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Fall 2012 Summative Evaluation Phase I

Stroud Water Research Center's Model My Watershed
Grant # NSF ITEST 09-29763

February 27, 2013

Prepared for: Stroud Water Research Center

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NewKnowledge Report #NSF1.6465.02

Executive Summary

In 2009, NSF funded development of Model My Watershed (MMW), a place-based, watershed cyber-modeling tool for middle and high school students and teachers. The online learning tool encourages students to investigate their neighborhoods and use scientific reasoning with real-world decision-making models similar to those used by STEM professionals to simulate systems and analyze processes. The project also sought to increase youth interest in possible opportunities in the STEM workforce and to aid in development of knowledge about earth science. This report represents the first of a two-phase mixed-methods summative evaluation of the MMW learning tools at the conclusion of the development phase.

The evaluation employed a quasi-experimental design in one rural Pennsylvania high school, consisting of two classes treated as a control setting using traditional lecture instruction, compared to two classes offered the opportunity for self-directed learning with the MMW tool. To further explore contrast, each pair of classes in the test and control groups consisted of one basic science class and one college prep class. The curriculum was implemented for three block schedule class periods in Fall 2012 (270 minutes of instruction). To assess outcomes, the evaluators observed the classes, deployed a quantitative survey to assess pre/post attitudes, identity, career disposition, and knowledge gain, and conducted four focus groups with student representatives from each of the test and control classes.

The evaluation resulted in the following outcomes:

- MMW positively increased knowledge development about watersheds, at least equivalent to that of traditional teaching when students pursued self-directed study during class.
- MMW also contributed to youth confidence in themselves as scientists, and even their understanding of the problem of the scope of watershed management.
- The open-ended nature of the exploration within the MMW class was unfamiliar to the students, leading to some challenges that could be overcome with additional scaffolding. Given the strict testing regimes now in place in most schools, contemporary youth may not have practice in self-directed learning.
- Refinements were recommended for surveys for use in subsequent phases.
- Further experimentation with blended instructional pedagogies where student self-direction is supplemented with scaffolding or guided inquiry may offer new insights into the value of the software.
- Based on these results, we believe that further quantitative testing with students, and peer-review by teachers drawn from a more diverse urban/suburban and rural settings will provide new insight into the MMW learning experience.

Overview

In 2009, the Stroud Water Research Center received grant funding from the National Science Foundation to develop Model My Watershed (MMW), a place-based, watershed cyber-modeling tool set for middle and high school students and teachers. The project is based on prior research that indicates that providing students with an interactive tool set that encourages them to investigate their own neighborhoods will demonstrate the relevance of scientific knowledge to real-world decision-making, model the dynamic nature of science, and entice students to explore STEM careers. The project also introduces students to scientific models and modeling, tasks and tools used by scientists, engineers, and other STEM professionals to simulate complex systems and analyze intricate processes. The project also aimed to use the inherent complexity of environmental science to encourage students to think about the broad range of STEM careers in the field. This report represents the first of a two-phase mixed-methods summative evaluation of the learning tools.

Fall 2012 Study

This evaluation assessed the MMW curriculum tools in a rural high school class setting using 2 x 2 comparison of class settings to identify specific outcomes that could be attributed to a self-directed learning program. Two veteran teachers agreed to implement the test using a quasi-experimental design, in which they each taught one class using a "traditional" didactic approach (control group) to teach about watersheds, and one class where they encourages their students to use the Model My Watershed programs to support self-directed learning (test group). One of the high school teachers was part of the MMW core teacher design group and has other connections to the university where a member of the project research team is employed. This teacher taught the basic science students, while the other teacher's two classes were both categorized as college prep.

The current study also sought to pilot test a set of quantitative evaluation tools for deployment in the second phase quantitative summative evaluation when the learning software is released in Spring of 2013. Concurrent with this independent evaluation, a parallel mixed-methods research study was conducted by the project team, and data from that effort were incorporated in this report when they offered additional explanatory value to the information that surfaced in this study.

Data Collected

The study conducted by the independent evaluators consisted of a mixed-methods approach, including observation, focus groups, and quantitative testing. In order to gain a better sense of how the two different pedagogical approaches were used in the classrooms, 8 observations of classroom instruction and a participant observation by one of the researchers in the accompanying class field trip following the instructional phase were conducted. The independent evaluator observed classroom instruction on 2 separate days for each of the teachers' MMW self-directed learning classes and 1 day each for "traditional" instruction, as well as the field trip. A second evaluator observed classroom instruction on the first day the program was introduced to all four classes. Student focus groups were conducted following the entire course including a field trip that all students attended. The evaluator who conducted the majority of observations conducted four focus groups, one with each participating class: both the MMW class and the traditional instruction class led by each teacher.

Quantitative data consisted of 84 matched pairs of pre/post student surveys. Surveys were administered to students by their teachers before implementing the curriculum and after the classroom component was completed, but before the field trip. The purpose of these surveys was to assess student learning outcomes, that could be attributed to the MMW project. The survey included modules exploring: youth sense of place; science identity; career aspirations; nature of science; and a set of knowledge questions directly related to the curriculum goals, and an item to determine if out-of-class student discussions about the variation in pedagogical approach or awareness of the software or self-directed explorations of the software by students in the control group might have influenced the results. In these cases, we used a 5-point Likert-type scale. The knowledge survey used multiple choice options (Appendix B).

Youth Sense of Place

The MMW program is designed to provide students with ways of analyzing conditions in their own community through maps and images. Therefore, we hypothesized that the program may have an impact on sense of place, and sought to explore these anticipated impacts from the intervention through Jorgensen and Stedman's (2001) scale. This scale is defined as a multidimensional construct comprising beliefs about the relationship between self and place, feelings toward a place, and their dependence on it relative to other alternatives.

Science Identity

It was anticipated that learning through self-directed exploration with modeling tools may help students feel more capable of participating in decisions about land-use planning and help them feel more capable with earth science. Therefore, we suggested that success may lead youths to feel they demonstrated competence in science through their development of new knowledge and understanding of earth science topical content, developed new skills for the performance of relevant scientific modeling practices through application of MMW scientific tools, and developed new facility for engaging in scientific talk. To address this point, we deployed Carlone and Johnson's Science Identity scale that assesses three overlapping components of science identity: competence, performance, and recognition of the self as a science person.

Career Aspirations

Career aspirations are conceptualized as individuals' career-related goals and ideals. Apart from providing information on motivations and strivings towards a professional life, these aspirations may also be precursors of more specific career choices. For the purpose of this project, career aspirations were proposed as important outcomes from students' use of the software. To operationalize this effort, we employed two scales, the Career Interest Scale (Gray & O'Brien, 2007) and the Careers in Science scale (Tyler-Wood, Knezek & Christensen, 2010). The latter section of the survey explored how perceptions of a supportive environment for pursuing a science career, interest in future studies that toward securing a career in science, and perceived importance of a science career. While we did not anticipate the short duration of the treatment would influence these scores pre/post, we explored this aspect to determine if these aspirations were related to increased success.

Nature of Science

According to Schwartz, Lederman, and Crawford (2004) the basic principles of science acknowledge that scientific knowledge is tentative, that it is founded on a strong empirical foundation, that knowledge is subjective, that its interpretation can be highly creative, that it is socio-culturally dependent, that it is based on observations and inferences, that it takes the form of laws and theories, and that it depends on the interdependence of all these aspects. Therefore we assessed students' understanding of the *nature of science* (NOS) both before and after the instruction to determine if using the MMW software had any impact on that understanding. We adapted Tobin & McRobbie's (1997) pre-validated scale to reflect the specific curriculum focus.

Knowledge Gain

Lastly, knowledge was assessed through a set of 20 multiple-choice questions and 7 true/false statement questions derived from the teacher's curriculum for the control class. This portion of the survey was developed by the teachers and was believed to represent the core content required for their class.

Surveys were completed by 37 students in the test group and 47 students in the control group. Of these 84 students, 43 were in the college prep classes and 41 were in the basic classes. This participant pool represents just over the minimum population required to undertake correlational statistics for validity assessment using two-tailed tests (Onwuegbuzie & Leech, 2004).

NOTE: The project team supervised the collection and analysis of student formative assessment data measuring changes in watershed content knowledge. The Draw-a-Watershed tool and scoring rubric was adapted from a pre-validated tool (Shephardson, et al, 2007) (see Appendix C for tool and rubric). Results of this effort are referenced below where it illuminates the findings from this independent study.

Results

Instructional Pedagogy

Classroom observations suggested there were some similarities and some differences in test and control instruction. Overall, both teachers were quite engaging and appeared to have a very positive rapport with the students. Both teachers used humor and interesting stories as strategies to engage the students in the learning experience, both in the control classes and the test classes. The students appeared to be engaged in the learning experience in both the test and control settings. For both types of instruction, most of the questions that the teachers asked were managerial, rhetorical, or closed, with few truly open-ended questions that allowed students to explore their own perceptions of the phenomenon in question. Student questions were also primarily closed in nature, addressing matters of fact.

The teachers understood the goals of the experimental design and tailored the classroom experience to the goals of the project. The traditional instructional model for the control classes consisted of a lecture with PowerPoint slides and questions of fact and recall. In contrast, the MMW self-directed learning program was introduced as a set of overarching learning goals followed by a large amount of independent exploration time afforded to students, either independently or in small groups. The evaluators noted that the instruction for the traditional classes had a tendency to focus on the delivery of watershed content factual information.

Student Reaction to MMW Learning Experience

Students had mixed reactions to their experience with the MMW experience. The experience of delving into the WikiWatershed site during class appeared to be a new experience for many students. It seemed that for many students, this was the first time they explored a mapping and online satellite image of their community. Once online, several used the website to navigate to their own house, look around the map, and generally explore the world including well-known deserts, the arctic, and distant cities. Even though most of these students would be considered digital natives, it appeared that they may not have had experience with Google Earth or familiarity with aerial modeling tools.

We note that the novelty of the new tools captured some interest, but in general students did not feel that MMW was anything unexpected. MMW appeared to raise little excitement among students outside of the classroom instruction. There were no reports of students (in either the MMW group or the traditional instruction group) visiting the WikiWatershed website on their own time. Only a handful of students from the MMW group reported discussing the experience with their friends. Two students in the basic science class claimed that they were proud of doing something special in class. One student mentioned that they had told a friend outside of the class about the website. The student reported that their friend was surprised to hear about the different class approach and had expressed envy, because they thought it was "cool." Students in the basic science class felt that the computer work was more interactive and interesting than typical class work, and that it helped them to gain mastery of the core concepts than they might have if the material was presented in a traditional lecture format. One student said, "I remember more, it sticks with me better than taking notes."

While the students in the basic science class were excited about their special status as research participants, two students from the test college prep class were concerned that they were not learning as much about watersheds as their friends in the traditional instructional class. We address the actual learning outcomes later in this report, but note that this perception of self-directed learning as lacking rigor required of a college prep course may be related to the increased focus on traditional lecture style teaching that has been a hallmark of the standardized testing regimes that have been broadly implemented in most school systems over the past ten years.

Students in the college prep MMW class expressed less satisfaction with the instruction than those in the basic science class. In particular, they mentioned several ways that the felt the MMW instruction was lacking:

- The software was best suited to visual learners versus those who learn best in a more traditional instructional setting;
- WikiWatershed maps seemed disconnected from the real world; and
- Class lectures and computer work were not well integrated.

Change in Student Outcomes

The instruction period resulted in noticeable increases in learning about watersheds. Student surveys revealed statistically significant change in content knowledge in the pre/post test for both the test and control groups. The Draw-a-Watershed results mirrored the survey findings, in that there was a statistically significant increase in student understanding of what watersheds are over the course of the instruction for both groups. Students in both teachers' classes showed increased learning on the surveys following the instructional treatment (see Table 3 in Appendix A). In contrast, analysis of the Draw-a-Watershed task revealed change only for those students in the college prep class. While these changes were somewhat small in magnitude, along the order of one standard deviation in all cases, they were nevertheless statistically significant. This finding for such a small group of students suggests that while students may not believe self-directed learning is as effective as the familiar lecture format, the knowledge outcomes reveal the contrary (Figure 1). Despite an apparently higher level of increased knowledge attributed to the test case compared to the control, this difference was not statistically significant, leading us to the finding that the self-directed MMW learning outcomes were comparable to traditional well-structured lectures and presentations by teachers.

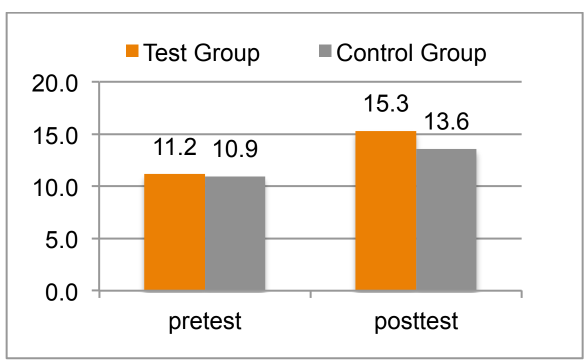

Figure 1. Increase in accurate responses from pre to post test

Table 1. Comparison of Pre-Post Surveys for the Test Group (*n*=37)

Variable	PRE-Test M (*SD*)	Post-Test M (*SD*)	*t*-test
Nature of Science Understanding	3.8 (0.4)	3.8 (0.4)	0.5
Career Inventory Scale - Leadership/Achievement Aspirations	3.9 (0.7)	3.9 (0.7)	0.5
Career Inventory Scale - Educational Aspirations	4.0 (0.9)	4.0 (0.9)	0.4
Sense of Place - Identity	2.8 (0.6)	2.7 (0.6)	0.7
Sense of Place - Attachment	3.1 (0.6)	2.9 (0.6)	2.4*
Sense of Place - Dependence	2.8 (0.6)	2.9 (0.6)	1.1
Science Self	2.4 (0.8)	2.6 (0.8)	2.4*
Science Social	2.3 (0.7)	2.4 (0.8)	2.0┼
Science Competence	3.1 (0.7)	3.1 (0.7)	0.0
Pre-test and Post-test (#correct)	11.2 (3.5)	15.3 (3.2)	7.8**

NOTE: Mean = average; SD = Standard Deviation; t-test = statistical test for difference in means between pre- and post- groups; p is a test of the statistical significance; * = p < .05, ┼ = p < .102)

Scale is a 5 point scale, with 1 as the lowest, 3 as the midpoint, and 5 as the highest

Qualitative student focus groups expanded our understanding of the distinction between the MMW test and the control curriculum. Commentaries demonstrated that both traditional and MMW instruction increased knowledge about watersheds, but students in MMW classes appear to have gained more understanding of watershed health, and the cause and effect relationships. When asked what they had learned in the class, students from traditional classes reported learning factual information about watershed structure and what bodies of water were in their watershed. Students in the MMW group also discussed what that they learned about watersheds but were more likely to focus on strategies for improving watershed health. This finding is particularly important because it appears that MMW test students were more likely to develop knowledge that aligns with the anticipated structure of the Next Generation Science Standards (NGSS) where the focus is on performance expectations. NGSS will increase focus on the expectation that students will demonstrate mastery over concepts through blending knowledge about a core idea or cross-cutting concept such as the hydrology cycle and how the choices people make will influence watershed management. In this case, the MMW student knowledge was more likely to explain watershed health by presenting arguments about land-use patterns and science reasoning about the relationship between population and aquifer protection than those who were part of the test group where the factual knowledge did not necessarily offer them the chance to synthesize concepts in real world settings.

Beyond content knowledge, analysis of the various attitude, aspirations, and identity scales data indicated slight changes in other outcomes for both test and control groups. These results suggest that hydrology and earth science topics covered in this instruction increase student self-confidence as science thinkers or having capacity in science learning (Table 1). While this general finding was true across all students, further detailed comparison indicated that students in the MMW test group noted a slightly higher increase in self-confidence as scientist thinkers following the program. Rather unexpectedly, students in the control reported a slight but significant decrease in place identity following the study (Table 2), suggesting that there was some variation in the two cohorts for this study.

Table 2.

Comparison of Pre-Post Surveys for the Control Group (*n*=47)

Variable	PRE-Test *M (SD)*	Post-Test *M (SD)*	*t*-test
Nature of Science Understanding	3.8 (0.4)	3.7 (0.4)	0.1
Career Inventory Scale - Leadership/Achievement Aspirations	3.7 (0.7)	3.7 (0.8)	0.8
Career Inventory Scale - Educational Aspirations	3.9 (1.0)	4.1 (0.9)	1.3
Sense of Place - Identity	2.9 (0.7)	2.8 (0.6)	0.8
Sense of Place - Attachment	3.0 (0.8)	3.0 (0.8)	0.0
Sense of Place - Dependence	2.6 (0.7)	2.6 (0.7)	0.2
Science Self	2.5 (1.1)	2.7 (1.1)	2.6*
Science Social	2.2 (1.0)	2.4 (1.0)	1.9+
Science Competence	3.1 (0.9)	3.2 (0.8)	1.9+
Pre-test and Post-test (#correct)	10.9 (2.7)	13.6 (3.4)	5.4**

NOTE: Mean = average; SD = Standard Deviation; t-test = statistical test for difference in means between pre and post- groups; p is a test of the statistical significance; * = p < .05, + = p < .102)
Assessed with a 5 point scale, where 1 is lowest/least, 3 is the midpoint, and 5 is highest/most response

Neither test nor control students showed any changes in:

- Understanding the Nature of Science (NOS)
- Likelihood to increase their interest in pursuing a science- or engineering-related career as measured through the Career Inventory Scale – and as assessed with leadership/achievement and educational aspirations
- Sense of Place - assessed through identification and dependence measures

There is lack of sufficient evidence to suggest that learning about watersheds or MMW instruction impacted student interest in science or science careers. This finding was validated by the responses received during the student focus groups. In both test and control settings, some students in the focus groups expressed interested in science or science careers, but there was no evidence that these interests were influenced by the content in the classes assessed in this study. We note, however, that expected change after only a few classes presented in one week may not fully capture the reflections and long term impacts of these learning experiences. While we are confident in these measures as valid constructs, it seems that assessing change in future tests likely also fail to indicate transformative impact given the small amount of time dedicated to the program.

Lastly, learning about watersheds did appear to influence student awareness and behavior in some meaningful ways. Focus group results seemed to confirm that students in the traditional instructional setting were more likely to have a sense of how their own behaviors could negatively impact the health of the watershed (e.g. littering, dumping liquids out, etc.). On the other hand, MMW students in both basic science and college prep classes were more likely to focus on broader principles or activities that might improve watershed health, including cluster housing, no till farming and the like. MMW students were less likely to mention the small incremental things they could do personally to increase watershed health, and were more likely to describe personal actions as having negligible impact. It would seem that MMW offered students a more holistic understanding of the system conditions that influence watershed health in their area but it is important to note that this knowledge is accompanied by a higher likelihood that they realized they were less self-effective or personally capable of having an impact on the hydrological systems on which their community depends.

Conclusions

Although MMW instruction only lasted for three block-schedule class periods, there is evidence that it helped positively increase knowledge development about watersheds, at least equivalent to that of traditional teaching when students explored the software under their own direction. MMW also contributed to youth confidence in themselves as scientists, and even their understanding of the problem of the scope of watershed management.

Both of the teachers seemed to approach the MMW instructional experience differently than would appear to be typical for how they teach their regular classes. The open-ended nature of the exploration within the MMW class was unfamiliar to the students. Indeed, despite the media sophistication of students in this generation, their ability to generalize from working on computers to being able to actively pursue self-directed learning in the WikiWatershed website may have required more scaffolding. We note that this conclusion should not be interpreted as a negative result for MMW, but rather a reflection on the general system conditions that characterize the formal structure of schools in the recent past. Curriculum developers, education theorists, and even teachers may be more capable of imagining how self-directed youth learning works based on their own experience as students during the experimental 1970s and 1980s, and may not account for the lack of experience youth have in more free-form learning settings.

Given the short amount of time devoted to this test, we suggest that measures that focus on long-term change such as career aspirations, sense of place, and Nature of Science be eliminated as not measuring effectively the type of impact that can be expected.

This 2 x 2 study explored the distinction in two starkly different types of learning experience, one highly lecture-driven and the other completely free-form learning. We suggest that this comparison was valuable for identifying learning potential of the software, we are limited in drawing inference from the experiment because more blended use of self-direction, guided inquiry, or other techniques that encourage student involvement in their own learning may produce higher results than might be achieved in this more classic quasi-experimental design.

Despite most MMW-taught students' assumptions that they were not learning as much during the self-directed classes, results suggested that the MMW experience resulted in compelling evidence that they had learned in ways that are at least equivalent to the teacher-led lectures.

Recommendations:

- The knowledge tests indicated a set of questions and content that were not evident in the curriculum. Therefore, we recommend a revision to the topics for the knowledge survey be developed and aligned to the potential learning anticipated by the program developers prior to deployment in Phase 2 of the summative evaluation.
- Use only those questions from the teacher-constructed pre-post test that showed change over time and are not too specific to the local environment.
- As noted in the conclusions, remove modules that revealed no change in outcomes.
- Further experimentation with blended instructional pedagogies where student self-direction is supplemented with scaffolding or guided inquiry may offer new insights into the value of the software.
- Based on these results, we believe that further quantitative testing with students, and peer-review by teachers drawn from a more diverse urban/suburban and rural settings will provide new insight into the full range of value that may be possible for the MMW learning experience.

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Appendix A. Student Pre- and Post-Survey Analyses

Table A-1. Comparison of Pre-Post Surveys for College Prep Class (*n*=43)

Variable	PRE-Test Mean (*SD*)	Post-Test Mean (*SD*)	*t*-test
Nature of Science Understanding	3.8 (0.3)	3.8 (0.3)	0.9
Career Inventory Scale - Leadership/Achievement Aspirations	3.9 (0.5)	3.9 (0.6)	0.3
Career Inventory Scale - Educational Aspirations	4.2 (0.9)	4.3 (0.7)	1.1
Sense of Place - Identity	3.0 (0.6)	2.9 (0.6)	1.5
Sense of Place - Attachment	3.1 (0.6)	3.0 (0.6)	2.3*
Sense of Place - Dependence	2.6 (0.6)	2.7 (0.6)	1.7†
Science Self	2.6 (1.0)	2.7 (1.0)	2.6*
Science Social	2.3 (1.0)	2.5 (1.0)	2.4*
Science Competence	3.2 (0.8)	3.3 (0.8)	1.1
Pre-test and Post-test (#correct answers)	12.0 (3.2)	15.5 (3.1)	6.6**

NOTE: Mean = average; SD = Standard Deviation; t-test = statistical test for difference in means between pre- and post- groups; p is a test of the statistical significance; * = $p < .05$, † = $p < .10$

Scale is a 5-point scale, with 1 as the lowest, 3 as the midpoint, and 5 as the highest

Table A-2. Comparison of Pre-Post Surveys for Basic Science Class (*n*=41)

Variable	Mean (*SD*) PRE	Mean (*SD*) POST	*t*-test
Nature of Science Understanding	3.7 (0.4)	3.7 (0.4)	0.3
Career Inventory Scale - Leadership/Achievement Aspirations	3.7 (0.8)	3.6 (0.8)	1.0
Career Inventory Scale - Educational Aspirations	3.8 (1.0)	3.7 (1.0)	0.6
Sense of Place - Identity	2.7 (0.7)	2.7 (0.8)	0.1
Sense of Place - Attachment	2.9 (0.8)	2.8 (0.8)	0.7
Sense of Place - Dependence	2.7 (0.7)	2.7 (0.7)	0.7
Science Self	2.3 (0.9)	2.5 (1.0)	2.6*
Science Social	2.1 (0.8)	2.3 (0.9)	1.5
Science Competence	2.9 (0.8)	3.0 (0.9)	1.1
Pre-test and Post-test (# questions correctly answered)	10.0 (2.5)	13.2 (3.2)	6.3**

NOTE: Mean = average; *SD* = Standard Deviation; *t*-test = statistical test for difference in means between pre- and post- groups; *p* is a test of the statistical significance; * = $p < .05$, ⸸ = $p < .10$

Scale is a 5-point scale, with 1 as the lowest, 3 as the midpoint, and 5 as the highest

Appendix B. Student Draw-a-Watershed Analyses

Table B-1. Comparison of Pre-Post Answers for Draw-a-Watershed for

Class Group	Mean (*SD*) PRE	Mean (*SD*) POST	*t*-test
All students (n=67)	3.2 (0.8)	2.3 (0.8)	6.6*
Control (n=39)	3.2 (0.7)	2.3 (0.8)	5.5*
Test (n=28)	3.2 (0.9)	2.4 (0.8)	3.8*
Basic science (n=27)	3.2 (0.9)	2.9 (0.5)	1.6
College prep (n=40)	3.2 (0.7)	1.9 (0.8)	8.2*

NOTE: Mean = average; *SD* = Standard Deviation; *t*-test = statistical test for difference in means between pre- and post- tests; *p* is a test of the statistical significance; * = $p < .05$, ┼ = $p < .10$

Scale is a 4-point scale, with 1 as the highest understanding, 4 as the lowest understanding:

1= Watershed as a natural and dynamic process consisting of a developed hydrologic cycle.

2= Watershed as a natural process containing elements of the hydrologic cycle.

3= Watershed as the natural storage of water (i.e. bodies of water-lake or pond).

4= Watershed as a human-built facility for storing water (e.g. water stored in a “shed” or “tower”).

Appendix C. Student Pre- and Post-Survey Modules

Section 1: Student Pre/Post Quantitative Surveys

Welcome students. This survey seeks to understand how you are thinking about topics that are part of your coursework, how you think about yourself as a science thinker and what you hope to do in the future. This survey is part of an evaluation of education materials that are designed to increase learning in students like you and your classmates. Your honest answers to the following questions help us to learn how useful these tools are and what we can do to improve them for others like you in the future.

Dr. Susan Gill the Director of Education at Stroud Water Research Center and Dr. N M-D Associate Professor at Millersville University are doing a study look at the curriculum tools. All information provided in this survey is confidential and only you and your teacher know your unique identifier. Please do not share your unique identifier with anyone else. Results of this survey will be provided back to your teacher, but the independent evaluator will not know who you are. This survey is anonymous to everyone but your teacher who will be able to tell you your grades on the knowledge section after all students in your school complete the survey and test. This survey will take you about 30 minutes to complete.

If you or your parents have questions about this survey, you are welcome to ask your teacher about the project or to contact Dr. Dietrich directly at ndietrich@millersville.edu. *This project has been approved by the Millersville University of Pennsylvania Institutional Review Board for the Protection of Human Subjects

We appreciate your participation in the project.

To start the survey, please enter your unique identification code given to you by your teacher to get started:

Click submit.

Nature of Science Scale:

Tobin, K. & McRobbie, C. (1997). Beliefs about the nature of Science and the enacted science curriculum. Science and Education, 6, 355-371.

Schwartz, R. S., Lederman, N. G., & Crawford, B. A. (2004). Developing views of nature of science in an authentic context: An explicit approach to bridging the gap between nature of science and scientific inquiry. Science Teacher Education, 88, 610-645.

These items assess students' understanding of the nature of science. According to Schwartz, Lederman, and Crawford (2004) the basic principles of science acknowledge that scientific knowledge is tentative, that it is founded on a strong empirical foundation, that knowledge is subjective, that its interpretation can be highly creative, that it is socio-culturally dependent, that it is based on observations and inferences, that it takes the form of laws and theories, and that it depends on the interdependence of all these aspects. Assessing students' understanding of the nature of science will allow testing of some of the proposed impacts of using the MMW software. The items included are selected and modified from the ones used by Tobin and McRobbie (1997) in their study with an Australian high school group.

For the following questions, we want to know what you think about science. Remember, there are no "right" or "wrong" answers and you will not be graded on your responses:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Scientific knowledge does not change with time.	□	□	□	□	□
Scientific knowledge is subject to review and change.	□	□	□	□	□
In developing areas of scientific knowledge, competing theories may be held for a long time.	□	□	□	□	□
Science progresses by refining and replacing old theories with new ones.	□	□	□	□	□
Today's science laws, theories, and concepts may have to be changed in the face of new evidence.	□	□	□	□	□
There are still many unresolved issues to be solved in science.	□	□	□	□	□
Scientific truth changes with time.	□	□	□	□	□
Scientists often disagree about scientific knowledge.	□	□	□	□	□
Scientific knowledge is always correct.	□	□	□	□	□
Once a law of science is discovered it should never need to be changed.	□	□	□	□	□
Scientific knowledge is the same throughout the world.	□	□	□	□	□
Scientific knowledge is verified by experiment.	□	□	□	□	□
Science is a search for truth.	□	□	□	□	□
Scientific knowledge gets closer to the truth as time goes by.	□	□	□	□	□
Scientific laws, theories, and concepts are continually being tested.	□	□	□	□	□
Scientific knowledge does not have to be repeatable to be accepted.	□	□	□	□	□
The evidence to support scientific knowledge need not be communicated to other scientists for their examination.	□	□	□	□	□

Career Inventory Scales

Career Interest Scale, Gray, M. P., & O'Brien, K. M. (2007). Advancing the assessment of women's career choices: The Career Aspiration Scale. Journal of Career Assessment, 15, 317-337.

Career aspirations are conceptualized as individuals' career-related goals and ideals. Apart from providing information on motivations and strivings towards a professional life, they may also be precursors of more specific career choices. For the purpose of the MMW Stroud project, career aspirations may be important outcomes from students' use of the software.

First, we'd like you to tell us a bit about your goals for your career. Remember, there are no "right" or "wrong" answers; we are only interested in your opinions. In the space next to the statements below please circle a number from "1" (Not at all true of me) to "5" (Very true of me):

	Not at all true of me				Very true of me
I hope to become a leader in my career field.	□	□	□	□	□
When I am established in my career, I would like to manage other employees.	□	□	□	□	□
I do not plan to spend time trying to get promoted in my job.	□	□	□	□	□
When I am established in my career, I would like to train others.	□	□	□	□	□
Once I finish the basic level of education needed for a particular job, I see no need to continue in school.	□	□	□	□	□
I would like to pursue graduate training in my field of interest.	□	□	□	□	□
Becoming a leader in my career is not that important to me.	□	□	□	□	□
I hope to move up through any organization or business I work in.	□	□	□	□	□

Careers in Science:

This section of the instrument was developed by Tyler-Wood, T., Knezek, G. & Christensen R. (2010). Instruments for assessing interest in STEM content and careers. *Journal of Technology and Teacher Education 18*(2), 341-363.

The module explores how curriculum interventions created through NSF ITEST funded research have direct impact on youth. The survey is administers three scales measuring: perceptions of a supportive environment for pursuing a science career, interest in future studies that toward securing a career in science, and perceived importance of a science career.

Next, we'd like you to tell us about your interest in science careers . Remember, there are no "right" or "wrong" answers; we are only interested in your opinions. In the space next to the statements below please check the box that is most like how you feel today, from "1" (Strongly Disagree) to "5" (Strongly Agree):

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I would like to have a career in science.	□	□	□	□	□
My family is interested in the science courses I take.	□	□	□	□	□
I would enjoy a career in science.	□	□	□	□	□
My family has encouraged me to study science.	□	□	□	□	□
I will make it into a good college and major in an area needed for a career in science.	□	□	□	□	□
I will graduate with a college degree in a major area needed for a career in science.	□	□	□	□	□
I will have a successful professional career and make substantial scientific contributions.	□	□	□	□	□
I will get a job in a science-related area.	□	□	□	□	□
Some day when I tell others about my career, they will respect me for doing scientific work.	□	□	□	□	□
A career in science would enable me to work with others in meaningful ways.	□	□	□	□	□
Scientists make a meaningful difference in the world.	□	□	□	□	□
Having a career in science would be challenging.	□	□	□	□	□

Sense of Place:

Jorgensen, B. S., & Stedman, R. C. (2001). Sense of place as an attitude: Lakeshore owners attitudes toward their properties. Journal of Environmental Psychology, 21, 233-248.

Sense of place as captured by this scale is defined as a multidimensional construct comprising beliefs about the relationship between self and place, feelings toward a place, and their dependence on it relative to other alternatives. The use of a place- based tool such as the MMW software may inculcate a greater sense of place as manifest in their identity, attachment, and reliance on it, and hence are proposed for inclusion in this survey.

In this section, we're interested in learning about how you feel about your connections to where you live. In the space next to the statements below please check the box that is most like how you feel today, from "1" (Strongly Disagree) to "5" (Strongly Agree):

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Everything about my community is a reflection of me.	□	□	□	□	□
My community says very little about who I am.	□	□	□	□	□
I feel that I can really be myself in my community.	□	□	□	□	□
My community reflects the type of person I am.	□	□	□	□	□
I feel relaxed when I'm in my community.	□	□	□	□	□
I feel happiest when I'm in my community.	□	□	□	□	□
My community is my favorite place to be.	□	□	□	□	□
I really miss my community when I'm away from it for too long.	□	□	□	□	□
My community is the best place for doing the things that I enjoy most.	□	□	□	□	□
My community is not a good place to do the things I most like to do.	□	□	□	□	□
As far as I am concerned, there are better places to be than my community	□	□	□	□	□
For doing the things that I enjoy most, no other place can compare to my community.	□	□	□	□	□

Assessment of Data Contamination:

The following single question will explore the degree to which peer-to-peer communications about curriculum may result in changed knowledge or attitude within the community influencing results in a comparative studuy within a single school

Please tell us how much you talk about what you learn in this class with students in other classes in your grade? All the time, sometimes, once in a while, just before tests. :

	Never	Only before tests	Once in a while	A few times a week	Every day after class
I talk about what I learn in class with my peers in other classes	□	□	□	□	□

Science Identity Scales:

Carlone, H. B., & Johnson, A. (2007). Understanding the science experience of successful women of color: Science identity as an analytic lens. Journal of Research in Science Teaching, 44, 1187–1218.

This scale assesses perceptions that one demonstrates competence in science through one's knowledge and understanding of topical content, has the necessary skills for the performance of relevant scientific practices (e.g., application of scientific tools, facility in engaging in scientific talk), and is recognized by meaningful others (including the self) as a "science person." Thus, their model addresses three overlapping components of science identity: competence, performance, and recognition.

Please rate your agreement or disagreement with the following statements:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	N/A
I think of myself as a science person.	□	□	□	□	□	
I am comfortable thinking of myself as a science person.	□	□	□	□	□	
Things I do (work, study, hobbies) help me think of myself as a science person.	□	□	□	□	□	
Teachers/Professors/Instructors see me as a science person.	□	□	□	□	□	
My friends see me as a science person.	□	□	□	□	□	
My family see me as a science person.	□	□	□	□	□	
It is important to me that others see me as a science person.	□	□	□	□	□	
I enjoy doing science-related activities.	□	□	□	□	□	
I am successful at science-related activities.	□	□	□	□	□	
I understand the basic concepts and principles associated with science inquiry.	□	□	□	□	□	
I can conduct a scientific investigation.	□	□	□	□	□	
Doing science-related activities is important to who I am.	□	□	□	□	□	
My science knowledge and skills allow me to explain things to other people.	□	□	□	□	□	
My knowledge and skills in science allow me to contribute to issues that are important to me.	□	□	□	□	□	

Watershed Unit Pre-test (with correct answers shown in bold text)

Name______________________ Score_____________

1a. If you were a city planner, what is the best building design to provide everyone with a place to live while protecting the environment?

1b. Explain your answer.

2. Looking at the picture below, give the farmer specific suggestions on how to limit the harm to the stream.

3. Which of the following definition best describes a watershed?

   a. An area of land that drains down slope until it reaches a common point

   b. An area on the earths surfaces that stores water.

   c. A valley dividing two areas that are drained by different river systems.

   d. The area drained by a river, but not its 'tributaries.

   e. An area characterized by all runoff being conveyed to the different outlets.

4. Which of the following is not a stream system associated with the lower Susquehanna watershed.

   a. Pequea Creek

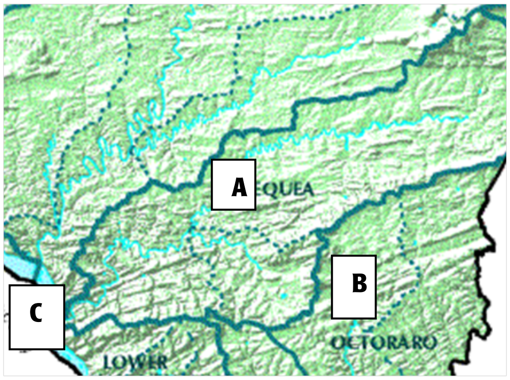
   b. Tucquan Creek

   c. Conestoga River

   d. Mill Creek

   e. Willow Creek

5. Using the following Map match the letter with a local river/stream system



5a.___**C**___Susquehanna 5b.___**A**___Conestoga 5c..___**B**___Pequea

6. Forested areas play a very important role in the health of a watershed. Which of the following is not considered an important role?

A. The plant cover and leaf litter absorb moisture and help maintain soil structure

B. Root masses keep soil permeable and stable so moisture can move into it for storage.

C. It allows water to be filtered and released slowly into the stream system.

D. It allows the soil to be transported downstream and deposited at the headwater

Choose whether the following hydrologic terms are identified with Groundwater, Surface Water, both or neither.

A. Groundwater B. Surface water C. Both D. Neither

__**A**__7. Aquifer

__**A**__8. Capillary Water

__**B**__9. Meander scar

__**B**__10. Oxbow

__**B**__11. Levee

__**A**__12. Cap rock

__**C**__13. Artesian Flow

__**B**__14. Delta

__**A**__15. Unconfined aquifer

__**A**__16. How is the speed of groundwater movement measured?

A. Feet per day
B. Feet per week
C. Feet per month
D. Feet per year

__**A**__17. How is stream flow usually measured?

A. Feet per second
B. Feet per minute
C. Feet per hour
D. Yards per hour

__**D**__18. Which way(s) can groundwater move?

A. Up
B. Down
C. Sideway
D. All of the above

__**D**_ 19. What determines how fast groundwater moves?

a. Temperature

b. Air pressure

c. Depth of water table

d. Size of materials

__**E**__ 20. Which of the following are examples of non-point water pollution?

a. Septic systems

b. Agricultural runoff

c. Road drainage,

d. Fertilizers,

e. All the above

21. Building houses and roads increases the water run-off in the area	**True** or False
22. Water infiltration is greater now than before people lived in this area.	True or **False**
23. Conserving wetlands is an excellent way to sustain good water quality.	**True** or False
24. Porous pavers increase water in already developed areas.	**True** or False
25. Cluster housing is way to limit watershed impact in a populated area.	**True** or False
26. No till farming limits run-off with the use of cover crops.	**True** or False

27. You tested 2 local streams and found the following invertebrates. Which stream is a HEALTHY stream and which stream is UNHEALTHY?

a. Stream 1: Stoneflies, mayflies, caddisflies, and rifflebeetles.	**Healthy**
b. Stream 2: Fly larva, nematodes, leeches, and planeria	**Unhealthy**

Appendix D: Draw-A-Watershed Tool

Draw-A-Watershed

Draw what you think a watershed is:

1. Explain the drawing in your own words. Write at least 2 sentences.

Draw-A-Watershed Reflection

This activity encourages dialogue about what watersheds are.

Reflection

When students are finished with their drawings, ask students to share some of the details of their pictures. Use the following questions to get their discussion going:

How many people drew something about the water cycle?

How many people thought about the natural environment?

How many people thought about the built environment (e.g. buildings, cities, etc.)?

How many people thought of the watershed as a dynamic system?

Quickly brainstorm a list of the key characteristics of watersheds.

Encourage students to think about watersheds in general and their watershed in particular and revisit this conversation as the year progresses.

Draw-a-Watershed Test Modified Scoring Tool1

School Name: ____________________   Teacher Name: _________________________

How many drawings total did you receive? ________

OVERALL CODING OF THE WATERSHEDS

Conception 1: Watershed as a natural and dynamic process consisting of a developed hydrologic cycle.

Conception 2: Watershed as a natural process containing elements of the hydrologic cycle.

Conception 3: Watershed as the natural storage of water (i.e., bodies of water—lake or pond).

Conception 4: Watershed as a human-built facility for storing water (e.g., water stored in a "shed" or "tower").

Overall coding	How many?	% of Drawings
Conception 1		
Conception 2		
Conception 3		
Conception 4		

Comments:

[1] Adapted from Shepardson, D. P., Wee, B., Priddy, M., Schellenberger, L., & Harbor, J. (2007). What is a watershed? Implications of student conceptions for environmental science education and the National Science Education Standards. *Science Education, 91(4*), 554–578.