An Evaluation of National Oceanic and Atmospheric Administration Chesapeake Bay Watershed Education and Training Program Meaningful Watershed Educational Experiences

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February 2007

Funding for this evaluation was provided by:
NOAA Chesapeake Bay Office
The Chesapeake Bay Trust
The Keith Campbell Foundation for the Environment

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OMB Control Number: 0648-0530
Expires: 02/28/2009

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EXECUTIVE SUMMARY

The National Oceanic and Atmospheric Administration (NOAA) funds Meaningful Watershed Educational Experiences (MWEEs) for students and professional development for teachers in the Chesapeake Bay watershed through its Bay Watershed Education and Training Program (B-WET). NOAA, with support from the Chesapeake Bay Trust and the Keith Campbell Foundation for the Environment, commissioned this evaluation to assess the effects of NOAA B-WET-funded Chesapeake Bay MWEEs on teachers' practices and students' environmental stewardship and academic achievement.

Data were obtained and analyzed from about:

- 500 MWEE professional development participants who completed a post-program questionnaire,
- 640 MWEE and comparison students who completed pre/post-test questionnaires, and
- 1,000 MWEE and comparison students who completed their state's standardized science tests.

Additional insights were derived from interviews with thirteen program managers from nine NOAA-funded organizations that provided MWEEs and professional development.

TEACHER PRACTICE

Do the professional development programs increase teachers' confidence in their ability and intentions to implement MWEEs?
Yes. On average, teachers reported increasing from "somewhat" to "very" confident in their ability and from "likely" to "very likely" to implement a MWEE as a result of their professional development.

Do the professional development programs result in teachers implementing MWEEs with their classes?
Yes. However, not all MWEE practices were implemented equally. Almost all of the teachers reported that they taught about the watershed or the Bay after the professional development, including the large majority of those who had not taught about the watershed or Bay in the past. Importantly, many teachers reported conducting more MWEE practices as a result of the professional development. However, about a quarter of the teachers reported that they were not teaching outdoors and about half reported that they were not conducting issue research or action projects with their students. About one third of the teachers implemented complete MWEEs that included Bay or watershed ecology instruction, outdoor learning, issue research, and environmental action.

It is likely that teachers' satisfaction with their professional development experiences contributed to the above outcomes. The majority of teachers reported having an "excellent" professional development experience. Teachers were most satisfied with the instructors, the quality of the information provided, and the usefulness of what they learned for improving their students' environmental stewardship.

What best professional development practices contribute to teachers' confidence in their ability and intentions to implement MWEEs?

Teachers expressed their degree of satisfaction with seventeen professional development practices. The six practices most strongly related to teachers' confidence and intentions to implement MWEEs were:

- Demonstration of how MWEEs will improve student academic achievement,
- Demonstration of how MWEEs will improve student environmental awareness, knowledge, and actions,
- Demonstration of the applicability of curriculum materials and activities to teachers' school district's learning standards,
- Follow-up support from professional development providers,
- Instruction and modeling of ways to guide students in conducting environmental action, and
- Instruction and modeling of ways to guide students in researching an environmental issue.

The following practices were also positively related to teachers' confidence and intentions to implement MWEEs:

- More professional development days,
- Time for hands-on learning,
- Time for practicing new skills, and
- Time for teachers to plan ways to integrate MWEEs into their curriculum.

What enables or limits teachers' use of MWEEs?

Teachers who participated in MWEE professional development in the past were asked about the extent to which they had a variety of resources (sixteen in total) to implement MWEEs with their students. In response, teachers most often reported having sufficient:

- Information on local watershed or Chesapeake Bay ecology,
- Information on local watershed or Chesapeake Bay environmental issues, and
- Knowledge and skills for teaching outdoors.

Teachers most often reported having insufficient:

- Flexibility in their curriculum,
- Funds for equipment, field trip fees, and transportation,
- Opportunities to collaborate with other teachers, and
- Professional development during the school year.

Recommendations

NOAA should continue to support high-quality MWEE professional development with priority given to multi-day programs. The professional development should include specific guidance on how teachers can incorporate MWEEs into their existing curriculum. Providers should allocate sufficient time for this during professional development. Teachers should be encouraged to bring their teaching guides to the professional development so that they can use this time to determine how best to integrate MWEEs. Providing teachers with sample lesson plans that illustrate how MWEEs can be incorporated into the existing curriculum is also likely to be helpful.

To address teachers' desire for collaboration, professional development should include sufficient time for teachers to learn from their peers and to partner with another or several teachers.

Providers should also consider offering MWEE professional development to teams of teachers from the same school to help ensure teachers will be able to support each other as they implement MWEEs.

Professional development providers should offer follow-up support in the form of instructional assistance, in the classroom and the field, to enable teachers to implement all components of a MWEE, especially environmental issue research and action projects. Teachers would benefit from funding to enable them to obtain the resources they need to implement MWEEs.

In collaboration with teachers, MWEE providers, and other stakeholders, NOAA should explore if and how school district standards can be revised so that MWEEs become an essential part of instruction (e.g., contained in curriculum pacing guides).

STUDENT ENVIRONMENTAL STEWARDSHIP

Do MWEEs increase students' characteristics associated with environmental stewardship?
Yes. Students improved in three of eight stewardship characteristics as a result of participating in B-WET-funded MWEEs. Importantly, students moderately increased in the characteristic most closely associated with future behavior, their intention to act to protect the Chesapeake Bay watershed. Students strongly increased in their knowledge of issues confronting the watershed or Bay and moderately increased in their knowledge of actions in which they can engage to protect the watershed or Bay. There is also some evidence that students moderately gained in their knowledge of watershed or Bay ecology, although this result was not statistically significant. All of these students' teachers agreed that their students knew more about the local watershed or the Chesapeake Bay. There was no evidence, however, to suggest that students improved in the remaining four environmental stewardship characteristics (environmental sensitivity, personal responsibility, or individual or group locus of control).

Which best MWEE practices result in the highest stewardship and engagement in learning?
Students scored higher in two or more stewardship qualities and engagement in learning when they experienced any of the following MWEE practices (listed in descending order of positive effects):

- Learning things that are important to them,
- Hands on learning,
- Collecting and analyzing data, and
- Learning outdoors.

In addition, reflecting on their learning had many positive effects on students' stewardship qualities. Participating in an action project and/or listening to talks and reading about issues also had positive, but more modest, effects on students' stewardship.

Importantly, students' sense of responsibility to protect the environment and their feeling that they can make a difference on their own (individual locus of control) appeared to be most positively influenced by (in descending order of positive effects) collecting and analyzing data, conducting action projects, and listening to talks and reading about issues. Because about a quarter of the students in the pre/post stewardship analysis did not collect or analyze data and about a third of the students did not participate in an action project (only a small number did not listen to talks or read about issues), it may be that these particular stewardship qualities would have improved if more students had experienced these practices.

Recommendations
Encourage teachers and providers of MWEEs to learn what is important to students and to be sure to connect MWEEs to these interests to make learning about the watershed or Bay relevant for students. In addition, instructors should foster MWEEs that incorporate hands-on learning, reflection, and learning outdoors. Ideally, MWEEs should include collecting and analyzing data and issue research based action projects. These specific practices have positive effects on environmental stewardship characteristics that other practices are less likely to influence. When engaging students in learning about the watershed, Bay, or their community and in action projects, be sure that these are empowering experiences. Negative experiences have the potential to decrease students' environmental stewardship characteristics. To the extent possible, all students should be involved in all aspects of quality MWEEs.

STUDENT ACADEMIC ACHIEVEMENT

Do MWEEs increase students' academic achievement in science?
Potentially. MWEEs have the potential to increase students' academic achievement in science. This observation is based on a case study of one B-WET-funded Virginia program that provided MWEEs to students who also completed a state standardized science test, as well as on teachers' impressions. In this case, third grade students performed moderately better on the Science Investigation category (one of four categories) of the state standardized science test. In addition, most teachers who participated in MWEE professional development believed that their students were better prepared for the state standardized tests as a result of MWEEs. Almost all teachers believed their students' engagement in learning increased, a factor associated with student achievement. Our analyses, however, did not detect a change in students' engagement in learning.

Recommendations
Additional research and evaluations are necessary to determine to what extent MWEEs can increase students' academic achievement. This evaluation focused on assessing gains in achievement based on students' performance on standardized science tests and engagement in learning. Other standardized tests and ways to measure achievement can be explored. To generalize the effects of MWEEs on state standardized tests, B-WET providers would have to target students in grades that are tested and for whom districts and authorities are willing and able to provide test scores.

In collaboration with teachers, providers, and other stakeholders, NOAA should explore to what extent MWEEs should have student achievement, in addition to environmental stewardship, as a desired goal. If student achievement remains a desired goal, further study is needed on how MWEEs can best foster student achievement. If not, NOAA should explore alternative ways to promote MWEEs' educational value to teachers and administrators.

INTRODUCTION

NOAA B-WET PROGRAMS

The National Oceanic and Atmospheric Administration (NOAA) envisions "An informed society that uses a comprehensive understanding of the role of the oceans, coasts and atmosphere in the global ecosystem to make the best social and economic decisions." Under the umbrella of that overarching vision, the NOAA Chesapeake Bay Office (NCBO) strives "To understand, predict, and explain changes in the Chesapeake Bay ecosystem, and to coordinate efforts to conserve and manage coastal and estuarine resources to meet the Region's economic, social, and environmental need." One strategy the NCBO uses is education. Their belief is that an educated citizenry will make well-informed decisions that will protect, conserve, and improve the Chesapeake Bay ecosystem.

As a strategy for implementing their mission, the NCBO education program supports the Chesapeake 2000 Agreement. On June 28, 2000, the members of the Chesapeake Executive Council, including the governors of Maryland, Pennsylvania, Virginia and the mayor of Washington, DC, renewed their commitment to improving the health of the Chesapeake Bay by signing the Chesapeake 2000 Agreement. These signatories committed to goals to restore fisheries, protect habitat, improve water quality, develop sound land use practices, and empower the watershed's citizenry through education and outreach. One significant goal for Education and Outreach is:

> Beginning with the class of 2005, provide a meaningful Bay or stream outdoor experience for every school student in the watershed before graduation from high school (Chesapeake 2000 Agreement).

To bolster the watershed-wide effort to attain this goal, in 2002 NOAA began administering the Bay Watershed Education and Training (B-WET) program to offer competitive grants to support existing environmental education programs, foster the growth of new programs, and encourage the development of partnerships among environmental education programs throughout the Chesapeake Bay watershed. The funding, over $2 million per year, assisted school jurisdictions in providing "Meaningful Watershed Educational Experiences" (MWEEs) to all students before they graduated from high school. B-WET funding was awarded to organizations that provided MWEEs directly to students and to organizations that provided professional development to teachers, training those teachers to conduct MWEEs with their students. For FY2005, 32 organizations, including nonprofits, school districts, state agencies, and universities, were funded to provide MWEEs to over 27,000 students and professional development to over 2,000 teachers.

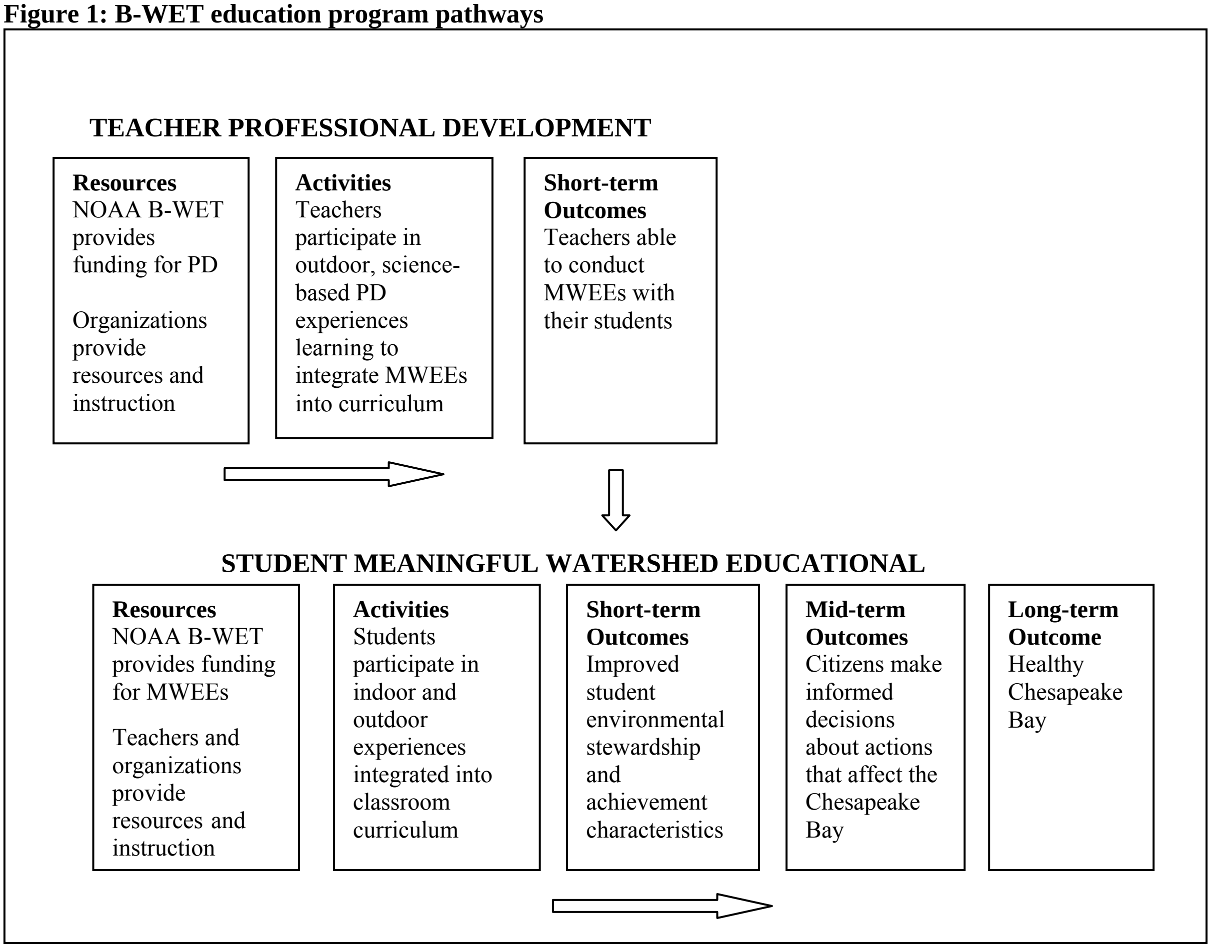
A MWEE integrates field experiences in the Chesapeake Bay watershed with multi-disciplinary classroom activities and instruction (Chesapeake Bay Program Education Workgroup 2001, Appendix G). Students then share their discoveries about the watershed with local schools and communities, both orally and in written form. MWEEs:

Are investigative or project-oriented,
Are integrated within the instructional program,
Involve preparation, action, and reflection,

Reveal the watershed as a system, and
Are integrated into a significant amount of instructional time, ideally a school year.

By directly providing students with MWEEs and training teachers to conduct their own MWEEs, the B-WET program strives to improve students' stewardship and academic achievement in the short-term (Figure 1). These students will become informed and empowered Bay watershed citizens who will act in ways to improve and protect the health of the Chesapeake Bay and its watershed in the long-term.

Figure 1: B-WET education program pathways



EVALUATION QUESTIONS

NOAA, the Chesapeake Bay Trust, and the Keith Campbell Foundation commissioned this evaluation to determine if NOAA B-WET professional development and MWEEs were attaining the short-term outcomes as measures of potential for a future Bay-protecting citizenry: (1) Teacher use of MWEE practices and (2) Student improvement in stewardship characteristics and academic achievement. The specific evaluation questions were:

Teacher Programs

- Do the professional development programs increase teachers' confidence in their ability and intentions to implement MWEEs?
- Do the professional development programs result in teachers implementing MWEEs with their classes?
- What best professional development practices contribute to teachers' confidence in their ability and intentions to implement MWEEs?
- What enables or limits teachers' use of MWEEs in the classroom?

Student Programs

- Do MWEEs increase students' characteristics associated with environmental stewardship?
- Do MWEEs increase students' academic achievement in science?
- Which best MWEE practices result in the highest stewardship and engagement in learning?

EVALUATION TIMELINE

This evaluation of NOAA's Chesapeake B-WET program started in November 2004 and was completed in February 2007 (Table 1). The evaluation design was finalized in early spring 2005, followed by instrument development and an application for Paperwork Reduction Act (PRA) clearance from the Office of Management and Budget. Full PRA clearance was obtained in February 2006 (expiration 02/28/2009). Data collection occurred between August 2005 and August 2006.

Table 1: NOAA B-WET evaluation timeline

Task	Project timeline
Stakeholder meeting	2004 November
Evaluation design and instrument development	2005 January-June
OMB emergency clearance approval process	2005 April-August
Current-year PD teacher post-questionnaire	2005 August-September
MWEE student pre/post questionnaires	2005 September-2006 June
OMB full clearance approval process	2005 October-2006 February
Prior-year PD teacher questionnaire	2006 April-June
Virginia SOL test results obtained	2006 May-August
Data analyzed	2006 July-November
PD and MWEE provider interviews	2006 November-December
Report writing	2006 October-2007 February
Project completed	2007 February

EFFECTS OF PROFESSIONAL DEVELOPMENT

EVALUATION QUESTIONS

This part of the NOAA B-WET evaluation sought to answer the following questions:

- Do the professional development programs increase teachers' confidence in their ability and intentions to implement MWEEs?
- Do the professional development programs result in teachers implementing MWEEs in their classes?

To answer these questions we conducted two surveys: (1) A survey of teachers who participated in a MWEE professional development in 2005 ("current PD participants") and (2) A survey of teachers who participated in MWEE professional development in the past between 2002 and 2006 ("past PD participants"). The latter survey included, but was not limited to, the current PD participants about 7 months after the first survey.

METHODS

Surveys

We surveyed teachers using questionnaires with valid and reliable measures adapted from past studies (Guskey 2000, Kirkpatrick 1998, Braus & Monroe 1994, Zint et. al. 2002).

Questionnaires

Current PD Participants

Teachers who participated in B-WET-funded professional development during the summer or early fall of 2005 (current PD participants) were asked to complete a web-based questionnaire immediately or shortly following their professional development experience.

Intention

Current PD participants were asked to self-report on changes in their preparedness to implement MWEEs with their students by providing retrospective pre-test and present-time post-test responses. Specifically, they were asked how likely or unlikely it was (before and after their professional development) that they would:

- teach about the local watershed or Chesapeake Bay,
- use the outdoors when teaching about the local watershed or the Bay,
- research an environmental issue with their students, and
- guide their students through taking an action on an environmental issue.

Confidence

Current PD participants were also asked about their confidence in their ability (before and after their professional development) to engage in the above four behaviors as well as the following additional ones:

- integrate local watershed or Bay issues into their curriculum,

- collect watershed or Bay data in the field, and
- analyze watershed or Bay data.

We asked teachers about these particular sets of behaviors because they were considered important components of MWEEs (Chesapeake Bay Program Education Workgroup 2001).

Satisfaction
Lastly, current PD participants were asked to rate their overall professional development experience and satisfaction with 17 best professional development practices such as presentation effectiveness, materials provided, and time for planning how to implement MWEEs with their classes. Teachers also responded to two open-ended questions about what best prepared them to teach about the local watershed and the Bay and how could the professional development be improved.

Past PD Participants
Teachers who participated in NOAA B-WET-funded professional development since its inception in 2002 (past PD participants) were asked to complete a web-based questionnaire between April and June 2006.

Past PD participants were asked about the implementation of MWEEs in their classes. Specifically, they were asked if (before and after the professional development) their students:

- learned about local watershed or Bay ecology,
- learned outdoors about the local watershed or Bay,
- researched a watershed a watershed or Bay environmental issue, and
- completed an action to address a local watershed or Bay environmental issue

Past PD participants were also asked about their overall satisfaction with their MWEE professional development, including an open-ended question about what was most helpful about the professional development. Lastly, they were asked to identify in closed- and open-ended questions, what resources they need to implement MWEEs.

Response Rates

Current PD Participants
We collected data from 14 NOAA B-WET-funded professional development programs that implemented workshops during the summer and fall of 2005. We asked the program providers for teachers' names and email addresses. We were given the information by providers who stored this contact information and felt comfortable sharing it with us (they were not breaking a privacy agreement with the participants). We contacted teachers using SurveyMonkey, an online survey program. Two organizations preferred to email teachers directly (for privacy reasons) and one distributed the survey web link at the workshop. One organization provided email addresses for one workshop, but then had teachers complete paper questionnaires at two other workshops. The teachers who were contacted using SurveyMonkey were sent two reminders to complete the questionnaire, if necessary. Overall, 354 teachers completed the post-program questionnaire with a response rate of 70% (exceeding our expected response rate of 65%).

Past PD Participants

Twenty-six providers offered NOAA B-WET-funded teacher professional development programs between 2002 and 2006. Fourteen of these organizations provided names and contact information for their participants. Seven providers did not have this information and five providers never responded to our request.

We emailed past PD participants using Zoomerang and SurveyMonkey in April, May and early June 2006, requesting that they complete our questionnaire. Each past PD participant received an initial email, a reminder if they did not respond to the first email, and another reminder if they had not responded to the first two emails.

We emailed requests to 1,046 past PD participants (excluding emails that bounced). These emails resulted in 334 completed questionnaires for a 32% response rate (lower than our expected 50% response rate). Our final total past PD participant sample of 386 teachers includes 52 additional respondents who participated in programs offered by two providers that preferred to contact participants themselves.

Our lower-than-expected response rate may have been due to several factors:

- teachers were very busy during the end of the school year (April-June),
- many of the teachers had completed a similar questionnaire in the fall and were less likely to complete an additional questionnaire,
- some teachers indicated that they could not open the Zoomerang questionnaire (thus SurveyMonkey was used for the final requests),
- teachers were not offered an incentive to complete the questionnaire,
- the web-questionnaire programs were not 100% reliable in tracking bounced emails,
- teachers may not have recognized the name of the provider that offered their watershed or Bay professional development and thus did not complete the questionnaire, and
- an unknown number of emails were intercepted by spam filters.

Respondents

Current PD participants who responded to the fall 2005 questionnaire participated in professional development offered by 14 NOAA B-WET-funded organizations (Table 2). The past PD participants who responded to the spring 2006 questionnaire participated most recently in professional development offered by 25 NOAA B-WET-funded organizations (Table 2).

Table 2: Organizations which provided PD for current and past participants

Organization	Current PD Participants	Past PD Participants
Alice Ferguson Foundation, Inc.	✓	✓
Anacostia Watershed Society	✓	✓
Arlington Echo Outdoor Education Center	✓	✓
Chesapeake Bay Foundation	✓	✓
Chesterfield County Public Schools		✓
CRC Foundation		✓
Earth Force, Inc		✓
Environmental Concern, Inc	✓	✓
Fairfax County Public Schools	✓	✓
James River Association		✓
Mary Baldwin College		✓
Maryland Association for Environmental and Outdoor Education	✓	✓
Maryland State Department of Education		✓
Pennsylvania Department of Education		✓
Rivanna Conservation Society	✓	
The Mountain Institute		✓
Thorpe Foundation	✓	✓
Towson University		✓
University of Delaware	✓	✓
University of Maryland, Biotechnology Institute	✓	✓
University of Maryland, Center for Environmental Science	✓	✓
Virginia Department of Environmental Quality	✓	✓
Virginia Institute of Marine Science		✓
Virginia Polytechnic Institute and State University		✓
Virginia Resource Use Education Council	✓	✓

The majority (73%) of current PD respondents' most recent local watershed or Bay professional development was between 4 and 10 days in length. Similarly, the majority (61%) of past PD respondents' most recent professional development was between 3 and 10 days in length.

The majority of past PD respondents (n=386) taught in public schools (Table 3). Several taught in private schools and some were non-formal educators. Teachers and faculty in public and private K-college as well as educators teaching in non-formal settings are referred to as "teachers" in the remainder of the report (n=374). Because our focus was on classroom-based MWEEs, data from past PD respondents who were not teachers (e.g., school administrators and natural resource agents) were not included in this study. We did not collect data on current PD respondents' occupation.

Table 3. Occupations of past PD participants

n=386	Number	Percent
K-12 public school teacher	335	86.7
K-12 private school teacher	29	7.5
Non-formal educator of K-12 students	8	2.1
College or university faculty member	2	0.5
School administrator	3	0.8
Natural resource agent	1	0.3
Other	8	2.1

Current PD participants completed their MWEE professional development during the summer or fall of 2005. And, some of the past PD participants (16%) completed their local watershed or Chesapeake Bay professional development in 2006, not long before completing the questionnaire (Table 4). More than a third of the teachers (35%) participated in their local watershed or Bay professional development before 2005.

Almost half of past participants completed their most recent local watershed or Chesapeake Bay professional development the previous year, 2005. There is overlap between the current PD participants and the past PD participants. We were able to match 60 of these teachers' two questionnaires to examine the intentions they had for implementing MWEEs just after their professional development (2005) and their actual practice several months later (2006).

Table 4: Year of past participants' most recent local watershed or Chesapeake Bay professional development

n=374	Number	Percent
2002	16	4
2003	38	10
2004	79	21
2005	181	49
2006	60	16

About 1/3 of both current and past PD participants did not teach about the Chesapeake Bay before participating in their most recent watershed or Bay professional development (Table 5). (Data were not collected from past PD participants on number of years of teaching, only whether they had or had not taught about the watershed or Bay.) On the other extreme, many (14%) of current PD participants had taught about the Bay for over 10 years.

Table 5: Number of years current PD participants taught about the watershed or Bay before the PD

	Current PD Participants n=354 %
None	34
1-3 school years	28
4-6 school years	12
7-10 school years	8
More than 10 school years	14
Missing	4

Both current and past PD participants were evenly distributed between elementary, middle, and high school grade levels (Table 6).

Table 6: Grade levels taught by PD participants

Grade level	Current PD Participants n=336 %	Past PD Participants n=374 %
Elementary (K-5)	31	29
Middle (6-8)	34	37
High (9-12)	28	29
Other	7	5

Most of both current and past PD participants taught science (Table 7).

Table 7: Subjects taught by PD teachers

Subject	Current PD Participants n=354 %	Past PD Participants n=374 %
Science	64	80
Math	28	28
Social studies	21	20
English or language arts	24	24
Reading	24	25
Fine arts	4	2
Other[1]	16	16

The majority of both current and past PD participants taught in either Maryland or Virginia (Table 8).

Table 8: Teachers' jurisdictions

State	Current PD Participants (n=340) %	Past PD Participants (n=361) %
Delaware	1	1
Maryland	46	38
Pennsylvania	4	4
Virginia	37	51
Washington, DC	4	3
West Virginia	7	2
Other	1	1

Over their teaching careers, almost all past PD participants completed three or more professional development days focused on the local watershed or the Chesapeake Bay (Table 9). Similar data were not collected for current PD participants.

[1] Other subjects taught included: agriculture, computers/technology, enrichment, environmental education, gifted, health, horticulture, language, library skills, life skills, natural resources, physical education, religion, special education, and speech.

Table 9: Number of days of local watershed or Chesapeake Bay PD during past PD participants' careers

n=356	Number	Percent
1/2 day	3	1
1-2 days	18	5
3-10 days	164	46
11-20 days	81	23
More than 20 days	90	25

Analysis

To measure changes in current PD participants' intention (4 items, scale 1-6) and confidence (7 items, scale 1-4) to implement MWEEs, we used a paired sample nonparametric analysis (Wilcoxon Signed Ranks Test) to test for differences in their retrospective pre- and post-program responses. This method is used to test for significant differences when data are measured on an ordinal scale, which was the case for these items.

In addition, we created indexes of pre- and post-program intention and confidence. We created an "Overall Intention" index (scale 6-24) by summing the 4 post teacher intention variables. Similarly, we created "Overall Confidence" index (scale 7-28) by summing the 7 post teacher confidence variables. We conducted ANOVAs to determine if there were differences between teachers' overall retrospective pre- and post-test intentions and confidences.

We used the Chi Square test to determine if participant groups were different in implementation of MWEE practices. We explored the relations between PD participants' confidence and intentions to implement MWEEs with their actual MWEE practices using Spearman's rho correlation.

RESULTS

Do the professional development programs increase teachers' confidence in their ability and intentions to implement MWEEs?

Teachers' Confidence in their Ability to Implement MWEEs

As indicated earlier, current PD participants were asked to report their before- and after-program confidence in their MWEE abilities (with 1=Not at all confident, 2=Somewhat confident, 3=Very confident, 4=Extremely confident). For each of the seven practices, teachers reported that they significantly increased in their confidence to implement these practices from the beginning to the end of the professional development (Table 10). On average, teachers reported changing from being "somewhat confident" to "very confident" in their ability to implement each of the seven MWEE practices.

Table 10: Current PD participants' retrospective pre- to post-program confidence in implementing MWEEs

How confident are you in your ability to ___________?	Scale	n	Pre Mean	Post Mean	p	Change
Teach students about the local watershed or the Chesapeake Bay	1-4	330	1.98	3.21	<0.001	Somewhat to very confident
Integrate local watershed or Bay lessons into your required curriculum	1-4	330	1.90	3.18	<0.001	Somewhat to very confident
Use the outdoors to teach about your local watershed or the Bay	1-4	331	2.06	3.20	<0.001	Somewhat to very confident
Research an environmental issue with your students	1-4	328	2.16	3.13	<0.001	Somewhat to very confident
Collect watershed or Bay data in the field	1-4	328	1.76	2.97	<0.001	Somewhat to very confident
Analyze watershed or Bay data	1-4	326	1.72	2.81	<0.001	Somewhat to very confident
Guide students through an action project that addresses a local or Bay environmental issue	1-4	325	1.75	2.98	<0.001	Somewhat to very confident
Overall confidence	7-28	313	13.23	21.45	<0.001	

Teachers' Intentions to Implement MWEEs

Current PD participants were also asked to report their before- and after-program intentions to implement MWEEs (with 1=Extremely unlikely, 2=Very unlikely, 3=Unlikely, 4=Likely, 5=Very likely, 6=Extremely likely). For each of the four practices, teachers reported that their intentions significantly increased from the beginning to the end of the professional development (Table 11). On average, teachers reported changing from being "likely" to "very likely" to engage in each of the four MWEE practices.

Table 11: Current PD participants' retrospective pre- to post-program intentions to implement MWEEs

How likely or unlikely is it that you will ___ during the next school year?	Scale	n	Pre Mean	Post Mean	p	Change
Teach about your local watershed or the Chesapeake Bay	1-6	352	3.79	5.26	<0.001	Likely to Very likely
Use the outdoors when teaching about your local watershed or the Chesapeake Bay	1-6	350	3.71	5.21	<0.001	Likely to Very likely
Research an environmental issue with your students	1-6	349	3.97	5.13	<0.001	Likely to Very likely
Guide your students through taking action on an environmental issue	1-6	349	3.62	5.03	<0.001	Likely to Very likely
Overall intention	6-24	345	15.10	20.62	<0.001	

Do the professional development programs result in teachers implementing MWEEs with their classes?

Teachers' Confidence in their Ability and Intention to Implement MWEEs and their Actual Practice

Did teachers' confidences and intentions predict their subsequent practice? We were able to answer related questions for the 60 teachers who (1) completed a questionnaire in the fall of 2005, (2) completed another questionnaire in the spring of 2006 (about 8 months later), and (3) provided identifying information (i.e., birth day and month) that allowed us to match the two questionnaires.

Confidence and Actual Practice

Teachers' confidence in their ability to implement MWEEs was not significantly correlated with their reported actual practices (Table 12). In other words, teachers who expressed more confidence in their abilities to implement MWEEs were not more likely to engage in these practices than less confident teachers.

Table 12: Correlations between teachers' confidence in their ability to implement MWEEs and their actual MWEE practices

n=57-59	Correlation coefficient	p
Teach about the watershed/Bay	.198	0.133
Teach outdoors	.213	0.105
Research issues	-.085	0.527
Implement action project	.254	0.057

Confidence and Intention

Teachers' post-program confidence and intentions were strongly, positively correlated (Table 13). In other words, teachers who expressed more confidence in their abilities to implement MWEEs were more likely to intend to engage in these practices than less confident teachers.

Table 13: Correlations between teachers' confidence and intentions

n=311-376	Correlation coefficient	p
Teach about the watershed/Bay	0.504	<0.001
Teach outdoors	0.602	<0.001
Research issues	0.525	<0.001
Implement action project	0.457	<0.001
Overall	0.591	<0.001

Intention and Actual Practice

Only two of the four correlations between teachers' intentions and actual practices were statistically significant at our preferred level of $\alpha=0.05$ (teach outdoors, research issues), the other two at an acceptable level of $\alpha=0.10$ (teach about Bay, implement action project) (Table 14). Given our relatively small sample size, it is likely that all of these intentions are indeed related to subsequent actual practices; i.e., the higher teachers' intentions to engage in these practices, the more likely they are to actually engage in them.

Table 14: Correlations between teachers' intentions and MWEE practices

n=60	Correlation coefficient	p
Teach about the watershed/Bay	0.234	0.072
Teach outdoors	0.413	0.001
Research issues	0.256	0.049
Implement action project	0.223	0.087

The frequency of teachers who taught about the Bay was different from those who taught outdoors (chi square=6.656, p=0.010) (Table 15). The frequency of teachers who taught outdoors was different than those who researched issues (chi square=15.207, p<0.001). And the frequencies of those who implemented actions were not different from those who researched issues (chi square=0.032, p=0.857). By looking at the teachers who were "extremely likely" to do MWEE practices, more taught about the Bay than the other three practices. More taught outdoors than implemented research or conducted action projects. But about the same number implemented issue research as conducted action projects.

Table 15: Comparisons of teachers' intentions with their practices

Intention expressed in fall 2005 n=60	Teaching practice reported in spring 2006			
	Percent who taught about watershed or Bay	Percent who taught outdoors	Percent who implemented research	Percent who implemented action
Unlikely (n=1-2)	0	50	0	0
Likely (n=6-12)	67	22	25	23
Very likely (n=10-19)	90	50	26	47
Extremely likely (n=32-43)	91	78	50	52

Teachers who intended to teach about the watershed or Bay (indicated "likely", "very likely", or "extremely likely), and subsequently did not, gave the following reasons:

- Did not fit into grade 6 curriculum this year
- Did not get to it with the current school schedule
- I teach language arts. My involvement in the program was to create an interdisciplinary unit regarding the local watershed. My part is to support my team's science teacher's watershed lesson by working with the written part of his lesson.
- It was not part of my pre-set curriculum.
- My class schedule has changed.
- The Maryland Voluntary State Curriculum and the time allocated for science did not leave enough time to teach the local watershed. Hopefully, we will have enough time this year.

Change in MWEE Implementation

Results in the previous section indicated that current PD participants' confidence in their ability and intentions to conduct MWEEs increased as a result of their PD. Importantly, results from current PD participants with whom we were able to follow up with another questionnaire also indicated that teachers with higher intentions to conduct MWEEs were more likely to report that they had actually engaged in MWEE practices. In other words, teachers' intentions predicted their actual practices. This section supplements what we learned about the subset of past PD teachers' implementation of MWEEs after their professional development by examining the full group of past PD teachers' changes in their self-reported practices.

Past PD participants were asked if they taught about the local watershed or the Bay before and after the professional development (Table 16). Importantly, almost all of the 370 respondents (93%) taught about the Bay after their professional development. As suggested by these results, almost all teachers (96%) who taught about the watershed or the Bay before the professional development did so afterward, as did the majority of teachers (87%) who did not teach about it before.

Table 16: Number and percent of teachers who taught about the Bay after their PD

	Did teach after PD (n=343)	
n=370	Number	Percent
Did not teach before PD (n=124)	108	87
Did teach before PD (n=246)	235	96

For teachers who reported teaching about the local watershed or the Bay before and after the professional development, there was no difference in the number who reported that their students learned about watershed or Bay ecology before and after the professional development (Table 17). However, the same teachers also indicated that more of their students learned outside (18% more), researched environmental issues (21% more), and completed action projects (25% more) after the professional development than before.

Table 17: MWEE practices of teacher who taught about the Bay before and after their PD

When you taught about the local watershed or the Bay, did your students _____? n=235	Before the PD % of teachers	After the PD % of teachers	Chi square	p
Learn about local watershed or Bay ecology	92	91	.541	0.462
Learn outdoors about the local watershed or Bay	61	79	22.891	<0.001
Research a watershed or Bay environmental issue	45	66	42.965	<0.001
Complete an action to address a local watershed or Bay environmental issue	30	55	67.892	<0.001

Fewer teachers who did not teach about the local watershed or the Bay before the professional development reported that their students were participating in each of the 4 MWEE practices than teachers who did teach about the watershed or Bay before (Table 18). Thus, as might be expected, teachers who are new to teaching about the Bay are not conducting MWEE practices as often as those with past experience.

Table 18: MWEE practices of teachers who did and did not teach about the Bay before their PD

When you taught about the local watershed or the Bay, did your students _____?	Teachers who did teach about the watershed/Bay before PD n=235	Teachers who did not teach about watershed/Bay before PD n=108		
MWEE Practice	**% who did the MWEE practice**	**% who did the MWEE practice**	**Chi square**	**p**
Learn about local watershed or Bay ecology	91	83	10.111	0.001
Learn outdoors about the local watershed or Bay	79	62	27.783	<0.001
Research a watershed or Bay environmental issue	66	40	69.224	<0.001
Complete an action to address a local watershed or Bay environmental issue	55	36	35.934	<0.001

Of the teachers who taught about the Bay after the professional development, many (23%) of those who did not implement all 4 MWEE practices before the professional development did so afterward (Table 19). Of those teachers who did implement all 4 MWEE practices before the professional development, the majority (83%) continued to do so afterward.

Table 19: Percent of teachers who conducted all 4 MWEE practices

		After the PD	
		Implemented 3 or fewer MWEE practices	Implemented all 4 MWEE practices
Before the PD	Implemented 3 or fewer MWEE practices (n=283)	77%	23%
	Implemented all 4 MWEE practices (n=52)	17%	83%

MWEE Implementation after the PD

Of the past PD participants who indicated they taught about the local watershed or the Bay after the professional development, the majority (89%) reported that their students were learning about ecology, the majority (74%) reported that their students were learning outdoors, slightly more than half (58%) reported that their students were conducting research, and about half (49%) reported that their students were completing action projects (Table 20). Almost one third (32%) of these teachers also reported that their students were experiencing all 4 MWEE practices after the NOAA B-WET funded professional development.

Table 20: Percent of teachers using MWEE practices with their students after professional development

After the professional development…	Teachers who taught about watershed or Bay after PD n=345 %
Students learned about local watershed or Bay ecology	89
Students learned outdoors about the local watershed or Bay	74
Students researched a watershed or Bay environmental issue	58
Students completed an action to address a local watershed or Bay environmental issue	49
Students did all of these	32

The following two paragraphs provide some additional information about students' action projects and outdoor experiences:

Action Projects

Of the 169 past PD participants whose students engaged in action projects after completion of the NOAA B-WET funded professional development, most consisted of restoration projects (Table 21). Many teachers also reported conducting more than one type of action project with their students.

Table 21: Action projects conducted by students of teachers who completed professional development

Type of action project n=169	% of teachers
Restoration project (for example, growing/planting wetland plants or raising/releasing fish)	63
Communication or information-sharing (for example, making a presentation to the community)	46
Monitoring project (for example, conducting periodic water tests)	42
Pollution prevention project (for example, erosion control)	40

Outdoor Teaching

Of the 243 past PD participants who indicated that they taught outdoors after completing the NOAA B-WET funded professional development (74% of all respondents) and answered this question, most (71%) indicated that all of their students participated in an outdoor experience during their watershed or Bay unit (Table 22). The remaining teachers (29%) did not include all of their students in an outdoor experience.

Table 22: Percent of students who participated in an outdoor experience during their watershed or Bay unit

	n=248 %
100% or close to 100%	71
About 75%	9
About 50%	6
About 25%	14

PROFESSIONAL DEVELOPMENT BEST PRACTICES

EVALUATION QUESTIONS

This part of the NOAA B-WET evaluation sought to answer the following questions:

- What best professional development practices contribute to teachers' confidence in their ability and intentions to implement MWEEs?
- What enables or limits teachers' use of MWEEs in the classroom?

METHODS

Surveys

Questionnaires and Respondents

This section reports results for the same questionnaires and respondents described in the previous Effects of Professional Development section (Page 9).

Analysis

Teacher Satisfaction

We summarized teachers' impressions of the professional development and their resource needs and supported these findings with selected quotes.

Best Practices

To determine which professional development practices were positively related to PD participants' intentions and confidence to implement MWEEs, we first conducted a factor analysis of these practices using a principle components analysis. We then ran a regression to explore the extent to which the 3 resulting factors predicted participants' intentions and confidence to implement MWEEs. We supplemented this analysis with an ANCOVA that explored which PD practices were most highly rated by teachers who changed the most (versus least) in their confidence and intention.

We used the Chi Square test to determine whether ongoing professional development affected MWEE implementation. We used the Spearman's rho correlation to examine the relationship between the duration of the professional development and teachers' confidence in their ability and intention to implement MWEEs.

Provider Interviews

Respondents

We interviewed 13 program managers from 9 B-WET funded programs organizations. These providers were selected based on whether students included in our evaluation's sample had participated in their programs. Several of the organizations also provided professional development. They were asked the questions below pertaining to teachers' resource needs:

- Based on your interactions with teachers, what are the barriers teachers encounter for implementing MWEEs with their students?
- Based on your interactions with teachers, what is most helpful to the teachers in preparing them to implement MWEEs? What additional resources do you think they need?

Analysis

A summary of the comments is provided.

RESULTS

What best professional development practices contribute to teachers' confidence in their ability and intentions to implement MWEEs?

Teachers' Satisfaction with PD Practices

Overall, the majority of teachers (71% and 68% of current and past PD participants, respectively) rated their most recent professional development as "excellent" (Table 23).

Table 23: Teachers' overall rating of their most recent local watershed or Chesapeake Bay professional development

	Current PD n=343 %	Past Year PD n=374 %
Excellent	71	68
Very good	22	22
Good	6	9
Fair	1	1
Poor	0	0

Many of the current PD teachers made complimentary statements about the professional development such as:

The variety of experiences was phenomenal. The presenters were very knowledgeable and informative. The related assignments were very appropriate and manageable. This was the most relevant continuing education I have done in the past 10 years. I thoroughly enjoyed it and will recommend it highly to my fellow teachers. I look forward to future experiences with my class. Please continue to provide this excellent program for our area teachers and students!

This was an outstanding professional development course. It provided hands-on activities that educated us about the Bay. Also, we are now able to give our students an authentic, integrated experience while helping the environment.

In nearly 20 years of professional development, this was probably the best. I rate it highly because of my personal development and improved knowledge not just how it translates to the classroom.

The majority of current PD participants also indicated that that they were satisfied with the different elements of the professional development programs (Table 24). Specifically, the large majority rated as "excellent" the:

- knowledge of the instructor,
- quality of the information that was provided,
- usefulness of what they learned for improving students' environmental awareness, knowledge and actions, and
- quality of examples provided of watershed or Chesapeake Bay lessons and activities.

Specifically, teachers made these comments:
Instructor Quality:

> *The knowledge, experience, and dedication of the staff was astounding. Our instructor was a thoughtful, meticulous, and generous leader – an amazing resource! Another instructor attended to all contacts promptly, addressed any logistical concerns, and provided an enthusiastic welcome. The depth and experience of the personnel set a high standard for environmental education organizations.*

Information Quality:

> *I gained enormous amounts of valuable information for my students, staff, community, and for myself, and am really motivated to begin this project, and build on what our school has in place already.*

Student Stewardship:

> *I have taken my students canoeing with the Chesapeake Bay for almost 20 years and it is always their favorite part of the school year. This class has now shown me how to take canoeing to the next level where they can now take action on the Bay in many ways.*

Lesson Examples:

> *The 5-day field experience they provided is just the kind of professional development I dream about – well-organized, accompanied by excellent curriculum materials, handled by experts, chock full of lessons, labs, and activities to experience, etc.*

Most also appeared satisfied with elements ranging from the quality of examples provided of lessons and activities to the presentation on how to guide students in researching an environmental issue.

Teachers appeared least satisfied with the following.

- amount of time available for practicing new skills,
- plans made for follow-up support from professional development providers,
- plans made for future collaboration with other teachers, and
- amount of time allowed for planning how you will integrate what you learned into your own teaching.

Specifically, teachers made these comments:

Skill Practice:

If the program were a day longer to practice the skills learned, I would feel more confident about ability to convey what was covered.

Follow-up Support:

Several of the instructors offered to come help with projects at our individual schools. I hope to be able to arrange that.

Future Collaboration:

I suggest a follow up meeting with the group about 1 month after the experience to discuss how plans are coming and going to be implemented

Integration:

I would have been better able to integrate the information into my curriculum had I brought a list of grade-level indicators or curriculum benchmarks with me. Additionally, it would have helped me to make connections had we had journal prompts related to curriculum.

Teachers' Satisfaction with PD Practices and their Confidence and Intention to Conduct MWEEs

To answer the question of which professional development practices best predicted teachers' confidences and intentions to conduct MWEEs with their students, we conducted two sets of analyses with data from 345 current PD participants.

First, we identified which of the 17 professional development practices were most closely related to each other based on teachers' level of satisfaction with these practices. A factor analysis (principal components analysis with Varimax rotation) identified 3 components with an Eigenvalue > 1.0, with the first factor accounting for most of the variance (Table 25).

Based on examining the items that loaded on the respective factors (Table 26), these seemed to reflect the following aspects of the professional development practices:
(1) Relevancy of MWEEs and support for MWEE implementation
(2) Quality of professional development resources and comfort during professional development
(3) Amount of active learning time during professional development

We then conducted a regression analysis to determine if these 3 factors predicted teachers' self-reported change in their overall intentions (sum of 4 items) and overall confidence to conduct MWEEs (sum of 7 items), controlling for pre-test intention and confidence, respectively (Table 27). All three components were significantly and positively related to changes in teachers' confidences and intentions to conduct MWEEs. In addition, these factors predicted a relatively large amount of the variance in both cases. Thus, the extent to which teachers were satisfied with all of these sets of practices related to their confidence and intentions to conduct MWEEs. Based on the standardized regression coefficients, practices associated with the first factor (i.e., Relevancy of MWEEs and support for MWEE implementation), however, appeared to be more influential than the other two factors in predicting changes in both teachers' intentions and confidences.

Table 24: Current PD participants' post-program impressions of their professional development

	n	N/A %	Poor %	Fair %	Good %	Very good %	Excellent %	Mean score (scale 1-5)
Knowledge level of primary instructor(s)	342	1	0	1	4	21	73	4.64
Quality of information provided (written or presented) about the local watershed or the Bay	345	2	0	1	4	20	73	4.60
Usefulness of what you learned for improving student environmental awareness, knowledge, and actions	344	1	0	1	6	20	72	4.58
Quality of examples provided of watershed or Chesapeake Bay lessons and activities	345	2	0	1	7	23	67	4.48
Amount of time for hands-on learning	341	1	1	3	8	24	63	4.46
Your physical comfort during the indoor sessions	344	1	0	2	10	31	56	4.38
Helpfulness of community resources such as natural resource experts	343	3	0	3	8	30	56	4.31
Applicability of curriculum materials and activities to your school district's learning standards	345	4	0	2	10	26	58	4.29
Usefulness of what you learned for improving student academic achievement	345	2	0	2	9	36	51	4.28
Your physical comfort during the outdoor sessions	343	1	1	2	14	31	51	4.28
Amount of time available for teachers to learn from and share ideas with each other	342	1	1	4	15	32	47	4.19
Presentation effectiveness on how to guide students in conducting environmental action (e.g., restoration, monitoring, prevention, communication)	345	4	1	4	13	32	46	4.06
Presentation effectiveness on how to guide students in researching an environmental issue	344	5	1	4	13	33	44	3.99
Amount of time available for practicing new skills	344	2	0	7	19	36	36	3.94
Plans made for follow-up support from PD providers	344	3	2	6	19	33	37	3.89
Plans made for future collaboration with other teachers	344	4	2	8	20	31	35	3.77
Amount of time allowed for planning how you will integrate what you learned into your own teaching	343	3	2	8	26	34	27	3.70

Table 25: Variance explained by components

Component	Initial Eigenvalues	% of Variance Explained	Cumulative % Variance Explained
1	7.817	45.980	45.980
2	1.405	8.267	54.248
3	1.276	7.507	61.755

Table 26: Loadings of principle components analysis

PD Practice	Correlations 1	2	3	Component
Usefulness of what you learned for improving student academic achievement	0.795	0.309	0.152	1
Applicability of curriculum materials and activities to your school district's learning standards	0.781	0.203	0.046	
Usefulness of what you learned for improving student environmental awareness, knowledge, and actions	0.749	0.354	0.177	
Presentation effectiveness on how to guide students in researching an environmental issue	0.664	0.182	0.379	
Presentation effectiveness on how to guide students in conducting environmental action	0.634	0.159	0.462	
Plans made for future collaboration with other teachers	0.555	0.120	0.400	
Plans made for follow-up support from PD providers	0.460	0.192	0.396	
Quality of information provided (written or presented) about the local watershed or Chesapeake Bay	0.306	0.767	0.047	2
Knowledge level of primary instructor(s)	0.158	0.682	0.343	
Your physical comfort during the indoor sessions	0.066	0.673	0.334	
Quality of examples provided of watershed or Chesapeake Bay lessons and activities	0.465	0.597	0.143	
Your physical comfort during the outdoor sessions	0.151	0.579	0.303	
Helpfulness of community resources such as natural resource experts	0.392	0.577	0.058	
Amount of time available for practicing new skills	0.156	0.223	0.821	3
Amount of time available for teachers to learn from and share ideas with each other	0.178	0.298	0.784	
Amount of time allowed for planning how you will integrate what you learned into your own teaching	0.475	0.115	0.678	
Amount of time for hands-on learning	0.215	0.48	0.613	

Table 27: Regression of 3 PD practice components with change in overall intention and confidence

	Relevancy of MWEEs and support for MWEE implementation		Quality of professional development resources and comfort during professional development		Amount of active learning time during professional development	
	Standardized coefficient	p	Standardized coefficient	p	Standardized coefficient	p
Change in overall intention (adjusted R square=.618)	.282	<0.001	.126	<0.001	.144	<0.001
Change in overall confidence (adjusted R square=.529)	.353	<0.001	.161	<0.001	.132	0.001

To further explore the question of which professional development practices best predicted teachers' confidence and intentions to implement MWEEs, we distinguished between how two groups of teachers' rated the 17 different professional development practices (Table 28). The two groups consisted of: (1) those who started out low in intention or confidence and reported a large change from pre- to post-program (n=129 for intention, n=103 for confidence) and (2) those who also started out low in intention or confidence and reported a small change from pre- to post-program (n=44 for intention, n=56 for confidence).

Teachers in the "large change in intention" group rated the overall professional development and 12 professional development practices significantly higher than those in the "small change in intention" group (Table 28). The "large change in confidence" group rated the overall professional development and 11 professional development practices significantly higher than those in the "small change in confidence" group. Nine practices were rated significantly higher by both the intention and confidence "large change" groups:

- Presentation effectiveness on how to guide students in implementing environmental action
- Usefulness of what teachers learned for improving student environmental awareness, knowledge, and actions
- Plans made for follow-up support from professional development providers
- Usefulness of what teachers learned for improving student academic achievement
- Applicability of curriculum materials and activities to teachers' school district's learning standards
- Presentation effectiveness on how to guide students in researching an environmental issue
- Amount of time allowed for planning how teachers will integrate what you learned into your own teaching
- Amount of time for hands-on learning
- Amount of time available for practicing new skills

Note that the first six practices identified above were also identified as part of the first factor and the last three practices as part of the second factor predicting teachers' intentions and confidences to implement MWEEs. In combination these results suggest that the above practices may be particularly helpful in increasing teachers' confidence and intentions to implement MWEEs.

Table 28: Differences in ratings of PD practices between teachers with small and large changes in intention and confidence

	Change in Intention				Change in Confidence			
	p	Large change mean n=129	Small change mean n=44	Difference in means	p	Large change mean n=103	Small change mean n=56	Difference in means
Overall impression of PD	0.001	4.73	4.25	0.48	0.041	4.73	4.57	0.15
Presentation effectiveness on how to guide students in implementing environmental action	<0.001	4.15	3.18	0.97	<0.001	4.39	3.77	0.62
Usefulness of what you learned for improving student environmental awareness, knowledge, and actions	<0.001	4.74	3.90	0.84	<0.001	4.82	4.49	0.33
Plans made for follow-up support from PD providers	0.001	4.03	3.25	0.78	<0.001	4.11	3.27	0.84
Usefulness of what you learned for improving student academic achievement	0.029	4.29	3.53	0.76	0.009	4.41	4.00	0.41
Applicability of curriculum materials and activities to your school district's learning standards	0.031	4.32	3.63	0.70	0.001	4.44	3.95	0.49
Presentation effectiveness on how to guide students in researching an environmental issue	0.035	4.02	3.40	0.62	<0.001	4.30	3.63	0.67
Amount of time allowed for planning how you will integrate what you learned into your own teaching	0.005	3.77	3.18	0.59	0.001	3.92	3.30	0.62
Plans made for future collaboration with other teachers	0.063	3.79	3.25	0.54	0.001	3.98	3.25	0.73
Amount of time for hands-on learning	0.001	4.60	4.13	0.48	0.045	4.60	4.45	0.15
Amount of time available for practicing new skills	0.016	4.06	3.63	0.44	0.047	4.09	3.79	0.30
Your physical comfort during the indoor sessions	0.006	4.43	4.00	0.43	0.115	4.41	4.20	0.21
Your physical comfort during the outdoor sessions	0.064	4.32	3.93	0.40	0.180	4.24	4.07	0.17
Quality of examples provided of watershed or Chesapeake Bay lessons and activities	0.021	4.55	4.18	0.37	0.106	4.61	4.43	0.18
Amount of time available for teachers to learn from and share ideas with each other	0.122	4.29	3.95	0.34	0.150	4.31	4.02	0.29
Helpfulness of community resources such as natural resource experts	0.067	4.33	4.08	0.26	0.051	4.37	4.21	0.16
Quality of information provided (written or presented) about the local watershed or Chesapeake Bay	0.046	4.68	4.43	0.25	0.290	4.67	4.61	0.06
Knowledge level of primary instructor(s)	0.167	4.72	4.50	0.22	0.006	4.77	4.59	0.18

We were also able to further explore the influence of on-going support and of the duration of the professional development. Results are presented in the next two paragraphs:

Differences in Teachers' MWEE Practices Based on On-going PD Support

Past participants who received on-going support were more likely to implement MWEE practices than those who did not receive such support (Table 29).

Table 29: Comparison of teachers' MWEE practices when did and did not receive ongoing provider support

	No ongoing support n=81-82	Ongoing support n=271		
MWEE Practice	% did the MWEE practice	% did the MWEE practice	Chi square	p
Taught about the Bay	87	95	11.616	0.001
Taught outside	56	73	30.308	<0.001
Implemented issue research	44	59	24.002	<0.001
Implemented action project	39	48	9.882	0.002

Differences in Teachers' Confidence and Intention to Implement MWEEs Based on PD Duration

The longer the professional development experience, the greater the teachers' overall intention to implement MWEEs (Table 30). The same relation, however, was not significant (at $\alpha=0.05$) for teachers' overall confidence.

Table 30: Correlation of PD duration with overall intention and confidence

Post Overall Intention n=348		Post Overall Confidence n=313	
Correlation coefficient	p	Correlation coefficient	p
0.218	<0.001	0.108	0.056

What enables or limits teachers' use of MWEEs in the classroom?

Teachers' Perspectives on their Resource Needs

To answer this question, we asked teachers what resources they had to provide MWEEs to their students. Teachers indicated that they had sufficient information about watershed and Bay ecology, environmental issues, and how to investigate those issues (Table 31). They also reported having adequate knowledge and skills for teaching outdoors. In contrast, curriculum flexibility, school year professional development, teacher collaboration, and funds appeared to be most desired. Regarding these last 4 resource needs, teachers said:

<u>Curriculum Flexibility</u>:

I would love to see more involvement by the county Language Arts, Science, and Social Studies resource offices. These staff members will be key to helping us incorporate more environmental science time into our curriculums. Currently, we are very restricted by programs our school day does not support (timewise) as well as 'pacing guides' telling us what page to be on on any given day. The various departments would be instrumental in assisting with this difficulty we will face whenever we want to take the time to teach local watershed and bay lessons.

We need resource people hired to come into the schools to demonstrate how to teach the watershed material. The problem is that the schools are so immersed in teaching to the standardized tests that all else is neglected. I taught the watershed material anyway and integrated it into my curriculum, but I was a long time teacher; the younger teachers are afraid to deviate from the standards' "blueprint" studies and it is harming studies of our natural world. 'There is no time,' they say, 'Standardized tests are king.' If you had people (ex-teachers like myself) who could go into the schools and show how to blend the teaching of our Chesapeake Bay material into curriculum, the schools would accept it. As it is, few teachers actually have time to absorb the most wonderful material you gave us unless they are obsessed with ecology as I was. I found ways to work it into the standards and could teach others.

<u>School Year PD</u>:

I think that ongoing professional development opportunities are necessary to keep teachers excited about making learning alive for their students by researching real life issues. We, as teachers, never stop learning and are always looking for opportunities to learn more to share with colleagues.

<u>Teacher Collaboration</u>:

I would like more opportunities to collaborate with others as well as funding to attend conferences.

<u>Funding</u>:

I wonder if there is any monetary assistance for outdoor activities. Every year, there is less money for field experiences so I have reduce my outdoor activities.

Funds for equipment to develop an outdoor pond/watershed area or take advantage of field trips.

Transportation is still a problem. We need access to school buses that don't have to be back to make the elementary school runs. We struggle each year getting bus drivers. We cannot charter buses - the cost is prohibitive.

I'd like more boots for student accessibility to the stream for macro-invertebrate sampling. I'd also like funds for making a bluebird trail at school.

The most frequently mentioned reason for not teaching about the watershed or the Bay following the professional development were related to curriculum restrictions (Table 32 & Table 33).

Table 31: Teacher resource needs for implementing MWEEs

I have adequate ____ to provide MWEEs to my students.	n	Strongly disagree %	Disagree %	Neutral %	Agree %	Strongly agree %	Mean score (scale: 1-5)
Information on local watershed or Chesapeake Bay ecology	357	1	2	5	45	47	4.34
Information on local watershed or Chesapeake Bay environmental issues	356	1	2	6	48	43	4.29
Knowledge and skills for teaching outdoors	356	1	3	7	46	43	4.27
Information on how to investigate local watershed or Chesapeake Bay issues	356	2	3	11	47	37	4.15
Information on how to collect data from the local watershed or Bay	353	2	5	10	47	36	4.10
Information to identify local field trip sites	355	1	7	12	44	36	4.08
Information on where to obtain instructional materials	354	1	6	14	48	31	4.02
Information on how to integrate watershed or Bay lessons into existing curriculum	352	2	7	14	42	35	4.02
Information on how to implement actions with students to address local watershed or Chesapeake Bay issues	353	2	6	12	51	29	4.00
Sample lesson plans	349	4	10	14	40	32	3.87
Support from school administrators	352	5	9	22	35	29	3.75
Access to field trips led by other professionals	354	3	15	17	37	28	3.72
Flexibility in my curriculum	355	7	25	17	30	21	3.34
Professional development during the school year	346	4	22	25	33	16	3.34
Opportunities to collaborate with other teachers	351	6	25	23	32	14	3.23
Funds	352	16	33	22	19	10	2.75

Table 32: Comments of teachers who did not teach about the local watershed or the Bay before the PD and did not teach about it after the PD

n=16
Did not get to it with the current school schedule.
I am a health teacher, so it is not in my curriculum. However, I do use my knowledge from the course when I participate (yearly) in 6th grade outdoor ed.
I am a librarian so do not teach science directly. I did share information with teachers so that could work on it.
I am a Spanish/French teacher. Although I have discussed conservation with regard to use of paper, etc, with my students I did not formally teach about the Bay or the watershed.
I ran out of time before the SOL test--I have posters from the workshop that I will use to base a classroom exercise---when I get the time to develop it!
I taught about the soils but watershed is not in the third grade curriculum.
I teach Computer Programming
I teach language arts. My involvement in the program was to create an interdisciplinary unit regarding the local watershed. My part is to support my team's science teacher's watershed lesson by working with the written part of his lesson. My role is to allow language arts class time to organize the data acquired in science lessons into a well written informational article. The final written article/ project is graded by the science teacher for accuracy and observation; my role is grade project on the students' writing process.
I teach math for 6th grade and have not found a way to incorporate it in a time-lined curriculum enforced by Baltimore County.
It did not directly fit my curriculum and for lack of time opted not to address this topic
It is not part of the science curriculum at my grade level.
It was not part of my pre-set curriculum.
Moved to teaching 8th grade physical science
My trip was ecology related and it was my AP- Biology class, we have a lot to cover syllabus wise. We had discussion related to our topic and the trip which blended well.
Not part of a rigorous curriculum developed by PG county public schools in my grade level. Not to mention there is not enough time in the day to teach what is required, much less anything outside of that
The Maryland VSC and the time allocated for science did not leave enough time to teach the local water shed. Hopefully, we will have enough time this year.

Table 33: Comments of teachers who did teach about the local watershed or the Bay before the PD and did not teach about it after the PD

n=11
Change in position resulting in a change in curriculum.
Did not fit into Gr. 6 curriculum this year
I am currently teaching math to all 5th grade students, so I am unable to do the science at this time. I did however share ideas with my teammate so he could use them with our students.
I am teaching 5th grade in Montgomery County Maryland, where we must adhere to the curriculum provided. Ecology is studied in the fourth grade
I had already finished that unit.
I taught it before, so I had already covered watershed. Although, it was helpful w/ the information they shared to explain watershed even more clearly.
My class schedule has changed.
No longer at that grade level.
Not at that point in curriculum yet...I will when I get there
The local watershed topic was covered as part of the professional development project.
Third Grade Science SOLs do not require in-depth teaching on the watershed. I do teach the value of protecting the watershed through conservation especially the planting of trees and protection of plants along the rivers that prevent erosion into the bay.

Providers' Perspectives on Teachers' Resource Needs

The number of providers who made a specific comment is indicated in parentheses after the statement.

School Environment

Providers commented on the climate in which teachers work and how that affected their use of MWEEs in the classroom:

- Teachers are accountable for student performance on standardized tests, so teachers are teaching to the test. If a teacher does not perceive a connection between a MWEE and the standardized test, then he/she will not implement a MWEE. (3)
- Teachers have to use pacing guides and will not add any lessons that are not in those guides. Teachers have far less autonomy in choosing what they teach than they used to. (3)
- The pacing guides sometimes put the ecology curriculum at a time of year that is less inviting for outdoor learning (e.g., early spring when flora and fauna are scarcer). (1)
- MWEE providers need to provide self-contained programs (i.e., all resources are provided including staff time) so that teachers are not required to do any extra work. (1)
- Environmental topics not part of the standard curriculum. (1)
- Standardized tests occur during the best time to do outdoor learning (e.g., May) creating a time conflict. (1)
- Very experienced teachers incorporate field experiences despite curriculum restrictions, but schools are losing those teachers (high turnover). (1)
- It is hard to get teachers to change their ways if they are comfortable with the ways they already teach. (1)

Teacher Needs

Providers reported on their observations of what teachers need to implement MWEEs with their students:

- Teachers need the support of their administrators to implement MWEEs. Many school systems limit the number of field trips that can be taken in a school year. (5)
- Teachers need the resources (including time) and personnel (including volunteers) to take their students outside to learn. Teachers are not comfortable managing students outside, implementing issue research, and implementing action projects without assistance. (4)
- Teachers need money for buses and substitutes. (4)
- MWEEs have to be integrated into the existing curriculum and accountability standards thus not taking time from required curriculum. (2)
- Teachers need time to see how MWEEs fit into their curriculum; 1- or 2-week professional development program are too short. (2)
- Teachers need pre-service professional development in science, outdoor learning, and field research. (2)
- Teachers need ongoing professional development that is long-term and sustaining. (1)
- Teachers need to connect with local watershed organizations for resources and personnel. (1)
- Someone should try to change state standards so that MWEEs are a required part of curriculum. (1)
- Teachers need opportunities for sharing with other teachers. (1)

- Teachers need practical examples of how other teachers have implemented MWEEs. (1)
- Teachers need to understand that MWEEs are "required" by the Bay states. The department of education does not communicate that MWEEs are a required part of the curriculum. (1)

EFFECTS OF MWEES ON STUDENT ENVIRONMENTAL STEWARDSHIP

EVALUATION QUESTIONS

This part of the NOAA B-WET evaluation sought to answer the following question:

- Do MWEEs increase students' characteristics associated with environmental stewardship?

To answer this question, we collected data from students, their teachers, and teachers who had participated in MWEE professional development (past PD participants described in the Effects of Professional Development section, page 11).

METHODS

Surveys

Student Questionnaires

We developed a pre- and post-test questionnaire to collect data from students who experienced MWEEs and a comparison group of students who did not.

The student questionnaires were designed primarily to assess changes in students' environmental stewardship characteristics based on experiencing MWEEs. The specific characteristics that we measured have been associated with environmental stewardship behavior (Hungerford & Volk 1990) (Figure 2). These characteristics include: environmental sensitivity, knowledge of ecology, knowledge of environmental issues, sense of personal responsibility, knowledge of environmental action strategies, individual and group locus of control, and intention to protect/restore the watershed.

We used valid and reliable measures from past evaluations of environmental education programs to measure changes in these characteristics (Ajzen & Fishbein 1980, Kraemer et. al. 2002, Nowak et. al., 1995, Zint et. al. 2002). For the knowledge of ecology questions, students responded to multiple choices questions. For the 7 other characteristics, students in elementary school (grades 3-5) were given 3 response options of 'no'/ 'not sure'/'yes' or 'never'/'sometimes'/'always' (depending on the question). Secondary students (grades 6-12) were asked the same questions but had 5 response options.

Last, students were asked to share their gender, age, grade level, and to rate their prior academic performance on a scale from A to F.

We relied on teachers to administer these student questionnaires, but assisted them by providing them with relevant instructions. For example, the teachers of MWEE students (see details in next section) were asked to administer the pre-questionnaire to their students immediately before the MWEE program began and the post-questionnaire on the last day of the MWEE during the 2005-06 school year. One of our other requests was that teachers distribute active consent forms to obtain parental permission for their child's participation in this evaluation. Only students for whom parental consent was obtained were given paper questionnaires and a scannable sheet for marking their responses.

Figure 2: Hungerford & Volk (1990) Behavior Flow Chart
(*Italicized* variables were included in this evaluation)

Entry-level variables	**Ownership variables**	**Empowerment variables**	***Citizenship behavior***
Major variable *Environmental sensitivity*	**Major variable** *In-depth knowledge about issues*	**Major variables** *Knowledge of* and skills in using *environmental action strategies* *Locus of control (expectancy of reinforcement)* *Intention to act*	
Minor variables *Knowledge of ecology* Androgyny Attitudes toward pollution, technology, and economics	**Minor variables** Knowledge of the consequences of behavior – both positive and negative *A personal commitment to issue resolution*	**Minor variable** *In-depth knowledge about issues*	

MWEE Teacher Questionnaire

We also designed a post-MWEE questionnaire for teachers. As part of this questionnaire, we asked teachers to what extent they believed that their students improved in watershed or Bay knowledge and intentions to protect the watershed or the Bay. In addition, the questionnaire asked teachers to provide information about the MWEE practices their students experienced. Specifically, we asked teachers to report on the following:
Curriculum duration:

- How many hours was the curriculum?
- How many weeks/months was the curriculum?
- Issue research:
- Did the students explore the community for issues?
- Did the students listen to talks about, or read about, local watershed or Bay environmental issues?

- Did the students study social, economic, historical, or archaeological issues?

Data collection and analysis:

- Did the students collect data?
- Did the students use field equipment, such as hand-held technology, for data collection?
- Did the students analyze watershed or Bay data?
- Did the students graphically display data (e.g., create charts, graphs)?

Environmental action project:

- Did the students implement an action project that involved communication, monitoring, pollution prevention, and/or restoration?

We asked teachers and their students about these particular MWEE practices because these practices are considered important components of MWEEs (personal communication with B-WET staff; Chesapeake Bay Program Education Workgroup 2001).

Past PD Questionnaire

As described in the Effects of Professional Development section (page 9), teachers who had participated in MWEE professional development completed a questionnaire (past PD participants) (n=334). As part of this questionnaire, we asked teachers to what extent they believed that their students improved in watershed or Bay knowledge and intentions to protect the watershed or the Bay. Descriptive statistics were generated to summarize teachers' responses.

Respondents & Response Rates

Our primary goal for this part of the evaluation was to survey the students of teachers who implemented MWEEs and to compare these students' responses with those of students who did not experience MWEEs. To identify MWEE students, we needed to identify MWEE teachers which we did with the help of MWEE providers. We asked 16 organizations who had received NOAA B-WET funding (contact information provided by NOAA) to provide lists of teachers whom they expected to implement MWEEs with their students during the 2005-06 school year. If the organizations did not yet have teachers enrolled in their programs, we asked them to provide estimates of how many teachers they expected to participate and subsequently, implement MWEEs. Based on this information, we created a list of potential MWEE teachers for the 2005-2006 school year, with placeholders for teachers not known by name.

Based on the assumption of a 65% response rate, a power of 80%, an alpha of 0.05, and a 0.1 effect size, a power analysis suggested that we needed contact 78 teachers to generate the desired student sample. To select these teachers, we first randomized the complete list of MWEE teachers for the 2005-2006 school year and then selected 24 elementary, 30 middle, and 24 high school teachers from this list. We then contacted these teachers by email, fax, and occasionally by telephone (most teachers were in class and not available to speak by phone). When teachers agreed to participate, instructions and pre-test materials were mailed to them about two weeks before they began their program. If teachers indicated they could not participate, the next teacher on the randomized list was contacted until the sample was complete. Post-test materials were sent only to teachers whose students completed the pre-test (or were expected to complete the pre-test).

To obtain comparison classes (ones that did not experience MWEEs), we asked MWEE teachers to identify another teacher at their school willing to administer the questionnaire to their students at the same time MWEE students completed theirs. The MWEE teacher was not always able to identify such a teacher. For example, in some schools, all the students in a grade level participated in a MWEE. In other schools, the principal would not permit non-MWEE students to use class time for the questionnaire.

In the end, the overall pre-test response rate was 43% and the overall post-test response rate was 65% (Table 34). MWEE teachers' response rates were higher than the comparison teachers' for both the pre- and post-tests.

Table 34: Response rates for student data

	MWEE	Comparison	Total
Class sets of pre-tests sent	74	53	127
Class sets of pre-tests returned	36	19	55
Pre-test response rate	**49%**	**36%**	**43%**
Class sets of post-tests sent[1]	45	33	78
Class sets of post-tests returned	34	17	51
Post-test response rate	**76%**	**52%**	**65%**

[1]Some post-tests were sent to teachers who had not returned pre-tests

In total, teachers returned questionnaires completed by 1,345 children from 60 classes across grades 3 through 12 (Table 35). Of those, 37 classes with 880 students experienced MWEEs and 23 classes with the remaining children did not. The final sample we were able to use for this section's analyses, however, was smaller and consisted of 20 MWEE and 12 comparison classes (we used all 29 matched MWEE classes for subsequent Best Practices analyses). We could only use the questionnaires of students:

- who correctly completed the identification question used for matching pre- and post-test responses,
- who did not have the same identification number as another student because they had the same birthday and gender (e.g., twins),
- who completed both the pre- and post-test (this was the case for 29 treatment and 12 comparison classes), and
- in the MWEE classes, could be matched by grade with comparison classes (this was the case for 20 treatment classes).

Table 35: Class data returned

	MWEE classes	Comparison classes	Total
Matched pre- and post-tests	29	12	37
Class with no ID info on post-test	2	0	2
Class with no post-tests	3	6	9
Class with no pre-tests	1	4	5
Different students in pre- and post-tests	2	1	4
Total classes	37	23	60

MWEE Providers

The students in our sample were in classes taught by teachers who participated in the MWEE programs offered by 10 different providers (Table 36).

Table 36: MWEE programs included in the pre/post analysis

Program	State	Number of MWEE classes matched pre/post	Number of MWEE classes in pre/post analysis
Arlington Echo	MD	2	1
Boxerwood	VA	2	2
Keystone Central	PA	1	1
Living Classrooms MD	MD	1	0
Living Classrooms DC	DC	1	1
MD DNR	MD	12	8
National Aquarium	MD	2	1
RCS	VA	2	2
VA Aquarium	VA	2	3
VA DEQ	VA	3	1
TOTAL		29	20

MWEE Instructional Practices

Of the 20 MWEE teachers whose students could be included in our analyses, 19 teachers returned completed questionnaires. As part of these questionnaires, teachers provided information about the MWEEs experienced by their students.

The MWEEs lasted from less than a week to 8-10 months (Table 37) with the majority of students (84%) receiving 6-40 hours of MWEE instruction (Table 38).

Table 37: Duration of the MWEEs

n=19	Number	Percent
Less than 1 week	2	10
1 to 3 weeks	5	26
1 month	4	21
2-4 months	4	21
5-7 months	2	11
8-10 months	2	11

Table 38: Number of MWEE instructional hours

n=19	Number	Percent
1-5 hours	2	11
6-10 hours	6	32
11-20 hours	5	26
21-40 hours	5	26
61-80 hours	1	5

Table 41 indicates which MWEE practices teachers reported engaging in with their students. The majority of teachers indicated that their students conducted issue research of some kind (63-95%) and that their students collected watershed or Bay data (68%) and analyzed data (79%). Less than half of the teachers, however, reported that their students implemented a solution to a Bay or watershed problem (47%), although in contradiction, most of the teachers reported that their students participated in a restoration project (63%). Almost all teachers reported that their students spent time reflecting on their learning (95%). Most teachers reported that their students learned outdoors either on the water (68%) or in the school yard (63%). When asked what percent of their students learned outdoors, 68% said all of their students did (Table 39).

Table 39: Percent of students who learned outdoors during the MWEE

n=19	Number	Percent
100% or close to 100%	13	68.
About 75%	1	5
About 25%	3	16
Zero	2	11

The following table indicates how often students reported engaging in these MWEE practices (Table 40). About half of the students said they often learned things that were important to them. About two-fifths of the students often engaged in hands on learning, over a third often learned outdoors, and about a quarter of the students often reflected on their learning.

Table 40: How often students reported participating in these MWEE practices

N=252-256	Never %	Sometimes %	Often %
Learn outdoors	10	53	37
Reflect on learning	20	54	26
Hands on learning	14	45	41
Learn things that are important	9	40	51

Table 41: MWEE practices in which students participated

MWEE Practices	n=19 classes	Yes n	Yes %	No n	No %	NA n
Classroom-based learning	Participate in a school classroom-based, local watershed or Bay curriculum?	18	95	1	5	
Research issues	Explore the local community (beyond the classroom) for information on local watershed or Bay environmental issues?	12	63	7	37	
	Study social, economic, historical, or archaeological issues?	13	68	5	26	1
	Listen to talks about, or read about, local watershed or Bay environmental issues?	18	95	1	5	
Collect and analyze data	Collect local watershed or Bay data?	13	68	6	32	
	Use field equipment, such as hand-held technology, for data collection?	9	47	9	47	1
	Analyze watershed or Bay data?	15	79	4	21	
	Graphically display data (e.g., create charts, graphs)?	8	42	11	58	
Action projects	Implement a solution to a local watershed or Bay problem?	9	47	10	53	
	Participate in a communication/information-sharing action (e.g., making a presentation to the community)?	7	37	12	63	
	Participate in a monitoring project (e.g., periodic water testing)?	7	37	12	63	
	Participate in a pollution prevention project (e.g., erosion control)?	7	37	12	63	
	Participate in a restoration project (e.g., growing/planting wetland plants)?	12	63	7	37	
Reflect on learning	Have an opportunity to reflect on their local watershed/Bay unit?	18	95	1	5	
Outdoor learning	Learn about the local watershed or Bay outdoors on an on-the-water field trip?	13	68	5	26	1
	Learn about the local watershed or Bay outdoors in the schoolyard?	12	63	7	37	
Subjects learned	Learn fine arts content and skills?	10	53	9	47	
	Learn language art content and skills?	15	79	4	21	
	Learn math skills?	16	84	3	16	
	Learn reading skills?	17	89	2	11	
	Learn science content and skills?	18	95	1	5	
	Learn social studies content and skills?	14	74	4	21	1

Analysis

Before we could proceed with analyzing the impact of MWEEs on students' environmental stewardship characteristics, we needed to prepare our data and examine our scales' reliabilities[2]. First, students' responses were excluded if their pre- and post-tests could not be matched. For example, if pre- or post-tests were not available for a particular student or if no identifying

[22] Measures for "engagement in learning" were included on the student questionnaire and this description of the data analysis, but results are reported in the Student Academic Achievement section.

information was provided to allow matching of pre- and post-tests. Students in treatment classes were also removed if they did not have matching grade level comparison class. This was the case for classes in grade 5, 7, 11, and 12. This reduced our sample to 451 students in 32 classrooms in grades 3, 4, 6, 8, 9 and 10. Of these students, 57% participated in B-WET funded programs.

To determine the reliability of the questionnaire's measures, we conducted a confirmatory factor analysis with questions grouped by stewardship characteristic using pair-wise deletion. Because elementary and secondary students completed different questionnaires, we (1) analyzed their responses independently, (2) standardized both (as part of the factor analysis; mean=0, SD = 1), and then (3) combined them for the multi-level analyses. The 8 factors (pre- and post-test) had reliabilities (Cronbach's alpha) ranging from 0.57 to 0.85 (Appendix A).

To assess the impact of MWEEs on students' environmental stewardship characteristics, we conducted a multi-level analysis of covariance (ANCOVA) using hierarchical linear modeling (HLM) (Raudenbush & Bryk 2002). Multi-level analysis was appropriate because it can control for the shared, group nature of students' MWEE experiences in classes. ANCOVA permits controlling for variables in addition to the treatment (i.e., MWEEs), such as students' grade, that may also influence their environmental stewardship qualities.

For these multi-level analyses, we created dummy-coded variables for females (1=yes; 0=no) and grade levels (one for each grade level; 1=yes, 0=no). For past academic performance, approximately 50% of students indicated that they received mostly A's. We therefore created a dummy-coded variable for receiving A's (1=yes, 0=no). We also created scores for students who did not provide information about their academic performance on their pre-test to maximize our useable sample size. We generated the necessary scores by using means substitution by gender, grade, and class (Allison 2002).

We began the HLM analysis for each of the post-test environmental stewardship characteristics by testing a fully-unconditional model (Raudenbush & Bryk, 2002). These tests were conducted to reveal what percent of variance was occurring between classes. The between class variance (ICC) was 10% or greater for half of the characteristics (Appendix B). The remainder had less than 10% variance. Though less than 10% between class variance makes finding class level effects difficult, it does not preclude the use of HLM. Single level methods (e.g., ANOVA, OLS Regression) introduce bias by assuming that each student's experience of MWEEs is independent which it is not. If a single-level analysis were used it would underestimate standard errors, increasing the likelihood of identifying a difference between the treatment and comparison group where none exists (Type II error).

To determine what variables to include as covariates in our multi-level analysis, we first determined if gender, grade, and academic achievement were associated with the 8 environmental stewardship characteristics (e.g., were females more likely to score higher/lower than males on these outcomes?). These preliminary analyses indicated that there were a number of significant relations (Appendix C provides detailed results on the relations between gender, academic performance, grade level, and pre-test environmental stewardship characteristics with post-test environmental stewardship characteristics):

- Girls scored significantly higher than boys on intention to act, knowledge of actions, and engagement in learning by small to moderate amounts (effect sizes 0.22, 0.22, and 0.38 respectively).

- Students who indicated getting mostly As scored significantly higher than their lower performing counterparts on environmental sensitivity, engagement in learning, and knowledge of ecology by small to large amounts (effect sizes 0.22, 0.52, and 0.19 respectively).
- Sixth, 9^{th}, and 10^{th} graders tended to be the highest scorers on post-test environmental stewardship characteristics.
- As one would expect, all of the pre-tests were related to their corresponding post-tests; i.e., scoring higher on the pre-tests was correlated with scoring higher on the post-tests.

Next, we determined if the treatment group differed from the comparison group in gender (e.g., were females more likely to be in a B-WET funded program?), grade, past academic performance, and pre-test stewardship outcomes (Table 42). Gender, past academic performance, and grade differences were tested with a chi-square statistic. Pre-test differences were tested with a t statistic. There were two significant differences. First, the two groups differed in their pre-test knowledge of actions. Second, the two groups differed in their grade level composition. There were more children in lower grade levels (3^{rd}, 4^{th}, and 6^{th}) in the treatment versus comparison group. The distribution of classes between the treatment and comparison group was more even for 9^{th} and 10^{th} grade students.

Table 42: MWEE and comparison groups' gender, academic performance, and grade level

n=433-451	MWEE (n=258 students) %	Comparison (n=193 students) %	Chi square	p
Female	51%	57%	1.61	0.200
Receive mostly A's	49%	55%	1.20	0.273
Grade			63.47	<0.001
3rd Grade	71%	29%		
4th Grade	80%	20%		
6th Grade	62%	38%		
8th Grade	27%	73%		
9th Grade	52%	48%		
10th Grade	50%	50%		

Table 43: MWEE and comparison groups' pre-test stewardship characteristics and engagement in learning

	MWEE (n=258 students)	Comparison (n=193 students)		
n=451	**Pre-test mean**	**Pre-test mean**	**Difference**	**p**
Intention to Act	0.06	-0.08	0.14	0.160
Personal Responsibility	0.03	-0.04	0.07	0.504
Environmental Sensitivity	0.05	-0.07	0.12	0.180
Knowledge of Issues	0.04	-0.05	0.09	0.364
Knowledge of Actions	0.09	-0.11	0.20	0.036
Internal Locus of Control	-0.02	0.02	-0.04	0.657
Group Locus of Control	0.06	-0.09	0.15	0.111
Knowledge of Ecology	0.05	-0.06	0.11	0.245
Engagement in Learning	0.04	-0.05	0.09	0.342

Based on these sets of preliminary analyses, we were able to determine which variables to include as covariates in the HLM analysis of each respective post-test environmental stewardship characteristic (Table 44). Note that gender and past academic performance were not included as covariates in any of the subsequent analyses because while they were related to post-test scores, the proportions of girls/boys and high/low academic performers were the same in the treatment and comparison groups. Grade was included because the treatment and comparison groups differed in grade composition and because there were differences in how students in different grades scored on post-test environmental stewardship characteristics. The pre-test for knowledge of actions was included in the analyses for the testing of differences in post-test knowledge of actions because this was the one pre-test score in which the treatment and control groups differed.

Table 44: Covariates used in ANCOVA

Characteristic	Covariate(s)
Intention to Act	Grade
Personal Responsibility	Grade
Environmental Sensitivity	Grade
Knowledge of Issues	Grade
Knowledge of Actions	Grade, Pre-test
Internal Locus of Control	Grade
Group Locus of Control	Grade
Knowledge of Ecology	Grade
Engagement in Learning	Grade

Last, we tested the interactions between grade and the treatment for each of the post-test environmental stewardship outcomes to ensure that we did not violate ANCOVA's assumption of homogenous regression slopes (Appendix B). When we encountered significant interactions, we divided and analyzed data by grade.

Effect Size

To help determine to what extent results may have had educational significance, we converted all results to effect sizes. Effect sizes are the standardized difference between treatment and control group means (standard deviation=1). Effect sizes are useful because instead of using units based in different scales, their standardized nature allows for comparison of results across studies. The meaning of a 0.30 effect size is that a one standard deviation change in the treatment is related to a 0.30 standard deviation change in an outcome. Cohen (1988) suggests that a 0.30 effect size be considered small, 0.50 moderate, and 0.80 effects size large for social science research. To the best of the authors' knowledge, however, in education settings, effect sizes of 0.30 and even below can be considered substantively significant. We therefore considered an effect size of 0.10-0.29 as "small", 0.30-0.49 as "moderate", 0.50-0.79 as "large", and 0.80 and higher as "very large."

RESULTS

Do MWEE programs increase students' characteristics associated with environmental stewardship?

To answer this question we collected data from 20 MWEE and 12 comparison classes (n=451 students) and the MWEE students' teachers (n=19), as well as from other teachers who had participated in MWEE professional development in the past (n=334).

The HLM analysis of the student data indicated that students who experienced MWEEs increased significantly in 3 of the 8 environmental stewardship characteristics we measured (Table 45). The three characteristics were intention to act, knowledge of issues, and knowledge of actions. NOAA B-WET funded programs had a moderate positive effect on students' intentions to act (ES=0.33; $p < .05$) and a large positive effect on students' knowledge of issues (ES=0.60; $p < .001$). There was also a moderate positive effect on knowledge of actions. However, because knowledge of actions varied by grade level (i.e., we found an interaction between this outcome and grade level), results were interpreted at that level. As evident from Table 43 below, NOAA B-WET funded programs had a large positive effect on students in 3rd, 9th, and 10th grade (ES = 0.98, 0.53, and 0.95, respectively) but not on students in 4th, 6th and 8th grade.

While MWEE students did not differ significantly from the comparison group in their knowledge of ecology, the effect size was relatively large (ES=0.30). This finding may be a function of a small sample size. With 32 classes, the analysis did not have the power to detect effect sizes smaller than 0.33.

Table 45: HLM Results

n=451	Effect Size	p	% Class Level Variance Explained
Intention to Act	0.33	0.027	69.2
Personal Responsibility	0.10	0.508	90.0
Environmental Sensitivity	0.21	0.159	33.3
Knowledge of Issues	0.60	<0.001	100
Knowledge of Actions	0.47	<0.001	94.7
3rd Grade	0.98	0.004	-
4th Grade	0.29	0.186	-
6th Grade	0.26	0.197	-
8th Grade	0.27	0.197	-
9th Grade	0.53	0.021	-
10th Grade	0.95	0.003	-
Internal Locus of Control	0.24	0.143	71.4
Group Locus of Control	0.09	0.580	100
Knowledge of Ecology	0.30	0.133	69.7

What were teachers' perceptions of changes in these and other students' environmental stewardship characteristics as result of experiencing MWEEs? And, how consistent were their responses with our findings? We are able to answer these questions for two environmental stewardship characteristics: knowledge of ecology and intention to act. We can report on the perspectives of the teachers whose students were described above (n=19) as well as on the perspective of teachers who participated in NOAA B-WET funded professional development in the past (n=334).

First, all of the teachers of the students described above, agreed or strongly agreed that their students knew more about the local watershed or the Bay as a result of their MWEE and the majority (89%) also agreed or strongly agreed that their students were more likely to act to protect the watershed or Bay (Table 46).

Table 46: Beliefs of teachers whose MWEE student's data were analyzed in this evaluation

As a result of completing their local watershed or Chesapeake Bay unit, I believe my students …	Strongly Disagree %	Disagree %	Neutral %	Agree %	Strongly Agree %
Know more about the local watershed or the Chesapeake Bay (n=19)	0	0	0	32	68
Are more likely to protect their local watershed or the Chesapeake Bay (n=19)	0	0	11	68	21

Similarly, almost all of the past professional development teachers agreed or strongly agreed that their students knew more about the local watershed or the Chesapeake Bay and were more likely to protect them as a result of experiencing MWEEs (97 and 93% of teachers, respectively) (Table 47).

Table 47: Beliefs of teachers who participated in past year MWEE professional development

As a result of completing their local watershed or Chesapeake Bay unit, I believe my students …	Strongly Disagree %	Disagree %	Neutral %	Agree %	Strongly Agree %
Know more about the local watershed or the Chesapeake Bay (n=329)	2	0	1	29	68
Are more likely to protect their local watershed or the Chesapeake Bay (n=327)	2	0	5	43	50

In light of the above results, it is evident that teachers' perceptions of their students' increases in intentions to act as a result of MWEEs were consistent with our results that students indeed increased in their intentions to act. There was some inconsistency, however, with regard to knowledge of ecology. Teachers believed that their students increased in this environmental stewardship characteristic, whereas our results suggested that they may not have. Although we found a relatively large effect size for students' knowledge of ecology, it was not statistically significant.

EFFECTS OF MWEES ON STUDENT ACADEMIC ACHIEVEMENT

EVALUATION QUESTIONS

This part of the NOAA B-WET evaluation sought to answer the following question:

- Do MWEEs increase students' academic achievement in science?

METHODS

We examined students' standardized science test scores, students' pre/post-test self-reported "engagement in learning" (a characteristic that has been associated with academic achievement)[3], and teachers' opinions of their students' academic achievement. We collected data from 3 sources:

- 2004-2005 school year Virginia Standards of Learning (SOLs) Assessment science test results for students who participated in a B-WET funded Virginia MWEE program,
- 2005-2006 school year students' changes in their engagement in learning questionnaire measures from before to after their MWEE programs, and
- Beliefs of past professional development teachers (training occurred between 2002-06) about how well MWEEs helped to prepare their students for state standardized science tests and increased their students' engagement in learning.

State Standardized Test Scores

Respondents

We focused on science achievement because all interviewed 2004 B-WET funded organizations mentioned science learning as a goal of their programs and only one program targeted reading and math. We focused on Virginia because this was the only state that tested students in science at the time of this evaluation (i.e., Maryland, Pennsylvania, and Washington, DC did not). Finally, we focused on one MWEE program (which we will refer to as the "Virginia MWEE Program") because we learned that it was the only one of the nine Virginia organizations funded by NOAA B-WET to conduct MWEEs serving students who were SOL-tested at the end of the school year (as of spring 2006) (Table 48). The state of Virginia tested students in science at the end of 3^{rd}, 5^{th} and 8^{th} grade (and at the end of high school courses such as biology and earth science) and the Virginia MWEE program included a focus on 3^{rd} and 5^{th} grades. The remaining B-WET funded programs primarily targeted grades 4, 6, and 7 which are not SOL-tested, and a summer high school program not associated with an SOL-tested high school science course. One reason the B-WET programs targeted grades 4, 6, and 7 was because Virginia's science SOL curriculum standards emphasized watershed concepts at these grades.

[3] Connell, Spencer, & Aber 1994, Marks 2000, Skinner, Wellborn & Connell 1990, Connell & Wellborn 1991, Fredericks, Blumenfeld & Paris 2004.

Table 48. Background on NOAA B-WET funded organizations in Virginia

NOAA B-WET funded organization	Grade level targeted	SOL scores available?	Reason for being included in or excluded from study
Virginia MWEE Program	3, 4, 5	Yes	3rd and 5th graders tested during 2004-05
MWEE 2	6-12	No	No reply
MWEE 3	6, 7	No	Not SOL-tested grade level
MWEE 4	6, 7	No	Not SOL-tested grade level
MWEE 5	4	No	Not SOL-tested grade level
MWEE 6	7	No	Not SOL-tested grade level
MWEE 7	6	No	Not SOL-tested grade level
MWEE 8	n/a	No	Private school
MWEE 9	10, 11	No	Summer-only program

We engaged in a substantial effort to expand the sample beyond the one organization's students. As part of our spring 2006 web questionnaire (Prior Year Professional Development), we asked approximately 400 Virginia teachers who had participated in B-WET funded professional development if their students were tested at the end of the school year in which they taught about the Bay. In addition, we requested similar information from about 250 teachers who had received a Classroom Grant from the Virginia Department of Environmental Quality. Ultimately, 58 teachers indicated they used MWEEs with their students and that their students had been SOL-tested in the year of their MWEE.

Because Virginia's science SOL scores are not centrally-stored, data needed to be requested from each of the 58 teachers' school divisions. We contacted the Division Directors of Testing in the respective 25 school divisions. As a result, data were shared by 6 school divisions for 10 MWEE teachers and corresponding comparison teachers (Table 49). Eleven school divisions would not release SOL data and 8 districts did not respond. Given that the sample size for each grade/subject was very small (the largest was 36 classes of Earth Science students), we decided not to analyze these data and instead focused on the one Virginia MWEE program.

Table 49: Additional SOL data collected but not analyzed

School Divisions	Teachers	Grade or Subject	Year(s)	MWEE Classes	Comparison Classes	PD Provider or Source of Grant
A	1	5	2003, 2004, 2005	3	6	Virginia Institute of Marine Science
B	1	8	2006	1	1	VDEQ Classroom Grant Recipient
B	1	Biology	2003, 2004, 2005	3	3	Virginia Polytechnic Institute and State University
C	1	Biology	2003, 2004, 2005	3	12	CRC Foundation
D	1	Biology	2006	3	3	VDEQ Classroom Grant Recipient
A	1	Earth science	2004, 2005, 2006	3	3	Chesapeake Bay Foundation
B	1	Earth science	2003, 2004, 2005	3	3	Virginia Polytechnic Institute and State University
D	1	Earth science	2003, 2004, 2005	7	7	Virginia Polytechnic Institute and State University
E	1	Earth science	2005	1	0	Chesapeake Bay Foundation
F	1	Earth science	2003, 2004, 2005	3	6	Chesapeake Bay Foundation
6 divisions	10 teachers			30 classes	44 classes	TOTAL

The Virginia MWEE Program

The Virginia MWEE program had the following goals, objectives, and activities:

Goals:

- To increase student awareness and understanding of watersheds and the Chesapeake Bay,
- To develop skills students need to become active environmental supporters, and
- To help students achieve higher academic success in science.

Objectives:

- Provide meaningful watershed programming through a series of hands-on and investigative outdoor experiences to over 1,100 students in 3rd, 4th, and 5th grades in four schools.
- Provide opportunities for students to communicate their new knowledge of watersheds to other students within their schools, to students at non-participating

schools, and to the community.

- Provide multiple MWEE program-led experiences and teacher-led in-class activities for classes that will integrate the topic into their curriculum for the entire school year.

Activities:
All activities focused on a local watershed as a model for watershed dynamics, and strategic teaching techniques to help students connect lessons learned about the local watershed with the Chesapeake Bay watershed. After an introduction to the watershed by MWEE program staff, each grade investigated its own standards-based watershed questions through hands-on field and outreach experiences. Each grade completed their study by informing the community about watersheds. The MWEE programs were scheduled throughout the school year and integrated into the curriculum through a series of teacher-led, multidisciplinary in-class activities. Teachers received instructional materials, orientation to all programs and activities, and on-going support from the project coordinator. The program was evaluated by its managers through pre- and post-participation surveys for students, oral pre- and post-activity quizzes on content, mid-term and end-of-year evaluations from teachers, and journals kept by college students serving as class mentors.

The program was a multiple-experience program including 4 interactions with program staff. The students:

- visited the MWEE program staff for an introduction in the fall,
- participated in a fall field experience (includes data collection) that was appropriate for their age group and theme (3rd grade - marsh grass planting, 4th grade - forest/marsh walk, 5th grade – aquatic studies on boat),
- were visited in the spring at school by the program staff,
- participated in the spring in a second outdoor experience (includes data collection) that was in their schoolyard or nearby area (connects schoolyard to local waterways),
- participated in in-class activities with their teachers in the classroom between the Virginia MWEE program led experiences, and
- participated in a community outreach experience (not all students) at the local library or recreation center; the students presented what they learned to the public.

Teachers participated in an orientation at the beginning of the year to introduce them to the Virginia MWEE program and the in-class activities. The teachers also participated in a mid-year workshop hosted by the program staff.

SOL Data
As mentioned earlier, the Virginia MWEE program was the only B-WET funded organization that targeted students who were SOL-tested at the end of the school year (as of spring 2006). Upon our request, the Virginia MWEE program provided the names of the teachers whose classes participated in their program during the 2004-05 school year.

The Virginia MWEE program targeted all 3rd and 5th grade students in the respective schools. We therefore obtained comparison data from the same grade levels at comparable schools in the same school division. After a formal application process, permission to use the SOL data was granted by the school division.

The three Virginia MWEE program schools held Title 1 status[4]. The three comparison schools were also Title 1 and matched the MWEE schools' Average Yearly Progress (AYP)[5] status ("Made AYP") for the last 3 school years.

In the end, we were able to obtain data for 31 MWEE classes and 30 comparison classes from a total of six schools from one school division (Table 50).

Table 50. Study Sample Information

	MWEE Participants		Comparison	
	3rd Grade	5th Grade	3rd Grade	5th Grade
Students	242	248	246	269
Classes/Teachers	15	16	15	15
Schools	3	3	3	3

2005 Virginia Science Sol Test

We analyzed scores from 3rd and 5th grade science 2005 SOL tests (Virginia Department of Education 2006). The SOL science test scores were reported as an aggregate score, by category, and by item. We analyzed data at all three levels.

The four science categories were: "Life Processes and Living Systems" (LPLS), "Earth/Space Systems & Cycles" (ESSC), "Force, Motion, Energy, & Matter" (FMEM), and "Scientific Investigation" (5th grade)/"Scientific Investigation, Reasoning, and Logic" (3rd grade) (SI). To ensure that we selected appropriate items, we asked the Virginia MWEE program staff to identify the most relevant ones, i.e., the items they felt their program targeted. No items were identified in the FMEM category. Thirteen items on the 3rd grade test (9 primary/4 secondary) and 10 items on the 5th grade test (7 primary/3 secondary) were identified for this purpose (Table 51).

[4] Title I - Federal-funding program designed to help low-income children who are behind academically or at risk of falling behind. Title I funding is based on the number of low-income children in a school, generally those eligible for free lunch or reduced-fee lunch programs (Virginia Department of Education).

[5] AYP - "Adequate Yearly Progress" (AYP) represents the minimum level of improvement that schools and school divisions must achieve each year as determined by No Child Left Behind (Virginia Department of Education).

Table 51: 2005 science SOL items identified by the Virginia MWEE staff as targeted by their program

	Category	Primary Target Item Descriptor (Item Number)	Secondary Target Item Descriptor (Item Number)
Grade 3 Science	Earth/Space Systems & Cycles	Identify natural resources. (6) Identify how humans can help keep the air clean. (7) Distinguish between reusable objects and nonreusable objects. (12) Understand importance of soil to plants. (33)	
	Life Processes & Living Systems	Identify example of organism with a specific role in the food chain. (11) Identify a part of a plant that provides a basic function. (27) Identify animal's adaptation that protects it from predators. (28) Predict the effects on food chain of removal of organism from ecosystem. (35)	Identify life needs of animals. (14) Analyze the populations in a community. (22)
	Scientific Investigation	Measure length with accuracy to the nearest inch. (9)	Identify the physical attribute that differs between objects in two groups. (17) Identify graph that shows data collected. (31)
Grade 5 Science	Earth/Space Systems & Cycles	Identify the importance of the Chesapeake Bay to the ocean ecosystem. (14) Select proper instruments to record weather data. (39)	
	Life Processes & Living Systems	Classify organisms by shared characteristics. (30) Differentiate between vertebrates and invertebrates. (33)	Apply an understanding of a food web. (6) Recognize an organism's relationship to its environment. (21)
	Scientific Investigation	Identify appropriate graph to represent data. (3) Draw a conclusion based on an observation. (5) Extrapolate trends from graphs. (40)	Identify instrument used to make an accurate measurement. (11)

State Standardized Science Test Scores Analysis

As is the case for most formal educational settings, questions about the effectiveness of a program tend to be multi-level in nature. That is, although test scores are generated by individual students, these students are grouped with other children in classes and schools. It is at the class or grade level where the treatment is usually administered. This is the case with the Virginia MWEE program which was administered by the teachers of all 3rd and 5th graders at the respective schools. We therefore chose a multi-level analysis to account for the shared experiences of children in these classes.

We conducted a multi-level analysis of covariance (ANCOVA) using hierarchical linear modeling (HLM) (Raudenbush & Bryk 2002) to evaluate the relation between the Virginia MWEE program and students' performance on the science SOL assessment test, controlling for grade level. Pre-test scores are not included in the analyses because such data were not available at the student level.

We received and analyzed the following data

- Aggregate Science Scaled Score by Individual Student
- Category Scaled Score by Individual Student (4 categories)
- Percent Correct for Each Item by Teacher (by individual student was not available)

We began with creating and testing a fully unconditional model (FUM) (Raudenbush & Bryk 2002) to confirm that enough variation occurred between classes to warrant multi-level modeling. Indeed classes differed sufficiently in their performance on the science SOL test: the variations were above 10% for the aggregate and four categories (i.e., they were 18% for the aggregate and 12%, 13%, 20% and 15% for the SI, FMEM, LPLS, ESSC categories, respectively).

Next we investigated if 3rd and 5th graders performed differently on the test, in aggregate and for the four categories (Table 52). HLM analysis indicated that this was indeed the case. For example, children in 5th grade classes scored lower on the test by 0.64 standard deviations than children in 3rd grade classes.

Table 52: VA Science SOL scores for all MWEE and comparison students

n=1005 students, 61 classes	Total Mean (SD)	3rd Grade Mean (SD)	5th Grade Mean (SD)	p
Aggregate Science SOL Score	447 (57)	467 (64)	428 (43)	<0.001
Scientific Investigation Score	36 (9)	38 (9)	35 (8)	<0.001
Force Motion Energy Matter Score	36 (8)	37 (7)	35 (8)	<0.001
Life Processes Living Systems Score	35 (8)	37 (8)	33 (7)	<0.001
Earth Space Systems Cycles Score, SD	36 (8)	37 (8)	35 (8)	<0.001

We then proceeded by testing to what extent the Virginia MWEE program was related to student performance on the 1) aggregate science SOL test score, 2) followed by the same analysis controlling for grade level and 3) by separate analyses for 3rd and 5th grade students. For the purposes of all of these analyses, we created a dummy-coded variable for children who participated in the Virginia MWEE program (0=no, 1=yes) and one for whether or not these children were in 5th grade (0=no, 1=yes). These same set of analyses were subsequently also conducted for each of the four SOL categories.

For the item analysis we were not able to use HLM because of data limitations. For the items that the Virginia MWEE staff identified as targeted, we only had access to the percent of students who correctly answered the item by teacher (or class). Because we did not have individual student scores, we were unable to use HLM and instead we used an independent samples t test at the class level.

We first looked at the targeted items as a whole as a “targeted aggregate science score” and compared the MWEE and comparison groups separately for each grade.

We also examined the targeted items grouped by category. To do this, we averaged all items within a category by teacher so that each teacher had 3 category scores (i.e., an average of item averages for each category). For example, for a grade 3 teacher, we averaged the percent correct for items 11, 14, 22, 27, 28, and 35 for the Life Processes & Living Systems category. Because the questions that were included in each category differed for 3rd and 5th graders, we analyzed 3rd and 5th grade scores separately.

Surveys

Engagement in Learning

The sample for this part of the study was the same as that described in the Environmental Stewardship section (page 39). It consisted of responses by students who participated in MWEE programs in Maryland, Virginia, Pennsylvania, and Washington, DC during the 2005-06 school year. The students who participated in the Virginia MWEE program (discussed immediately above) participated in a MWEE during the 2004-05 school year and were not a part of the engagement in learning sample.

As a proxy measure for student achievement, we measured MWEE students' engagement in learning. Past studies have found student engagement to be closely associated with academic achievement (Connell, Spencer, & Aber 1994, Marks 2000, Skinner, Wellborn &Connell 1990, Connell &Wellborn 1991, as reported in Fredericks, Blumenfeld & Paris 2004). Based on the valid and reliable scales used by these studies, students were asked about their class participation, preparation, and effort (Fredricks et. al. 2003, Institute for Research and Reform in Education, Inc. 1998, Marks 2000, U.S. Department of Education 1992).

The engagement in learning measures were included on the pre- and post-questionnaires described in the Environmental Stewardship section (page 37). For example, the students were asked if they:

- pay attention in class,
- ask questions and share ideas in class discussions,
- finish classwork on time,
- finish homework on time, and
- try as hard as you can in class.

The scales for engagement in learning had the following reliabilities: elementary pre-test (.57), elementary post-test (.62), secondary pre-test (.75), and secondary post-test (.74).

Engagement in Learning Analysis

The analysis of the pre/post-test engagement in learning items was the same as that described in the Environmental Stewardship section (page 43). We conducted a multi-level analysis of covariance (ANCOVA) using hierarchical linear modeling (HLM).

Teachers' Beliefs

Data for the following analyses were provided by 19 teachers (response rate 95%) of students included in the pre- to post-engagement in learning analysis. In addition, data were provided by 11 (response rate 35%) teachers whose students participated in the Virginia MWEE program during the 2004-05 school year, as well as by 334 (response rate 32%) teachers who had participated in NOAA B-WET-funded professional development since its inception in 2002 (past PD participants) (a description of the teacher sample is in the professional development section, page 11). All 3 groups of teachers were asked about the extent to which they thought their students were more engaged in learning and the latter 2 groups were asked if their students were more prepared for state standardized tests as a result of participating in a MWEE.

Teacher Beliefs Analysis
Descriptive statistics were generated to summarize teachers' responses.

Provider Interviews

We interviewed 13 program managers from 9 B-WET funded programs organizations. These providers were selected based on whether students included in our evaluation's sample had participated in their programs. Several of the organizations also provided professional development. We obtained their responses to several questions including two pertinent to this part of the evaluation:

- In general, do MWEEs improve students' academic achievement? Would you expect students who participated in MWEEs to do better on their science state standardized tests than students who did not?
- Would you expect students to be more engaged in their science learning as a result of participating in a MWEE? Do you think there is a connection between engagement in learning and performance on standardized tests?

A summary of providers' perspectives follows. The number of providers who made a specific comment is indicated in parentheses after each theme.

RESULTS

Do MWEEs increase students' academic achievement in science?

State Standardized Test Scores

Students' Performance on Aggregate Science SOL
Significant differences in test results suggested that students who participated in the Virginia MWEE program performed no differently overall on the aggregate science SOL test than students who did not participate in the program, including at the two different grade levels (Table 53) (more detailed results are in Appendix D). It is possible, however, that 3rd graders who participated in the Virginia MWEE program scored higher on the test than 3rd graders who did not participate in the program. This possibility is based on the observation that 3rd graders who participated in the program scored 0.21 standard deviations higher than those who did not. Our sample was not large enough to detect a significant effect of this size, only effect sizes of 0.30 or higher.

Students' Performance on Categories of Science SOL

When we tested for differences between students who participated in the Virginia MWEE program and those who did not in terms of their performance on the four categories of the science SOL, we found one significant difference (Table 53) (more detailed results are in Appendix E). Third grade students who participated in the program performed moderately higher on the Scientific Investigation, Reasoning, and Logic category than those who did not participate in the program. For one standard deviation increase in the independent treatment variable, these 3rd grade students performed 0.32 standard deviations higher on this particular category of the test.

Again, one potential reason for not finding a significant difference in how students scored on a few of the other categories with relatively larger effect sizes (e.g., 0.19 on Earth/Space Systems & Cycles) may be because the study did not have a large enough sample for detecting significant effects sizes below 0.30.

Table 53: Aggregate and category test scores for 3rd and 5th grade participants in the Virginia MWEE program compared to non-participants

n=1005 children; n=61 classes	3rd Grade effect size	p	5th Grade effect size	p
Aggregate Science	0.21	0.262	0.04	0.808
Scientific Investigation[1]	0.32	0.024	-0.06	0.643
Life Processes and Living Systems	0.01	0.952	0.09	0.552
Earth/Space Systems & Cycles	0.19	0.263	0.12	0.436
Force, Motion, Energy, & Matter	0.12	0.465	0.00	0.976

[1]Called "Scientific Investigation, Reasoning, and Logic" on the 3rd grade test

Students' Performance on Targeted Items of the Science SOL

We compared the 3rd grade MWEE and comparison classes' mean percent correct on the Virginia MWEE program targeted items (Grade 3 - 13 items, Grade 5 - 10 items). We did the same analysis with the 5th grade classes. Neither one of these analyses identified significant differences between the MWEE and comparison classes for the targeted items (Table 54).

Table 54: Comparison of MWEE and comparison group % correct scores on MWEE-targeted SOL items in aggregate

Grade	Group	n	% correct mean	Difference in % correct mean (MWEE-comp)	t test p
3	MWEE	195	82.55	2.44	0.155
	Comp	195	80.11		
5	MWEE	160	69.73	0.30	0.891
	Comp	150	69.43		

We then conducted the same analyses by category (Table 55). These analyses identified one significant difference: 3rd grade MWEE classes' SI scores were significantly higher than comparison classes' SI scores.

Table 55: Comparison of MWEE and comparison group % correct scores on MWEE-targeted SOL items by category

Grade	Category	Group	n	% correct mean	Difference in % correct mean (MWEE-comp)	t test p
3	ESSC	MWEE	15	79.97	1.87	0.546
		Comp	15	78.10		
	LPLS	MWEE	15	77.44	1.25	0.650
		Comp	15	76.19		
	SI	MWEE	15	92.42	7.49	0.007
		Comp	15	84.93		
5	ESSC	MWEE	16	66.47	0.30	0.950
		Comp	15	66.17		
	LPLS	MWEE	16	69.33	3.98	0.243
		Comp	15	65.35		
	SI	MWEE	16	70.24	-3.24	0.308
		Comp	15	73.48		

Engagement in Learning

MWEE students' engagement in learning was not significantly different from that of students who did not participate in MWEEs (Table 56).

Table 56: Comparison of pre- and post-engagement in learning for MWEE and comparison students

n=451	Effect Size	p
Engagement in Learning	0.02	0.904

Teachers' Beliefs

In contrast to the student results (Table 56), the majority (79%) of teachers of the students included in the engagement in learning analysis agreed or strongly agreed that their students are more engaged in their learning as a result of completing their local watershed or Chesapeake Bay unit (Table 57). Most of these teachers (65%) agreed or strongly agreed that their students were better prepared for the state standardized tests.

Table 57: MWEE teachers' opinions about students' engagement in learning

As a result of completing their local watershed or Chesapeake Bay unit, I believe my students …	Strongly Disagree %	Disagree %	Neutral %	Agree %	Strongly Agree %
Are more engaged in their learning (n=19)	0	0	21	16	63
Are better prepared for the end-of-year state assessments (n=17)	0	6	29	41	24

As shown in Table 58, almost all of the teachers whose students participated in the Virginia MWEE program agreed or strongly agreed that their students were more engaged in learning. Slightly over half also agreed that their students were better prepared for the end-of-year assessment.

Table 58: Virginia MWEE program teacher beliefs about student changes attributed to the MWEE

As a result of completing their local watershed or Chesapeake Bay unit, I believe my students …	Strongly Disagree %	Disagree %	Neutral %	Agree %	Strongly Agree %
Are more engaged in their learning (n=11)	0	9	0	55	36
Are better prepared for the end-of-year state assessments (n=11)	0	18	27	55	0

Like the teachers who implemented the 2004-05 Virginia MWEE program almost all of the teachers who participated in a B-WET funded professional development agreed or strongly agreed that their students were more engaged in learning (92%) (Table 59). More teachers in this group, compared to the Virginia MWEE program group, however, agreed or strongly agreed that their students were better prepared for end-of-year state assessments as a result of completing the local watershed or Bay unit (75%).

Table 59: B-WET trained teachers' beliefs about student changes attributed to MWEE

As a result of completing their local watershed or Chesapeake Bay unit, I believe my students …	Strongly Disagree %	Disagree %	Neutral %	Agree %	Strongly Agree %
Are more engaged in their learning (n=328)	2	1	5	36	56
Are better prepared for the end-of-year state assessments (n=277)	1	4	25	40	30

Providers' Impressions

The number of providers who made a specific comment is indicated in parentheses after the statement.

Academic Achievement in Science

The following summarizes providers' beliefs related to MWEEs and students' achievement:

- MWEEs should improve students' engagement in learning and academic achievement by making learning more relevant to students' lives. (3)
- Hands on learning should improve students' attitudes toward and performance in science. (2)
- Stewardship is the primary goal of a MWEE, so it is best to measure this outcome rather than science knowledge alone. (1)

Standardized Science Test Scores

The following summarizes providers' beliefs related to MWEEs and standardized tests:

- Standardized tests are not an accurate or appropriate way to measure MWEE outcomes. (4)
- Standardized tests are generally not a good way to measure science knowledge because some students perform better on multiple choice questions than others and some students understand science but do not pass the standardized test. (2)
- The science standards targeted by MWEEs were not tested on the standardized test. (2)
- If MWEEs increase test scores, then it would be great marketing message for Chesapeake Bay education. (2)

- MWEEs are a minor part of the school year curriculum, so they do not have a strong influence on science learning during the span of a school year. (1)
- The degree to which a teacher reviews science content and test-taking techniques with their students before the test greatly influences the students' test performance. (1)
- Especially with younger, more literal learners, to pass the test they need to study very specific content in the form of the test questions. MWEEs are not always test-specific in nature (e.g., during the MWEE the students learn how to identify a marine animal, but they are tested on how to identify an insect). (1)
- If MWEEs are tightly aligned with science standards and the test includes items for those standards then, in theory, MWEEs should increase test scores. (3)
- MWEEs should improve test scores if they are an integrated, repeated part of the curriculum rather than a stand-alone experience. (1)

MWEE BEST PRACTICES

EVALUATION QUESTION

This part of the NOAA B-WET evaluation sought to answer the following question:

- Which best MWEE practices result in the highest stewardship and engagement in learning?

To answer this question we drew on results reported by students (i.e., the frequency with which students reported they experienced different MWEE practices) and teachers (i.e., whether or not teachers indicated they implemented specific MWEE practices). When we had student reports we relied on their perceptions, otherwise we relied on teachers' reports of their practices for the following sets of analyses. Lastly, we also interviewed MWEE providers to help answer this question.

METHODS

Surveys

Student Questionnaire

Students completed the questionnaire described in the Environmental Stewardship section (page 37). In addition to asking students to report on their environmental stewardship characteristics, we asked them how frequently they experienced the following four MWEE practices:

- learned outdoors,
- talked or wrote about how they helped the watershed or Bay,
- participated in hands-on learning, and
- learned things important to them.

Because secondary students responded to the 4 MWEE practices questions on a 4-point Likert-scale (e.g., Never, Rarely, Sometimes, Often) and elementary students responded on a 3-point scale (i.e., Never, A few times, Many times), we collapsed the middle two options in the secondary sample (i.e., Rarely and Sometimes) into one for our analyses.

MWEE Teacher Questionnaire

As described in the Stewardship section (page 38), teachers completed a questionnaire at the completion of their students' MWEE. We asked teachers to provide information about the MWEE practices their students experienced. Specifically, we asked teachers to report on the following:

Curriculum duration:

- How many hours was the curriculum?
- How many weeks/months was the curriculum?

Issue research:

- Did the students explore the community for issues?
- Did the students listen to talks about, or read about, local watershed or Bay

environmental issues?
- Did the students study social, economic, historical, or archaeological issues?

Data collection and analysis:
- Did the students collect data?
- Did the students use field equipment, such as hand-held technology, for data collection?
- Did the students analyze watershed or Bay data?
- Did the students graphically display data (e.g., create charts, graphs)?

Environmental action project:
- Did the students implement an action project that involved communication, monitoring, pollution prevention, and/or restoration?

For curriculum duration, teachers were asked about the number of hours of watershed or Bay instruction their students received (1-5 hours, 6-10 hours, 11-20 hours, 21-40 hours, 41-60 hours, 61-80 hours, or more than 80 hours). For analysis, we grouped the sample into thirds: low=6-20 hours, average=21-60 hours, and high=61 hours or more. Teachers were also asked the length of the watershed or Bay curriculum (Less than 1 week, 1 to 3 weeks, 1 month, 2-4 months, 5-7 months, 8-10 months, and more than 10 months). For analysis, we grouped the sample into thirds: low=1-4 weeks, average=2-7 months, and high=8 months or more. The remainder of the MWEE practices were reported as Yes/No.

Respondents

To determine which MWEE practices resulted in the highest stewardship and engagement in learning, we examined the responses of all MWEE students who completed a pre- and post-test (n=29 classes, 434 students). The teachers of the 29 classes completed the post-MWEE questionnaire. This sample included about the same number of boys as girls (Table 60), but students were unevenly distributed across grade levels (Table 61).

Table 60: Student gender

Sex	Male	Female	Chi square	p
Percent	46	54	2.986	0.084

Table 61: Student grade level

Grade	3	4	5	6	7	8	9	10	11	12	Chi square	p
Percent	6	20	17	13	13	6	8	4	6	7	136.320	<0.001

Analysis

To determine whether student-reported or teacher-reported MWEE practices were related to environmental stewardship outcomes and engagement in learning, we conducted a series of analysis of covariance (ANCOVA) analyses. For these ANCOVAs, the independent variable was the amount of time students reported having participated in each of the MWEE practices (i.e., never, sometimes, often) and whether or not teachers reported that the students experienced each of the MWEE practices (i.e., yes or no). The dependent variables were each of the 8 respective environmental stewardship and the engagement in learning post-test factors. We also included pre-test, grade, and gender as covariates in these analyses.

We chose a conservative approach for determining the statistical significance between multiple means, the Bonferroni adjustment. For example, when comparing the intention to act mean between the 3 frequency groups ("never", "sometimes", and "often"), we multiplied the p value by 3 and judged differences as significant only if they were less than our desired 0.05 significance level.

For the student-reported practices, we reported the difference between the Never and Often responses because our sample was fairly small and if there was going to be a significant and meaningful difference, it would be between the lowest and the highest response choices.

As in the stewardship section, we considered an effect size of 0.10-0.29 as "small", 0.30-0.49 as "moderate", 0.50-0.79 as "large", and 0.80 and higher as "very large."

Provider Interviews

We interviewed 13 program managers from 9 B-WET funded programs organizations. These providers were selected based on whether students included in our evaluation's sample had participated in their programs. Several of the organizations also provided professional development. We obtained their responses to several questions including one pertinent to this part of the evaluation:

- What were the most important things the students learned or did for achieving your program's MWEE goals?

We summarized the statements of the MWEE providers.

RESULTS

Which best MWEE practices result in the highest stewardship and engagement in learning?

Student-reported MWEE Practices

Results for the student-reported MWEE practices are summarized in Table 62 (detailed results can be found in Appendix F). This table indicates effects sizes for the 8 environmental stewardship characteristics and engagement in learning for 4 MWEE practices students reported experiencing. The following paragraphs describe the relations between the 4 practices and the 9 outcomes we focused on.

Outdoor Learning

"Doing outdoor learning activities" had a moderate positive effect on knowledge of actions and engagement in learning, and a large positive effect on knowledge of issues. Outdoor learning appeared to have fewer and weaker associations with stewardship than the other 3 student-reported practices (e.g., reflection, hands-on learning, and learning what is important to them).

Reflection
"Talking or writing about how they helped their local watershed or the Bay" had a moderate positive effect on students' group locus of control and a large positive effect on intention to act, personal responsibility, environmental sensitivity, knowledge of actions, individual locus of control, and knowledge of ecology.

Hands-on Learning
"Doing hands-on learning about the Bay instead of just reading or hearing about it" had a large positive effect on environmental sensitivity, knowledge of actions, individual locus of control, and engagement in learning and a very large positive effect on students' intention to act, personal responsibility, and knowledge of issues.

Relevancy
"Learning things that were important to their lives" had a large positive effect on environmental sensitivity and individual locus of control and a very large positive effect on students' intention to act, personal responsibility, knowledge of issues, knowledge of actions, group locus of control, and engagement in learning.

In summary, all of these practices influenced how students scored on at least some of these 9 outcomes. Results also suggest that learning outdoors, for example, may not be as influential in increasing students scores on these outcomes compared to the other 3 practices. In addition, ensuring that students felt what they were learning was important to them (i.e., relevant) appeared to be particularly successful in increasing students scores on almost all 9 of the outcomes.

Teacher-reported MWEE Practices

The following paragraphs describe the relations between 9 teacher-reported MWEE practices and the students' stewardship characteristics and engagement in learning. Results for 8 of the practices, not including duration, are summarized in Table 63 (detailed results can be found in Appendix F). This table indicates effects sizes for the 8 environmental stewardship characteristics and engagement in learning for 8 MWEE practices teachers reported implementing.

MWEE Duration
We asked teachers about the number of hours and span of time over which they implemented a MWEE with their students. Students who spent the most number of hours (61 or more) in MWEE instruction had higher personal responsibility than those who spent the fewest number of hours in MWEE instruction (6-20 hours) (ES=0.25, p=0.026). We found no other significant effects based on the length of the MWEEs.

Issue Research
"Exploring the local community (beyond the classroom) for information on local watershed or Bay environmental issues" had a negligible negative effect on students' group locus of control, a small negative effect on personal responsibility, and a moderate negative effect on students'

individual locus of control, suggesting that their experiences were negative. For example, they may have had experiences that led them to believe they were less able to make a difference by working on their own or with others than they initially believed. Alternatively, their experiences may have resulted in greater awareness of the complexity of the issues and thus a more accurate assessment of students' abilities to make a difference on these issues.

"Listening to talks about, or read about, local watershed or Bay environmental issues" had a small positive effect on students' knowledge of actions, and a moderate positive effect on intention to act and personal responsibility. These results are consistent with work by DeYoung and Monroe (1996), for example, that suggest that stories can have such effects.

"Studying social, economic, historical, or archaeological issues" had a small effect on students' personal responsibility and a large effect on knowledge of ecology.

Data Collection and Analysis

"Collecting local watershed or Bay data" had a moderate positive effect on students' personal responsibility and individual locus of control, and a small effect on engagement in learning.

"Using field equipment, such as hand-held technology, for data collection" had a moderate positive effect on students' personal responsibility and individual locus of control, and a small effect on knowledge of actions.

"Analyzing watershed or Bay data" had a large positive effect on students' personal responsibility and knowledge of ecology, and a moderate effect on intention to act, knowledge of actions, individual locus of control, and engagement in learning.

"Graphically displaying data (e.g., creating charts, graphs)" had no effect on students' stewardship characteristics or engagement in learning.

Action Projects

Implementing an action project that involved communication, monitoring, pollution prevention, and/or restoration had a large positive effect on students' personal responsibility and individual locus of control.

In summary, most of these practices influenced how students scored on at least some of the 9 outcomes. Personal responsibility and individual locus of control seemed to most positively affected stewardship qualities.

Exploring the community had negative effects. This may be due to the discovery of community issues that seemed to be too large to be within the students' control. On the other hand, talking and reading about issues had positive effects. The way that information about issues is gathered seems to be a factor in students' stewardship qualities.

Although collecting and analyzing data had strong effects on stewardship, graphing that data was a neutral practice. Completing an action project had very few positive effects. It may be that engaging in an action project allows students to feel that they have done their part for the environment and they do not need to engage in further actions.

Our data had limitations, mostly due to sample size. Further exploration of best practices is needed.

Providers' Impressions

What were providers' opinions on best MWEE practices? While three of the 10 providers we interviewed felt that repeated exposure to MWEEs over a long period of time will have the most effect on students' environmental stewardship characteristics, one was unsure that the amount of time students spent experiencing MWEE (e.g., 12 hours over a month), even with repeated exposure, had a strong influence relative to the rest of the students' curriculum.

In addition, 3 providers believed that when they assisted teachers with instruction in the classroom and met with students, they built important relations with teachers and students that enhanced students' learning.

Table 62: Student-reported MWEE practices

n=434	Intention to Act (effect size)	Personal responsibility (effect size)	Environmental sensitivity (effect size)	Knowledge of issues (effect size)	Knowledge of actions (effect size)	Individual locus of control (effect size)	Group locus of control (effect size)	Knowledge of ecology (effect size)	Engagement in learning (effect size)
Learn Outdoors	0.49	0.49	0.46	0.59***	0.38**	0.51	-0.01	0.36	0.40**
Reflect	0.60**	0.66**	0.70***	0.72***	0.62***	0.62**	0.40**	0.62**	0.5
Hands On	0.87***	0.81***	0.65**	0.82***	0.79***	0.61***	0.39	0.63	0.72***
Relevancy	1.17***	0.93***	0.73**	0.83**	0.87***	0.59**	0.85***	0.51	0.94***

**p<=0.05, ***p<=0.001

Table 63: Teacher-reported MWEE practices

n=434	Intention to Act (effect size)	Personal responsibility (effect size)	Environmental sensitivity (effect size)	Knowledge of issues (effect size)	Knowledge of actions (effect size)	Individual locus of control (effect size)	Group locus of control (effect size)	Knowledge of ecology (effect size)	Engagement in learning (effect size)
Explore community	-0.02	-0.17**	-0.19	-0.04	-0.20	-0.32**	-0.01**	0.27	-0.04
Talk/read about issues	0.46**	0.58***	0.28	0.11	0.12**	0.31~	0.34	0.72	0.32
Study social issues	0.00	0.16**	0.12	0.11	-0.15	0.09	0.07	0.59**	0.00
Data collection	0.30	0.46***	0.24	0.21	0.11	0.43***	0.09	0.38	0.15**
Field equipment	0.18	0.46***	0.20	0.17	0.16**	0.36***	0.00	0.45	0.23
Data analysis	0.39**	0.65***	0.30	0.24	0.25**	0.47***	0.22~	0.55**	0.25**
Graph data	0.13	0.21~	0.01	0.12	0.08	-0.02	0.00	0.21	-0.07
Action project	0.60	0.52***	0.51~	0.08	0.18	0.40**	0.18	0.24	0.83~

~p<=0.10, **p<=0.05, ***p<=0.001

DISCUSSION

NOAA and other members of the Chesapeake Bay education community hope their programs are fostering environmental stewardship attitudes, knowledge, and skills in students throughout the Bay watershed. Because the B-WET programs are screened and meet the criteria for a Meaningful Watershed Educational Experience (MWEE) to be funded, the B-WET programs included in this evaluation are considered to be MWEE models. The Bay education community would like to know if these programs are improving students' environmental stewardship, their learning (as measured by standardized tests), and teachers' instructional practices.

Professional Development

Teachers had excellent professional development experiences in which their confidence and intentions increased. Almost all of the teachers taught about the watershed or the Bay after the professional development, including the large majority of those who had not taught about the watershed or Bay in the past. Teachers were most happy with the instructors, the quality of the information provided, and the usefulness of what they were learning for improving their students' stewardship.

Many teachers were conducting more MWEE practices as a result of the professional development. However, not all teachers were teaching outdoors and many were not conducting issue research and action projects. And, teachers who were new to teaching about the Bay were not conducting MWEE practices as often as those with past experience. Teachers may recognize the importance of having their students do this type of learning, but they are limited by their existing curriculum and standardized tests. They expressed the need for time to plan lessons, time in the school year curriculum to integrate MWEE practices, and time during the day to incorporate hands-on, outdoor learning. Teachers also want to collaborate with other teachers and get ongoing support from providers. They expressed a need for funds for equipment, field trip fees, and transportation.

PD Best Practices

Teachers expressed their degree of satisfaction with seventeen professional development practices. The six professional practices most strongly related to teachers' confidence and intentions to implement MWEEs were:

- Demonstration of how MWEEs will improve student academic achievement,
- Demonstration of how MWEEs will improve student environmental awareness, knowledge, and actions,
- Demonstration of the applicability of curriculum materials and activities to teachers' school district's learning standards,
- Follow-up support from professional development providers,
- Instruction and modeling of ways to guide students in conducting environmental action, and
- Instruction and modeling of ways to guide students in researching an environmental issue.

The following practices were also positively related to teachers' confidence and intentions to implement MWEEs:

- More professional development days,
- Time for hands-on learning,

- Time for practicing new skills, and
- Time for teachers to plan ways integrate MWEEs into their curriculum.

Recommendations
NOAA should continue to support high-quality MWEE professional development with priority given to multi-day programs. The professional development should include specific guidance on how teachers can incorporate MWEEs into their existing curriculum. Providers should allocate sufficient time for this during professional development. Teachers should be encouraged to bring their teaching guides to the professional development so that they can use this time to determine how best to integrate MWEEs. Providing teachers with sample lesson plans that illustrate how MWEEs can be incorporated into the existing curriculum is also likely to be helpful.

To address teachers' desire for collaboration, professional development should include sufficient time for teachers to learn from their peers and to partner with another or several teachers. Providers should also consider offering MWEE professional development to teams of teachers from the same school to help ensure teachers will be able to support each other as they implement MWEEs.

Professional development providers should offer follow-up support in the form of instructional assistance, in the classroom and the field, to enable teachers to implement all components of a MWEE, especially environmental issue research and action projects. Teachers would benefit from funding to enable them to obtain the resources they need to implement MWEEs.

In collaboration with teachers, MWEE providers, and other stakeholders, NOAA should explore if and how school district standards can be revised so that MWEEs become an essential part of instruction (e.g., contained in curriculum pacing guides).

Environmental Stewardship
Overall
To investigate the effects of MWEEs on students' stewardship, we examined the characteristics outlined in the Hungerford and Volk model of stewardship behavior (1990): Entry-level (environmental sensitivity, knowledge of ecology), Ownership (knowledge of issues, personal responsibility), and Empowerment (knowledge of actions, locus of control, intention to act). Our results suggest that students are improving their stewardship qualities as a result of their participation in B-WET funded MWEEs. Students improved their knowledge of watershed or Bay issues and actions. There is some evidence that the students also gained in knowledge of ecology. The students improved their intention to act on behalf of the Chesapeake Bay watershed, the characteristic most closely associated with future stewardship behavior.

Entry-Level: Environmental Sensitivity and Knowledge of Ecology
We did not see improvements in the students' environmental sensitivity, but this is not surprising. The MWEEs were classroom-based and students spent a small proportion of their Bay or watershed unit learning outdoors relative to indoors. Also, when we looked at the amount of time students spent outdoors, there was no relationship with environmental sensitivity. According to Drs. Hungerford and Volk (1990), "it seems important that learners have environmentally positive experiences in nonformal outdoor settings over long periods of time" to develop environmental sensitivity. We do not have enough information about the types of outdoor learning the students experienced, but it may be that their experiences were short or were purely instructional rather than any form of nature appreciation. Also, some of the students (10%) reported that they never learned outdoors.

We suspect that students' knowledge of ecology also improved, despite a lack of statistical evidence (effect size=0.30, p=0.133). All of these students' teachers believed that their students gained in their watershed or Bay knowledge.

Ownership: Knowledge of Issues and Personal Responsibility
Students gained in their knowledge of watershed and Bay issues, a prerequisite for making informed decisions. We did not see an improvement in the students' sense of being personally responsible for environmental problems. It may be that they are not seeing the connection between their personal actions and the environment, or they may feel that the problems belong to the community and are too large for them to "own".

When the students spent time reflecting, doing hands-on learning, and learning about things they thought were important, their sense of personal responsibility increased. Participating in action projects was also associated with higher personal responsibility. Students who were actively participating in a solution to an environmental problem seemed to make the personal connection to their own behaviors. According to their teachers, not all students participated in action projects. Given the importance of relevancy of the material learned, we would predict that the more involved the students are in choosing actions to take, the more ownership they will have of the results.

Empowerment: Knowledge of Action, Locus of Control, and Intention to Act
The students increased their knowledge of actions they could take to protect the watershed and the Bay. However, they did not seem to improve in their feeling of being able to make a difference (locus of control). As with other stewardship characteristics, reflecting, hands-on learning, and learning things that are important were associated with higher locus of control. And as with personal responsibility, participating in action projects improved students' locus of control. By seeing positive results from their actions, they developed a sense that they were able to make a difference.

Given that the students increased their intention to act, it is likely that they will act in ways that will help protect and improve the condition of the watershed and the Chesapeake Bay. According to theories from psychology (Ajzen & Fishbein 1980), individuals' intentions to act are the best predictors of their future behavior.

Stewardship Best Practices
Students' participation in the following MWEE practices resulted in higher scores in two or more stewardship characteristics:

- Collecting and analyzing data
- Conducting an action project
- Hands-on learning
- Learning outdoors
- Learning things that are important to them
- Reading about and discussing issues
- Reflection

Six of the above practices are basic components of a MWEE. "Learning things that are important to the students" has been found to be an important variable in changing human behavior. Researchers have proposed that teachers need to consider what is important to students and make the connection to the environment in addition to trying to make the environment important to students (Covitt 2004). Environmental education, like all education, is not a one-way street.

Recommendations
Encourage teachers and providers of MWEEs to learn what is important to students and to be sure to connect MWEEs to these interests to make learning about the watershed or Bay relevant for students. In addition, instructors should foster MWEEs that incorporate hands-on learning, reflection, and learning outdoors. Ideally, MWEEs should include collecting and analyzing data and issue research based action projects. These specific practices have positive effects on environmental stewardship characteristics that other practices are less likely to influence. When engaging students in learning about the watershed, Bay, or their community and in action projects, be sure that these are empowering experiences. Negative experiences have the potential to decrease students' environmental stewardship characteristics. To the extent possible, all students should be involved in all aspects of quality MWEEs.

Academic Achievement
Standardized Test Scores
Because of the high stakes testing required by the No Child Left Behind Act, teachers are feeling added pressure to teach only the materials that will be on the state standardized tests. Because MWEEs are not directly part of the tested standards, teachers have a difficult time justifying class time devoted to this type of watershed or Bay education. Chesapeake Bay educators assume that MWEEs will help students learn science in a meaningful, hands-on way, and that this engagement in learning science will result in higher science test scores. If the standardized tests are true measures of science knowledge (something not all agree with), then students should do better on the tests after a MWEE experience. And if this relationship between MWEEs and standardized tests can be "proven", then school doors will open to MWEEs.

Our results suggest that there is potential for MWEEs to improve students' performance on standardized science tests. Third grade students did better on the Science Investigation category (1 of 4 categories) of their science test. Because of limited access to actual standardized test data and a subsequent small sample, we were not able to make generalized statements about this effect.

It may be that the MWEE as designed was not fully implemented. The Virginia MWEE program provided staff-directed field trips and school visits 4 times during the school year, but they relied on the teachers to supplement those visits with in-class lessons. Not all teachers completed those lessons.

Many providers said it is not appropriate to measure MWEE gains with standardized tests. MWEE programs are not designed to improve test scores, but to improve environmentally responsible behavior. Test taking itself requires specific skills, and MWEEs do not teach test-taking skills. As is evident in the amount of effort schools are making to raise their students' test scores, achieving this goal may need to be a direct effort of a MWEE rather than a "hope it happens" goal.

Engagement in Learning

Research suggests that the more engaged students are in their lessons, the more they learn, and the better they should perform on assessments. MWEEs are hands-on experiences in real world settings, so in theory they should improve students' engagement. Our results did not show an improvement in engagement in learning. However, almost all teachers said their students were more engaged. It may be that our measures did not adequately capture "engagement in learning". And even if the MWEE did have a positive effect on engagement, it may be that the MWEEs were not a significant enough part of the school year curriculum to have a lasting effect that would translate into higher scores on the standardized tests.

In this evaluation, more teachers agreed that their students were more engaged in their learning than agreed that their students were better prepared for the state assessments as a result of the MWEE. It may be that these teachers would say that engagement in learning is not that strongly related to test performance. Or it may be that the MWEEs are not sufficiently integrated into the tested curriculum and the teachers do not see the connection between the MWEE lessons and the standardized test.

Engagement in Learning Best Practices

Participation in the following MWEE practices resulted in higher engagement in learning:

- Learning outdoors
- Hands-on learning
- Collecting and analyzing data
- Learning what is important to students

Recommendations

Additional research and evaluations are necessary to determine to what extent MWEEs can increase students' academic achievement. This evaluation focused on assessing gains in achievement based on students' performance on standardized science tests and engagement in learning. Other standardized tests and ways to measure achievement can be explored. To generalize the effects of MWEEs on state standardized tests, B-WET providers would have to target students in grades that are tested and for whom districts and authorities are willing and able to provide test scores.

In collaboration with teachers, providers, and other stakeholders, NOAA should explore to what extent MWEEs should have student achievement, in addition to environmental stewardship, as a desired goal. If student achievement remains a desired goal, further study is needed on how MWEEs can best foster student achievement. If not, NOAA should explore alternative ways to promote MWEEs' educational value to teachers and administrators.

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APPENDICES

APPENDIX A: FACTOR ANALYSIS INFORMATION

Factor Analysis Tables

		3rd through 5th Grade			6th through 11th Grade	
		Pre-test	Posttest		Pre-test	Posttest
Intention to Act						
	Save water, (n)	0.46 (369)	0.44 (329)		0.41 (666)	0.39 (625)
	Care for local stream or waterway, (n)	0.45 (370)	0.44 (329)		0.42 (666)	0.39 (625)
	Teach others, (n)	0.45 (368)	0.44 (329)		0.43 (666)	0.41 (625)
	(Reliability, Cronbach's Alpha[1])	(.58)	(.63)		(.71)	(.79)
	(Eigen value)	(1.62)	(1.73)		(1.89)	(2.12)
	(Proportion of variance explained)	(54%)	(57%)		(63%)	(70%)
Personal Responsibility						
	for Watershed, (n)	0.40 (368)	0.41 (327)		0.37 (665)	0.38 (625)
	for Aquatic Animals, (n)	0.43 (370)	0.40 (328)		0.38 (664)	0.38 (625)
	for Natural Areas, (n)	0.42 (370)	0.38 (330)		0.40 (667)	0.37 (625)
	(Reliability, Cronbach's Alpha[1])	(.71)	(.79)		(.84)	(.87)
	(Eigen value)	(1.91)	(2.12)		(2.26)	(2.38)
	(Proportion of variance explained)	(63%)	(71%)		(75%)	(79%)
Environmental Sensitivity						
	Care About Watershed, (n)	0.46 (367)	0.46 (329)		0.40 (662)	0.39 (625)
	Care About Aquatic Animals, (n)	0.38 (371)	0.38 (329)		0.38 (665)	0.38 (624)
	Care About Natural Areas, (n)	0.47 (373)	0.44 (329)		0.43 (667)	0.40 (624)
	(Reliability, Cronbach's Alpha[1])	(.63)	(.66)		(.76)	(.82)
	(Eigen value)	(1.73)	(1.81)		(2.02)	(2.22)
	(Proportion of variance explained)	(58%)	(60%)		(67%)	(73%)
[1] Standardized cronbach alpha						
[2] response order reversed						

Factor Analysis Tables

	3rd through 5th Grade			6th through 11th Grade	
	Pre-test	Posttest		Pre-test	Posttest
Knowledge of Issues					
Know About Loss of Forests, (n)	0.36 (369)	0.36 (320)		0.32 (642)	0.30 (690)
Know About Nutrients, (n)	0.34 (368)	0.37 (328)		0.33 (651)	0.31 (605)
Know About Loss of Habitat, (n)	0.35 (366)	0.33 (328)		0.34 (641)	0.31 (602)
Know About Too Much Sediment, (n)	0.34 (377)	0.38 (329)		0.32 (650)	0.31 (607)
(Reliability, Cronbach's Alpha[1])	(.69)	(.65)		(.75)	(.83)
(Eigen value)	(2.07)	(1.96)		(2.32)	(2.65)
(Proportion of variance explained)	(51%)	(49%)		(58%)	(66%)
Knowledge of Actions					
Know How To Save Water, (n)	0.37 (367)	0.33 (330)		0.30 (665)	0.30 (623)
Know How To Teach Others, (n)	0.40 (369)	0.42 (330)		0.35 (665)	0.32 (625)
Know How To Care for Local Stream or Waterway, (n)	0.35 (367)	0.33 (330)		0.35 (666)	0.32 (620)
Know How To Plant Trees, (n)	0.36 (367)	0.44 (330)		0.32 (663)	0.30 (625)
(Reliability, Cronbach's Alpha[1])	(.60)	(.55)		(.75)	(.82)
(Eigen value)	(1.82)	(1.72)		(2.32)	(2.59)
(Proportion of variance explained)	(45%)	(43%)		(58%)	(65%)
Internal Locus of Control					
Can Make a Difference on Own at School, (n)	0.57 (368)	0.55 (327)		0.54 (664)	0.53 (622)
Can Make a Difference on Own in Community, (n)	0.57 (368)	0.55 (329)		0.54 (666)	0.53 (624)
(Reliability, Cronbach's Alpha[1])	(.71)	(.77)		(.83)	(.88)
(Eigen value)	(1.54)	(1.63)		(1.71)	(1.78)
(Proportion of variance explained)	(77%)	(81%)		(86%)	(89%)
1 Standardized cronbach alpha					
2 response order reversed					

Factor Analysis Tables

Factor components		3rd through 5th Grade			6th through 11th Grade	
		Pre-test	Posttest		Pre-test	Posttest
Group Locus of Control						
	Can Make a Difference with Others at School, (n)	0.57 (367)	0.56 (328)		0.54 (665)	0.53 (624)
	Can Make a Difference with Others in Community, (n)	0.57 (363)	0.56 (327)		0.54 (664)	0.53 (624)
	(Reliability, Cronbach's Alpha[1])	(.70)	(0.75)		(.85)	(.89)
	(Eigen value)	(1.54)	(1.60)		(1.74)	(1.80)
	(Proportion of variance explained)	(77%)	(80%)		(87%)	(90%)
Knowledge of Ecology						
	Knowledge of Wetlands/Marshes , (n)	0.37 (365)	0.35 (329)		0.39 (647)	0.39 (610)
	Knowledge of Underwater Grasses, (n)	0.36 (365)	0.34 (328)		0.35 (644)	0.33 (610)
	Knowledge of Forested Buffer, (n)	0.35 (363)	0.39 (329)		0.36 (645)	0.41 (614)
	Knowledge of Sediment, (n)	0.39 (368)	0.38 (327)		0.38 (643)	0.33 (613)
	(Reliability, Cronbach's Alpha[1])	(.61)	(.62)		(.61)	(.61)
	(Eigen value)	(1.85)	(1.86)		(1.84)	(1.84)
	(Proportion of variance explained)	(46%)	(47%)		(46%)	(46%)
Engagement in Learning						
	Pay Attention in Class, (n)	0.36 (365)	0.35 (327)		0.28 (661)	0.28 (620)
	Ask Questions and Share Ideas, (n)	0.23 (366)	0.27 (329)		0.21 (664)	0.19 (620)
	Finish Classwork on Time, (n)	0.33 (367)	0.26 (329)		0.28 (663)	0.27 (620)
	Finish Homework on Time, (n)	0.26 (350)	0.31 (315)		0.27 (660)	0.28 (618)
	Try as Hard as Can, (n)	0.27 (362)	0.29 (324)		0.27 (659)	0.26 (614)
	Feel Bored in Class[2], (n)	0.27 (367)	0.18 (329)		0.15 (652)	0.18 (624)
	(Reliability, Cronbach's Alpha[1])	(.57)	(.62)		(.75)	(.74)
	(Eigen value)	(1.95)	(2.09)		(2.71)	(2.69)
	(Proportion of variance explained)	(32%)	(35%)		(45%)	(45%)
1 Standardized Cronbach alpha						
2 response order reversed						

APPENDIX B: PRE/POST-TEST HLM ANALYSIS INFORMATION

Multi-level Variance Breakdown

	Tau (ICC)	$Sigma^2$
Intention to Act Post-test	0.13	0.87
Personal Responsibility Post-test	0.10	0.91
Environmental Sensitivity Post-test	0.09	0.91
Knowledge of Issues Post-test	0.17	0.84
Knowledge of Actions Post-test	0.19	0.81
Internal Locus of Control Post-test	0.07	0.93
Group Locus of Control Post-test	0.08	0.92
Engagement in Learning Post-test	0.09	0.91
Knowledge of Ecology Post-test	0.33	0.70

Intention to Act HLM Results (n=449 students; N=32 classes)

	Final Model [3]		Interaction Model [3]	
Intercept	0.04		0.12	
MWEE (Treatment) [1]	0.33	*	0.32	
3rd Grade [1,2]	-0.76	*	-0.81	
4th Grade [1,2]	-0.55	*	-0.56	
6th Grade [1,2]	0.01		0.05	
8th Grade [1,2]	-0.32		-0.33	
9th Grade [1,2]	-0.06		-0.24	
3rd Grade x MWEE [1,2]			-0.06	
4th Grade x MWEE [1,2]			-0.02	
6th Grade x MWEE [1,2]			-0.11	
8th Grade x MWEE [1,2]			-0.10	
9th Grade x MWEE [1,2]			0.20	
Between class variance, τ_{00}	0.04		0.08	
Within class variance, σ^2	0.89		0.89	
[1] Model tested for significant variance using t statistic				
[2] Compared to 10th grade				
[3] Effect size (standard deviation 1)				
~ p < .10, * p <.05, ** p < .01, *** p < .001				

Personal Responsibility (n=449 students; N=32 classes)

	Final Model [3]		Interaction Model [3]	
Intercept	-0.09		-0.15	
MWEE (Treatment) [1]	0.10		0.33	
3rd Grade [1,2]	-0.22		-0.32	
4th Grade [1,2]	-0.17		0.17	
6th Grade [1,2]	0.31		0.36	
8th Grade [1,2]	-0.10		-0.04	
9th Grade [1,2]	0.29		0.33	
3rd Grade x MWEE [1,2]			0.09	
4th Grade x MWEE [1,2]			-0.66	
6th Grade x MWEE [1,2]			-0.19	
8th Grade x MWEE [1,2]			-0.12	
9th Grade x MWEE [1,2]			-0.16	
Between class variance, τ_{00}	0.01		0.01	
Within class variance, σ^2	0.90		0.90	
[1] Model tested for significant variance using t statistic				
[2] Compared to 10th grade				
[3] Effect size (standard deviation 1)				
~ p < .10, * p <.05, ** p < .01, *** p < .001				

Environmental Sensitivity (n=447 students; N=32 classes)

	Final Model [3]		Interaction Model [3]	
Intercept	-0.05		-0.39	
MWEE (Treatment) [1]	0.21		0.88	*
3rd Grade [1,2]	-0.18		0.11	
4th Grade [1,2]	-0.39		-0.03	
6th Grade [1,2]	0.32		0.90	*
8th Grade [1,2]	-0.16		0.23	
9th Grade [1,2]	0.10		0.28	
3rd Grade x MWEE [1,2]			-0.60	
4th Grade x MWEE [1,2]			-0.69	
6th Grade x MWEE [1,2]			-1.07	~
8th Grade x MWEE [1,2]			-0.86	
9th Grade x MWEE [1,2]			0.41	
Between class variance, τ_{00}	0.06		0.06	
Within class variance, σ^2	0.90		0.90	
[1] Model tested for significant variance using t statistic				
[2] Compared to 10th grade				
[3] Effect size (standard deviation 1)				
~ p < .10, * p <.05, ** p < .01, *** p < .001				

Knowledge of Issues (n=442 students; N=32 classes)

	Final Model [3]		Interaction Model [3]	
Intercept	0.00		-0.21	
MWEE (Treatment) [1]	0.60	***	1.00	*
3rd Grade [1,2]	-0.75	*	-0.98	*
4th Grade [1,2]	-0.53	*	0.16	
6th Grade [1,2]	-0.22		0.02	
8th Grade [1,2]	-0.41		-0.16	
9th Grade [1,2]	0.08		0.13	
3rd Grade x MWEE [1,2]			0.20	
4th Grade x MWEE [1,2]			-0.99	~
6th Grade x MWEE [1,2]			-0.46	
8th Grade x MWEE [1,2]			-0.58	
9th Grade x MWEE [1,2]			-0.13	
Between class variance, τ_{00}	0		0.03	
Within class variance, σ^2	0.85		0.85	
[1] Model tested for significant variance using t statistic				
[2] Compared to 10th grade				
[3] Effect size (standard deviation 1)				
~ p < .10, * p <.05, ** p < .01, *** p < .001				

Knowledge of Actions (n=449 students; N=32 classes)

	Final Model [3]		Interaction Model [3]	
Intercept	-0.13		-0.40	*
MWEE (Treatment) [1]	0.47	***	0.95	**
Pre-test	0.51	***	0.58	***
3rd Grade [1,2]	-0.40	~	-0.46	
4th Grade [1,2]	-0.29		0.11	
6th Grade [1,2]	0.07		0.47	*
8th Grade [1,2]	-0.12		0.20	
9th Grade [1,2]	-0.10		0.16	
3rd Grade x MWEE [1,2]			0.03	
4th Grade x MWEE [1,2]			-0.64	~
6th Grade x MWEE [1,2]			-0.70	*
8th Grade x MWEE [1,2]			-0.67	~
9th Grade x MWEE [1,2]			-0.41	
Between class variance, τ_{00}	0.01		0	
Within class variance, σ^2	0.62		0.61	
[1] Model tested for significant variance using t statistic				
[2] Compared to 10th grade				
[3] Effect size (standard deviation 1)				
~ p < .10, * p <.05, ** p < .01, *** p < .001				

Knowledge of Actions by Grade (n=449 students; N=32 classes)

	3rd Grade		4th Grade		6th Grade		8th Grade		9th Grade		10th Grade	
MWEE (Treatment) [1]	0.98	**	0.29		0.26		0.27		0.53	*	0.95	**
[1] Treatment tested for significance in each grade using F statistic generated for the grade's slice. Coefficient displayed in effect size units (standard deviation of one).												
~ p < .10, * p <.05, ** p < .01, *** p < .001												

Internal Locus of Control (n=446 students; N=32 classes)

	Final Model [3]		Interaction Model [3]	
Intercept	0.19		0.05	
MWEE (Treatment) [1]	0.24		0.71	
3rd Grade [1,2]	-0.31		-0.19	
4th Grade [1,2]	-0.53	~	-0.26	
6th Grade [1,2]	-0.29		-0.21	
8th Grade [1,2]	-0.03		0.17	
9th Grade [1,2]	-0.53	~	-0.44	
3rd Grade x MWEE [1,2]			-0.42	
4th Grade x MWEE [1,2]			-0.67	
6th Grade x MWEE [1,2]			-0.31	
8th Grade x MWEE [1,2]			-1.03	
9th Grade x MWEE [1,2]			-0.33	
Between class variance, τ_{00}	0.02		0.03	
Within class variance, σ^2	0.91		0.91	
[1] Model tested for significant variance using t statistic				
[2] Compared to 10th grade				
[3] Effect size (standard deviation 1)				
~ p < .10, * p <.05, ** p < .01, *** p < .001				

Group Locus of Control (n=447 students; N=32 classes)

	Final Model [3]		Interaction Model [3]	
Intercept	-0.04		-0.19	
MWEE (Treatment) [1]	0.09		0.47	
3rd Grade [1,2]	-0.03		0.39	
4th Grade [1,2]	-0.14		0.21	
6th Grade [1,2]	0.30		0.59	
8th Grade [1,2]	-0.21		-0.15	
9th Grade [1,2]	0.03		0.09	
3rd Grade x MWEE [1,2]			-0.85	
4th Grade x MWEE [1,2]			-0.66	
6th Grade x MWEE [1,2]			-0.68	
8th Grade x MWEE [1,2]			0.21	
9th Grade x MWEE [1,2]			-0.19	
Between class variance, τ_{00}	0		0	
Within class variance, σ^2	0.92		0.92	
[1] Model tested for significant variance using t statistic				
[2] Compared to 10th grade				
[3] Effect size (standard deviation 1)				
~ p < .10, * p <.05, ** p < .01, *** p < .001				

Engagement in Learning (n=421 students; N=32 classes)

	Final Model [3]		Interaction Model [3]	
Intercept	0.08		0.00	
MWEE (Treatment) [1]	0.02		0.18	
3rd Grade [1,2]	-0.29		-0.17	
4th Grade [1,2]	-0.32		-0.38	
6th Grade [1,2]	0.13		0.22	
8th Grade [1,2]	-0.19		-0.02	
9th Grade [1,2]	0.21		0.14	
3rd Grade x MWEE [1,2]			-0.24	
4th Grade x MWEE [1,2]			0.00	
6th Grade x MWEE [1,2]			-0.20	
8th Grade x MWEE [1,2]			-0.58	
9th Grade x MWEE [1,2]			0.09	
Between class variance, τ_{00}	0		0	
Within class variance, σ^2	0.94		0.94	
[1] Model tested for significant variance using t statistic				
[2] Compared to 10th grade				
[3] Effect size (standard deviation 1)				
~ p < .10, * p <.05, ** p < .01, *** p < .001				

Knowledge of Ecology (n=439 students; N=32 classes)

	Final Model [3]		Interaction Model [3]	
Intercept	0.15		0.23	
MWEE (Treatment) [1]	0.30		0.09	
3rd Grade [1,2]	-1.05	*	-1.42	*
4th Grade [1,2]	-0.15		0.32	
6th Grade [1,2]	-0.44		-0.61	
8th Grade [1,2]	-0.64	~	-0.72	~
9th Grade [1,2]	0.25		0.07	
3rd Grade x MWEE [1,2]			0.72	
4th Grade x MWEE [1,2]			-0.52	
6th Grade x MWEE [1,2]			0.41	
8th Grade x MWEE [1,2]			0.24	
9th Grade x MWEE [1,2]			0.46	
Between class variance, τ_{00}	0.1		0.11	
Within class variance, σ^2	0.69		0.69	
[1] Model tested for significant variance using t statistic				
[2] Compared to 10th grade				
[3] Effect size (standard deviation 1)				
~ p < .10, * p <.05, ** p < .01, *** p < .001				

APPENDIX C: COVARIATE INFORMATION

Post-test by Gender, Academic Performance, and Pre-test

	Gender [1]					Academic Performance [1]				Pre-test [2]	
	Female		Male			Mostly A's		Mostly below A's			
Intention to Act Post-test, mean	0.10	*	-0.12			0.07		-0.07		0.62	***
(SD)	(0.93)		(1.07)			(1.03)		(0.98)			
Personal Responsibility Post-test, mean	0.05		-0.06			0.07	~	-0.10		0.54	***
(SD)	(0.96)		(1.05)			(1.03)		(0.98)			
Environmental Sensitivity Post-test, mean	0.07		-0.08			0.10	*	-0.12		0.64	***
(SD)	(0.96)		(1.05)			(0.98)		(1.01)			
Knowledge of Issues Post-test, mean	0.01		-0.02			0.04		-0.07		0.53	***
(SD)	(0.97)		(1.04)			(1.02)		(0.98)			
Knowledge of Actions Post-test, mean	0.10	*	-0.12			0.04		-0.05		0.57	***
(SD)	(0.98)		(1.02)			(1.02)		(0.97)			
Internal Locus of Control Post-test, mean	0.00		0.00			0.06	~	-0.11		0.51	***
(SD)	(0.99)		(1.01)			(1.01)		(0.98)			
Group Locus of Control Post-test, mean	0.07		-0.08			0.08		-0.05		0.42	***
(SD)	(0.93)		(1.08)			(0.97)		(1.03)			
Engagement in Learning Post-test, mean	0.17	***	-0.21			0.25	***	-0.27		0.58	***
(SD)	(0.98)		(0.99)			(0.93)		(0.99)			
Knowledge of Ecology Post-test, mean	-0.03		0.034			0.05	*	-0.14		0.57	***
(SD)	(0.97)		(1.04)			(0.99)		(0.98)			

[1] Difference in means tested using t-statistic. If a statistically significant difference existed, the appropriate symbols are placed in the column with the higher mean

[2] Difference in means tested using regression. If the model was not significant (using F test), then values not displayed. If the model was significant, the effect size is displayed (standard deviation units)

~ $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$

Post-test by Grade

	3rd Grade	4th Grade	6th Grade	8th Grade	9th Grade	10th Grade	Significance Level [1]
Intention to Act Post-test, mean	-0.48	-0.19	0.32	-0.12	0.22	0.21	***
(SD)	(1.03)	(0.99)	(0.94)	(1.05)	(0.86)	(0.93)	
Personal Responsibility Post-test, mean	-0.26	-0.21	0.30	-0.13	0.30	-0.01	***
(SD)	(1.06)	(1.04)	(0.94)	(1.06)	(0.75)	(0.92)	
Environmental Sensitivity Post-test, mean	-0.10	-0.25	0.41	-0.15	0.16	-0.02	***
(SD)	(0.87)	(1.06)	(0.97)	(0.94)	(0.88)	(1.06)	
Knowledge of issues Post-test, mean	-0.35	-0.04	0.18	-0.27	0.36	0.23	***
(SD)	(1.12)	(0.94)	(0.93)	(0.99)	(0.92)	(1.09)	
Knowledge of Actions Post-test, mean	-0.32	-0.13	0.41	-0.21	0.09	0.12	***
(SD)	(1.11)	(1.02)	(0.93)	(1.00)	(0.76)	(1.02)	
Internal Locus of Control Post-test, mean	-0.02	-0.17	0.10	0.10	-0.14	0.27	~
(SD)	(0.01)	(0.93)	(1.04)	(1.06)	(0.90)	(1.12)	
Group Locus of Control Post-test, mean	-0.08	-0.12	0.28	-0.13	0.06	0.00	*
(SD)	(0.97)	(1.07)	(1.00)	(0.98)	(0.89)	(0.98)	
Engagement in Learning Post-test, mean	-0.21	-0.22	0.23	-0.11	0.29	0.05	**
(SD)	(0.91)	(1.15)	(0.86)	(1.01)	(0.89)	(0.93)	
Knowledge of Ecology Post-test, mean	-0.76	.21	-.078	-0.41	.57	0.41	***
(SD)	(0.85)	(0.91)	(0.93)	(0.90)	(0.88)	(1.09)	
[1] Differences in scores tested using ANOVA							
~ p < .10, * p <.05, ** p < .01, *** p < .001							

Treatment vs. Comparison by Gender, Academic Performance, and Grade

	MWEE (n=258 students)		Control Group (n=193 students)		N[1]
%Female [2]	51.3%		57.4%		451
% Receive mostly A's	49.2%		54.5%		433
Grade [3]	***		***		451
3rd Grade	70.7%		29.3%		
4th Grade	80.5%		19.5%		
6th Grade	62.0%		38.0%		
8th Grade	27.3%		72.7%		
9th Grade	51.5%		48.5%		
10th Grade	50.0%		50.0%		
Intention to Act Pre-test, mean [4]	0.06		-0.08		451
(SD)	(1.02)		(0.97)		
Personal Responsibility Pre-test, mean [4]	0.03		-0.04		451
(SD)	(1.05)		(0.92)		
Environmental Sensitivity Pre-test, mean [4]	0.05		-0.07		451
(SD)	(0.97)		(1.02)		
Knowledge of Issues Pre-test, mean [4]	0.04		-0.05		451
(SD)	(1.00)		(1.00)		
Knowledge of Actions Pre-test, mean [4]	0.09	*	-0.11		451
(SD)	(1.05)		(.92)		
Internal Locus of Control Pre-test, mean [4]	-0.02		0.02		451
(SD)	(1.01)		(0.98)		
Group Locus of Control Pre-test, mean [4]	0.06		-0.09		451
(SD)	(1.00)		(1.00)		
Engagement in Learning Pre-test, mean [4]	0.04		-0.05		451
(SD)	(0.99)		(1.02)		
Knowledge of Ecology Pre-test, mean [4]	0.05		-0.06		451
(SD)	(1.022)		(0.97)		

[1] the number of observations that were available for the variable. E.g., 451 observations were available on the male/female indicator

[2] tested with chi-square statistic. If significant, symbols are placed by the larger value

[3] tested with chi-square statistic. To indicate the statistically significant difference across groups, the appropriate symbols are placed in the top row in both columns

[4] tested with t statistic. If there was a statistically significant difference between groups, the appropriate symbol appears next to the group with the higher score

~ p < .10, * p <.05, ** p < .01, *** p < .001

APPENDIX D: RESULTS OF HLM ON AGGREGATE SOL SCORES

This appendix summarizes results from four analyses. The table identifies which variables were found to be significant and reports effect sizes. The first column summarizes results from a test for difference in performance on the aggregate science SOL based on the treatment, without considering grade level differences. The second column summarizes results for the same test with grade level included as a covariate. The last two columns summarize results 3rd grade and 5th grade students, respectively.

n=1005 children n=61 classes	Treatment Only[1]		Covariates [1]		3rd Grade [2]		5th Grade [2]	
Intercept	0.05		-0.26	*	0.08		0.01	
Virginia MWEE Program	.14		0.13		0.21		0.04	
5th Grade			-0.64	***				
Level-2 (Classroom) Variance	.28		0.17	***	0.2	***	0.17	***
Residual (Student)Variance	.72		0.73	***	0.8	***	0.84	***
[1] reported in effect size units								
[2] reported in effect size units relative to the specific grade								
~ p < .10, * p <.05, ** p < .01, *** p < .001								

APPENDIX E: RESULTS OF HLM ON CATEGORY SOL SCORES

VA Science SOL: Scientific Investigation Results (n=1005 children; n=61 classes)

	Treatment Only[1]		Covariates[1]		3rd Grade[2]		5th Grade[2]	
Intercept	0.07		-0.14	~	0.15		-0.03	
Virginia MWEE Program	0.14		0.14		0.32	*	-0.06	
5th Grade			-0.42	***				
Level-2 (Classroom) Variance	0.12	***	0.08	***	0.07	*	0.07	*
Residual (Individual)Variance	0.88	***	0.73	***	0.90	***	0.93	***
[1] reported in effect size units								
[2] reported in effect size units relative to the specific grade								
~ p < .10, * p <.05, ** p < .01, *** p < .001								

VA Science SOL: Life Processes & Living Systems (n=1005 children; n=61 classes)

	Treatment Only[1]		Covariates[1]		3rd Grade[2]		5th Grade[2]	
Intercept	0.01		-0.26	**	-0.02		0.04	
Virginia MWEE Program	0.04		0.03		0.01		0.09	
5th Grade			0.54	***				
Level-2 (Classroom) Variance	0.2	***	0.13	***	0.16	**	0.11	**
Residual (Individual)Variance	0.80	***	0.80	***	0.85	***	0.9	***
[1] reported in effect size units								
[2] reported in effect size units relative to the specific grade								
~ p < .10, * p <.05, ** p < .01, *** p < .001								

VA Science SOL: Earth/Space Systems & Cycles (n=1005 children; n=61 classes)

	Treatment Only[1]		Covariates[1]		3rd Grade[2]		5th Grade[2]	
Intercept	0.07		-0.04		0.07		0.05	
Virginia MWEE Program	0.16		0.15		0.19		0.12	
5th Grade			-0.21	~				
Level-2 (Classroom) Variance	0.14	***	0.13	***	0.15	**	0.12	**
Residual (Individual)Variance	0.86	***	0.86	***	0.85	***	0.88	***
[1] reported in effect size units								
[2] reported in effect size units relative to the specific grade								
~ p < .10, * p <.05, ** p < .01, *** p < .001								

VA Science SOL: Force, Motion, Energy, & Matter (n=1005 children; n=61 classes)

	Treatment Only[1]		Covariates[1]		3rd Grade[2]		5th Grade[2]	
Intercept	0.19		-0.11		0.04		-0.01	
Virginia MWEE Program	0.06		0.06		0.12		0.00	
5th Grade			0.26	*				
Level-2 (Classroom) Variance	0.13	***	0.12	***	0.13	**	0.12	**
Residual (Individual)Variance	0.87	***	0.87	***	0.88	***	0.89	***
[1] reported in effect size units								
[2] reported in effect size units relative to the specific grade								
~ p < .10, * p <.05, ** p < .01, *** p < .001								

APPENDIX F: MWEE PRACTICE ANALYSIS

Time spent learning outdoors (student-reported) relationship with stewardship and engagement in learning

n=441	1 Never Post mean	n	2 Some-times Post mean	n	3 Often Post mean	n	2-1 Difference in means (effect size)	p	3-1 Difference in means (effect size)	p	3-2 Difference in means (effect size)	p
Intention to Act	-0.144	52	0.042	243	0.349	146	0.19	0.996	0.49	0.057	0.31	0.096
Personal responsibility	-0.246	52	0.025	243	0.241	149	0.27	1.000	0.49	0.450	0.22	0.680
Environmental sensitivity	-0.144	48	-0.003	242	0.316	146	0.14	1.000	0.46	0.140	0.32	0.098
Knowledge of issues	-0.236	45	0.184	230	0.356	139	0.42	0.037	0.59	0.001	0.17	0.098
Knowledge of actions	0.001	52	0.141	242	0.382	150	0.14	.400	0.38	.005	0.24	0.030
Individual locus of control	-0.221	51	-0.076	245	0.290	148	0.14	1.000	0.51	.068	0.37	0.006
Group locus of control	0.270	52	0.011	243	0.258	147	-0.26	0.124	-0.01	1.000	0.25	0.020
Knowledge of ecology	0.051	49	0.079	231	0.410	142	0.03	1.000	0.36	.848	0.33	0.517
Engagement in learning	-0.136	47	-0.067	220	0.260	135	0.07	0.540	0.40	0.018	0.33	0.073

Time spent reflecting (student-reported) relationship with stewardship and engagement in learning

n=441	1 Never Post mean	n	2 Some-times Post mean	n	3 Often Post mean	n	2-1 Difference in means (effect size)	p	3-1 Difference in means (effect size)	p	3-2 Difference in means (effect size)	p
Intention to Act	-0.270	86	0.150	237	0.334	115	0.42	0.014	0.60	0.013	0.18	1.000
Personal responsibility	-0.331	85	0.074	237	0.325	118	0.40	0.160	0.66	0.005	0.25	0.149
Environmental sensitivity	-0.268	82	0.035	233	0.434	117	0.30	0.219	0.70	0.001	0.40	0.013
Knowledge of issues	-0.247	76	0.205	224	0.468	111	0.45	0.012	0.72	<.0001	0.26	0.013
Knowledge of actions	-0.168	85	0.220	236	0.457	119	0.39	0.018	0.62	<.0001	0.24	0.040
Individual locus of control	-0.277	86	-0.021	235	0.339	119	0.26	1.000	0.62	0.008	0.36	0.010
Group locus of control	-0.131	86	0.138	237	0.272	116	0.27	0.051	0.40	0.024	0.13	1.000
Knowledge of ecology	-0.113	81	0.123	225	0.511	113	0.24	1.000	0.62	0.021	0.39	0.002
Engagement in learning	-0.169	75	-0.053	213	0.330	110	0.12	1.000	0.50	0.117	0.38	0.036

Time spent in hands-on learning (student-reported) relationship with stewardship and engagement in learning

n=441	1 Never Post mean	n	2 Some-times Post mean	n	3 Often Post mean	n	2-1 Difference in means (effect size)	p	3-1 Difference in means (effect size)	p	3-2 Difference in means (effect size)	p
Intention to Act	-0.494	62	0.085	197	0.374	178	0.58	0.005	0.87	<.0001	0.29	0.215
Personal responsibility	-0.547	61	0.062	199	0.265	180	0.61	0.004	0.81	0.000	0.20	0.490
Environmental sensitivity	-0.322	58	0.001	197	0.327	177	0.32	0.621	0.65	0.006	0.33	0.017
Knowledge of issues	-0.357	56	0.115	186	0.461	168	0.47	0.073	0.82	<.0001	0.35	0.002
Knowledge of actions	-0.333	61	0.139	198	0.459	181	0.47	0.018	0.79	<.0001	0.32	0.000
Individual locus of control	-0.372	62	-0.046	198	0.240	180	0.33	0.204	0.61	0.001	0.29	0.033
Group locus of control	-0.085	62	0.023	198	0.307	178	0.11	1.000	0.39	0.072	0.28	0.002
Knowledge of ecology	-0.172	62	0.056	187	0.459	170	0.23	1.000	0.63	0.152	0.40	0.139
Engagement in learning	-0.421	54	-0.078	181	0.300	164	0.34	0.080	0.72	0.000	0.38	0.033

Time spent learning things that are important (student-reported) relationship with stewardship and engagement in learning

n=441	1 Never Post mean	n	2 Some-times Post mean	n	3 Often Post mean	n	2-1 Difference in means (effect size)	p	3-1 Difference in means (effect size)	p	3-2 Difference in means (effect size)	p
Intention to Act	-0.812	38	-0.024	171	0.359	223	0.79	0.004	1.17	<.001	0.38	0.003
Personal responsibility	-0.681	38	-0.064	170	0.253	227	0.62	0.167	0.93	0.001	0.32	0.008
Environmental sensitivity	-0.387	38	-0.167	166	0.346	223	0.22	1.000	0.73	0.028	0.51	0.003
Knowledge of issues	-0.445	34	0.055	160	0.382	212	0.50	0.704	0.83	0.004	0.33	0.001
Knowledge of actions	-0.410	37	-0.019	170	0.461	228	0.39	0.926	0.87	0.000	0.48	<.001
Individual locus of control	-0.376	38	-0.143	169	0.213	228	0.23	1.000	0.59	0.024	0.36	0.001
Group locus of control	-0.534	38	-0.003	171	0.312	224	0.53	0.023	0.85	<.001	0.32	0.016
Knowledge of ecology	-0.175	33	0.058	162	0.332	218	0.23	0.676	0.51	0.181	0.27	0.737
Engagement in learning	-0.658	35	-0.160	153	0.279	207	0.50	0.425	0.94	0.001	0.44	0.002

Hours of MWEE instruction (teacher-reported) relationship with stewardship and engagement in learning

n=441	(1) 6-20 hours Post Mean	n	(2) 21-60 hours Post mean	n	(3) 61+ hours Post mean	n	2-1 Effect size	p	3-1 Effect size	p	3-2 Effect size	p
Intention to Act	0.05	155	0.16	198	0.07	75	0.11	1.000	0.02	1.000	-0.09	1.000
Personal responsibility	-0.09	155	0.11	201	0.16	75	0.20	0.029	0.25	0.026	0.05	1.000
Environmental sensitivity	-0.02	153	0.18	196	0.02	74	0.21	1.000	0.05	1.000	-0.16	1.000
Knowledge of issues	0.14	143	0.20	187	0.20	71	0.06	0.875	0.06	1.000	0.00	1.000
Knowledge of actions	0.18	154	0.24	202	0.08	75	0.06	1.000	-0.10	1.000	-0.16	1.000
Individual locus of control	-0.10	156	0.08	202	0.10	73	0.18	0.117	0.20	0.116	0.03	1.000
Group locus of control	0.05	155	0.15	201	0.19	73	0.10	1.000	0.14	0.887	0.03	1.000
Knowledge of ecology	-0.10	148	0.20	187	0.66	73	0.31	1.000	0.76	0.174	0.46	0.270
Engagement in learning	-0.23	144	0.17	170	0.09	74	0.40	0.853	0.32	1.000	-0.08	1.000

Length of MWEE (teacher-reported) relationship with stewardship and engagement in learning

n=441	(1) 1-4 weeks Post mean	n	(2) 2-7 months Post mean	n	(3) 8+ months Post mean	n	2-1 Effect size	p	3-1 Effect size	p	3-2 Effect size	p
Intention to Act	0.16	160	0.08	170	0.04	98	-0.08	1.000	-0.12	1.000	-0.03	1.000
Personal responsibility	0.05	160	0.05	172	0.04	99	0.00	0.294	-0.01	1.000	-0.01	1.000
Environmental sensitivity	0.13	157	0.07	169	0.01	97	-0.06	0.575	-0.12	0.381	-0.06	1.000
Knowledge of issues	0.18	149	0.14	157	0.23	95	-0.05	1.000	0.05	0.868	0.10	0.162
Knowledge of actions	0.25	160	0.22	173	0.06	98	-0.04	1.000	-0.19	1.000	-0.16	0.908
Individual locus of control	0.01	161	-0.03	173	0.11	97	-0.04	1.000	0.10	1.000	0.14	1.000
Group locus of control	0.11	160	0.12	172	0.13	97	0.01	1.000	0.02	1.000	0.00	1.000
Knowledge of ecology	-0.05	154	0.26	157	0.40	97	0.31	1.000	0.45	0.993	0.13	1.000
Engagement in learning	-0.10	152	0.12	140	-0.01	96	0.22	1.000	0.09	1.000	-0.13	1.000

Exploration of the community (teacher-reported) relationship with stewardship and engagement in learning

	No Post mean n=59-84	Yes Post mean n=325-348	Yes-No Difference Effect size	p
Intention to Act	0.12	0.10	-0.02	0.361
Personal responsibility	0.18	0.01	-0.17	0.012
Environmental sensitivity	0.24	0.04	-0.19	0.095
Knowledge of issues	0.21	0.17	-0.04	0.900
Knowledge of actions	0.36	0.15	-0.20	0.116
Individual locus of control	0.28	-0.04	-0.32	0.026
Group locus of control	0.13	0.12	-0.01	0.028
Knowledge of ecology	-0.04	0.23	0.27	0.420
Engagement in learning	0.04	0.00	-0.04	0.158

Talking or reading about watershed or Bay issues (teacher-reported) relationship with stewardship and engagement in learning

	No Post mean n=34-38	Yes Post mean n=354-393	Yes-No Difference Effect size	p
Intention to Act	-0.32	0.14	0.46	0.007
Personal responsibility	-0.49	0.10	0.58	<.001
Environmental sensitivity	-0.17	0.10	0.28	0.590
Knowledge of issues	0.07	0.19	0.11	0.952
Knowledge of actions	0.08	0.21	0.12	0.020
Individual locus of control	-0.27	0.04	0.31	0.064
Group locus of control	-0.19	0.15	0.34	0.112
Knowledge of ecology	-0.48	0.24	0.72	0.111
Engagement in learning	-0.29	0.03	0.32	0.198

Study of social issues (teacher-reported) relationship with stewardship and engagement in learning

	No Post mean n=114-124	Yes Post mean n=267-301	Yes-No Difference Effect size	p
Intention to Act	0.09	0.09	0.00	0.700
Personal responsibility	-0.06	0.09	0.16	0.020
Environmental sensitivity	-0.02	0.10	0.12	0.356
Knowledge of issues	0.09	0.20	0.11	0.981
Knowledge of actions	0.29	0.15	-0.15	0.949
Individual locus of control	-0.05	0.04	0.09	0.951
Group locus of control	0.07	0.13	0.07	0.596
Knowledge of ecology	-0.24	0.35	0.59	0.002
Engagement in learning	0.00	0.00	0.00	0.863

Data collection (teacher-reported) relationship with stewardship and engagement in learning

	No Post mean n=118-125	Yes Post mean n=284-305	Yes-No Difference Effect size	p
Intention to Act	-0.11	0.19	0.30	0.180
Personal responsibility	-0.28	0.17	0.46	0.001
Environmental sensitivity	-0.09	0.15	0.24	0.459
Knowledge of issues	0.03	0.25	0.21	0.891
Knowledge of actions	0.12	0.22	0.11	0.554
Individual locus of control	-0.29	0.14	0.43	0.004
Group locus of control	0.06	0.15	0.09	0.788
Knowledge of ecology	-0.10	0.28	0.38	0.279
Engagement in learning	-0.10	0.05	0.15	0.031

Use of field equipment (teacher-reported) relationship with stewardship and engagement in learning

	No Post mean n=150-162	Yes Post mean n=218-250	Yes-No Difference Effect size	p
Intention to Act	0.01	0.18	0.18	0.121
Personal responsibility	-0.23	0.23	0.46	<.001
Environmental sensitivity	-0.03	0.17	0.20	0.247
Knowledge of issues	0.09	0.26	0.17	0.440
Knowledge of actions	0.14	0.29	0.16	0.032
Individual locus of control	-0.19	0.17	0.36	0.000
Group locus of control	0.12	0.12	0.00	0.705
Knowledge of ecology	-0.11	0.34	0.45	0.284
Engagement in learning	-0.14	0.09	0.23	0.265

Data analysis (teacher-reported) relationship with stewardship and engagement in learning

	No Post mean n=91-98	Yes Post mean n=297-335	Yes-No Difference Effect size	p
Intention to Act	-0.20	0.19	0.39	0.019
Personal responsibility	-0.46	0.19	0.65	<.001
Environmental sensitivity	-0.16	0.15	0.30	0.160
Knowledge of issues	-0.01	0.23	0.24	0.392
Knowledge of actions	0.00	0.25	0.25	0.025
Individual locus of control	-0.35	0.12	0.47	0.001
Group locus of control	-0.05	0.17	0.22	0.077
Knowledge of ecology	-0.25	0.30	0.55	0.018
Engagement in learning	-0.18	0.06	0.25	0.021

Graphic display of data (teacher-reported) relationship with stewardship and engagement in learning

	No Post mean n=167-181	Yes Post mean n=220-251	Yes-No Difference Effect size	p
Intention to Act	0.02	0.16	0.13	0.201
Personal responsibility	-0.08	0.13	0.21	0.052
Environmental sensitivity	0.07	0.08	0.01	0.801
Knowledge of issues	0.11	0.23	0.12	0.121
Knowledge of actions	0.15	0.23	0.08	0.307
Individual locus of control	0.03	0.01	-0.02	0.781
Group locus of control	0.12	0.12	0.00	0.133
Knowledge of ecology	0.05	0.26	0.21	0.659
Engagement in learning	0.05	-0.03	-0.07	0.588

Participation in an action project (teacher-reported) relationship with stewardship and engagement in learning

	No Post mean n=43	Yes Post mean n=372-387	Yes-No Difference Effect size	p
Intention to Act	-0.44	0.16	0.60	0.343
Personal responsibility	-0.42	0.10	0.52	0.000
Environmental sensitivity	-0.38	0.13	0.51	0.075
Knowledge of issues	0.11	0.19	0.08	0.668
Knowledge of actions	0.03	0.21	0.18	0.778
Individual locus of control	-0.34	0.06	0.40	0.018
Group locus of control	-0.04	0.14	0.18	0.968
Knowledge of ecology	-0.03	0.20	0.24	0.577
Engagement in learning	-0.74	0.09	0.83	0.053

APPENDIX G: "STEWARDSHIP AND MEANINGFUL WATERSHED EDUCATIONAL EXPERIENCES"

STEWARDSHIP AND MEANINGFUL WATERSHED EDUCATIONAL EXPERIENCES

The "Stewardship and Community Engagement" Commitment of the *Chesapeake 2000* agreement clearly focuses on connecting individuals and groups to the Bay through their shared sense of responsibility and action. The goal of this Commitment, included below, not only defines the role of the jurisdictions to *promote* and *assist*, but formally engages schools as integral partners *to undertake initiatives* in helping to meet the Agreement. This goal commits to:

> *Promote individual stewardship and assist individuals, community-based organizations, businesses, local governments and schools to undertake initiatives to achieve the goals and commitments of this agreement.*

Similarly, two objectives developed as part of this goal describe more specific outcomes to be achieved by the jurisdictions in promoting stewardship and assisting schools. These are:

> *Beginning with the class of 2005, provide a meaningful Bay or stream outdoor experience for every school student in the watershed before graduation from high school.*
>
> *Provide students and teachers alike with opportunities to directly participate in local restoration and protection projects, and to support stewardship efforts in schools and on school property.*

There is overwhelming consensus that knowledge and commitment build from first-hand experience, especially in the context of one's neighborhood and community. Carefully selected experiences driven by rigorous academic learning standards, engendering discovery and wonder, and nurturing a sense of community will further connect students with the watershed and help reinforce an ethic of responsible citizenship.

To this end, the Chesapeake Bay Program Education Workgroup seeks to define a common set of criteria to help the Bay watershed jurisdictions meet the intent of this Commitment of the *Chesapeake 2000 Agreement.* From these criteria, each jurisdiction will continue to craft and refine its own plan, tailored to its own population, geography, and fiscal and human resources.

Defining *a Meaningful* Bay or Stream Outdoor Experience

A *meaningful* Bay or stream outdoor experience should be defined by the following.

Experiences are investigative or project-oriented. Experiences include activities where questions, problems, and issues are investigated by the collection and analysis of data, both mathematical and qualitative. Electronic technology, such as computers, probeware, and GPS equipment, is a key component of these kinds of activities and should be integrated throughout the instructional process. The nature of these experiences is based on each jurisdiction's academic learning standards and should include the following kinds of activities.

- Investigative or experimental design activities where students or groups of students use equipment, take measurements, and make observations for the purpose of making interpretations and reaching conclusions.

- Project-oriented experiences, such as restoration, monitoring, and protection projects, that are problem solving in nature and involve many investigative skills.

- Social, economic, historical, and archaeological questions, problems, and issues that are directly related to Bay peoples and cultures. These experiences should involve fieldwork, data collection, and analysis and directly relate to the role of the Bay (or other bodies of water) to these peoples' lives.

Experiences such as tours, gallery visits, simulations, demonstrations, or "nature walks" may be instructionally useful, but alone do not constitute a *meaningful* experience as defined here.

Experiences are richly structured and based on high-quality instructional design. Experiences should consist of three general parts including a) a preparation phase; b) an outdoor action phase; and c) a reflection, analysis, and reporting phase. These "phases" do not necessarily need to occur in a linear fashion. These include the following.

- The *preparation phase* should focus on a question, problem, or issue and involve students in discussions about it. This should require background research and student or team assignments as well as management and safety preparation.

- The *action phase* should include one or more outdoor experiences sufficient to conduct the project, make the observations, or collect the data required. Students should be actively involved with the measurements, planning, or construction as safety guidelines permit.

- The *reflection phase* should refocus on the question, problem, or issue; analyze the conclusions reached; evaluate the results; and assess the activity and the student learning.

Experiences are an integral part of the instructional program. Experiences should not be considered ancillary, peripheral, or enrichment only, but clearly part of what is occurring concurrently in the classroom. The outdoor experiences should be part of the division curriculum and be aligned with the jurisdiction's learning standards. Experiences should make appropriate connections among subject areas and reflect an integrated approach to learning. Experiences should occur where and when they fit into the instructional sequence.

Experiences are part of a sustained activity. Though an outdoor experience itself may occur as one specific event, occurring in one day, the total duration leading up to and following the experience should involve a significant investment of instructional time. This may entail smaller amounts of outdoor time spread over an entire school year. Likewise, the actual outdoor experiences may not necessarily involve all students in a class at the same time. Rich learning experiences, especially those involving monitoring and restoration activities, may require time increments spread over weeks or even months. A sustained activity will generally involve regularly-scheduled school time and may involve extended day or weekend activity.

Experiences consider the watershed as a system. Experiences are not limited to water-based activities directly on the Bay, tidal rivers, streams, creeks, ponds, wetlands, or other bodies of water. As long as there is an intentional connection made to the water quality, the watershed, and the larger ecological system, outdoor experiences that meet the intent of the Commitment may include terrestrial activities in the local community (e.g., erosion control, buffer creation, groundwater protection, and pollution prevention).

Experiences involve external sharing and communication. Experiences should warrant and include further sharing of the results beyond the classroom. Results of the outdoor experiences should be the focus of school-based reporting, community reporting, publishing, contribution to a larger database of water quality and watershed information, or other authentic communication.

Experiences are enhanced by natural resources personnel. Utilizing the expertise of scientists and natural resources professionals can heighten the impact of outdoor experiences. This includes both their participation in the classroom and leadership on-site during outdoor activities. These personnel have technical knowledge and experience that can serve to complement the classroom teacher's strengths and augment the array of resources for the learning. Additionally, these professionals can serve as important role models for career choices and as natural resources stewards.

Experiences are for all students. As it is crucial for all citizens to have an understanding of and connection with their own watershed, an outdoor experience is for all students regardless of where they live. Much of the land area in the jurisdictions is outside of the Bay watershed; however, it is intended that students residing in those areas have similar opportunities within their own local setting or beyond.

It is also clear that these kinds of experiences must be extended to all students including students with disabilities, in alternative programs, and special populations. No child should be excluded from a *meaningful* watershed experience.

Meaningful Experiences across the K-12 Program

It is the intention that every student somewhere in the K-12 program will have a *meaningful* outdoor watershed experience before graduation from high school; however, it is the expectation that these kinds of activities will occur throughout formal schooling. Beginning with the primary grades, the jurisdictions' academic learning standards in the social and natural sciences call for inquiry, investigation, and active learning. These skills, concepts, and processes increase in complexity and abstraction, "spiraling" and building throughout the elementary, middle, and high school programs. Likewise, the experiences should reflect this progression.

Outdoor experiences should occur at each level, elementary, middle, and high school. These experiences should be defined by the local curriculum, be aligned with the jurisdiction's learning standards, and mirror the developmental level of students.

The following example "scope and sequence" describes experiences that should be appropriate for many students in the K-12 program.

> **K-5 experiences** should be predominantly local, school, or neighborhood-based, including activities reflecting students' background knowledge, shorter attention span, and physical capabilities. Experiences must clearly relate to academic learning standards across subject areas and reinforce basic concepts such as maps and models, habitat principles, and the concept of the water cycle and watersheds. Care must be taken with the introduction or discussion of complex issues.

6-8 experiences should focus on team and class projects and investigations. These experiences should reinforce research skills requiring the use and analysis of more authoritative print and electronic resources. Longer-term restoration, monitoring, or investigative projects should be conducted locally or on school grounds. Actual student experiences in or near water may be appropriate for many middle school students (following school safety guidelines carefully). Activities such as water-quality testing can be used to reinforce many science, mathematics, and technology skills developed in middle school.

9-12 experiences should reflect students' more abstract reasoning and detailed planning ability. Locally based activities continue to be important, but student watershed experiences beyond the immediate community will have considerable impact in meeting academic and stewardship goals. First-hand experiences in or near water should be part of the implemented curriculum, especially as these experiences relate to the Earth and biological sciences, concepts developed in civics and government, and attitudes reinforcing responsible citizenship.

Conclusion

The preceding consensus criteria define a clear vision for bringing the Bay into every classroom and every child out into the watershed in a *meaningful* way. It will be the goal of every educator, teacher and administrator, to move toward incorporating those experiences that build academic success, reinforce responsible citizenship, and work toward the goals of the *Chesapeake 2000* agreement. With inspired leaders, committed parents, and supporting communities garnering the fiscal and human resources to help make this happen, young people will be significant contributors to healthy, bountiful, and enduring watersheds.