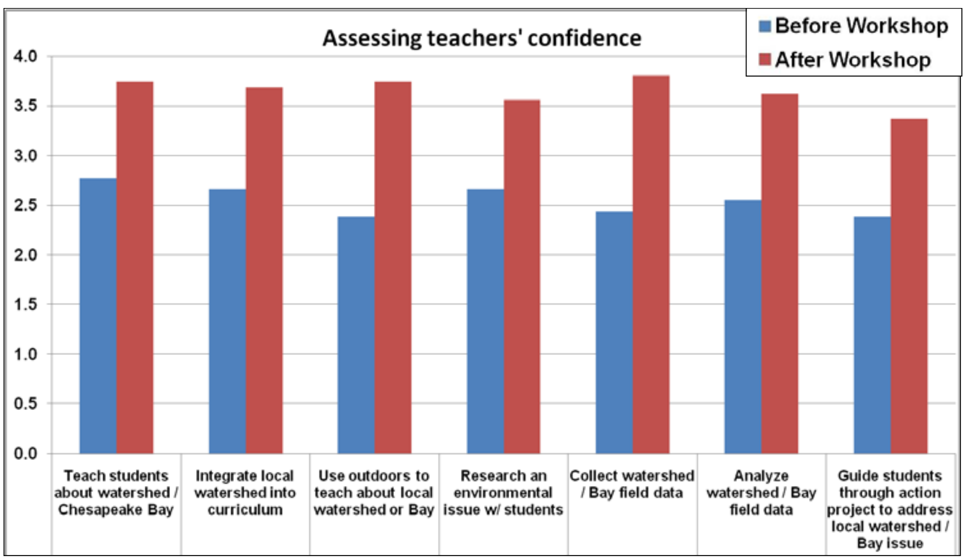

Figure 9 – Assessing Teachers' Confidence

Fifteen teachers that participated in the workshop completed both the pre- and post-workshop questionnaires. Table 7 indicates the results of the Kendall's tau-b test to address teachers' confidence in teaching about watersheds. The results indicate that we can reject the null hypotheses that the workshop has no impact ($p \leq 0.05$). In this case, the workshop improved the teachers' confidence to teach about watersheds (Figure 9).

Table 8 – Kendall's tau-b Test Results Regarding Teacher Intentions

	IntTeach	IntOutd	IntRsrch	IntGuide
Correlation Coefficient	0.09	0.542	0.302	0.33
Sig. (2-tailed)	0.603	0.001	0.064	0.043

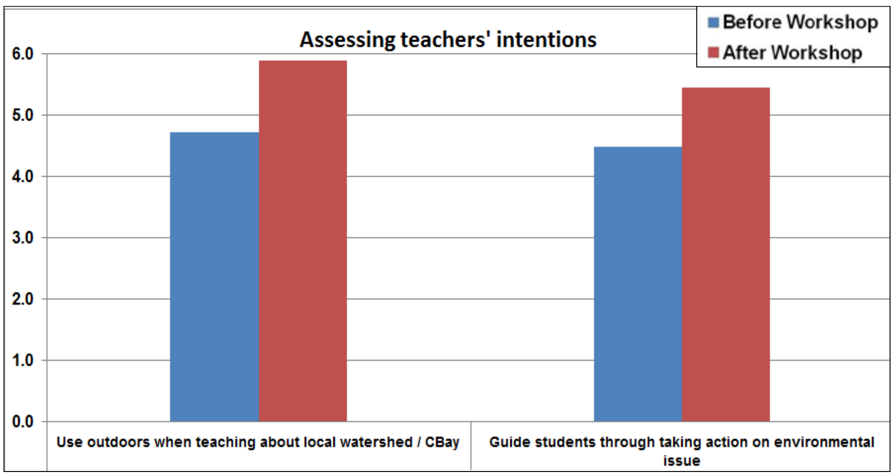

Figure 10 – Assessing Teachers' Intentions

Similarly, Table 8 indicates the results of Kendall's tau-b test to address teachers' intentions in teaching about watersheds. In this case, the results are varied. These results indicate that we fail to reject the null hypothesis for teachers' intention to teach about local watersheds (IntTeach) and teachers' intention to research environmental issues with students (IntRsrch) ($p \leq 0.05$). In this case, the workshop had no impact on the teachers' already high intentions in these areas. Alternatively, we can reject the null hypothesis for the other two variables – intention to use the outdoors when teaching about the local watershed (IntOutd) and intention to guide the students through taking action on an environmental issue (IntGuide) ($p \leq 0.05$). These results indicate that the workshop improved teachers' intentions in these two areas (Figure 10).

Teachers' comments in the workshop evaluations reflected the literature reviewed with respect to the difficulties in implementing lessons viewed as additions to the already burdened curriculum. Like elsewhere, teachers cited "lack of time" and "lack of materials" as to why they did not implement similar watershed lessons or experiences in their watershed curriculum. After the workshop, teachers indicated that they were more confident in teaching about watersheds and using the outdoors to integrate these lessons into their watershed curricula.

Research Question 2: What is the impact of an outdoor environmental education (OEE) experience on 6th grade students' watershed knowledge?

Table 9 – Pearson's Chi Square Results for watershed knowledge

	AtdOEE	Landareaanddrang	Macro
Chi-Square	79.419	1926.95	20.88
df	1	1	1
Asymp. Sig.	0.00	0.00	0.00

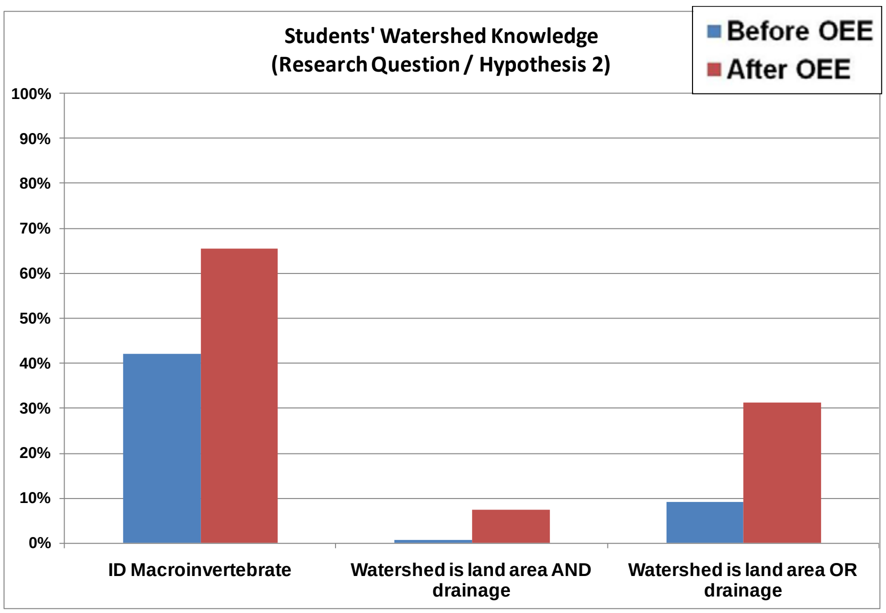

Figure 11 – Students' Watershed Knowledge

Table 9 indicates the results of a Pearson's Chi-square test to address the OEE impact on students' watershed knowledge based on their ability to correctly define *watershed* – deemed correct if they incorporated "land area" and "drainage" (a free-text response) – and *macroinvertebrate* – "organisms without a backbone that are large enough to see without using a microscope" (a multiple choice question). The results indicate that we can reject the null hypotheses that the OEE has no impact ($p \leq 0.05$).

Based on the survey results, 65% of the students correctly defined *macroinvertebrate* after the OEE (vs. 42% before the OEE) and 7% of the students correctly defined *watershed* (vs. 0.6% before). Of note, 9% of students defined watershed using *land* area or drainage pre-OEE, while 31% did post-OEE. This might indicate that the students did not know to note both aspects when they answered this question. In general, the OEE improved students' watershed knowledge (Figure 11), albeit not as dramatically as an educator might like.

Research Question 3: What is the impact of an OEE experience on 6th grade students ability to identify:

a. impervious surfaces;
b. sources of watershed pollution;
c. pollution mitigation activities; and
d. their own watershed?

Table 10 – Pearson's Chi Square Results for watershed issues

	AtdOEE	CorrectID3Pltnts	Impervious	pkuptrsh	rccle	buffer	chem	AnyChes PotOccAtl	WshedID
Chi-Square	79.4	1356.12	459.76	2.16	1322.82	1600.78	1732.44	16.26	342.46
Df	1	1	1	1	1	1	1	1	1
Asymp. Sig.	0.00	0.00	0.00	0.142	0.00	0.00	0.00	0.00	0.00

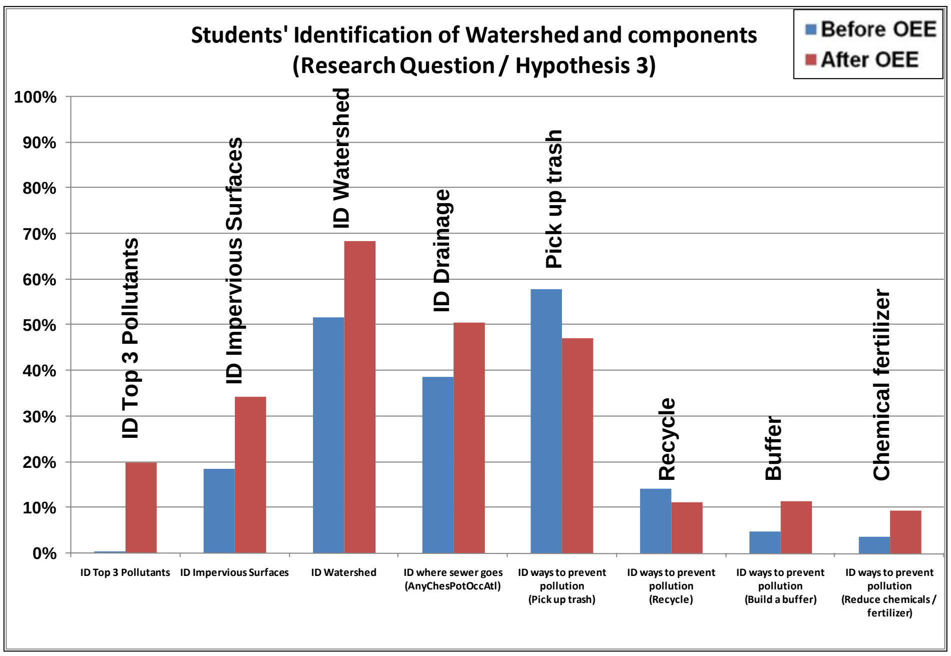

Figure 12 – Students' Identification of Watershed and components

Table 10 indicates the results of a Pearson's Chi-Square test to address the OEE impact on students' ability to identify their own watershed – Occoquan, Potomac, Chesapeake, or Atlantic – and associated watershed issues. *Watershed issues* were defined by the student's ability to correctly identify impervious surfaces - tennis courts, roads, and parking lots, and their ability to correctly identify the top three pollutants in a watershed – nitrogen, phosphorous, and sediment. With the exception of "picking up trash" to prevent pollution and based on a two-sided test, the results indicate that we can reject the null hypotheses that the OEE has no impact ($p \leq 0.05$) in each case. The OEE impact on "picking up trash" response was not statistically significant. In general, the OEE improved students' ability to identify their watershed and knowledge of watershed issues (Figure 12).

As indicated in Figure 12, the OEE impact varied with respect to students' identification of ways to prevent pollution. Of note, "recycle" decreased while "build buffers" and "use less chemicals / fertilizer" increased. This is reflective of the lesson plans included in this curriculum, which emphasize preventing pollution through riparian buffers, filtration, and using less fertilizers. While recycling was not an explicit part of the lessons, the OEE resulted in significantly fewer students citing "recycling" as a pollution prevention method. This may be due to students' attention focusing on newly learned pollution prevention means over a previously ingrained one. By contrast, although this analysis indicated that this OEE's impact on "pick up trash" was not statistically significant, it is worth noting that approximately half of the students indicated this as a way to prevent pollution before (58%) and after (47%) the OEE. This likely reflects the general pervasiveness of the idea that individuals can "simply" pick up trash to prevent pollution. These results indicate that after the OEE more students are conscious of more methods to prevent watershed pollution.

Research Question 4: What is the impact of an OEE experience on 6th grade students' ability to accurately assess the overall health of the Chesapeake Bay??

Table 11 – CBGrade Independent Samples t-Test Results (mean)

		t-test for Equality of Means			
		t	Df	Sig. (2-tailed)	Mean Difference
CBGrade	Equal variances assumed	4.3	2337	.000	.20069
	Equal variances not assumed	4.47	2280.9	.000	.20069

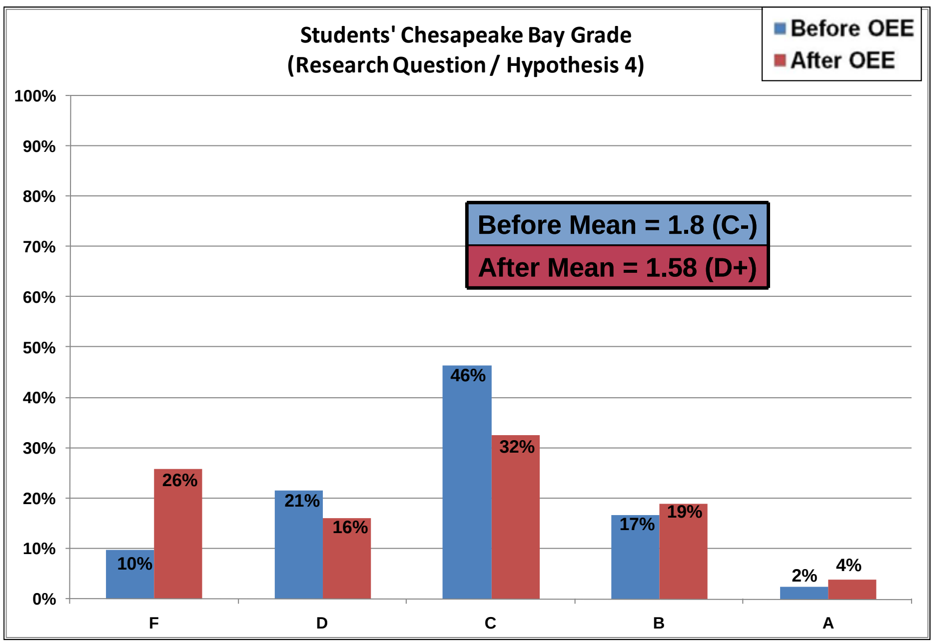

Figure 13 – Students' Chesapeake Bay Grade

Table 11 indicates the results of an independent samples t-test to address the OEE impact on students' ability to grade the health of the Chesapeake Bay (CBGrade). The results indicate that we can reject the null hypotheses that the OEE has no impact ($p \leq 0.05$). This indicates that the OEE impacted the students' ability to grade the health of the Chesapeake Bay. The average grade attributed to the Chesapeake Bay health in the pre-OEE responses was 1.8 (a C- on a 4.0 scale) while the average grade attributed to the Chesapeake Bay health in the post-OEE responses was 1.6 (a D+ on a 4.0 scale). In 2009, the University of Maryland's Center for Environmental Science Chesapeake Bay grade was a C (Chesapeake Ecocheck, 2010), while the Chesapeake Bay Foundation's 2010 grade was a D+ (31 points), up from a D (28 points out of 100) in 2008 (Chesapeake Bay Foundation, 2010).

Overall, the results indicate that the OEE impacted the students' ability to accurately grade the health of the Chesapeake Bay based on the collective means before and after the OEE. Positive or negative interpretation of these results depends on the official Chesapeake Bay grade that is referenced (C or D+). As Figure 13 indicates, this manifests itself in the C, D, and F grades. The percentage of A and B responses did not change significantly from before to after the OEE. After the OEE, C and D responses decreased while F responses increased. This may be indicative of interpreter delivery – some interpreters may leave the students with the idea that the Chesapeake Bay is in worse condition than it actually is, or students may be judging the results of the field tests they conducted to be more ominous than they really are. Alternatively, when compared to the Chesapeake Bay Foundation's 2010 grade (D+), the students' post-OEE assessment of a D+ is a more accurate assessment, thus the OEE would have a positive impact on the students' ability to accurately assess the health of the Chesapeake Bay.

Results Summary

This study indicates that this teacher workshop impacts teachers' confidence and intentions in using the outdoors to teach about watersheds, and leading students through practical lessons or projects to address watershed issues. With respect to the student OEE, the results of the student surveys show that, overall, the OEE portion of this watershed curriculum has a measurable impact on students' knowledge and understanding of their watershed.

Table 12 – Statistical Results Summary

<table>
<tr><th colspan="2">Research Question (RQ) / Hypothesis</th><th>Statistical Results</th></tr>
<tr><td rowspan="2">Hypothesis # 1: Teachers' Confidence and Intentions</td><td>• Confidence in teaching about watersheds</td><td>Reject Null Hypothesis</td></tr>
<tr><td>• Ability (intentions) to incorporate outdoor lessons into classroom curriculum</td><td>Fail to reject Null Hypothesis (IntTeach, Int Rsrch)

Reject Null Hypothesis (IntOutd, IntGuide)</td></tr>
<tr><td rowspan="2">Hypothesis #2: Students' Watershed knowledge</td><td>• Correctly define a watershed</td><td>Reject Null Hypothesis</td></tr>
<tr><td>• Correctly define macroinverterbrate</td><td>Reject Null Hypothesis</td></tr>
<tr><td rowspan="4">Hypothesis #3:
Students' ability to identify watershed components and issues</td><td>• Correctly identify top three pollutants in a watershed</td><td>Reject Null Hypothesis</td></tr>
<tr><td>• Correctly identify impervious surfaces</td><td>Reject Null Hypothesis</td></tr>
<tr><td>• Identify ways to prevent pollution
o Pick up trash
o Recycle
o Build a buffer
o Reduce chemicals</td><td>
Fail to Reject Null Hypothesis
Reject Null Hypothesis
Reject Null Hypothesis
Reject Null Hypothesis</td></tr>
<tr><td>• Correctly identify their watershed</td><td>Reject Null Hypothesis</td></tr>
<tr><td>Hypothesis #4: Students' ability to grade the health of the Chesapeake Bay</td><td>• Health grade for the Chesapeake Bay</td><td>Reject Null Hypothesis</td></tr>
</table>

Table 12 summarizes the results of 12 hypothesis tests. With exceptions in two of the teachers' intentions and the students' pollution prevention methods, these results reject the null hypotheses that the teacher workshop and the student OEE experience have no impact. As above, this evaluation indicates that the teacher workshop impacts teachers' confidence and intentions in teaching about watersheds and the OEE impacts students' knowledge of watersheds, familiarity with watershed issues, and the ability to accurately assess the health of the Chesapeake Bay.

These results are consistent with a 2007 independent evaluation of NOAA's Chesapeake BWET program, assessing impacts of both teachers' professional development and students' watershed training. Kraemer et al. (2007) found that a professional development program improved teachers' confidence and intentions, especially when the material presented to the teachers during the professional development included examples of students' improved academic achievement (e.g., higher standardized test scores) or students being more engaged in the learning process. For students, the 2007 evaluation indicated that the MWEEs improved some environmental stewardship characteristics, improved students' knowledge of watershed issues, and had a moderate impact on students' knowledge of ways to protect a watershed (Kraemer et al., 2007). With respect to teachers' improved confidence and intentions and students' improved watershed knowledge and awareness of watershed issues, the results presented here for Prince William County Public Schools are consistent with the 2007 evaluation results.

Prince William County Public Schools and George Mason University have created and implemented a difference-making 6th grade curriculum. With respect to sustaining this sort of program, an evaluation conducted by Virginia's Office of Environmental Education emphasized the need for community partnerships and the importance of the lead teacher in sustaining MWEE programs (Underwood, 2010). Because this program – "From the Mountains to the Estuary: From the Schoolyard to the Bay" – was designed and co-led by university professors and dedicated staff in the PWCS' Office of Science and Family Life Education, with support from local national park and wildlife refuge officials, prospects appear good for it being sustained by this strong community partnership.

6 – DISCUSSION

Assumptions and Limitations

The following assumptions apply to teacher questionnaire completion:

1. Teachers completed the questionnaires voluntarily and anonymously.
2. The small sample size required statistical tests not dependent upon assumptions regarding normally distributed data.
3. PWCS science teachers self-selected to participate in the workshop and were required to attend the subsequent PLCs to receive a monetary stipend, which may have impacted the pre-program level of knowledge.

The following assumptions apply to student survey completion:

4. Students completed the surveys voluntarily and anonymously (only a coded identification number was included on the survey).
5. Students were provided an ample amount of time to complete all survey questions.
6. Survey responses were based on each student's watershed knowledge before and after the OEE. Those administering the surveys did not provide answers or "coach" the students in any way.

7. The timing of survey completion did not distinguish whether students had completed the in-class portion of the watershed curriculum nor did account for the time between pre-OEE survey completion, receiving the OEE, and post-OEE survey completion.
8. Students only participated in one watershed OEE during the school year.

Violating any of these assumptions might impact these results and make them inaccurate. Any pressure on students to complete the survey, coaching about the answers, or participation in more than one OEE might skew the results to indicate that the OEE was more significant in improving the students' watershed knowledge.

With respect to assumptions six, seven, and eight, the students' results may be impacted by the timing of survey completion. Prince William County 6^{th} grade teachers completed the classroom portion of the watershed curriculum at different times during a given school year, thus not all 6^{th} graders receive watershed lessons at the same time (PWCS, 2011). The OEE component of the watershed curriculum was not scheduled in conjunction with an individual schools' or classrooms' watershed lessons, and each teacher administered the surveys to their students at a time of their choosing.

While pre-surveys were administered at some point before the OEE, they may have been administered before or after the in-class watershed lessons. Similarly, while the post-surveys were administered after the OEE, they may have been administered before or after the in-class watershed lessons or at different times since the OEE – e.g., some teachers may have waited until the end of the school year while others administered it immediately upon return from the OEE.

This research did not evaluate the results based on the timing of in-class watershed lessons relative to the OEE or survey completion. The number of valid survey responses makes it unlikely that this would affect a significant portion of the students. This also added to the randomness of the survey responses making it unlikely that the timing of survey completion would impact the results.

The anonymous coding was originally intended to provide the ability to analyze the results demographically or per individual school. Some identification numbers were missing and others did not follow the rubric to generate the number. While this did not prevent assessing the before and after results, it limits accurately scrutinizing the data at an individual respondent level and prevents grouping the responses by location or individual student. This study did not account for the variety of socio-economic factors that may impact students' pre- and post-OEE knowledge nor did it address the quality of education at County middle schools. Finally, this study did not factor in the varying levels of student aptitude.

Given the above assumptions and limitations of this study, the number of completed student surveys both pre- and post-OEE provided a random and representative sample of 6th grade students in Prince William County, irrespective of demographics, specific school or teacher, or curriculum timing. This randomness supports the representative nature of this study and supports the assessment of the analysis results.

Conclusions

Integrating a teacher pre-learning workshop and an OEE experience into a 6th grade watershed curriculum can be effective tools to improve teachers' confidence and intentions in incorporating additional watershed lessons as well as improving students' watershed knowledge. Based on the literature reviewed, this program can be categorized as an integrative model of program development.

The curriculum developed by PWCS and GMU offers these and other teachers a ready-made tool to teach watershed lessons. Furthermore, the cooperative process that GMU and PWCS used to develop the program is an effective way to encourage program sustainability, impact, and success while also addressing the teachers' lack of time, materials, and administrative support. A school systems' partnership with a local university could provide access to extensive research, tools, and subject matter expertise to leverage in a K-12 school system, as it did in this case.

Finally, this program laid the groundwork for students' awareness and understanding of their place in the natural environment and provided them an early set of tools to address environmental problems, satisfying two of the environmental education goals of the Belgrade Charter and Tblisi Declaration. This research indicates that the first-year of this program was a success.

Implications for Future Outdoor Environmental Education

This study indicates that this program is largely effective in improving teachers' confidence and intentions in teaching about watersheds and using the outdoors a tool to amplify their curriculum. The OEE incorporated into this watershed curriculum impacts students' overall watershed knowledge and understanding of the watershed and its issues. While this program benefitted from the integrative and cooperative development style between a school system and university, this might be restricted to the personnel involved rather than the actual institutions.

The presence of optimistic and resourceful program coordinators and educators and field interpreters that are excited about working together and motivated to provide these lessons might not be a common phenomenon in other locales. Similarly, the field interpreters' varied backgrounds and teaching styles might impact the students' learning abilities and could result in a less-than-effective OEE. Future OEEs should not only be sure to enlist resourceful and motivated program coordinators (as modeled here), they should also conduct periodic, in-stride interpreter evaluations by experienced educators to ensure appropriate and correct information delivery. This would ensure the sustainability and repeatability of a successful program.

Upon request, some teachers provided their e-mail address to be contacted for follow-up interviews about their schoolyard stewardship projects (a post-OEE activity). While these stewardship projects were not a part of this evaluation, it would be useful in future evaluations to interview teachers for a longitudinal assessment of program effectiveness.

Implications for Future Research

In Virginia, the Virginia Department of Environmental Quality (DEQ) coordinates the Commonwealth's environmental education program, Virginia Naturally (VA Naturally). Part of this coordination is promoting and funding grants to enable Meaningful Watershed Educational Experiences (MWEEs). These grants either come from the National Oceanic and Atmospheric Administration's (NOAA) Bay Watershed Education and Training (BWET) program (e.g., the GMU-PWCS BWET project) or through grant or mini-grant programs sponsored or coordinated by VA Naturally. By providing a centralized source of information, the VA Naturally program helps formal and informal educators find program materials and funding opportunities to deliver their programs.

NOAA's BWET program provides periodic workshops to assist in understanding some of these tools to evaluate BWET programs. Additionally, the North American Association for Environmental Education (NAAEE) offers a resource guide to evaluate environmental education programs (Ernst et al., 2009). These tools, among others, should be examined and possibly implemented to develop long-term evaluations of the range of programs in Virginia to justify continued funding for those that are effective in changing behaviors. As Louv (2005) emphasizes in his seminal work, *Last Child in the Woods*, without effective environmental education programs, we will have difficulty overcoming the nature-deficit disorder of future generations.

APPENDIX A

	PWC Objectives and Virginia Standards of Learning				
	6.1 Science Process Skills	**6.4 Nature of Matter**	**6.5(b) Earth's Waters: Role in the Environment**	**6.7 Watershed Ecology**	**6.9: Natural Resources and Public Policy**
Objective (The student will….)	…plan and conduct investigations that are increasingly sophisticated and involve a refinement of science process skills.	…investigate and understand that all matter is made up of atoms.	… investigate and understand the role of water in the natural and human-made environment.	…investigate and understand the natural processes and human interactions that affect watersheds systems.	…will investigate and understand public policy decisions relating to the environment.
Key Concepts (with corresponding SOL number)	➢ Making observations involving fine discrimination between similar objects and organisms (6.1a) ➢ Recording precise and approximate measures (6.1c) ➢ Using scale models to estimate distance, volume, and quantity (6.1d) ➢ Stating hypotheses in ways that identify the independent (manipulated) and dependent (responding) variables (6.1e) ➢ Devising a method to test the validity of predictions and inferences (6.1f) ➢ Manipulating one variable over time with repeated trials (6.1g) ➢ Collecting, analyzing, and reporting data using appropriate metric measurement (6.1h) ➢ Organizing and communicating data through graphical representations (graphs, charts, diagrams) (6.1i) ➢ Developing and reinforcing an understanding of the nature of science (6.1k)	➢ Chemical symbols (6.4c) ➢ Chemical formulas (6.4e) ➢ Elements that comprise solid Earth, living matter, oceans, and atmosphere (6.4g)	➢ The origin and occurrence of water on Earth (6.5e) ➢ The importance of water for agriculture, power generation, and public health (6.5f) ➢ The importance of protecting and maintaining water resources (6.5g)	➢ The health of ecosystems and the abiotic factors of a watershed (6.7a) ➢ The location and structure of Virginia's regional watershed systems (6.7b) ➢ Divides, tributaries, river systems, and river and stream processes (6.7c) ➢ Wetlands (6.7d) ➢ Estuaries (6.7e) ➢ Major conservation, health, and safety issues associated with watersheds (6.7f) ➢ Water monitoring and analysis using field equipment including hand-held technology (6.7g)	➢ Management of renewable resources and nonrenewable resources (6.9 a-b) ➢ The mitigation of land-use and environmental hazards through preventive measures (6.9c) ➢ Conservation policies, including consideration of costs and benefits (6.9d)

APPENDIX B

Prince William County
PUBLIC SCHOOLS
Providing A World-Class Education

Itinerary for Field Experience to E.A.G.L.E.S. Center &
Occoquan Bay National Wildlife Refuge

(Please allow enough travel time to arrive
10 minutes prior to program start)

Bus 1 (Groups 1 & 2)		**Bus 2 (Groups 3& 4)**	
9:45	**Students arrive at Occoquan Bay Refuge**	**9:45**	**Students arrive at E.A.G.L.E.S. Center**
9:50-10:30 **10:35-11:15**	Students will rotate between 2 stations a. macroinvertebrates b. water quality	**9:50-10:30** **10:35-11:15**	Students will rotate between 2 stations a. watersheds/human interactions b. watershed management
11:15-11:30	Travel to E.A.G.L.E.S. Center-Snack on bus	**11:15-11:30**	Travel to Refuge-Snack on bus
11:35-12:15 **12:20-1:00**	Students will rotate between 2 stations a. watersheds/human interactions c. watershed management	**11:35-12:15** **12:20-1:00**	Students will rotate between 2 stations a. macroinvertebrates b. water quality
1:00	Students depart E.A.G.L.E.S. Center Lunch on bus	**1:00**	Students depart Refuge Lunch on bus

Tentative Itinerary for Field Experience Manassas Battlefield
9:45 a.m. -1:00 p.m.

Bus 1 (Groups 1, 2, & 3)		**Bus 2 (Groups 4, 5, & 6)**	
9:45	**Students arrive at Site**	**9:45**	**Students arrive at Site**
9:50-10:40 **10:45-11:35** **11:40-12:30**	Students will rotate between 3 stations c. macroinvertebrates d. water chemistry/human interactions e. topographic maps/wetlands	**9:50-10:40** **10:45-11:35** **11:40-12:30**	Students will rotate between 3 stations a. macroinvertebrates b. water chemistry/human interactions c. topographic maps/wetlands
12:30-1:00	Lunch	**12:30-1:00**	Lunch
1:00	Students depart	**1:00**	Students depart

APPENDIX C

Student Data Sheet for Watershed Investigations

Name:_______________________________ **Date:**_______________

Water Quality

Bare Soil Around Water: (Circle One)	**Excellent**	**Good**	**Fair**	**Poor**
	0 - 10 %	11 - 40 %	41 - 80 %	81 - 100 %

Water Appearance: Color_____________________________________

Clarity_____________________________________

Water Odor: _____________________________________

Intensity (faint, distinct, strong) ___________________________

Temperature (Degrees C): **Air**_________ **Water**__________

	Excellent	Good	Fair	Poor
Dissolved oxygen ppm	7-11	5-6	3-4	0-2
% Saturation	91-110	71-90	51-70	Less than 50
pH	7	6 or 8		4, 5, 9, 10, 11
Nitrate ppm	0	1-4	5	Higher
Phosphate ppm	0 - 1	2	4	Higher
Turbidity (JTU)	0	0 to 40	40 to 100	100

Macroinvertebrates

1. How many different types of organisms did your group find? _______________

Choose one organism that your group collected to further investigate.

2. Examine your organism with the hand lenses, viewers, and/or Brock scopes.

3. Name of organism: ______________________________

4. Is your organism listed on the biotic index? ___________ If yes, in what type of water quality can your organism survive?_______________

5. List three factors that might influence the number and kinds of organisms that you found:
   a. ______________________
   b. ______________________
   c. ______________________

APPENDIX D

Year 1 - <u>Teacher Pre-Workshop questionnaire</u>

UniqueID: _________ (last 4 digits of your cell phone number + last 2 numbers of your current zip code)

e.g., if the last 4 digits of my phone number are 7172, and I live in zip-code 23112, I would write **717212**

Please remember this number so it can be used on a follow-up questionnaire / survey later in the area (some suggestions are to add it to your phone contact list or email it to yourself)

1. At your school, what is the length of a class period (in minutes)? _____ minutes

2. About how many class periods (including integrated courses) do you spend on watershed ecology?

   _________ class periods

3. What subject(s) do you teach? (check all that apply)

____ Science	____ Math	____ Social studies
____Language arts	____ Fine arts	____ Other (e.g., ESOL)

Use this scale to answer the following question:

1=Not at all confident, 2=Somewhat confident, 3=Very confident, 4=Extremely confident

4. Based on the above scale, how confident are you in your ability to:

a. Teach students about the local watershed or the Chesapeake Bay	1	2	3	4
b. Integrate local watershed or Bay lessons into your required curriculum	1	2	3	4
c. Use the outdoors to teach about your local watershed or the Bay	1	2	3	4
d. Research an environmental issue with your students	1	2	3	4
e. Collect watershed or Bay data in the field	1	2	3	4
f. Analyze watershed or Bay data	1	2	3	4
g. Guide students through an action project that addresses a local or Bay environmental issue	1	2	3	4

5. For the question above where you indicated a 1 or 2 (*not at all* or *somewhat* confident), list key reasons why this is so and indicate which letter it applies to:

   ____

   ____

   ____

   ____

(Be sure to answer the questions on the back too!)

Use this scale to answer the following question:
1=Extremely unlikely, 2=Very unlikely, 3=Unlikely, 4=Likely, 5=Very likely, 6=Extremely likely

6. Based on the above scale, how likely or unlikely is it that ***YOU*** will ___ during the next school year?
   a. Teach about your local watershed or the Chesapeake Bay
      1 2 3 4 5 6

   b. Use the outdoors when teaching about your local watershed or the Chesapeake Bay
      1 2 3 4 5 6

   c. Research an environmental issue with your students
      1 2 3 4 5 6

   d. Guide your students through taking action on an environmental issue
      1 2 3 4 5 6

7. For the question above where you indicated a 1 or 2 (*extremely* or *very* unlikely), list key reasons why this is so:

____

____

____

8. Do you feel that you provide students a personal connection to the Chesapeake Bay by showing them (outside in their schoolyard) how they are connected to the watershed? YES NO (circle one)

9. If you were to rate the health of the Chesapeake Bay, what grade you would you give it? (circle one)

   A B C D F

10. In the previous question, why did you give it this grade?

____

____

11. For questions 9 & 10, how do you know this?
    a. I heard it on the radio
    b. I saw it on TV
    c. I read it in the newspaper – (which one? ___________________)
    d. I read it in a magazine, book, or professional journal– (which one? ________________)
    e. I learned it in school
    f. I read it on-line
    g. Someone told me
    h. It's just my gut feeling

- -

As part of the program evaluation process, if you are willing to be part of a follow-up interview during the school-year, detach this portion at the dotted line above, put your email address here: ______________ @ ________________ **and give this portion to one of the workshop facilitators.**

(***Your email address will <u>only</u> be used to contact you for a follow-up interview***)

APPENDIX E

Year 1 - <u>Teacher Post-Workshop questionnaire</u>

UniqueID: _________ (last 4 digits of your cell phone number + last 2 numbers of your current zip code)

e.g., the last 4 digits of my phone number are 7172, and I live in zip-code 23112, I would write **717212**

Please remember this number so it can be used on a follow-up questionnaire / survey later in the area (some suggestions are to add it to your phone contact list or email it to yourself)

1. Based on what you learned during this workshop, do you plan to incorporate new lessons about watersheds or the Chesapeake Bay in your curriculum / classroom?

__1__	__2__	__3__	__4__	__5__	__6__
Extremely Unlikely	Very unlikely	Unlikely	Likely	Very likely	Extremely likely

---

Use this scale to answer the following question:

1=Not at all confident, 2=Somewhat confident, 3=Very confident, 4=Extremely confident

2. After this workshop and based on the above scale, how confident are you in your ability to:

a. Teach students about the local watershed or the Chesapeake Bay	1	2	3	4
b. Integrate local watershed or Bay lessons into your required curriculum	1	2	3	4
c. Use the outdoors to teach about your local watershed or the Bay	1	2	3	4
d. Research an environmental issue with your students	1	2	3	4
e. Collect watershed or Bay data in the field	1	2	3	4
f. Analyze watershed or Bay data	1	2	3	4
g. Guide students through an action project that addresses a local or Bay environmental issue	1	2	3	4
h. Teach this workshop at your school	1	2	3	4

3. For the question above where you indicated a 1 or 2 (*not at all* or *somewhat* confident), list key reasons why this is so and indicate which letter it applies to:

____

____

____

4. To teach the workshop at your school, what additional support, if any, do you feel you need to be successful?

____

____

____

(Be sure to answer the questions on the back too!)

Use this scale to answer the following question:
1=Extremely unlikely, 2=Very unlikely, 3=Unlikely, 4=Likely, 5=Very likely, 6=Extremely likely

5. After this workshop and based on the above scale, how likely or unlikely is it that you will ___ during the next school year?
   a. Teach about your local watershed or the Chesapeake Bay
      1 2 3 4 5 6
   b. Use the outdoors when teaching about your local watershed or the Chesapeake Bay
      1 2 3 4 5 6
   c. Research an environmental issue with your students
      1 2 3 4 5 6
   d. Guide your students through taking action on an environmental issue
      1 2 3 4 5 6

6. For the question above where you indicated a 1 or 2 (*extremely* or *very* unlikely), list key reasons why this is so:

   ____

   ____

   ____

7. Based on my experience at this workshop, I would recommend it to my colleagues (circle choice)

1=Extremely unlikely, 2=Very unlikely, 3=Unlikely, 4=Likely, 5=Very likely, 6=Extremely likely

---

8. Overall, the materials, and lessons provided during this workshop were:

__1__	__2__	__3__	__4__	__5__
Poor	Fair	Good	Very Good	Excellent

9. For this workshop, what lesson(s) or activities will help you the most in your teaching?

   ____

   ____

   ____

10. For this workshop, what could we improve?

   ____

   ____

   ____

THANKS FOR COMING and THANKS FOR COMPLETING THIS SURVEY!!

APPENDIX F

September 2009

Year 1 – Student questionnaire

UniqueID: _________ (last 4 digits of your home phone number + last 2 numbers of your current zip code)
If the last 4 digits of my phone number are 7172, and I lived in zip-code 23112, I would write ***717212***

Please answer the following questions:

1. What is a watershed?

   ____

   ____

2. Of the following, what are the top three (3) pollutants in a stream: (Place a check in 3 blanks)

   ___ a. plastic bags
   ___ b. tires
   ___ c. phosphorous
   ___ d. medicine
   ___ e. oil
   ___ f. oxygen
   ___ g. sediment
   ___ h. battery acid
   ___ i. hospital needles
   ___ j. grass
   ___ k. trash
   ___ l. carbon
   ___ m. cow manure
   ___ n. nitrogen
   ___ o. radiation
   ___ p. kool-aid
   ___ q. gasoline
   ___ r. uranium

3. Which of the following are impervious? (**check all that apply**)

   ___ a. tennis courts
   ___ b. wetlands
   ___ c. roads
   ___ d. parking lot
   ___ e. soccer fields
   ___ f. lawns
   ___ g. gardens
   ___ h. I don't know

4. Describe one (1) way you can prevent pollution from entering your local stream:

   ____

   ____

5. What is a macroinvertebrate? (choose one)

   ___ a. Animals that are too small to see without using a microscope
   ___ b. Large -organisms that have a backbone and live in the water .
   ___ c. Animals that breathe oxygen underwater, such as small fish and tadpoles.
   ___ d. Organisms without a backbone that are large enough to see without using a microscope.
   ___ e. Any living thing that has a backbone.

(Be sure to answer the questions on the back too!)

Page 1 of 2

6. In the United States, what activities use the most water? (*Rank these from 1 to 5; #1 uses the <u>most</u> water and 5 uses the least):

 ___ a. Irrigation (watering lawns and farm crops)
 ___ b. Public supply (drinking water, toilets and showers)
 ___ c. Thermoelectric power (dams on rivers that generate electricity)
 ___ d. Domestic livestock, fish farming, (giving drinking water to animals like cows, pigs, chicken etc…)
 ___ e. Water used to cool nuclear plants, build cars, manufacture things, etc….

7. In your neighborhood, where does the water that runs into the sewer end up?

 ____

 ____

8. If you were to rate the health of the Chesapeake Bay, what grade you would you give it? (circle one)

 A B C D F

9. Why did you give the Chesapeake Bay this grade?

 ____

 ____

10. How do you know information about the Bay??

 a. I heard it on the radio
 b. I saw it on TV
 c. I read it in the newspaper – (which one? ___________________)
 d. I read it in a magazine or book – (which one? ___________________)
 e. I learned it in school
 f. I read it on-line
 g. Someone told me
 h. It's just my gut feeling

11. Is there any kind of pollution from your school that pollutes local streams? YES NO (Circle one)

If you circled YES, please list the type(s) of pollution: ____

12. What is the name of the watershed where you live?

REFERENCES

REFERENCES

Archie, M. (2001). Environmental Education - Moving into the Educational Mainstream. *ASCD Policy Priorities – August 2001*. Retrieved from http://www.ascd.org/publications/newsletters/policy-priorities/aug01/num26/toc.aspx.

Bailie, P. (2010). From the One-Hour Field Trip to a Nature Preschool. *YC: Young Children*, 65(4), 76-82.

Berman, E. (2007). *Essential Statistics for Public Managers and Policy Analysts*. Washington, DC: CQ Press.

Bonnett, M. (1999). Education for Sustainable Development: a coherent philosophy for environmental education?. *Cambridge Journal Of Education*, 29(3), 313.

Bowers, C.A. (1993). *Education, cultural myths, and the ecological crisis: toward deep changes*. Albany, NY: State University of New York Press.

Cantwell, Evan. (2009, October). Prince William Watershed Field Trips. Provided by Evan Cantwell, George Mason University Creative Services.

Carleton-Hug, A., & Hug, W. (2010). Challenges and opportunities for evaluating environmental education programs. *Evaluation and Program Planning*, 33:2, 159-164.

Chawla, L., & Cushing, D. (2007). Education for strategic environmental behavior. *Environmental Education Research*, 13: 4, 437 – 452.

Chesapeake Bay Foundation (CBF). (2004). A Guide to Creating Meaningful Watershed Experiences. Retrieved from http://www.cbf.org/Document.Doc?id=190.

Chesapeake Bay Program (CBP). (2010). Meaningful Watershed Educational Experience (MWEE). Retrieved from http://www.chesapeakebay.net/education_mwee.aspx?menuitem=19534.

Chesapeake Ecocheck. (2010). *Chesapeake Bay Report Card 2009*. Oxford, MD: Integration and Application Network, University of Maryland Center for Environmental Science, and EcoCheck.

Chesapeake Bay Foundation. (2010). *2010 State of the Bay*. Annapolis, MD: Chesapeake Bay Foundation.

Comstock, A. B. (1939). *Handbook of Nature Study*. Ithaca, NY: Comstock Publishing Company.

Culen, G. R. (1998). The Status of Environmental Education with Respect to the Goal of Responsible Citizenship Behavior. In H. Hungerford, W. Bluhm, T. Volk, & J. Ramsey (Eds.), *Essential Readings in Environmental Education* (pp 37-46). Champaign, IL: Stipes Publishing.

Cutter-Mackenzie, A., & Smith, R.. (2003). Ecological literacy: the 'missing paradigm' in environmental education (part one). *Environmental Education Research*, 9:4, 497-524.

Dillon, J., Rickinson, M., Teamey, K., Morris, M., Choi, M. Y., Sanders, D., & Benefield, P. (2006). The value of outdoor learning: evidence from research in the UK and elsewhere. *School Science Review*, 87:320, 107-111.

Environmental Protection Agency. (2010, May 11). EPA Reaches Settlement in Chesapeake Bay Lawsuit. Retrieved December 5, 2011, from http://yosemite.epa.gov/opa/admpress.nsf/0/ac46af32562521d48525772000591133.

Ernst, J. (2007). Factors Associated with K-12 Teachers' Use of Environment-Based Education. *The Journal of Environmental Education*, 38:3, 15-31.

Ernst, J. A., Monroe, M. C., & Simmons, B. (2009). *Evaluating Your Environmental Education Programs: A Workbook for Practitioners*. Washington, DC: North American Association for Environmental Education.

Exec. Order No. 13,508, 3 C.F.R. 23099 (2010 comp.).

Federal Leadership Committee for the Chesapeake Bay. (2010). *Executive Order 13,508 – Strategy for Protection and Restoring the Chesapeake Bay Watershed*. Washington, DC: Environmental Protection Agency.

Franklin, J. (2004). Planting the seeds of knowledge: How environmental literacy helps students achieve. *ASCD Curriculum Update,* Summer 2004. Retrieved from http://www.ascd.org/publications/curriculum-update/summer2004/Planting-the-Seeds-of-Knowledge.aspx.

Gilbertson, K., Bates, T., McLaughlin, T., & Ewert, A. (2005). *Outdoor Education: Methods and Strategies*. Champaign, IL: Human Kinetics.

Greene, J., C. Smith, C., Sklarew, D., Jones, R. C., & Johnson, R. (2009). *From the Mountains to the Estuary: From the Schoolyard to the Bay: Meaningful Watershed Experiences for Grade 6 Students.* Woodbridge, VA: Prince William County Public Schools and Potomac Environmental Research and Education Center, George Mason University. (http://school2bay.pbworks.com/6th-Grade#BookletandLessonPlans)

Gruenewald, D. A., & Manteaw, B. O. (2007). Oil and water still: how No Child Left Behind limits and distorts environmental education in US schools. *Environmental Education Research, 13: 2*, 171 - 188.

Heimlich, J.E., & Ardoin, N. (2008). Understanding behavior to understand behavior change: a literature review. *Environmental Education Research*, 14:3, 215-237.

Hoelscher, D.W. (2009). *Cultivating the Ecological Conscience: Smith, Orr, and Bowers on Ecological Education*. (Unpublished Master's dissertation). University of North Texas, Denton, TX.

Hopkins, C., & McKeown, R. (1999). Education for sustainable development. *Forum for Applied Research and Public Policy*, 14(4), 25-9.

Hungerford, H. R. (1998). The Myths of Environmental Education – Revisited. In H. Hungerford, W. Bluhm, T. Volk, & J. Ramsey (Eds.), *Essential Readings in Environmental Education* (pp 49-56). Champaign, IL: Stipes Publishing.

Hungerford, H., & Volk, T. (1990). Changing learner behavior through environmental education. In H. Hungerford, W. Bluhm, T. Volk, & J. Ramsey (Eds.), *Essential Readings in Environmental Education* (pp 289-304). Champaign, IL: Stipes Publishing.

Jacobson, S. K. (1987). Conservation Education Programmes: Evaluate and Improve Them. *Environmental Conservation*, 14, 201-206.

James River Association (JRA). (2011). Education & Outreach. Retrieved from http://www.jamesriverassociation.org/what-we-do/education-and-outreach.

Keene, M, & Blumstein, D. (2010). Environmental education: A time of change, a time for change. *Evaluation and Program Planning*, 33:2, 201-204.

Kirk, M., Wilke, R., & Ruskey, A. (1993). A Survey of the Status of State-Level Environmental Education in the U.S. In H. Hungerford, W. Bluhm, T. Volk, & J. Ramsey (Eds.), *Essential Readings in Environmental Education* (pp 57-64). Champaign, IL: Stipes Publishing.

Kohlstedt , S. G. (2005). Nature, Not Books: Scientists and the Origins of the Nature ‐ Study Movement in the 1890s. *Isis*, 96(3), 324-352.

Kozicki, S. (2010a). National Environmental Education Foundation (NEEF) - Environmental Education Curricula Library. Retrieved from http://www.eeweek.org/resources/curricula_library.

Kozicki, S. (2010b). National Environmental Education Foundation (NEEF) - Benefits of Environmental Education. Retrieved from http://www.eeweek.org/resources/EE_benefits.htm.

Kraemer, A. M., Zint, M. T., & Kirwan, J. L. (2007). *An Evaluation of National Oceanic and Atmospheric Administration Chesapeake Bay Watershed Education and Training Program Meaningful Watershed Educational Experiences* (OMB Control Number: 0648-0530). Annapolis, MD: NOAA Chesapeake Bay Office.

Lieberman, G. A., & Hoody, L. (1998). *Closing the achievement gap: using the environment as an integrated context for learning*. Poway, CA: Science Wizards.

Louv, R. (2005). *Last Child in the Woods*. Chapel Hill, NC: Algonquin Books.

Monroe, M. (2010). Challenges for environmental education evaluation. *Evaluation and Program Planning*, 33:2, 194-196.

Norusis, M. (2009). *PASW Statistics 18 Statistical Procedures Companion*. Upper Saddle River, NJ: Prentice-Hall Inc.

Orr, D.W. (1994). *Earth in Mind: On Education, Environment, and the Human Prospect*. Washington, DC: Island Press.

Palmer, J. A. (1998). *Environmental Education in the 21st Century*. New York, NY: Routledge.

Peacock, A. (2009). Teaching eco-literacy during a period of uncertainty. *Policy and Practice: A Development Education Review*, 9, 23-38.

Prince William County Public Schools (PWCS). (2010). E.A.G.L.E.S. Center. Retrieved from http://eagles-center.pwcs.science.schoolfusion.us.

Prince William County Public Schools (PWCS). (2011). Science - 6th Grade Overview. Retrieved from http://6th-grade.pwcs.science.schoolfusion.us.

Prince William County Public Schools (PWCS) Office of Accountability. (2011). Virginia Department of Education - Educational Information Management 2009-2010 Fall Verification Report 75 - Prince William County Public Schools [Data file]. Retrieved from: http://accountability.departments.pwcs.edu/modules/groups/homepagefiles/cms/1007118/File/DataAnalysis/State%20Reports/FullTimeStudentEnrollmentbyGrade/Fall09StudentMembership_GenderEthnicity.pdf

Ramsey, J. M., Hungerford, H., & Volk, T. (1992) Environmental Education in the K-12 Curriculum: Finding a Niche. In H. Hungerford, W. Bluhm, T. Volk, & J. Ramsey (Eds.), *Essential Readings in Environmental Education* (pp 109-122). Champaign, IL: Stipes Publishing.

Robottom, I. (1987). Environmental Education as Educational Reform. *Environmental Conservation*, 14, 197-200.

Ruiz-Mallen, I., Barraza, L., Bodenhorn, B., & Reyes-García, V. (2009). Evaluating the impact of an environmental education programme: an empirical study in Mexico. *Environmental Education Research*, 15: 3, 371-387.

Saylan, C., & Blumstein, D. T. (2011). *The Failure of Environmental Education (And How We Can Fix It)*. Los Angeles, CA: University of California Press.

Sebba, R. (1991). The Landscapes of Childhood – The Reflection of Childhood's Environment in Adult Memories and in Children's Attitudes. *Environment and Behavior*, 23:4, 395-422.

Simmons, B., Archie, M., Mann, L., Vymetal-Taylor, M., … Weiser, B., (2010). *North American Association for Environmental Education (NAAEE) – Excellence in Environmental Education: Guidelines for Learning (K-12)*. Washington, DC: North American Association for Environmental Education.

Sklarew, D., & and Jones, R. C. (2008) *From the Mountains to the Estuary: From the Schoolyards to the Bay (grant proposal)*. Fairfax, VA: Potomac Environmental Research and Education Center, George Mason University.

Sklarew, D. (2010). *From the Mountains to the Estuary: From the Schoolyards to the Bay – NA09NMF457000 – Progress Report for December 1, 2009 – May 31, 2010*. Fairfax, VA: Potomac Environmental Research and Education Center, George Mason University.

Smith, G. A. (1999). *Ecological Education in Action: On Weaving Education, Culture, and the Environment*. Albany, NY: State University of New York Press.

Smith, G. A. (2000). Defusing Environmental Education: An Evaluation of the Critique of the Environmental Education Movement. In H. Hungerford, W. Bluhm, T. Volk, & J. Ramsey (Eds.), *Essential Readings in Environmental Education* (pp 363-374). Champaign, IL: Stipes Publishing.

Smith-Sebasto, N.J. & Cavern, L. (2006). Effects of Pre- and Posttrip Activities Associated With a Residential Environmental Education Experience on Students' Attitudes Toward the Environment. *The Journal of Environmental Education*, 37:4, 3-17.

Smithsonian National Air and Space Museum (NASM). (2004). Steven F. Udvar-Hazy Center – Behind the Scenes - Steps taken to preserve the wetlands. Retrieved from http://www.nasm.si.edu/udvarhazy/bts/bts_wetlands.cfm.

Sobel, D. (1996). *Beyond Ecophobia – Reclaiming the Heart in Nature Education*. Great Barrington, MA: The Orion Society.

Sobel, D. (2004). *Place-Based Education: Connecting Classrooms & Communities*. Great Barrington, MA: The Orion Society.

Sobel, D. (2008). *Childhood and Nature – Design Principles for Educators*. Portland, ME: Stenhouse Publishers.

Stapp, W. B. et al. (1969). The Concept of Environmental Education. In H. Hungerford, W. Bluhm, T. Volk, & J. Ramsey (Eds.), *Essential Readings in Environmental Education* (pp 33-36). Champaign, IL: Stipes Publishing.

Stokking, H., van Aert, L., Meijberg, W., & Kaskens, A. (1999). *Evaluating Environmental Education*. Cambridge, UK: International Union for Conservation of Nature and Natural Resources.

Strife, S. (2010). Reflecting on Environmental Education: Where Is Our Place in the Green Movement?, *The Journal of Environmental Education*, 41:3, 179-191.

Sutton, R., Cucurullo, K., Brown, R., & Gorsira, B. (2003). Environmental Assessment – Battlefield Restoration and Picnic Area Construction: The Stuart’s Hill Tract – Manassas National Battlefield Park, Virginia. Retrieved from http://data2.itc.nps.gov/nature/documents/Ea2.doc.

Thomashow, C., & Witham, A. (2008). Center for Environmental Education. Retrieved from http://www.ceeonline.org/.

Underwood, J. (2010). Virginia Naturally Classroom Grant Program Evaluation Conducted by the Virginia Office of Environmental Education For the Virginia Resource-Use Education Council – April 2010. Retrieved from http://www.deq.state.va.us/vanaturally/pdf/mwee_evaluation_report.pdf.

United Nations Educational, Scientific, and Cultural Organization (UNESCO). (2008). *The Contribution of early childhood education to a sustainable society.* Ingrid Pramling Samuelsson and Yoshie Kaga, (Eds.). Paris, France: UNESCO.

United States Environmental Protection Agency (US EPA) – Region 3 – Water Protection Division – Air Protection Division – Office of Regional Counsel. (2010). *Chesapeake Bay Total Maximum Daily Load for Nitrogen, Phosphorus and Sediment*. Philadelphia, PA: U.S. Environmental Protection Agency.

United States Fish and Wildlife Service (US FWS). (2004). U.S. Fish and Wildlife Service Occoquan Bay National Wildlife Refuge. Retrieved from http://library.fws.gov/Refuges/Occoquanbay04.pdf.

Virginia Board of Education (VA BOE). (2003). *Science Standards of Learning Curriculum Framework – Grade Six*. Richmond, VA: Virginia Board of Education.

Venkataraman, B. (2009). Education for Sustainable Development. *Environment*: *Science and Policy for Sustainable Development*, 51(2), 8-10.

Volk, T.L. (1993). Integration and curricular design. In H. Hungerford, W. Bluhm, T. Volk, & J. Ramsey (Eds.), *Essential Readings in Environmental Education* (pp 123-142). Champaign, IL: Stipes Publishing.

Wheeler, G., & Conley, B. (2009). Education for Environment and Sustainability - K-12 Integrated Environmental and Sustainability Learning Standards. Retrieved from http://www.k12.wa.us/EnvironmentSustainability/Standards/default.aspx.

Yerkes, R., & Haras, K. (1997). Outdoor Education and Environmental Responsibility. Charleston, WV: ERIC Clearinghouse on Rural Education and Small Schools. Retrieved from ERIC database (ED414112).

Zint, M., & Montgomery, N. (2010). My Environmental Education Evaluation Resource Assistant (MEERA). Retrieved from http://meera.snre.umich.edu/.

CURRICULUM VITAE

Robert Johnson received his Bachelor of Science in Mathematics from the United States Naval Academy in 1996. He served in the U.S. Navy for 5 years as a weapons officer, tactical operator, and project manager (including leadership positions) and received several meritorious awards and commendations for his performance and acumen. After separating from the Navy in 2001, he attended the Natural History program at the United States Department of Agriculture (USDA) Graduate School before enrolling in George Mason University's Environmental Science graduate program. He is currently employed as an operations research analyst for a private Department of Defense contractor.