RELATING ENVIRONMENTAL LITERACY TO STANDARDS OF LEARNING BIOLOGY AND EARTH SCIENCE: A CASE STUDY FROM PRINCE WILLIAM COUNTY, VIRGINIA, USA

by

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Environmental Science and Policy

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DEDICATION

This thesis is dedicated to the memory of my father, Gehrie A. Bair.

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I would like to thank all those involved with the development and baseline testing of the Secondary School Environmental Literacy Instrument that served as the basis of this paper. Specifically, I would like to thanks Dr. Tom Macinkowski who was integral in giving permission to use the Secondary School Environmental Literacy Instrument and doing background research that led to this project. I would like to thank Prince William County Schools for their willingness to allow this study to take place. I would like to thank the many friends, relatives, and supporters who have helped make this happen. Thanks to my wife Julia for her love and support and my children, Elizabeth and Nathaniel, for their love and understanding. Finally, I would like to thank my committee members, Drs. E. C. M. Parsons and Erin E. Peters-Burton, who were of invaluable help and particularly my advisor Dr. Dann Sklarew whose guidance has brought me to this point.

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ABSTRACT

RELATING ENVIRONMENTAL LITERACY TO STANDARDS OF LEARNING FOR HIGH SCHOOL BIOLOGY AND EARTH SCIENCE: A CASE STUDY FROM PRINCE WILLIAM COUNTY, VIRGINIA, U.S.A.

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Environmental problems are increasingly affecting the economic, health and welfare of our society. Because of this, our collective ability to knowledgably deal with issues of the environment is essential. For example, the Commonwealth of Virginia amended its constitution to include protections for "its atmosphere, lands, and waters from pollution, impairment, or destruction, for the benefit, enjoyment, and general welfare of the people of the Commonwealth." (Virginia Const. art. XI, **§ 1)** Creating youth who are literate about the environment and assessing this environmental literacy (EL), is vital to our realization of this responsibility.

This thesis analyzes the acquisition of three components of environmental literacy environmental knowledge, dispositions and action strategies (Roth, 1992) that result from biology and/or earth science courses taught in a suburban Northern Virginia high school.

Students at this school who had taken biology and earth science courses based on the Virginia Standards of Learning (SOL) were surveyed for environmental knowledge, dispositions and knowledge of action strategies using appropriate sections of the Secondary School Environmental Literacy Assessment Instrument (Marcinkowski and Rehrig, 1995). Comparison of means was conducted to determine what, if any, influence these courses have on these components of EL.

Significantly higher environmental sensitivity, an indicator of environmental dispositions, was found in students who had taken only biology when compared to students who took biology and earth science. Similarly, higher ecological knowledge was measured in students who had taken biology only as compared to those who had taken both courses. When course level was taken into account, students who took general level biology and general level earth science had lower environmental sensitivity than five of the other seven combinations of courses and lower total scores on environmental dispositions than two of the combinations. No significant differences were found between results of this study and results from the field test of the (SSELI) in 1995. Recommendations will be made based on these results which include the argument for a more organized direct treatment of EL within a single course and continued research to investigate EL within courses that more directly address components of EL.

INTRODUCTION

The quality of our environment has costly long-term social, economic, and health effects. Our ability to mitigate and prevent these environmental problems is determining the quality of that environment in the near future. Members of a society must possess the willingness and capability to assess efforts to mitigate and prevent environmental harms and make wise decisions about shared commons and natural resources in a changing world. Public education is one mechanism through which individuals can gain knowledge, tools and willingness to assess such efforts. In the United States, and many other countries, High school provides the most rigorous mandated public school experience. Thus, it is important that we accept high school as an opportunity to provide environmental literacy to students.

In the age of standards-based education, high school classes are created with specific learning objectives. In a quickly changing world with new and increasingly prevalent environmental problems the available window to influence students who will soon enter adulthood is small. The assessment of the effectiveness of classes based on those standards to deliver knowledge, dispositions, and ability to use action strategies to stem environmental problems deserves exploration. These three components, knowledge dispositions and ability to use action strategies define Environmental literacy (EL) (Roth, 1992; Hsu and Roth, 1998; Yavets et al., 2009; Shepard et al., 2013). High school students have a large degree of choice in their courses and no students are exposed to all courses. It is important to assess if we are effectively delivering environmental literacy to all students through common models of formal education.

The Commonwealth of Virginia, through its Standards of Learning (SOL), has implemented a standards-based system to delineate what K-12 students should know upon the completion of each course. There is no SOL-based course or set of required courses with the explicit goal of environmental education or environmental literacy improvement. There are, however, courses that focus on biology and earth science that include some components of environmental literacy. Even if experience with both of these classes may provide an exposure to environmental literacy components, students can choose to take only one of these courses and still graduate with the highest level of diploma offered by The Commonwealth (Virginia Graduation Requirements, 2012).

This thesis defines the concept of environmental literacy and in context of its history and provides consensus ideas that describe it today. As they create our best measurement of success in environmental education, EL assessment tools are examined and studies that seek to assess EL are analyzed. Specifically, the Secondary School Environmental Literacy Instrument is evaluated and discussed.

In order to assess the environmental literacy of high school students exposed to earth science or biology alone, as well as biology and earth science together, students at The High School studied, identified from here forth as The High School, located in suburban Northern Virginia were given three sections from the Secondary School Environmental Literacy Instrument (SSELI) (Appendix A). Results from this survey were used in combination with student course histories to see if significant differences exist between the mean of scores on the SSELI from each group of students. Finally, the implications of the survey were analyzed and discussed.

LITERATURE REVIEW

Environmental Literacy

The confluence of knowledge, dispositions and strategies that lead to environmental action define environmental literacy (Roth, 1992; Simmons, 2005). Environmental Literacy (EL) is a product of the late 1960's environmental movement in the United States. EL was coined in an age of increasing environmental threats, byproducts of prosperity and innovation. In an age of dichotomies, nuclear technology brought us both nuclear power and nuclear weapons; industry brought both innovation and pollution. A myriad of human-generated environmental disasters were imposed on fragile ecosystems previously thought invulnerable. Rachel Carson's (1962) *Silent Spring* spoke of the danger of pesticides not only to wildlife but also to human health. When the Cuyahoga River caught fire on one occasion it "burned with such intensity that two railroad bridges spanning it were nearly destroyed" (Cities, 1969). It was events like these, occurring with increasing regularity, which caused citizens to take action based on new realizations about the Earth's vulnerability. With such realizations, the need to take responsibility for our treatment of the environment became apparent and work to produce a citizenry with understanding and active acceptance of that responsibility became necessary. Indeed, "[f]or us to address these environmental problems and prevent new ones, we need an environmentally literate citizenry that is not only capable of taking individual action, but of making well-informed public policy decisions collectively" (Simmons, 2005). EL was a logical reaction to present danger.

Though important, it appears that knowledge alone is not enough to elicit action. A lack of connection between environmental knowledge and environmental action has been observed (Kollmuss and Agyeman, 2002). That said, researchers did not find consensus for the reasons why this disconnect exists nor what exactly causes people to take environmental action. Many psychological and sociological hypotheses have been proposed including "linear progression models; altruism, empathy and pro-social behavior models; and finally, sociological models" (Kollmuss and Agyeman, 2002). This lack of consensus has not prevented investigators from seeking a greater understanding of factors that contribute to pro-environmental behavior.

Literacy is defined as the knowledge and skills for a respective field (Simmons, 2005). In 1968 Charles Roth coined the term environmental literacy, then later elaborated on his definition: Roth (1992) writes that literacy should be defined in a way that requires people to demonstrate knowledge, skills, and disposition toward environmental issues. It is the skills and dispositions that lead to action when combined with knowledge that is important for environmental literacy.

Several frameworks have been developed to define factors that are important to environmental literacy. The National Project for Excellence in Environmental Education characterizes EL with seven factors: affect, ecological knowledge, socio-political knowledge, knowledge of environmental issues, cognitive skills, factors which determine environmentally responsible behavior, and environmentally responsible behaviors (Volk and McBeth, 2005). Roth establishes someone as environmentally literate if they recognize and evaluate environmental problems, take action, look for long-term solutions, work to sustain diversity, respect future generations in decision making, identify the impact of population growth on resources, and treat common property in the same way they treat personal property (1992).

Without action however, environmental literacy is not truly adopted (Simmons, 2005; Marcinkowski, 1995; Roth, 1992). This has resulted in the inclusion of tools viewed necessary to promote individual and collective action. This distinction can be seen within the difference found between the definition of environmental education and environmental literacy.

Perhaps the definitive consensus definition of Environmental Education was provided by the United Nations Educational Scientific and Cultural Organization (UNESCO) 1977 Intergovernmental Conference on Environmental Education in Tbilisi that stated environmental education:

> "should…prepare the individual for life through an understanding of the major problems of the contemporary world, and the provision of skills and attributes needed to play a productive role towards improving life and protecting the environment with due regard to ethical values".

The U.S. Environmental Protection Agency distinguishes its EL definition from those of Roth, and UNESCO, by including critical thinking, problem solving, decision-making skills, and possession of a viewpoint (U.S. EPA, 2013). Environmental Literacy goes beyond environmental education in that it necessitates not only the knowledge described in the Tbilisi Declaration but also factors that allow and incline one to act. This too supports Roth's inclusion of action toward long-term-solutions (Roth, 1992) The National Science Education Standards too concern themselves with action stating that they exist to critique not only what students know but also what they are able to do (National Committee on Science Education Standards and Assessment, 1996).

Environmental Methodological Issues in Environmental Literacy Assessment

The field of EL research has been simultaneously attempting to measure EL and define it. As Disinger and Roth (2000) point out that 20 years after it was first discussed it still lacks a clear consensus definition. The lack of an exact definition of EL has not stopped researchers from attempting to assess EL based on working definitions. As has been supported by many writing within the field of EL, one of the greatest liabilities of the study of EL since its inception in the 1970's is a lack of assessment standardization (Volk and McBeth, 2005). In response to this problem, the North American Association of Environmental Educators sponsored a workshop in 2012 to develop a greater consensus for EL assessment (Heimlich, 2012). When asked about the strongest criticisms of environmental literacy assessment, the attendee's disapprovals conveyed two major criticisms. The first was that the tools themselves were problematic, and the second regarded a lack of consensus on the important components of EL. Further they indicated that:

> "The tools [assessments] are needed to operationalize 'ways to assess dispositions/attitudes and behaviors so we can ask questions about the

> relationship between disposition, science content knowledge, and behavior.' Some of the participants felt there is a 'pressing need to improve instruments/tools for measuring behavior" and a need for "understanding/evaluating issues from multiple and interesting perspectives... dispositions" (Heimlich, 2012).

Over the past 50 years since Roth first introduced us to the term EL (1968), researchers and educators are still quibbling over some of the most basic components of environmental literacy and its assessment. Trudi Volk and William McBeth (1996) refer to several problems in the quality of environmental literacy studies:

- A variety of instruments are used to assess EL.
- Researcher-developed tools are preferred by researchers rather than using previously available tools.
- Validity and reliability of these instruments is left to chance. Only 53% of studies sampled included validity testing and only 40% included reliability data.
- Research in the United States has assessed some regions; the Northeast and Midwest, with disproportionate frequency, while only 20% of samples come from the southwest, west, and southeast together (Volk and McBeth, 2005).

While their meta-analysis of EL papers is biased toward the implementation of national assessments, they indicated that at the time of their writing there was a lack of funding to accomplish such an undertaking. Frank Leeming *et al.* (2005) directly support Volk and McBeth's points 1 and 2. They add to the list critiques that include:

- Alack of systematic sampling methods,

- The likely impact of experimenter bias that might be attributed by the person who administers the survey,
- The rarity of follow-up data gathering and
- A lack of studies that explored changes in behavior over time.

In response to problems referenced above, two major efforts in the United States provided a national study of environmental literacy: the Middle School Environmental Literacy Instrument (McBeth and Volk, 2010) and the Secondary School Environmental Literacy Instrument (Marcinkowski and Rehrig, 1995). More recently Hollweg *et al*. (2011) made another effort to guide the development of an agreed-upon framework for EL assessment for use in international, national, and state/province-based assessments.

The Secondary School Environmental Literacy Instrument was designed as a product of the 1993 efforts of the Environmental Literacy Assessment Consortium. It designed to add to the conversation and efforts of the North American Association for Environmental Education to develop National Standards for Environmental Literacy (Marcinkowski and Rehrig, 1995). The group set out to

1. Create a framework,
2. Develop instruments to assess students and teachers that were both valid, reliable, and at a proper reading level, and
3. Field-test the resulting tools (Marcinkowski and Rehrig, 1995).

The original parts of this tool were developed from existing instruments that had already been tested as both valid and reliable. In 1995 the SSELI, along with a middle school version of the assessment and teacher survey, were field tested in 6 school districts in 5 states. The intent of the survey was not to draw conclusions beyond the schools sampled but rather to draw baseline measures using the tools (Marcinkowski and Rehrig, 1995). Baseline measures for the sections used in this survey can be found in Appendix B. The SSELI was divided into 7 sections the titles of which are listed in Appendix C this provided the framework complete with components of EL. The components and descriptive indicators chosen based on part of the framework developed, for the three sections used in this study can also be found in Appendix D. Due to its length this assessment was eventually divided up into two parts (Marcinkowski and Rehrig, 1995).

Continued work and consensus building efforts like this may eventually lead to tools and frameworks which can be agreed upon with enough certainty to gain general support. For example the framework developed by the North American Association for Environmental Education by Hallweg et al. (2011) seeks to be comprehensive, research based, while including input from across disciplines thereby engaging groups that seldom interact. The SSELI is well suited to this study because it avoids many of the criticisms of these assessments. The tool has been used previously avoiding the problem of introducing a new EL assessment tool. It has been tested for validity and reliability and was designed with a secondary school level of readability. Data from the original field test exists and is available to use for comparison. This comparison should be limited, however, due to updating of portions of the Environmental Science Knowledge section and to a lesser degree the Perceived Knowledge of and Ability to Use Action Strategies section after their original field test in 1995 (T. Marcinkowski, personal communication, August 14, 2013).

Literacy Knowledge and Competencies Found in the Virginia Standards of Learning (SOL)

The Elementary and Secondary Education Act or No Child Left Behind (NCLB) was passed by Congress in 2001 and requires school systems to implement testing to track student progress in English, Math, Science and History, in order to receive federal educational funding (NCLB, 2001). The Virginia SOL implemented in 1997 became Virginia's response to the requirements for testing. The Virginia High School Standards of Learning in Science test students in areas of biology, earth science, and chemistry. Standards of Learning in Virginia are used for all grades, from kindergarten through high school. Basic science skills learned in early grades buttress the more rigorous skills and knowledge which high school students are expected to learn. As early as Kindergarten students are expected to understand the concepts of material reuse, recycling and conservation (Science SOL, 2010). Middle school science SOL also includes aspects of renewable and nonrenewable resources use in 6th grade, then life and physical science in 7th and 8th grades (Science SOL 2010). High school is not the only place where Virginia students are expected to acquire environmental knowledge but it is the source of the most demanding environmental objectives to which students will be exposed.

The SOL are made up of several different sections including goal statements and standards. It is these two sections that address the indicators of the EL components found in the SSELI framework (Appendix D). When the SOL for earth science and biology are compared to the EL as defined by the indicators of SSELI for the sections used in this study, (Table 1) (Appendix D) it is evident that the SOL address only 60% (3/5) of the indicators of environmental dispositions, 85% (34/40) of the environmental concept knowledge, and 80% (4/5) of the action strategy indicators. This seems adequate however this topical coverage presumes that all objectives are covered and that topics are learned. Furthermore, all of the environmental dispositions that are treated in the SOL, are found in goals, not standards, which are not directly assessed and therefore teachers and students are not held accountable for their transmittal. Similarly, 20% of the environmental action indicators are found in goals.

Table 1. Summary of Indicators From SSELI Directly Addressed in the SOL For Biology and Earth Science

	Environmental Knowledge	Action Strategies
Earth Science Only	13/40	8/10 (Includes 1 goal)
Biology Only	25/40	6/10 (All Goals)
Both Bio and ES	34/40	8/10 (Includes 1 goal)

If only one of the two courses is taken, there is a greater opportunity for missed EL. The treatment of environmental dispositions does not change because these are only treated in the untested SOL goals that both courses share as mentioned above. If biology only is taken coverage of indicators of environmental science knowledge and those of action strategies indicators slip to 63% (25/40) and 60% (3/5) respectively. If earth science only is taken coverage of indicators of knowledge in the SOL falls to 32% (13/40) while environmental action stays at 80%. The mainstream science courses, biology and earth science, encompass the majority of environmental experiences for students in their high school careers, but do not independently nor cohesively address components of environmental literacy.

High School SOL exist for earth science, biology, chemistry, and physics. In high school, however, a choice of classes allows students to focus on courses in some areas of study at the expense of others. Students in Virginia must take and pass three science classes that must include two for which SOL end-of-course tests exist. Additionally, they must pass two SOL end-of-course tests in two of these classes to receive verified credit. (Virginia Graduation Requirements, 2012) While the argument can be made that exposure to EL concepts in elementary and middle school justifies a more specific focus that may not include some components of EL at the high school level, it is possible to avoid significant components of EL by selectively avoiding Earth Science. Sadly, instead of bringing the pieces of all of these subjects into a cohesive study of the environment as is found in an elective course like AP Environmental Science (College Board, 2013), only a few components are explored, but are disconnected. Meanwhile, many other facets of EL are not explored at all. "At present, as in the past, educational leaders show little direct interest in education about the environment, except as it may be subsumed by traditionally defined curricular areas." (Disinger and Roth, 2000) As noted, students do gain exposure to EL within current Virginia curricula "[h]owever, only the development of a comprehensive environmental education program insures that it will not be marginalized or fragmented" (Simmons, 2005).

Several studies exploring student's learning indicate that beginning learners should be exposed to direct instruction and that implicit exposure to information proves less effective (Mayer, 2004; Sweller, 2003). For example, common methods used to teach the nature of science to students have undergone several transformations: science educators in the 1960's and 1970's were less direct and emphasized a more hands- on and inquiry-based curricula in order to teach the nature of science (Peters, 2013). This ultimately led to reduced understanding of the nature of science as compared to more traditional explicit models (Trent, 1965). The study of environmental science is defined by its interconnectedness that without explicit assembly, may get lost by many students.

The only courses that seek to explicitly address environmental issues in Virginia are electives such as Advanced Placement Environmental Science (College Board, 2013), Environmental Systems International Baccalaureate (Environmental Systems, 2010), and other fully integrated environmental science courses that are taken by a minority of students. While other curricula's effects on EL need also to be assessed, and their more cohesive treatment of environmental issues is promising for their effect on EL, they lay outside the scope of this thesis.

METHODOLOGY

Site Description

The High School surveyed, is located in the Prince William County Public Schools (PWCS) district located in Western Prince William County. In the year prior to which the survey was administered, the school boasted a 95.99% on-time graduation rate, and a student to teacher ratio of 16.6. Of the roughly 2,600 students, 18.7% are classified as gifted, 2.6% are in the English for the speakers of other languages program, 7.7% special education, 12.0% economically disadvantaged and 88.3% reported they will attend a 2 or 4 year college (PWCS, 2012). Currently students in the general track in portions of Prince William County when take earth science first then biology and elective science courses thereafter. The advanced track for students involves biology, chemistry and an elective course sequence. Many students, depending on the track they choose, are never exposed to earth science and the environmental objectives it contains. More integrated environmental courses like Advanced Placement (AP) Environmental Science do exist, but this elective course is only available as a third science class and taught only at an advanced level, which requires biology and chemistry as prerequisites. Students are also able to pursue pre-AP biology and advanced earth science courses instead of general level versions of the same courses. While the standards for the courses remain the same, the implicit difference is an increase in course pace and depth. Many other course frameworks are available elsewhere in the United States and internationally, including International Baccalaureate programs, Advanced Placement and other state and national curricula (College Board, 2013; Environmental Systems, 2010).

Study Hypotheses

When the questions of the SSELI are placed side by side with the SOL objectives, and compared to see which questions are directly covered by one or more objectives a prediction of student performance from those who took biology only those who took earth science only and those that took both can be made. A summary of questions and the SOL that do or do not address them can be found in Appendix D. When this analysis is complete, eliminating shared goals that are held by both sets of SOL, the results, summarized in Table 2 are clear.

Table 2. Researcher Hypotheses - Based on SSELI Questions Addressed Directly by SOL, Summary of Questions and the SOL That Address Them Can Be Found in Appendix D

	Dispositions	Knowledge	Action Strategies
Earth Science	4/16	13/40	4/10
Biology	4/16	25/40	3/10
Biology and Earth Science	4/16	38/40	4/10

Based on this analysis the hypothesis for dispositions is that there will be little difference between any of the groups because the only questions in the SSELI which are addressed are addressed in common goals of both the earth science and biology SOL. More knowledge questions are addressed by biology than by earth science but both address knowledge questions. The hypothesis therefore is that students who have taken biology and earth science will have the highest knowledge score followed by biology only followed by earth science only with the lowest. It is also predicted that ecology scores will be higher in biology students and will be higher than environmental science scores due to a lack of coverage of environmental science topics in both biology and earth science SOL. Finally, course level, pre-AP or Advanced vs. general, will only effect environmental knowledge and knowledge of action strategies, not disposition (Table1).

Project Design

The independent variables in this study will be exposure to earth science (ES), biology (Bio) or paired earth science and biology SOL curricula. Students who have taken earth science, biology or both courses were surveyed for affective disposition toward the environment, knowledge of ecological and environmental science concepts and knowledge of and ability to use environmental action strategies. Scoring for each section was done using the scoring tool provided along with the survey (Marcinkowski and Rehrig, 1995). The survey results in an overall environmental literacy score as a combination of the sub-scores from each of the sections used. Furthermore, sub-scores for each section were also calculated using the scoring tool presented in Appendix E.

Three of six original sections of the SSELI (Marcinkowski and Rehrig, 1995) were given to students at The High School (Appendix A). The three were selected for three reasons: First, they could be given in one survey session of less than one hour.

Second, they addressed the three consensus EL components, as identified from the EL research. Finally, these three sections could be answered using multiple choice or Likert scale options facilitating the scoring process. Combining mixed question types was problematic in the original 1995 field test because sections with different styles of response, open ended vs. selected response, among the original six sections necessitated several different answer sheets for each survey participant. Combining and coding scores together to get an individual score was difficult and led to less valuable data (Marcinkowski and Rehrig, 1995). Significant changes were made to the survey by Tom Marcinkowski following the 1995 field test. Tom Marcinkowski made changes to the knowledge section and less significant changes in the Perceived Knowledge of and Ability to use Action Strategies section. For the present project the survey was also updated to reflect changes in scientific knowledge where appropriate however few changes were made.

Students in each biology and earth science classroom were asked to complete a parent consent form prior to participation (Appendix F) and sign a student assent form just prior to survey participation (Appendix G). The survey took students approximately 50 min. The survey contained multiple choice and Likert scale questions (e.g., "On a scale of 1 to 6, please rate…"). Likert questions were changed from a five to a six-point scale in order to require more decisive decision-making.

Survey Components

1. Environmental Dispositions (How I Feel About the Environment) (16 Likert Scale Questions)

a. Environmental Sensitivity - Questions ask how sensitive respondents are and the level of their participate ion outdoor activities

b. Environmental Attitudes - Questions ask about respondents' level of concern for environmental problems and support for legal, economic and technological solutions

c. Locus of Control- Questions ask about respondents' belief in their ability to influence solutions to environmental problems

d. Personal Responsibility - Questions ask about respondents' feelings about their level of personal responsibility to help improve the environment

e. Willingness to Participate in Environmental Action – Questions ask about respondents' willingness to work alone and with others toward solutions to environmental issues

2. Knowledge of Environmental Concept (40 Multiple choice questions)

a. Ecological Knowledge (20 questions) – Questions include topics of soil quality, water pollution, energy generation methods, solid and liquid waste treatment, solid waste disposal, groundwater, bioaccumulation, pesticide use, and human population

b. Environmental Science Knowledge (20 questions) - Questions include topics of food chains, organism niches, biogeochemical cycles and succession

3. Action Strategies (10 Likert Scale Questions)

a. Perceived Knowledge about Action Strategies- Question ask about how knowledgeable respondents feel they are about ecomanagment, economic, persuasion, political, and legal strategies after a short definition of each

b. Perceived Ability to Use Action Strategies- Question ask to what extent respondents feel they are able to use ecomanagment, economic, persuasion, political, and legal strategies after a short definition of each

4. Survey of Student Demographics and Class History (13 Multiple Choice Questions) – Questions ask respondents about, race, gender, grade, age, education level of parents, Meaningful Watershed Educational Experience Participation, club involvement, and course history

Recruitment

Students were recruited by giving them a parent consent form (Appendix F) one month prior to the survey's delivery by their science teacher, along with a verbal description of the study itself (Appendix H).

Teachers collected parent consent forms from students. Approximately 30 days from the announcement, the survey was given in class to those for whom the teacher received signed consent and assent forms. Copies of the assessment were on file in the main office for 30 days prior to the assessment for anyone who wanted to see the survey in advance.

Survey Administration

A short tutorial on recruitment and survey administration was given to teachers giving the assessment, with special attention paid to confidentiality. Two to three minutes were necessary daily for the 4-week period prior to the testing for teachers to collect and check which students had completed the permission form.

Prior to handing out survey materials, teachers read the survey administration statement that gives instructions for students to follow (Appendix I). Students completed their survey and then handed in all supplies. Students then sign an assent form affirming their willing participation in the survey (Appendix G).

Confidentiality

No personally identifying data was taken from students. Random numbers selected by the student were available to be used by students, if they were interested in receiving results. Otherwise, surveyors could not connect student identity to answers submitted. Students indicated answers by using a randomly selected radio frequency clicker linked to a student response system that logged data into a computer. The only person with knowledge of the student's self-assigned student number was that student.

Efforts to Minimize Effects on Students

The total testing time was estimated to be approximately 50 min. Special efforts were made to gather data after Virginia Standards of Learning and Advanced Placement testing were completed to ensure that students were exposed to the full compliment of course topics and to avoid impinging on class time that could be used to prepare for these standardized tests. Additionally, it was not possible to test students before and after their exposure to biology and earth science curricula because all surveying needed to occur after SOL and AP testing had completed near the end of the school year as directed by the school district.

Statistics

In addition to SSELI data, information about each student's course history was collected simultaneously and matched with SSELI data. Data was processed using Microsoft Excel and tested in SPSS. The data was checked for normality by using a Shapiro-Wilkes test to eliminate skewness and kurtosis. Means for students who took biology only, earth science only and both biology and earth science were compared using a one way analysis of variance (ANOVA) test for variance and an independent samples T-test to determine what, if any, relationships were evident between sets of courses students had taken and their subsequent measured environmental literacy. Further the level of class (general or pre-AP/ advanced) in which the student was enrolled was also noted and independent samples T-tests were conducted on these groups to analyze for significant relationships.

FINDINGS

The purpose of the study was to assess the ability of Virginia SOL biology and earth science courses to deliver environmental literacy to students. Several areas of environmental literacy were measured. These included:

1. Environmental Dispositions (How I Feel About the Environment)
    - a. Environmental Sensitivity
    - b. Environmental Attitudes
    - c. Locus of Control
    - d. Personal Responsibility
    - e. Willingness to Participate in Environmental Action
2. Knowledge of Environmental Concept
    - a. Ecological Knowledge
    - b. Environmental Science Knowledge
3. Action Strategies
    - a. Perceived Knowledge about Action Strategies
    - b. Perceived Ability to Use Action Strategies

This study also measured several aspects of student background and course history. Descriptive statistics are presented below in terms of the specific areas measured.

The sample surveyed consisted of 345 students or 33.5% of the 1030 students enrolled in biology and earth science classes at The High School. Students from 19 of the 26 biology and 7 of the 8 earth science classes were sampled and 321 students answered questions about their coursework. Figure 1 presents how more students were surveyed who are currently enrolled in biology than in earth science. A greater proportion of biology students than of earth science students participated. More students currently enrolled in Pre-AP Biology and/or Advanced Earth Science were surveyed than general students in the same courses, also shown in Figure 1.

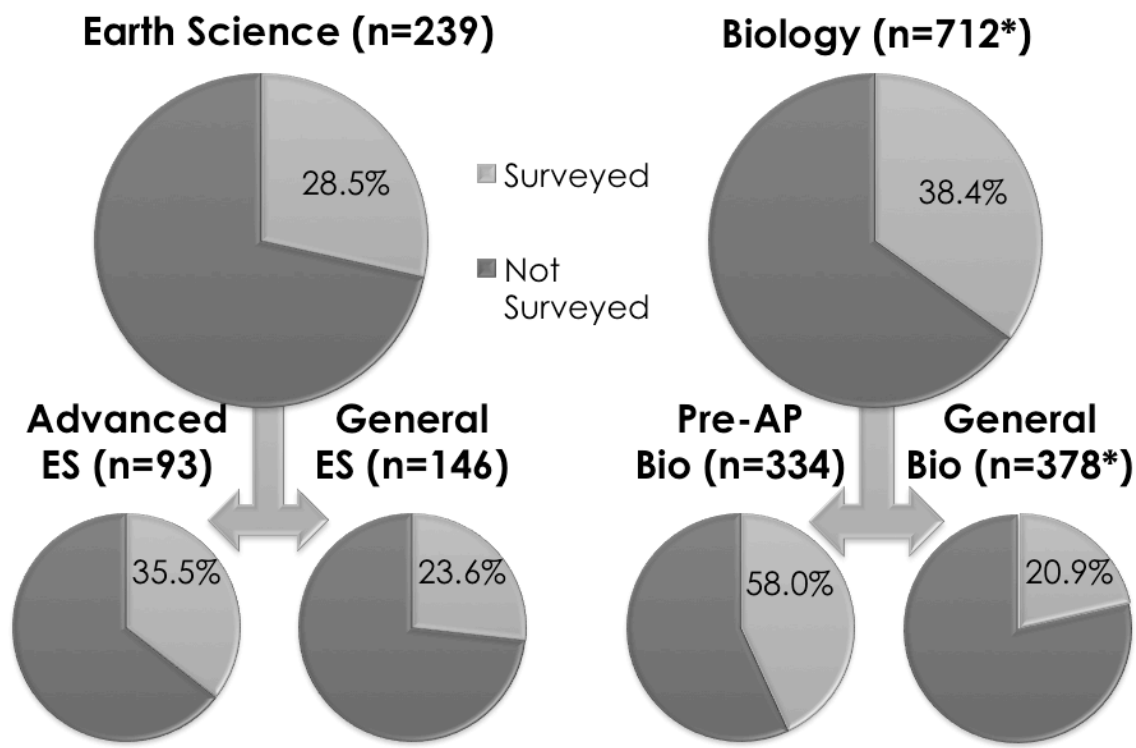

Figure 1. Student Participation in Survey, By Class In Which They Were Surveyed
*** The total students enrolled excludes general biology students taught by researcher and not included in survey to avoid conflict of interest. Total enrolled in biology and general biology including these students was 784 and 455 respectively.**

Students were asked if they had taken biology or earth science and the level of the class that they took for each. The number and percentage of students who answered that they have taken each course was calculated. This was further broken down by level, pre-AP vs. general biology and advanced vs. general earth science (Figure 2).

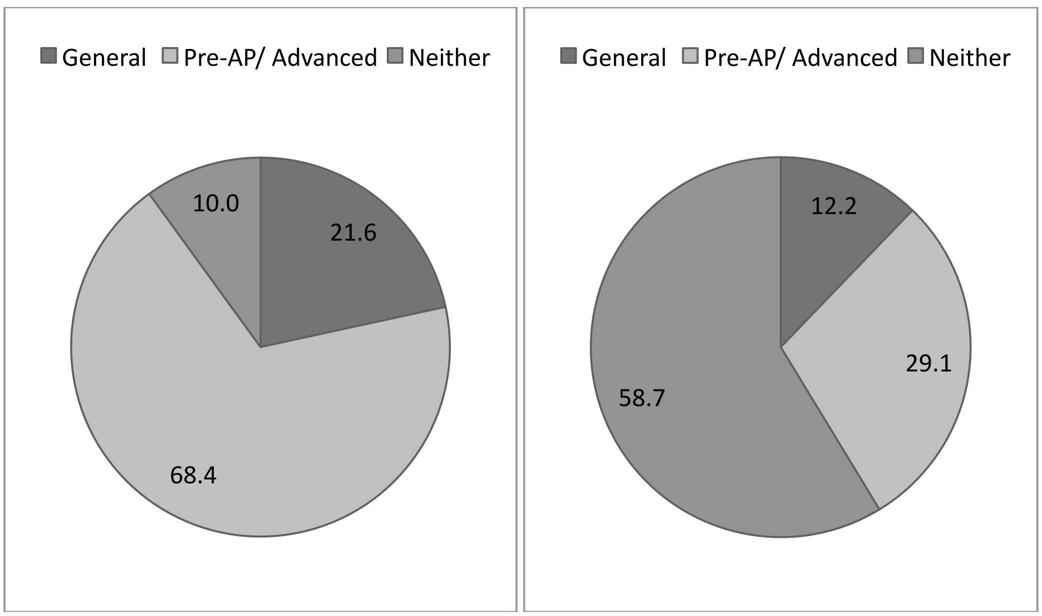

Figure 2. Percent of Students Who Reported Having Taken Biology and the Percent of Students Who Had Taken Earth Science Regardless of the Class in Which They Are Currently Enrolled

Responses, which can be found by indicator in Appendix J, were then categorized into three groups, for those who had taken (1) biology only, those who had taken (2) earth science only and those who had taken (3) both biology and earth science (Figure 3). Altogether 188 students (58.8%) had taken biology only, 33 (10.3%) had taken earth science only and 99 (30.8%) had taken both biology and earth science (n=321). The number of students was far greater among those that had taken biology only and smallest among those who had taken earth science only.

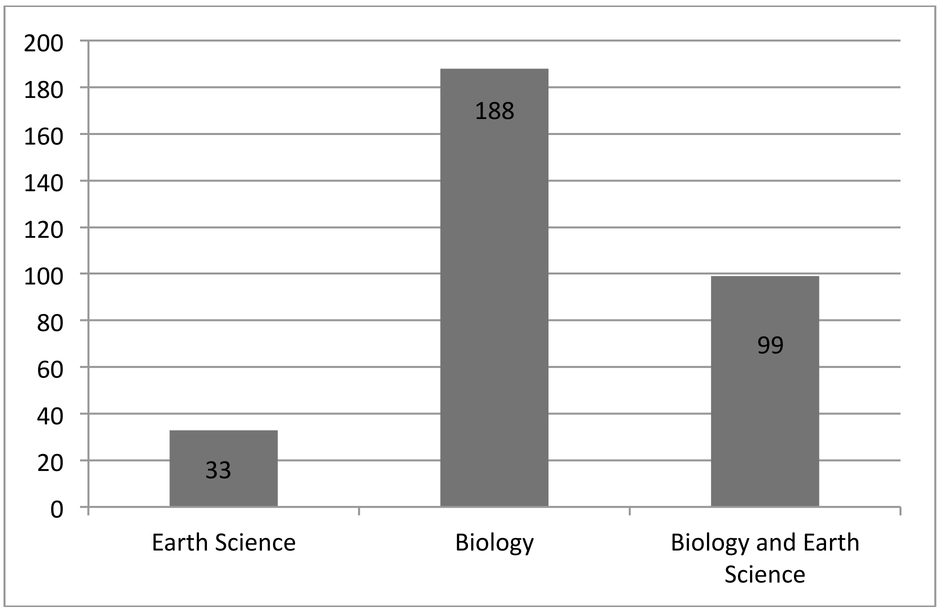

Figure 3. Number of Students Who Took Earth Science Only, Biology Only or Both Biology and Earth Science

The data was further classified one of eight possible combinations of general and advanced courses. All possible combinations of courses were found in the survey group however sample sizes among 5 of the groups were less than 30, as Figure 2 summarizes.

Table 3. Number of Students In Each Possible Combination of Courses

	No Earth Science	General Earth Science	Advanced Earth Science	Total Earth Science	All
No Biology	N. A	6	27	33	33
General Biology	39	13	17	30	99
Pre-AP Biology	150	20	49	69	288
Total Biology	189	33	66	99	288
All	189	39	93	132	321

Demographics of Sample

One hundred ninety-two students identified themselves as female (56.8%) and 126 (35.5%) identified as male and 10 (2.8%) as neutral gender identity. Twenty-six students (7.3%) identified as African American, 22 (6.2%) as Hispanic American, 54 (15.2%) as Asian American or Pacific Islander, 187 (52.7% as White American, 12 (3.4%) as Native American (Indian/ Eskimo/ Aleut) and 39 (11.0%) as other (n=340). Of the students that had taken biology only, 33% were 14 years old or younger, 64% were 15, 2% were 16 and 0% were older than 16. Of those students that had taken earth science only 30% were 14 years old or younger, 70% were 15, and 0 were older than 15. Of those students who have taken both earth science and biology, 4% were 14 years old or younger, 28% were 15, 57% were 16, 12% were 17 and 2% were 18 years or older.

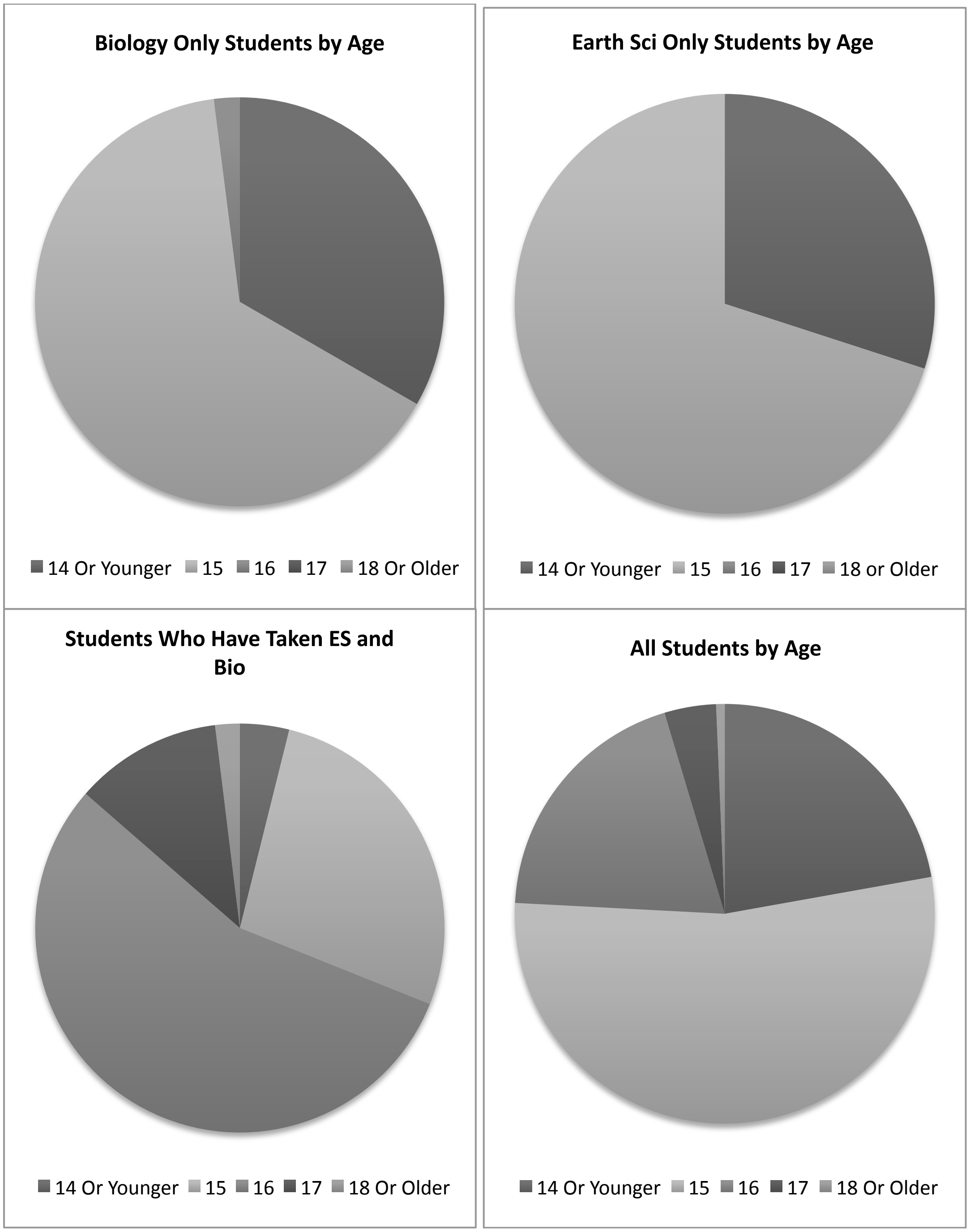

Figure 4. Age Distribution of Students Who Had Taken Biology Only, Earth Science Only, Biology and Earth Science and All Students Surveyed

Environmental Dispositions

The "How I Feel About the Environment" section of the survey contained items designed to measure 1) environmental sensitivity 2) environmental attitudes 3) locus of control 4) personal responsibility and 5) willingness to participate in solving environmental activities. Each question was framed as a six-point Likert scale question ranging from "No Extent" to "A Great Extent".

On two six-point questions, the 340 students responding to questions of environmental sensitivity scored an average of 7.23 out of 12 with a standard deviation of 2.24 (Table 3). The 322 students responding to questions of environmental attitudes averaged 31.5 out of 48 points with standard deviation of 5.33. When surveyed about their locus of control students averaged 7.10 out of 12 on two questions with standard deviation of 2.34 (n=334). Respondents averaged 7.55 out of 12 on a measure of personal environmental responsibility with standard deviation of 2.94 (n=334). Respondents on average reported a willingness to participate in environmental activities scoring 7.09 out of 12 with a standard deviation of 2.29 Three hundred eleven respondents answered each component of the "How I Feel About the Environment" section of the survey and averaged 37.2 of the 60 points possible with a standard deviation of 7.04. In the original field study students averaged 47.59 with a standard deviation of 11.184.32 (n=615) (Marcinkowski and Rehrig, 1995).

Table 4. Scores On Each Portion of the Environmental Dispositions/ "How I Feel About the Environment" Section of the Survey Along With Survey Questions That Assess That Aspect of Environmental Dispositions

	Mean/ Out of	Standard Deviation	(n=)	Survey Question Numbers (Appendix A)
Environmental sensitivity	7.23/12	2.24	340	1 and 2
Environmental attitudes	31.50/48	5.33	322	3-10
Locus of control	7.10/12	2.34	334	11 and 12
Personal responsibility	7.55/12	2.94	334	13 and 14
Willingness to participate	7.09/12	2.29	334	15 and 16
Total	37.21/60	7.04	311	

Knowledge of Environmental Concepts

The knowledge section of the survey was broken down into ecological and environmental science knowledge sections with 20 questions each. Each question had one correct answer, three distractors and the option of choosing unsure instead of choosing an answer. Three hundred two students responded to all of the ecology questions scoring an average of 11.60 with a standard deviation of 3.64 (Table 4). Two hundred ninety-four students responded to all the environmental science questions scoring an average of 9.44 with a standard deviation of 4.02. In total respondents averaged 21.23 questions correct with a standard deviation of 7.04 (n=272). In the original field study students asked about environmental concepts scored 17.19 out of 40 questions with a standard deviation of 7.00 (n=621) (Marcinkowski and Rehrig, 1995).

Table 5. Scores For "Environmental Science Knowledge" Section of the Survey

	Mean/ Out of	Standard Deviation	(n=)	Survey Question Numbers (Appendix A)
Ecological Science	11.60/20	3.64	302	17-36
Environmental Science	9.44/20	4.02	294	37-56
Total Environmental Knowledge	21.23/40	7.04	272	

Perceived Knowledge of and Ability to Use Action Strategies

In section three, students were surveyed about their knowledge of and ability to use action strategies towards environmental improvement. Both knowledge of and ability to use action strategies were surveyed using five six-point questions. Three hundred twenty eight students were surveyed about their knowledge of environmental action strategies scoring an average of 16.09 out of 30 with a standard deviation of 4.61 (Table 5). When asked about their ability to use action strategies, respondents averaged 14.59 out of 30 with a standard deviation of 4.48 (n=323). Students responding fully to all questions about knowledge and use of environmental action strategies (n=313) averaged 25.1 out of 50 with a standard deviation of 6.98.

Table 6. Scores for "Action Strategies" Section of the Survey

	Mean/ Out of	Standard Deviation	(n=)	Survey Question Numbers Appendix A
Knowledge of Action Strategies	16.09/30	4.61	328	59, 61, 63, 65
Ability to Use Action Strategies	14.59/30	4.48	323	60, 62, 64, 66
Total Action Strategy Score	25.06/50	8.37	313	

Comparing Students Who Took Biology, Earth Science, or Biology and Earth Science

How I feel about the environment

Students that had taken biology only showed a significantly higher environmental sensitivity, 7.38, than their peers who had taken biology and earth science, 6.74. This was verified by both independent samples T-test (p=0.012) and ANOVA (p= 0.038). Students who had taken earth science only could not be significantly differentiated from students who had taken biology only or from those who had taken biology and earth science.

Knowledge

The knowledge section of the survey included 20 questions about ecological knowledge and 20 questions about environmental science knowledge. Ecological knowledge tested higher among students who had taken biology only, 12.15, as compared to students who had taken earth science and biology, 10.69, (T-test, p=0.002; ANOVA, p=0.004). Students who had taken earth science only were not statistically more or less knowledgeable than students who had taken biology only or both biology and earth science.

Students who took Pre-AP Biology answered more ecological questions correctly, 11.90, than students who had taken general level biology, 10.52 (T-test, p=0.012).

There was no difference in environmental science knowledge between groups that have taken biology, earth science or both biology and earth science.

Perceived Knowledge of and Ability to Use Action Strategies

There were no significant differences in mean for self-assessment of knowledge of action strategies, or in self-assessment of ability to use action strategies among any groups.

Comparing Students in All Eight Possible Course Combinations

When the data was disaggregated into all eight possible course combinations, there were several differences found. When comparing scores on environmental sensitivity and “How I Feel About the Environment” students who took general biology and general earth science (6.00, 32.58) had significantly lower scores than students who took general biology and advanced earth science (7.69, 37.18), on both measures (T-test, p=0.022, p=0.031). Students who took general biology and general earth science also had a lower environmental sensitivity than those who had taken only advanced earth science and those who had taken pre-AP Biology only when using a one-way ANOVA (p=0.017 and p=0.042)

The environmental sensitivity of students who took general biology and general earth science was lower (5.54) than in students who had taken pre-AP biology and advanced earth science (6.98, T-test, p=0.015), pre-AP biology and general earth science (7.25, T-test, p=0.018), pre-AP biology only (7.48, T-test, p=0.003), general biology only (7.36, T-test, p=0.008), or advanced earth science only (8,04, T-test, p=0.001).

Students who took pre-AP Biology only and students who took advanced earth science only tested higher than their peers who had taken general biology and general earth science on the combined measurement of how they feel about the environment (32.58 as compared to 38.12, T-test, p=0.01 and 32.58 compared to 39.68, T-test, p=0.005).

CONCLUSIONS

Environmental Dispositions

Those students who had taken only biology had statistically higher scores on environmental sensitivity than those students who had taken biology and earth science. There are several factors that may be important to this observation. Those that had taken two courses were on average older than those who had only taken one. This is supported by data which shows that sensitivities of students who have taken only earth science are also higher than their peers who have taken biology and earth science though we can be less confident of this as support as $p=0.065$. It is also supported by McBeth and Volk (2010) who saw that within their survey of 6th and 8th graders, using the Middle School Environmental Literacy Survey, 8th graders scored lower on environmental sensitivity (30.11) than their 6th grade counterparts (32.54). Additionally Leeming and Dwyer (1995) observed that while knowledge tends to follow age development, that affective measures do not but rather rely on exposure to experiences.

There was no significant relationship between locus of control and any of the variables studied. Similarly students' experience with earth science and or biology showed no significant relationship to personal responsibility.

There was no statistical difference between any of the indicators of environmental dispositions nor in the component environmental disposition when data was compared to the sample gathered to field test the SSELI in 1995 (Appendix B) (Marcinkowski and Rehrig, 1995).

Knowledge of Environmental Concepts

The idea that students who had taken biology only scored higher in the ecology section than those who had taken biology and earth science is likely influenced by the fact that those who took biology only are in a biology class now and information is recent and more readily available. While some strategies have been studied to improve retention (Minakova, and Falkman, 2011) this is not a problem specific to environmental concepts.

The observation that pre-AP biology students performed better than general biology students is a sign of internal validity since ecology is most directly addressed in biology and we would assume that students who have chosen to take pre-AP are on average higher performing students. This is not uncommon as ecology tends to be a thrust of biology curricula (Erdoğan, Mehmet, 2007) A lack of any significant differences in means of environmental science knowledge and any class set indicates that there is little knowledge assessed in the environmental science section which is dealt with directly in the biology or earth science SOL (Appendix D). It is worth considering too that having standards in place that address issues does not necessarily mean that the standards are taught, nor does it mean that the standards are learned. Some standards are more difficult to learn than others and may show the effects of this. Additionally, teachers may run out of time before the end of the year and not teach a topic at all. There was no statistical difference between samples of environmental knowledge from this study when compared to the field test of the SSELI in 1995 (Appendix B). This lack of change was despite changes made since its original use (Marcinkowski and Rehrig, 1995).

Perceived Knowledge of and Ability to Use Action Strategies

No significant relationships existed within the survey questions that dealt with Perceived Knowledge of and Ability to Use Action Strategies. As ability to use action strategies goes along with experience, and with little opportunity to use action strategies in the classroom, a lack of confidence in one's ability to use such strategies may come as no surprise. This is supported by a study of 16 and 17-year-olds in Australia in which students were surveyed about a wide array of environmental topics. Students indicated that they were only capable of small actions that could help the environment. Researchers identified few experiences at home or school to contradict this conclusion. They also claim that in the future they will be capable of little more than they are doing now (Connell et. al., 1999). Public school has little opportunity to use any of the strategies; legal, persuasive, economic, and political and it should be of no surprise that students have little confidence in their knowledge of and their ability to use these strategies. Moreover, high school freshmen and sophomores, who make up the majority of the sample, have a limited ability to make many of the choices implicit in the strategies described. Programs designed to increase engagement in civic activities have shown some success (Santinello, et al. 2012), however, finding ways to integrate these into already full calendars may pose problems.

No significant difference was seen between those who had taken only biology and those who had taken only earth science in any action strategy metric assessed.

In this study of perceived knowledge of or ability to use action strategies showed no statistical difference when compared to the sample gathered to field test the SSELI in 1995 (Appendix B) (Marcinkowski and Rehrig, 1995). Though changes were made to this section since its original 1995 field test, the changes were characterized as "far less likely to influence such a comparison" when compared to the changes in the knowledge section (T. Marcinkowski, personal communication, August 14, 2013)

Table 7. Researcher Conclusions
O=No significant differences in mean, *=Positive Significant Difference in Mean

	Dispositions	**Knowledge**	**Action Strategies**
Earth Science	O	O	O
Biology	O	* (Eco when compared to Bio and ES)	O
Biology and Earth Science	O	O	O

Discussion

Science courses that increase EL in high school education could generate an environmentally educated citizenry, more ready to analyze and address local and global environmental problems. This study indicates there seems to be little significant positive relationship difference in students who have taken SOL biology or SOL earth science courses and their environmental dispositions, knowledge of environmental concepts, or self-confidence in their ability to understand or use environmental science action strategies nor of total environmental literacy as defined by a total of all of these factors.

While the researcher thought that perhaps an alteration in course sequence or course requirements might be enough to encourage improvements in these measures of environmental literacy, it seems that a reassessment and alteration of the core SOL standards with environmental literacy goals in mind would be more effective. Despite limitations due methodological choices and survey instruments exist, the results of this research point to several areas of future research that should be pursued.

Methodological Limitations

Before investigating conclusions of this study it is important to state that the conclusions included here are based on the sample that was tested and should not be viewed as an indication of impact of earth science and biology across the state. Several limitations were extant due to the data collection process. First, sample sizes were small within some sub-groups. While special efforts were made to assess as many students as possible, some teachers were very eager to participate and solicit permission forms from students and others were not. Because of this, a small group of teachers' classes made up a large portion of the sample. The number of sections of each class, general biology, general earth science, pre-AP biology, and advanced biology, differed greatly. This led to a greater number of students and opportunities for returned parent permission forms in biology classes which had many more sections and lower in earth science which had fewer sections. Too, there were lower numbers of general biology and general earth science classes. The number of students in each group who returned parent permission forms also differed across course levels. When issues of low participation due to teacher indifference were found in classes with fewer sections and general level students, low participation was seen.

Efforts to minimize the impact of the study on students' performance on SOL and AP tests prevented sampling of students prior to their experience with either biology or earth science. A paired T-test would have enabled the researcher to look directly at the effect of the course with a before and after comparison. Even an unpaired comparison would have been difficult to gather and in that case, getting samples that compare well across different demographics would have been difficult. Approval from the school district for a study that further impinged on instructional time may also have been problematic.

Survey Limitations

Changing the questions on the "How I Feel About the Environment" section of the survey from five selection choices to six proved difficult for students to understand. When the decision was made to go to 6 choices from 5, a subsequent change from five to six choice descriptors should have been made. Including the choice of "unsure", in the scoring of the knowledge section of the survey resulted in confusion on the survey taker's part. Students are more familiar with giving their best effort and getting the answer right or wrong. High-stakes AP testing has gone away from penalizing a wrong answer to only awarding points for a right answer. The intent of an "unsure" response that may prevent some guessing doesn't prevent all guessing and leads to questions of how sure one needs to be to not be "unsure". Some more confident students, likely those in higher-level courses, may earn more points due to ill-placed confidence in guessing over their less confident counterparts. All of these questions could have been avoided by simply asking for the correct answer and scoring the survey as right or wrong.

These results and their comparison to the field test results of these sections of the SSELI in 1995 (Appendix B) show no difference in any of the sections used. These comparisons have limitations due to significant changes in the knowledge assessment and less significant changes to the section that assessed perceived knowledge of and ability to use action strategies. Results of all three sections support the lack of significant change in EL despite 18 years. These results may be used to make future comparisons in similar studies.

Future Research Directions

Future research looking at different sets of standards may prove to find curricula that are more effectively providing EL to students. Additionally, courses which impact students in their EL are likely to be those which have an environmental focus, like AP Environmental Science, however, these courses in Virginia are not required in a majority of school systems and are often-upper level electives. Thus only a minority of students takes these courses. Results may suggest a need for establishing a more explicit treatment of environmental issues in course curriculum for existing Virginia SOL courses or a reassessment of the courses offered in Virginia schools. Prince William County Public Schools gives the opportunity for students to take the earth science SOL end of course test upon completion of AP Environmental Science as many of its learning objectives are shared between the courses. While perhaps not all students could handle the rigor of an AP course, a modified earth science course that more explicitly links environmental literacy concepts might prove to better address EL objectives. Further exploration of the effects of innovative programs like Virginia's Meaningful Watershed Educational Experience program and gender on EL acquisition, both considered briefly in Appendix K might also be explored. Finally, further surveys of civics courses that may speak more directly to school related influences on knowledge of action strategies and may shed light to these questions.

APPENDIX A - SECONDARY SCHOOL ENVIRONMENTAL LITERACY ASSESSMENT*

Parts I- III

Instrument contains significant portions of the Secondary School Environmental Literacy Instrument, which is protected under copyright. For this reason copyrighted materials have not been included in this document at the request of the author.

Questions about the use of this assessment can be directed to:

Dr. Tom Marcinkowski

Florida Institute of Technology

150 West University Blvd.

Melbourne, FL 3201-6975

(407) 674-8000 ext. 8946

marcinko@fit.edu

Part IV

STUDENT DEMOGRAPHIC AND BACKGROUND INFORMATION

Directions: Please respond to the items below and on the following pages to the best of your ability.

67. The last 3 digits of your zip code and the last 4 digits of your home phone number

* Marcinkowski and Rehrig, 1995

68. Your Age (n=337)

A. 14 or younger (21%)

B. 15 **(53%)**

C. 16 (21%)

D. 17 (4%)

E. 18 or older (1%)

69. Your Current Grade Level: (n=337)

A. 9 **(69%)**

B. 10 (25%)

C. 11 (6%)

D. 12 (1%)

70. Your Gender: (n=328)

A. Female **(59%)**

B. Male (37%)

C. Neutral gender identity (3%)

71. Your Ethnicity: (Choose as many as apply) (n=340)

A. African American (8%)

B. Hispanic American (7%)

C. Asian American or Pacific Islander (16%)

D. White American **(55%)**

E. Native American (Indian/Eskimo/Aleut); (4%)

F. Other (12%)

Check the highest level of education **completed** by your parent(s), or adult(s) caring for you:

72. Mother or first adult caring for you: (n=336)

A. Grade school (3%)

B. High school (17%)

C. College **(50%)**

D. Graduate school (18%)

E. Don't Know (11%)

73. Father or second adult caring for you: (n=339)

A. Grade school (4%)

B. High school (16%)

C. College **(47%)**

D. Graduate school (22%)

E. Don't Know (12%)

74. When in 6th grade did you participate in a class field trip to investigate your local watershed? (n=329)

a. Yes **(61%)**

b. No (24%)

c. I don't remember. (14%)

75. Choose any of the following clubs in which you are a member (choose all that apply): (n=65)

a. Environmental Club (45%)

b. Science National Honor Society (3%)

c. Space Club (3%)

d. Biology Olympiad (2%)

e. Envirothon (3%)

For each of the following courses you have taken, choose the year you took the course by indicating A-D or choose E if you have never taken the course.

	9th	10th	11th	12th	I have Never Taken This Course
76. General Biology (n=334)	A 14%	B 7%	C 0%	D 1%	E 77%
77. Pre-AP Biology (n=334)	A 53%	B 13%	C 0%	D 0%	E 13%

78. Advanced Earth Science	A	B	C	D	E
	20%	4%	5%	1%	70%
(n=338)					
79. General Earth Science	A	B	C	D	E
	12%	1%	1%	1%	85%
(n=338)					

APPENDIX B – DATA FROM 1995 FIELD TEST OF SSELI *

Table B 1 - Scores On Each Portion of the Environmental Dispositions/ "How I Feel About the Environment" Section of the Survey along with survey questions that assess that aspect of environmental dispositions

	Mean/ Out of	Standard Deviation	(n=)	Survey Question Numbers Appendix A
Environmental sensitivity	7.74/12	2.32	615	1, 2
Environmental attitudes	35.37/48	3.99	615	3-10
Locus of control	7.04/12	2.65	615	11, 12
Personal responsibility	7.82/12	2.53	615	13, 14
Willingness to participate	7.30/12	2.51	615	15, 16
Total	47.59/60	11.18	615	11-16

Table B 2 - Scores For "Environmental Science Knowledge" Section of the Survey

	Mean/ Out of	Standard Deviation	(n=)	Survey Question Numbers (Appendix A)
Total Environmental Knowledge	17.19/ 40	7.00	621	17-56

* Marcinkowski and Rehrig, 1995

Table B 3 - Scores for "Action Strategies" Section of the Survey

	Mean/ Out of	Standard Deviation	(n=)	Survey Question Numbers Appendix A
Knowledge of Action Strategies	11.46/ 25	5.76	595	59, 61, 63, 65
Ability to Use Action Strategies	10.96/ 25	5.68	595	60, 62, 64, 66
Total Action Strategy Score	22.37	11.19	595	59-66

APPENDIX C - SSELI ORIGIONAL SECTIONS*

1. An open-ended assessment of students' ability to identify problems and/ or issues;
2. A set of multi-item sub-scales designed to assess students' affective dispositions toward the environment;
3. A traditional, multiple choice test of students' knowledge of ecology, and of environmental problems;
4. An authentic assessment of student' issue-based skills, set in an issue-oriented story line;
5. A pair of sub-scales designed to elicit students' perceived knowledge of an ability to apply environmental action skills;
6. A series of sub-scales for assessing students' self-reported involvement in each of five categories of "responsible environmental behavior" over the most recent six-month period.
7. A supplemental instrument for recording students' demographics and assessing the dimensions of their experience reflected in the potential exploratory research questions.

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* Sections 2, 3,and 5 make up the survey used in this study
Marcinkowski and Rehrig, 1995

APPENDIX D – SUMMARY OF SSELI QUESTION OBJECIVES AND THE SOL WHICH ADDRESS THEM

Table D 1- Environmental Disposition Indicators and SOL Goals and objectives that address them. Goals are indicated with a G. Number of questions for each indicator is indicated in parenthesis.

Indicators	Environmental sensitivity (2)	Environmental attitudes (8)	Locus of control (2)	Personal responsibility (2)	Willingness to participate (2)
Components	Environmental Dispositions				
Biology					
Earth Science					
Both	G5, G6			G6	

Table D 2 - Environmental Concept (Ecology) Knowledge Indicators and SOL Goals and objectives that address them. Goals are indicated with a G. Number of questions for each indicator is indicated in parenthesis.

Indicators	Biodiversity	Symbiosis	Food Chains (5)	Photosynthesis/ Respiration (2)	Bio Geochemical cycles	Lifecycles (2)	Abiotic Factors	Adaptation	Niches	Decomposition (2)	Succession (2)	Bioaccumulation
Components	Knowledge of Ecology											
Biology	8c	8a	8a	2d	2a, 2d, 8b	8a	8a	7c	8a	8b	8c	
Earth Science					8d	3a						
Both												

Table D 3 - Environmental Concept (Environmental Science) Knowledge Indicators and SOL Goals and objectives that address them. Goals are indicated with a G. Number of questions for each indicator is indicated in parenthesis.

Indicators	Soil Erosion (4)	Energy Generation Methods (3)	Biodegradability	Sewage Treatment	Solid Waste Management	Nutrient Pollution	Groundwater Pollution	Soil Nutrients (2)	Pesticides (3)	Greenhouse Effect	Human Population (2)
Components	Knowledge of Environmental Science										
Biology			8b			8b		8b		2d	8a
Earth Science	7a, 8a, 8b	6a, 6b, 6c, 6d				8e	8c, 8d, 8e			11a, 11b, 11c, 11d	
Both											

Table D 4 - Environmental Action Indicators and SOL Goals and objectives that address them. Goals are indicated with a G. Number of questions for each indicator is indicated in parenthesis.

Indicators	Eco-management (2)	Economics (2)	Persuasion (2)	Political Action (2)	Legal (2)
Components	Action				
Biology					
Earth Science	6d	6d, 10e		10e	
Both		G6		G6	G6

APPENDIX E - EXERPTED SSELI SCORING GUIDELINES

***The Secondary School Environmental Literacy Assessment*·**

Instrument

Part I: How I Feel About the Environment

1. Environmental Sensitivity 10pts

2. Environmental Attitudes 20pts

3. Locus of Control 10pts

4. Personal Responsibility 10pts

5. Willingness to Participate 10pts

Part I Sub-score 60pts

Part II: Knowledge of Ecology and Environmental Science

1. Knowledge of Ecology 20pts

2. Knowledge of Environmental Science20pts

Part II Sub-score40pts

Part III: Knowledge of and Ability to Use Environmental Action Strategies

1. Knowledge of Action 25pts

2. Ability to Use Action 25pts

Part III Sub-score50pts

Total Environmental Literacy 150pts

· Marcinkowski and Rehrig, 1995

APPENDIX F - PARENTAL CONSENT FORM

An Assessment of Student Environmental Literacy

Ross Bair, Assessment Coordinator

The High School

1. What is the name and purpose of this project? "Evaluation of Environmental Literacy Assessment and Factors that Contribute to Environmental Literacy of High-School Students." The purpose of this study is to assess the environmental literacy of The High School students along with academic influences that affect factors that influence environmental literacy. The survey will of students who are currently enrolled in Earth Science, or Biology,.

2. How was your child chosen? Your child was chosen as a result of being enrolled in the courses listed above.

3. What is involved in participating? Students who participate in this assessment will be asked to respond to questions in sections outlined below.

Survey of environmental dispositions (16 Rating Likert Scale Questions)
Survey of environmental knowledge (40 Multiple choice questions)
Survey of Knowledge of Environmental Action Strategies (10 Rating Scale Questions)
Survey of Student Demographics and Class History (13 Multiple Choice Questions)

***If you agree to allow your child to participate in this assessment, the only things you need to do are*: (*1st) read and sign this consent form; and (2nd) return this signed form to your child's teacher in a timely manner.* Students not participating in the research activities will be involved in other school related activities. Students will not be rewarded or penalized for their participation or non-participation in this assessment.**

4. How will your child's participation be kept anonymous and confidential? Your child's teacher will assign an ID number to each student, and only this ID number will appear on the assessment instruments and optical scan form. Only the teacher will know which student has been assigned which ID number; at no time will members of the assessment team be able to connect specific students to their responses. Beyond this, no information will ever be disclosed to single out any individual student, nor will any student be identified in any report of this assessment. Your student's results for the survey will only be known to the researcher if the student uses their ID number to request their personal results from the researcher after the survey has been scored.

5. What are the risks and benefits associated with participating? We do not anticipate any risks associated with this assessment. Other than the commitment of time (less than one hour), there are no costs associated with participation. There are no direct benefits to your child for completing this survey. Upon request, a summary of the results of this assessment will be made available to personnel at your child's school.

6. What are your and your child's rights as participants? You may ask any questions at any time about this assessment and they will be answered to your satisfaction. Your child's participation in this assessment is voluntary. You may choose not to allow your child to participate, and you may withdraw your child from this assessment at any time. Not participating in the research project will have no affect on their standing with their school. Students not participating will work on other classwork.

7. How will this information be used? A report for this assessment will be prepared by the researcher. The results of this assessment will be used to refine the assessment program at The High School. Further, the aggregated results of this assessment will be used as data in a George Mason University Master's thesis. Finally, the findings may be used in presentations, professional meetings, and academic papers.

8. Who do you contact for more information? If you have any questions about this project, you can contact me by phone or email: Ross Bair, The High School, at (571) XXX-XXXX or <bairrm@pwcs.edu>. If you do not feel comfortable contacting our The High School, you may contact the Prince William County Public Schools, Institutional Review Board office at (703) 791-7277. This consent form will be kept on file at The High School for a period of three years.

I have read this form and give my consent to allow my child to voluntary participate in this assessment, as stated. I further understand that I am free to withdraw my child's participation in this pilot test at any time.

____

Signature of Parent or Guardian Date

____

Parent or Guardian's Name Printed Child's Name Printed

APPENDIX G - ASSENT FORM

ASSESSMENT OF THE RELATIONSHIP BETWEEN COURSE HISTORY AND ENVIRONMENTAL LITERACY AMONG HIGH SCHOOL STUDENTS IN WESTERN PRINCE WILLIAM COUNTY, VIRGINIA, USA

ASSENT FORM

INTRODUCTION

My name is Ross Bair, and I am studying to get a Master's degree in Environmental Science and Policy at George Mason University. I also teach biology and environmental science here at The High School.

RESEARCH PROCEDURES

The reason for this research is to find out what high school courses individually and in combination, have the greatest effect on environmental literacy. If you agree to take part in this study, you will be asked to spend about one hour answering questions about your environmental knowledge, feelings about the environment, and yourself. It will all take about one hour to finish.

RISKS AND BENEFITS

You will not lose any of your rights by being in the study. There are no rewards or money paid for being in this study and there are no direct benefits for participating. But the things I find out may help teachers and others within the education community to identify the best way to teach about the environment.

CONFIDENTIALITY

Your name will not be on the question answers your provide your teacher and the experimenter will not know who gave the answers you provide. Your identity will only be identified if you request your results from Mr. Bair after the survey has been scored.

PARTICIPTION

You do not need to do this survey if you don't want to. If you change your mind after we start talking and want to stop that is OK. Neither your teacher nor I will get mad and nothing will happen to you. If you choose not to participate you may work on other assignments.

CONTACT

You can call here at school at this phone number (571-XXX-XXXX) to speak with me or the building principal Mrs. Amy Ethridge-Conti about the study if you have any questions. You can also contact the Prince William County Public Schools, Institutional Review Board office at (703) 791-7277. The George Mason University Office of Research Subject Protections knows all about my research and said that it was OK for me to do it. You can call them at 703-993-4121 if you have any questions about being a part of this research.

CONSENT

I have read this form and I agree to be part of this study.

____

Name Date

APPENDIX H - VERBAL DESCRIPTION DELIVERED TO STUDENTS

Mr. Bair a teacher here at The High School is doing a research study on the effects of student classes on environmental literacy.

In order to do so he is asking you to participate in a survey that will be given in class.

The survey will take about 60 minutes and will contain questions about your knowledge and feelings about the environment in addition to questions about experiences you've had.

If you choose to participate in the survey the results will not affect your grade because any answers you give will not be connected in any way to your identity.

Not participating will also not affect your grade in any way.

If you choose not to participate neither your teacher, Mr. Bair nor anyone else at the school will be mad at you for this.

If you choose to participate please return the permission form provided as soon as possible to your teacher.

Mr. Bair thanks you for your help.

APPENDIX I - SURVEY ADMINISTRATION STATEMENT

Thank your for agreeing to take this survey. You should only be doing this survey if you have had a parent or guardian sign and return a permission form allowing you to do so and you have signed a student assent form. You may stop the survey at any time if you feel you do not want to participate.

At no time will anyone but you know how you responded on this survey. If you would like to retrieve your results on the survey you may do so from Mr. Ross Bair who teaches here at The High School using your self assigned personal number that you will know at the conclusion of the test.

Please do your best and answer all questions honestly and with your best effort.

During this survey you will be answering questions that survey your knowledge and feelings about the environment along with the classes you have taken and experiences you have had. Please do your best.

Thank you for your help.

APPENDIX J - RESULTS BY COMPONENT AND INDICATOR

Table J 1 - Key of abbreviations for Results By Component and Indicator Table J 2

KEY
Bold = High
Highlight = Correct Answer
Sens= Environmental Sensitivity
Att= Environmental Attitude
LOC= Locus of Control
PR= Personal Responsibility
WTP= Willingness to Participate
EK= Ecological Knowledge
ESK= Environmental Science Knowledge
UACT= Perceived Ability to Use Action Strategies
KACT= Perceived Knowledge of Action Strategies

Table J 2 - Results By Component and Indicator

				%	%	%	%	%	%	
Q#	Components	Indicator		A	B	C	D	E	F	n=
1	Affect	SENS		0.05	0.06	**0.30**	0.28	0.19	0.12	337
2	Affect	SENS		0.09	0.20	**0.29**	0.19	0.13	0.12	341
3	Affect	ATT		0.04	0.04	0.09	0.19	0.23	**0.42**	338
4	Affect	ATT		0.03	0.09	0.17	**0.32**	0.26	0.14	338
5	Affect	ATT		0.04	0.07	0.21	0.19	**0.26**	0.24	337
6	Affect	ATT		0.02	0.08	0.21	0.18	0.23	**0.29**	341
7	Affect	ATT		0.08	0.11	0.24	**0.27**	0.15	0.14	331
8	Affect	ATT		0.10	0.17	**0.33**	0.20	0.13	0.07	335
9	Affect	ATT		0.09	0.20	**0.33**	0.18	0.14	0.08	339

10	Affect	ATT		0.06	0.15	**0.29**	0.22	0.16	0.13	338
11	Affect	LOC		0.09	0.26	**0.32**	0.18	0.09	0.06	338
12	Affect	LOC		0.04	0.08	**0.26**	0.23	0.23	0.15	335
13	Affect	PR		0.10	0.15	**0.32**	0.20	0.15	0.08	338
14	Affect	PR		0.05	0.08	**0.26**	0.19	0.20	0.22	335
15	Affect	WTP		0.10	0.15	**0.37**	0.24	0.10	0.03	337
16	Affect	WTP		0.06	0.09	**0.28**	0.22	0.24	0.14	340
17	Knowledge	EK	B	**0.61**	0.25	0.07	0.01	0.07		342
18	Knowledge	EK	C	0.06	0.02	**0.85**	0.03	0.04		341
19	Knowledge	EK	A	**0.59**	0.23	0.07	0.01	0.09		339
20	Knowledge	EK	B	0.10	**0.74**	0.03	0.05	0.10		342
21	Knowledge	EK	A	**0.87**	0.03	0.02	0.03	0.05		339
22	Knowledge	EK	B	0.04	**0.75**	0.00	0.11	0.10		341
23	Knowledge	EK	D	0.28	0.01	0.06	**0.56**	0.09		340
24	Knowledge	EK	A	**0.23**	0.22	0.22	0.10	**0.23**		339
25	Knowledge	EK	D	0.03	0.15	0.20	**0.56**	0.07		340
26	Knowledge	EK	B	0.04	**0.78**	0.02	0.10	0.06		337
27	Knowledge	EK	C	0.26	0.05	**0.61**	0.04	0.04		339
28	Knowledge	EK	B	0.10	**0.65**	0.08	0.06	0.11		336
29	Knowledge	EK	A	***0.58***	0.04	0.14	0.04	0.21		339
30	Knowledge	EK	C	0.12	0.04	**0.62**	0.05	0.17		337
31	Knowledge	EK	B	0.02	0.43	0.02	**0.50**	0.04		338
32	Knowledge	EK	A	**0.60**	0.13	0.04	0.14	0.09		332
33	Knowledge	EK	C	0.19	0.07	**0.57**	0.06	0.12		339
34	Knowledge	EK	B	0.04	**0.35**	0.10	0.19	0.32		339
35	Knowledge	EK	D	0.17	**0.33**	0.05	0.24	0.20		335
36	Knowledge	EK	D	0.11	0.11	0.19	**0.39**	0.20		338
37	Knowledge	ESK	B	0.21	**0.39**	0.05	0.05	0.30		338
38	Knowledge	ESK	A	**0.46**	0.26	0.05	0.11	0.12		336
39	Knowledge	ESK	B	0.27	**0.36**	0.07	0.10	0.19		336
40	Knowledge	ESK	B	0.07	**0.49**	0.19	0.09	0.15		336
41	Knowledge	ESK	A	**0.44**	0.19	0.08	0.09	0.20		338
42	Knowledge	ESK	D	0.12	0.09	**0.31**	0.28	0.21		339
43	Knowledge	ESK	C	0.04	0.12	**0.72**	0.07	0.06		338
44	Knowledge	ESK	C	0.24	0.14	**0.40**	0.06	0.15		335
45	Knowledge	ESK	B	0.07	**0.75**	0.04	0.06	0.08		336
46	Knowledge	ESK	D	0.13	0.11	0.09	**0.55**	0.13		340
47	Knowledge	ESK	B	0.23	0.15	0.19	0.07	**0.36**		338
48	Knowledge	ESK	A	0.23	0.18	0.14	0.13	**0.31**		336

49	Knowledge	ESK	C	0.07	0.12	**0.61**	0.11	0.09		338
50	Knowledge	ESK	B	0.07	**0.48**	0.10	0.15	0.20		337
51	Knowledge	ESK	B	0.07	**0.58**	0.11	0.07	0.18		336
52	Knowledge	ESK	D	0.10	0.15	0.07	**0.48**	0.19		335
53	Knowledge	ESK	C	0.14	0.07	**0.58**	0.05	0.17		339
54	Knowledge	ESK	C	0.09	0.10	**0.48**	0.16	0.17		335
55	Knowledge	ESK	B	0.18	**0.23**	0.20	0.16	**0.23**		340
56	Knowledge	ESK	D	0.23	0.16	0.12	**0.26**	0.23		337
57	Action Strat	KACT		0.16	0.28	**0.32**	0.12	0.08	0.04	340
58	Action Strat	UACT		0.19	0.26	**0.33**	0.12	0.09	0.02	341
59	Action Strat	KACT		0.10	0.22	**0.31**	0.17	0.15	0.04	335
60	Action Strat	UACT		0.12	0.22	**0.30**	0.17	0.14	0.05	339
61	Action Strat	KACT		0.06	0.13	0.21	0.21	**0.27**	0.12	340
62	Action Strat	UACT		0.07	0.21	0.20	0.18	**0.22**	0.12	340
63	Action Strat	KACT		0.12	0.26	**0.28**	0.18	0.14	0.04	339
64	Action Strat	UACT		0.27	**0.34**	0.22	0.10	0.06	0.01	339
65	Action Strat	KACT		0.16	0.21	**0.26**	0.14	0.18	0.07	340
66	Action Strat	UACT		**0.25**	**0.25**	0.22	0.13	0.09	0.05	331
68	Action Strat	AGE		0.21	**0.53**	0.21	0.04	0.01		337
69	Action Strat	GRADE		**0.69**	0.25	0.06	0.01			337
70	Demographics	GEND		**0.59**	0.37	0.03				328
71	Demographics	ETH		0.08	0.07	0.16	**0.55**	0.04	0.12	340
72	Demographics	ED 1		0.03	0.17	**0.50**	0.18	0.11		336
73	Demographics	ED 2		0.04	0.16	**0.47**	0.22	0.12		339
74	Demographics	MWEE		**0.61**	0.24	0.14				329
75	Demographics	CLUB		**0.45**	0.03	0.03	0.02	0.03		65
76	Demographics	GBIO		0.14	0.07	0.00	0.01	**0.77**		334
77	Demographics	PA-BIO		**0.53**	0.13	0.00	0.00	0.33		334
78	Demographics	ADV ES		0.20	0.04	0.05	0.01	**0.70**		338
79	Demographics	G-ES		0.12	0.01	0.01	0.01	**0.85**		338

APPENDIX - K

Meaningful Watershed Experience and Environmental Literacy

Two hundred two students (56.9%) reported participating in the meaningful Watershed Experience field trip when they were in 6th grade. Eighty-one students (22.8%) reported that they did not participate in this field trip and 46 students (13.0%) did not remember if they had participated (n=338). This program, the result of Prince William County's effort to meet the Meaningful Watershed Experience mandate by the State of Virginia, exposes students to watershed instruction followed by a day-long outdoor watershed experience, and often schoolyard-based environmental stewardship activities.

Students who had participated in the Meaningful Watershed Experience showed a significantly higher environmental sensitivity, a score of 7.50, over 9% greater than those who had had not, 6.86 (p=0.032). There were no other significant differences in means measured for those who had participated in the Meaningful Watershed Experience versus those who had not.

It could be inferred that this experience had a positive effect on their sensitivity to issues. It will be interesting to see if this holds true over time as many of those who participated were freshman and therefore younger. The age of students may also be a factor as just as it may also be a factor in differences seen in students who have and those who have taken both biology and earth science and those who have taken only one of the two courses.

Gender and Environmental Literacy

Students' gender was surveyed but lay outside to focus questions of this thesis. One hundred ninety-two students identified themselves as female (56.8%) and 126 (35.5%) identified as male and 10 (2.8%) as neutral gender identity. Males tested higher on tests of ecological knowledge (males =12.53, females = 11.38, p=0.011), environmental science knowledge (males = 10.16, females = 9.14, p=0.037), and on the combined set of ecological and environmental science knowledge (males 22.80, females = 20.54, p=0.010).

Female Students surveyed as being more willing to participate in finding solutions to environmental problems, 7.31, than their male counterparts 6.79 (p=0.048).
Other than knowledge and willingness to participate the means of males and females surveyed showed no significant differences. This is supported by a study by Blocker and Eckberg who found that women show more personal concern than do men but that this does not translate to actual environmental action (1997).

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BIOGRAPHY

Ross Bair received his Bachelor of Arts in Biology from Bridgewater College in 2002. He was employed as a teacher in Carroll County, Maryland for two years where he attained his Master of Science in Secondary Science Education from McDaniel College in Westminster, Maryland. Ross moved on with his wife to Harrisonburg, Virginia where he taught for six years. Later he relocated with his wife and twin children to Manassas Virginia. While there he received his Master of Science in Environmental Science and Policy from George Mason University in 2013. Ross teaches AP environmental Science in Prince William County,Virginia.