Investigating the Effects of an Aquatic Ecology Graduate Course for Teachers: Linking Teaching to the Environment and Community

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Abstract

The purposes of this study were to determine the impact of a graduate teacher education course on the confidence levels and classroom practices of teachers**.** The three-credit hour, field-based course was taught during the summer using a two-week workshop and one follow-up day format. Place-based teaching approaches were utilized during the course. These approaches were designed to immerse teachers in studies of their local aquatic environment and community-based resources that are associated with the aquatic environment. Pre, post, and delayed post-survey data were analyzed using MANOVA and ANOVA measures to determine changes in the teachers' confidence levels and classroom practices. Positive changes were found in the teachers' confidence and classroom teaching in the use of various instructional technology, standards-based teaching strategies, community resources, field investigations, and in the teaching of water quality topics, real life topics, societal issues, and career education. An analysis of responses to open-ended questions on the delayed post-survey revealed the strengths of the course in regard to the learning of science content, instructional pedagogy and applications to classroom teaching, the potential impact on K-12 student learning, and barriers to implementing desired classroom practices. Implications and recommendations are presented that can be generalized across a variety of educational programs.

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Introduction

Place-based educational approaches are designed to develop a sense of connectedness to where one lives by grounding learning in the local natural and community-based environment. The characteristics of place-based learning that make it a distinctive approach to education, as summarized by Woodhouse and Knapp (2000), are the emergence of education from the particular geography, ecology, sociology, & politics of a local community, a focus of study that is inherently multidisciplinary and experiential, and the connection of place with self and community.

Place-based education is an approach to education that is aligned with the goal of improving K-12 educational outcomes, as evidenced by an increasing number of studies reported in the literature. Among the educational benefits of place-based education evidenced in K-12 schools are an improved performance on standardized tests in all academic subjects, a reduction of discipline problems and absenteeism, an increase in engagement and enthusiasm for learning, greater pride in accomplishments, and greater teacher job satisfaction (Athman & Monroe, 2004; Audubon Washington, 2004; Ernst & Monroe, 2004; Heimlich, 2002; Lieberman & Hoody, 1998; NEETF, 2000; Powers; 2004, SEER, 2000; Smith, 2002; Sobel, 2005).

In addition to the educational value of place-based education, this approach to learning is viewed as a potential means of sustaining the culture and natural environment (Orr, 1994; Smith & Williams, 1999). According to David Orr (1994), people must have knowledge of ecological patterns, systems of causation, and the long-term effects of human actions on those patterns if they are to work on behalf of sustaining the cultural and ecological integrity of the places they inhabit.

While the value of place-based education is gaining increased recognition, it is not yet a mainstream approach used to design K-12 curricula, nor is this approach yet a substantial part of teacher education. For schools to successfully implement place-based teaching approaches, it is critical to provide teachers with training in the use of teaching practices that many have not experienced themselves.

Recent studies conducted with K-12 teachers in Kentucky revealed specific environmental science education needs of teachers that are relevant in building a foundation upon which teachers can effectively utilize place-based educational approaches. In a statewide survey conducted by Doug Carr (2005), 67% of teachers reported incorporating environmental content in their teaching, but relatively few incorporated it extensively. Few teachers received training related to environmental content within the past 3 years, but those that did appeared more likely to teach environmental content. The most important reasons identified for teaching environmental content were the relevance of the environment to the everyday lives of students and to teach their students about current issues. One of the most frequent reasons given for not teaching about the environment in this study was the lack of teaching materials and lesson ideas. The results of an environmental education needs assessment of K-12 teachers conducted by Meichtry and Harrell (2002) indicated that the three greatest needs of teachers, in order of frequency, were training in the use of outdoor learning sites, training in the alignment of curriculum with state standards, and the availability and use of curricula.

The Graduate Course

The graduate course used as the focus for this study was a three-credit hour course offered in the summer. The course was taught using a two-week workshop format and one day follow-up session. An overview of the course schedule is presented in Figure 1.

Figure 1: Overview of Graduate Course Schedule

<u>Week 1: Day 1</u>

1. Pre-course survey
2. Project WET activity – Humpty Dumpty (Restoration of aquatic systems)
3. Course overview
4. Overview of Field Station and programs

5. Video (After the Storm, EPA)
6. KY Watershed Watch overview/KY Watershed basins
7. Enviroscape Demonstration
8. Small group activity – Identify state standards addressed by lesson & develop open-response assessment for K-12 students.

<u>Week 1: Day 2</u>

Discuss previous day state standards & assessment questions
Set up river productivity line

Microbiology and Water Chemistry

1. Introduction to river ecosystem and sampling methods
2. Sampling of river-productivity line, collect plankton (pontoon boat) and water samples for chemistry testing, demonstrate use of YSI SONDE to instantly collect & graph multiple river parameters, & collect coliform samples
3. Measure oxygen levels in productivity bottles & calculate river productivity
4. Use microscopes and keys to identify microscopic life
5. Discuss impact of water parameters on biodiversity of the river

Identify state standards & open-response assessment for lesson.

<u>Week 1: Day 3</u>

Discuss previous day state standards & assessment questions
Observe & discuss coliform results

Geology and Chemical Cycling and Geologic History of Ohio River

1. Geologic History of Ohio River
2. Review of the hydrologic cycle
3. River systems & flood plain development
4. How various constituents can enter a river system
5. Collect water samples (from the Ohio River at field station and upstream from a tributary)
6. Field station: Analyze samples and plot data in histograms using Excel
7. Discuss results
8. Hypothesize concentrations in downstream tributary

Identify state standards & open-response assessment for lesson.

<u>Week 1: Day 4</u>

Discuss previous day state standards & assessment questions

- Demonstrate and practice use of LabPro and Dana technology to collect water parameter data

Field Trip to Ohio River Tributary: Stream Survey

- Biological Index
- Habitat Assessment
- Chemical and physical water quality parameters
- Fish seine

- Plankton & coliform sample
- Stream velocity

Identify state standards & open-response assessment for lesson.

Week 1: Day 5
Morning:
Discuss previous day state standards & assessment questions

- Microscope study of algae, protista, & microscopic invertebrates and study of macroinvertebrates collected in the Ohio River on Wednesday and in the Ohio River Tributary on Wednesday. Compare samples.
- Mussels of the Ohio River

Afternoon:

- 1:00-1:30-Speaker, Sierra Club Water Sentinels Program
- 1:30-2:00-Speaker, Ohio River Sanitation Commission (ORSANCO)
- Classroom curriculum activities

Identify state standards & open-response assessment for lesson.

Week 2: Day 6
Discuss previous day state standards & assessment questions

Terrestrial, Wetlands, & Upland Ecosystem and Biodiversity Study

- Wetlands and floodplains orientations (St. Ann's)
- Vegetation monitoring/research methods
- Data interpretation/forest evaluation
- Upland: Exotic species and their effects on ecosystems
- Watersheds/storm water management
- Calculate coefficient of similarity
- Habitat restoration (theory & practice)

Identify state standards & open-response assessment for lesson.

Week 2: Day 7
Morning:
Discuss previous day state standards & assessment questions
Field Trip: Lafarge Gypsum Plant – role of industry in protecting aquatic systems and biodiversity; education efforts for schools and community members

Afternoon: Field trip: Sanitation District #1 – best management practices for storm water runoff and education program and facilities.

Identify state standards & open-response assessment for lesson.

Week 2: Day 8 - Evening session 5:00-10:00 PM
Discuss previous day state standards & assessment questions

- Electrofish and aquatic organism study, fishes of the Ohio River
- Water quality parameters

Develop core content for assessment & open-response assessment for Wednesday lesson

Week 2: Day 9
Field Trip: Licking River study:
Canoe trip and field study

- Stream monitoring – chemistry, habitat assessment, and macroinvertebrate
- Canoe safety and paddling techniques
- Drainage patterns in watersheds
- Flooding and water management issues
- Point & nonpoint source pollution issues & best management practices
- Enjoy the river!

Identify state standards & open-response assessment for lesson.

Week 2: Day 10
Morning:
Discuss previous 2 days state standards & assessment questions
10:00- Speaker, Conservation Districts
10:40-Speaker, KY Energy Education Development Project (NEED)
11:20-Speaker, Ohio River Foundation
Identify state standards & open-response assessment for lesson.

Afternoon:
Individual Work time on curriculum projects

- Discuss previous day core content & assessment questions
- Professional river-based and education organizations
- Kentucky Watershed Watch and Licking River Watershed Watch
- Curriculum Resources

Follow-Up Session: 2 Weeks After Completion of 2-Week Segment of Course

- Teacher presentations of course projects
- Work on KAEE presentation
- Projects and notebooks due
- Post-course survey

Student Enrollment and Course Instruction

Students enrolled in the course were K-12 teachers seeking a Masters degree or Rank 1 certification. The course is cross-listed in the departments of Education and Biology and can be applied as a science content course requirement, an elective course, and/or as one of four courses that apply to an Environmental Education Endorsement.

The course was co-taught by two faculty; one with expertise in biology and environmental science and the other with expertise in science education and environmental education. Both instructors were trained and experienced in the use of the place-based teaching strategies that were used throughout the course. These strategies included experiential learning, use of the environment and community as a focus to integrate disciplines, inquiry-based learning, relevancy of learning to real life and current societal issues, and student reflection. Guest instructors during the course were university professors who specialized in the content areas of geology, microbiology, and botany/ecology.

Course Description

This course was designed to incorporate place-based teaching approaches as a means to improve K-12 science education outcomes and to address the needs of practicing teachers in the field of environmental science education. During the two-week segment of the course, teachers were engaged in field-based studies of aquatic systems, field trips to community facilities, presentations made by community-based guest speakers, classroom discussions to reflect on what they were learning, and small group work to apply what they were learning to their K-12 classrooms. Topics of the field studies used to investigate the local aquatic environment were microbiology, water chemistry, geology and chemical cycling, geologic history of the Ohio River and watershed area, stream survey components (macroinvertebrate sampling, habitat assessment, chemical parameters, stream flow, and coliform and plankton sampling), terrestrial, wetlands and upland ecosystems, and fishes of the Ohio River.

All field-based studies were inquiry-based. Teachers were required to keep a notebook record of all investigations made during the course. The standard format used to conduct investigations was the development of a question and a hypothesis, conducting the procedure to test the hypothesis, recording and analyzing results, and drawing conclusions.

The course utilized the monitoring protocols and scientific equipment used by the Kentucky Watershed Watch (Kentucky Division of Water, 2000a-c), which consisted of Lamotte dissolved oxygen and pH test kits, an aquatic thermometer, and a conductivity meter (Lamotte, 2006). Using state-recognized protocols made it possible for the teachers to become certified as volunteer monitors for the Kentucky Watershed Watch program

Community site visits were made to an industry to learn about the role of industry in protecting aquatic systems, the local water treatment agency to learn about it's best management practices for storm water runoff, and a canoe and kayak business to learn about the impact of flooding on local businesses and about water management issues. Information presented at each of the community sites included the educational opportunities offered for schools and community members.

Representatives from the community also served as guest speakers, representing county government, an Ohio River regulatory agency, two non-profit organizations, and the National Energy Education Development project. These speakers described their role in protecting aquatic systems, presented information about programs that they offered for schools, such as classroom resources, teacher professional development, K-12 field trips and grant programs, and citizen volunteer opportunities.

Teachers were led in a 4-hour canoe trip as a means to experience the river. Half of the teachers in the course had not previously been in a canoe or kayak. It was therefore a unique experience for them to be on a river, and an experience which helped to connect them to place as the river they canoed or kayaked was the main stem of the river which formed the watershed basin in which they live and work.

The course was designed to increase the potential that teachers would transfer their course learning to their classroom teaching by explicitly addressing the state science standards. In the early stages of designing the course, the instructors identified the K-12 state science standards to be addressed in the course. The general areas of science standards taught in the course included properties and changes of properties in matter, and transfer of energy in the physical sciences; structure of the earth system – lithosphere, hydrosphere and atmosphere, geochemical cycles, and formation and ongoing changes of the earth system in the earth sciences; diversity and adaptations of organisms, behavior of organisms, populations and ecosystems, biological change, and interdependence of organisms in the life sciences; science and technology, science in personal and social perspectives, history and nature of science, and scientific inquiry.

All course topics and experiences were then aligned with these standards. Reflection and discussion about these standards were built into the daily course activities. Teachers met in grade level groups at the end of each class session to identify the standards that were addressed by the lessons taught that day. During the beginning of each day, a class discussion was facilitated by the instructors to discuss the standards taught during the previous day. In addition, teachers were assigned homework each night to develop an open-response assessment item related to the standards taught that day. These questions modeled the type of questions that K-12 students are required to answer as part of the state testing system. Teachers were required to record the science standards and their assessment question on a daily basis in their course notebooks. These notebooks were graded at the end of the course by the instructors.

Another major assignment that required teachers to utilize the state science standards was the final project. At the end of the two-week session of the course, teachers spent two weeks developing a unit of study based on their course learning that they would teach to their students. This unit was aligned to the state science standards.

A follow-up session, held two weeks after the two-week segment of the course, focused on classroom applications of the two-week training. Teachers presented their unit of study that they had designed to teach their students. All projects were posted on the course website as a means for teachers to share ideas and resources with each other and with other educators.

Ongoing Support for Teachers

Support for teachers to make and sustain changes in their classrooms is recognized as a critical component of training programs (AAAS, 1998; NRC, 1996; Powers, 2004; Rhoton, et al., 1999). The types of support made available in this course included: 1) establishing a network of university and community-based professionals; 2) providing classroom resources to teachers; 3) requiring that a unit of study, aligned with state standards, be developed and used in the classroom by teachers; 4) conducting a follow-up sessions for teachers to share their units; and 5) developing a course website, http://www.nku.edu/~enved/aet.htm and a group email list, which allowed teachers continued access to information from each other, the course instructors, and the community-based experts they encountered during the course.

Place-Based Course Components

A broad goal of the program was to use the local environment as an integrating context to teach about the interactions between environmental systems and human systems. A more specific program goal was to promote awareness and understanding of the human and environmental forces that impact the health of a watershed. Instruction to accomplish these goals addressed the three important ideas that shape the instructional vision as stated in the Guidelines for the Preparation and Professional Development of Environmental Educators (NAAEE, 2004c). These ideas emphasize a systems approach to education, the interdependence between human systems and ecological systems, and the importance of where one lives.

Salient aspects of placed-based teaching approaches used and modeled in the program were using the environment as an integrating context across disciplines, collaboration between program leaders, participants and members of the community, reflective learning, experiential learning, relevancy to real life and current societal issues, and citizenship education.

Structuring time during the course for teachers to reflect about what they were learning is an important practice within educational programs (Clark, 1994; Ginsbury & Clift, 1990; Henson, 1996; Johnson, Guice, Baker, Malone, & Michelson, 1995; Meichtry, (1998); Reynolds, 1992; Rhoton, Madrazo, Motz, & Walton, 1999; Shulman, 1986). Teachers in this course reflected on their experience and applications to teaching through journaling, class and small group discussions, the course assignments, and the course evaluation.

The practice of using outside experts is supported as a way to enhance learning and of increasing the potential for community change (e.g., Bouillion & Gomez; 2001; Ciffone, Morelock, Turner, Sivek, & Daudi, 2002; Jakowska, 1987; Niesenbaum & Gorka, 2001; O'Neill & Gomez, 1998; Rhoton, et al., 1999). To this end, seven community-based specialists and three university faculty were scheduled throughout the course to share their expertise about the environment and/or community-based efforts and resources.

Experiential learning is advocated as a teaching approach for accomplishing educational objectives in both the cognitive and affective domains (Chawla, 1998; Chawla, 1999; Heimlich & Daudi, 2002; Jarvis, 1987; Niesenbaum & Gorka, 2001; Reeder, 1998; Rome & Romero, 1998; Uno, 1990). The experiential study of an aquatic system, river monitoring, and interaction with community-based experts accomplished each of the five objective areas of the Tbilisi Declaration (1978). The teachers developed awareness, conceptual understandings, attitudes and values, citizen action skills, and citizen action experience. The course also addressed each of the four curriculum goals derived from the Tbilisi Declaration objectives by Hungerford, Peyton, and Wilke (1980). These goals are ecological foundations, conceptual awareness about issues and values, investigation of environmental issues and evaluation of alternative solutions, and training in skills and action for the purpose of achieving equilibrium between the quality of life and quality of the environment.

Purpose of Study

The objectives of the course were to increase the level of confidence and degree to which the teachers a) use technology in their teaching, b) use standards-based teaching strategies,
c) integrate the sciences, d) integrate science with other subject areas, e) use the local environment, f) conduct field-based investigations, g) use community-based resources, h) teach watershed topics, and i) teach real-world current issues. The purpose of the study was to evaluate the impact of the course on teachers' confidence levels and classroom practices which related to the program objectives.

Methods

Participants

There were 16 course participants. Four of the participants taught K-4th grades, seven taught 5-8th grades, and five taught high school. Their number of years teaching experience ranged from one year to thirteen years. The teachers represented eleven school districts; three taught in rural schools, nine in suburban schools, and four in urban schools. Thirteen of the teachers taught in public schools and three taught in private schools.

Participants in the course received three graduate credits which they could apply to a Masters degree in Education or Rank 1 certification, which is 30 credits beyond a Masters degree. Twelve of the teachers were enrolled in a Masters degree program, with some at the beginning, some at the mid-point, and some near the end of their program. Four of the teachers had completed their Masters degree.

The design and measures utilized in this study were developed as part of an earlier professional development program evaluation (Meichtry & Smith, in press). The authors' descriptions of the design and measures from this previous study are included in the following two sections.

Design

This design was a repeated measures pre-test, post-test, delayed-term post-test design. The independent variable was the time of testing: pre-program, post-program and long-term (9 months) post-program. The nine-month post measure was included in order to assess the long-term impact of the program. Dependent measures of confidence in the ability to teach program related topics were assessed at all three time periods. Dependent measures of actual teaching of program related topics were assessed only at preprogram and long-term post program time periods. The major advantage of this type of repeated design is that each participant acts as his/her own control, resulting in the need for fewer subjects and a higher level of statistical sensitivity (Martin, 1991; pp. 67-70).

Measures

Participants' confidence in the ability to teach course relevant topics were assessed just prior to the beginning of the course, immediately after the course, and nine months after the end of the course, using a 5-point Likert scale with the response options being very low (1), low (2), average (3), high (4) and very high (5) confidence.

Participants' use of course related instructional techniques were assessed just prior to the beginning of the course and nine months after the end of the course using 5 point Likert scales. The response options, depending on the phrasing of the question, were as follows: never (1), 1-2 times a year 2), 3-4 times a year (3), 5-6 times a year (4), over 6 times a year (5) or never (1), rarely (2), sometimes (3), often (4), and always (5).

Five areas of assessment were developed to be consistent with the five major course curriculum areas. These areas were, confidence in: 1) the ability to use workshop demonstrated teaching technologies (9-items), 2) the ability to use workshop demonstrated instructional strategies (5-items), 3) the use of community resources, (3-items), 4) the ability to conduct field-based investigations (7-items), and 5) the ability to teach water quality topics and the connections between science and real life, social issues and science related careers (4-items). See Survey Instrument presented in Appendix A for a listing of the specific items.

The actual teaching of course topics by participants was assessed just prior to the beginning of the course and again nine months after the course ended. The areas of assessment and number of items were the same as the confidence areas listed above, except that they addressed the actual use of classroom practices rather than level of confidence in using these practices.

In addition to the statistical measures used to determine the course impacts, an open-ended questionnaire was administered to the participants as part of the delayed post-survey assessment. The questionnaire asked participants to identify the strengths of the course, the single most beneficial aspect of the course related to content, pedagogy and classroom teaching, impact of the course on student learning, and barriers to implementing the course material in a K-12 setting.

Results

Confidence Ratings

Comparisons between pre, post and long-term post participant confidence measures were made. Confidence measures were grouped into five areas, which were confidence in 1) the ability to use workshop demonstrated teaching technologies, 2) the ability to use workshop demonstrated teaching and instructional strategies, 3) the use of community resources, 4) the ability to conduct field-based investigations and 5) the ability to teach watershed topics and teach the connections between science and real life, social issues and science related careers.

A MANOVA was performed to make a pre, post, and long-term post comparison using the nine-dependant variable assessing the use of technology. The MANOVA was conducted because it creates a combined dependent measure for interrelated items which reduces the probability of type 1 error when there are multiple interrelated dependent variables being analyzed (Pallant, 2005, p. 247). Due to insufficient degrees of freedom, the MANOVA could not be calculated. Separate ANOVA analyses were performed on the nine individual items making up the scale. All nine of the individual scale items were significant. Post hoc Bonferroni comparisons analyses found greater confidence on eight of the nine items on the long-term post measures as compared to the pre workshop assessment, with the exception being the use of Excel which was found to be significantly different from post to long-term post; see Table 1.

TABLE 1. ANOVA and mean pre, post and long-term post confidence ratings for the use of instructional technologies.

Items	Pre	Post	Long-term	F(2,26)	p
Water quality sampling kits	3.0a	4.3b	4.2b	20	.001
Water study data probes	2.5a	3.9b	3.7b	14	.001
Excel spread sheet program	3.1ab	2.9a	3.6b	5	.01
Internet	4.0a	4.4ab	4.6b	4.7	.02
Microscopes	3.8a	4.0a	4.6b	7	.004
Videoscopes and/or display monitor	2.9a	3.2a	3.9b	7.1	.003
Digital camera	3.8a	4.1a	4.8b	8	.002
Global positioning system	1.9a	3.7b	3.8b	28	.001
Two-way radio	3.1a	3.9ab	4.3b	9	.001

Note: Means not sharing a common letter are significantly different at the $p<.05$ level using the Bonferroni procedure.

Five items assessing confidence in the ability to use effective instructional strategies were compared across the time of testing using a MANOVA. A significant multiple F was obtained (Wilks' Lambda=.03; F(10,6)=17.5, *p*=.001). Separate ANOVAs were performed on all five dependent variables. All five variables were found to be statistically significant with greater confidence found in the post and long-term post measures as compared to the pre workshop assessment; see Table 2.

TABLE 2. ANOVA and mean pre, post and long-term post confidence ratings for the use of instructional strategies.

Items	Pre	Post	Long-term	F(2,26)	*p*
Use hands-on instructional strategies	4.1a	4.7b	4.8b	9	.001
Use inquiry-based teaching strategies	3.9a	4.6b	4.4b	5.3	.01
Address gender and minority equity	3.1a	4.3b	4.1b	17	.001
Integrate the sciences in teaching	3.8a	4.4b	4.6b	9	.001
Integrate science as a subject with other subject areas	3.7a	4.4b	4.4b	10	.001

Note: Means not sharing a common letter are significantly different at the $p<.05$ level using the Bonferroni procedure.

The three items assessing confidence in the use of community resources were compared across time of testing using a MANOVA. A significant multiple F was obtained (Wilks' Lambda=.18; F(6,8)=6, *p*=.012). Separate ANOVAs were performed on all three dependent variables. Significant differences were found for all three, with greater confidence found in the post and long-term post measures as compared to the pre workshop assessment; see Table 3.

TABLE 3. ANOVA and mean pre, post and long-term post confidence for the use of community resources.

Items	Pre	Post	Long-term	F(2,26)	*p*
Guest speakers	3.6a	4.1b	4.1b	3.2	.001
Natural environment field sites related to watershed studies	2.9a	4.3b	4.1b	19	.001
Field trips to watershed-related community resource sites	3.0a	4.4b	4.1b	13	.001

Note: Means not sharing a common letter are significantly different at the p<.05 level using the Bonferroni procedure.

Seven items assessing confidence in the ability to conduct field investigations were compared across time of testing using a MANOVA. A significant multiple F was obtained (Wilks' Lambda=.13; F(14,1)=5.5, *p*=.001). ANOVA tests were performed separately on all seven dependent measures. Significant differences were also obtained for all seven measures, with greater confidence found in the post and long-term post measures as compared to the pre workshop assessment; see Table 4.

TABLE 4. ANOVA and mean pre, post and long-term post confidence in the ability to conduct field investigations.

Items	Pre	Post	Long-term	F (2,26)	*p*
Geological study of water Systems	2.3a	3.6b	3.8b	26	.001
Microscopic study of aquatic Life	2.8a	4.1b	3.9b	17	.001
Macroinvertebrate Study	2.6a	4.3b	4.2b	31	.001
Habitat assessment	2.7a	4.1b	4.3b	31	.001
Fish Study	2.5a	3.9b	3.8b	38	.001
Terrestrial ecology	2.6a	3.9b	3.8b	24	.001
Water Chemistry	2.9a	4.4b	4.5b	37	.001

Note: Means not sharing a common letter are significantly different at the p<.05 level using the Bonferroni procedure.

Four items assessing confidence in the ability to teach watershed topics and the connections between science, real life, social issues and science careers were combined into a MANOVA. A significant multiple F was obtained (Wilks' Lambda=.15; F(8,54)=11, *p*=.001). Follow-up ANOVAs were performed on each of the separate dependent measures. Significant differences were obtained for all of the measures. Post hoc tests found greater confidence in the post and long-term post measures as compared to the pre workshop assessment for all of the items; see Table 5.

TABLE 5. ANOVA and mean pre, post and long-term post confidence in the ability to teach watershed and science linked topics.

Items	Pre	Post	Long-term	F (2,26)	*p*
Water quality topics	2.9a	4.4b	4.4b	61	.001
Connections between science and real life	3.8a	4.6a	4.6b	21	.001
Connections between science and societal issues	3.6a	4.6b	4.5b	22	.0001
Connections between science and science-related careers	3.8a	4.2b	4.2b	3.9	.03

Note: Means not sharing a common letter are significantly different at the p<.05 level using the Bonferroni procedure.

In summary, the positive impacts on teachers' confidence are evidenced by the overall significant gains in all five of the confidence level measures. The course had a strong impact on teachers' confidence to teach in all five of the major program curriculum areas. Compared to the pre-course assessment, greater confidence was reported in all but one of the 28 post-survey measures and in each of the 28 delayed post-survvey measures.

Classroom Practice Assessments

Pre workshop and long-term follow-up comparisons were made of the actual use of 1) workshop-demonstrated teaching technologies, 2) workshop-demonstrated instructional strategies, 3) use of community resources, 4) conducting field-based investigations and 5) the teaching of watershed topics, connections between science and real life, social issues and science related careers.

The nine items assessing the use of technologies were combined in a MANOVA. A non-significant multiple F was obtained (Wilks' Lambda=.17; F(9,4)=2.1, *p*=.23). Separate pre to long-post comparisons were preformed on each of the nine dependent variables using an ANOVA. Two of the seven, the use excel and Internet web sites were found to be significant, with greater use reported after the workshop. A third measure, the use of video scopes was found to approach statistical significance, see Table 6.

TABLE 6. ANOVA, Mean pre and long-term post use ratings of instructional technologies.*

Items	Pre	Long	F(2,26)	*p*
Water quality sampling kits	2.0	2.78	1.9	ns
Water study data probes	1.8	2.15	.55	ns
Excel	2.38	2.69	7	.02
Internet websites for research and support materials	4.0	4.9	11	.006
Microscopes	2.9	3.23	.34	ns
Videoscopes	2.08	3.31	3.7	.08
Digital camera	3.46	3.46	2.9	ns
Global positioning systems	1.07	1.38	2.2	ns
Two-way radio	2.08	1.46	.43	ns

*Scale values: 1 = never, 2 = 1-2 times a year, 3 = 3-4 times a year, 4 = 5-6 times a year, 5 = over 6 times a year. Note: p<.05 was determined to be significant.

The five items assessing the use of instructional strategies were combined in a MANOVA. A non-significant multiple F was obtained (Wilks' Lambda=.54; F(5,8)=1.4, *p*=.33). Separate pre to long-post comparisons were preformed on each of the five dependent variables using an ANOVA. The use of inquiry based teaching strategies was found to significantly differ pre to long-term post, with greater use reported after the workshop. A second item, integrate the sciences in teaching, was found to approach significance; see Table 7.

TABLE 7. ANOVA, mean pre and long-term post use ratings for the use of instructional strategies.*

Items	Pre	Long-term	F(2,26)	*p*
Use hands-on instructional strategies	4.69	5.0	1.7	ns
Use inquiry-based teaching strategies	4.31	4.69	7.5	.02
Address gender and minority equity	1.92	2.38	.51	ns
Integrate the sciences in teaching	4.23	4.85	3.5	.09
Integrate science as a subject with other subject areas	3.92	4.62	2.6	ns

*Scale values: 1 = never, 2 = 1-2 times a year, 3 = 3-4 times a year, 4 = 5-6 times a year, 5 = over 6 times a year. Note: p<.05 was determined to be significant.

The three items assessing the use of community resources were combined into a MANOVA. A non-significant multiple F was obtained (Wilks' Lambda=.86; F(3,10)= .57, *p*=.65). Each of the three items making up the scale were also compared pre to post using an ANOVA. However, no significant differences were found; see Table 8.

TABLE 8. ANOVA, mean pre and long-term post use ratings for the use of community resources.

Items	Pre	Long-term	F(2,26)	*p*
Guest speakers	2.15	2.46	.45	ns
Natural environment field sites related to watershed studies	1.54	2.54	1.9	ns
Field trips to watershed related community resources sites	1.46	1.77	.79	ns

*Scale values: 1 = never, 2 = 1-2 times a year, 3 = 3-4 times a year, 4 = 5-6 times a year, 5 = over 6 times a year. Note: p<.05 was determined to be significant.

Seven items assessing the use of field investigations were combined into a MANOVA. A non-significant multiple F was obtained (Wilks' Lambda F(7,3)=.88, *p*=.60). Individual ANOVA comparisons on each of the dependent measures found none of the individual items to be significant; see Table 9.

TABLE 9. ANOVA, mean pre and long-term post use ratings for the use of field-based investigations.

Items	Pre	Long-term	F (2,26)	*p*
Geological study of water systems	1.69	2.23	.87	ns
Microscopic study of aquatic life	2.08	2.0	.23	ns
Macroinvertebrate study	1.58	2.0	.07	ns
Habitat assessment	1.84	2.3	.07	ns
Fish Study	1.77	1.92	.0	ns
Terrestrial ecology	1.58	2.17	1.0	ns
Water chemistry	1.92	2.62	1.6	ns

*Scale values: 1 = never, 2 = 1-2 times a year, 3 = 3-4 times a year, 4 = 5-6 times a year, 5 = over 6 times a year. Note: p<.05 was determined to be significant.

Four items assessing the teaching of watershed topics and the connections to life were combined in a MANOVA. A significant multiple F was obtained (Wilks' Lambda F(8,8)=8.1, *p*=.006). ANOVA comparisons on each of the dependent measure found significant difference in two of the four measures, teaching about watershed topics and connections between science and real life, with greater teaching in the long-term post measures as compared to the pre course assessment: see Table10.

TABLE 10. ANOVA, mean pre and long term post means on the extent of teaching watershed and science linked topics.

Items	Pre	Long-term	F (2,26)	*p*
Waters quality topics	2.85	3.54	6.7	.03
Connections between science and real life	4.23	4.85	9.1	.012
Connections between science and societal issues	4.08	4.67	1.8	ns
Connections between science and science-related careers	3.75	3.83	0	ns

*Scale values: never (1), rarely (2), sometimes (3), often (4) and always (5). Note: $p<.05$ was determined to be significant.

In summary, the results of the MANOVA revealed significant gains in the teaching of watershed topics and connections to real life and social issues. While the MANOVA results showed a lack of overall significance in the use of instructional technologies, standards-based instructional strategies, field-investigation, and community-based resources, the program did have a significant impact, as evidenced by the ANOVA procedure, on the use of Excel, Internet-based resources and inquiry-based teaching strategies, and on the teaching of water quality topics and the connections between science and real life.

Delayed Post-Survey Open-Ended Questionnaire Assessments

The two most frequently identified strengths of the course, reported by eight of the 16 teachers, were the hands-on activities and field studies taught throughout the course. Another five teachers reported the course strengths as the practical uses of content, skills, lessons, pedagogy, equipment, and the resources provided to them to use in their teaching.

Teachers were asked to identify the single most beneficial aspect of the course in regard to content, pedagogy, and classroom teaching. The most frequent response for the course strength related to content, reported by eight teachers, was the depth of content learned. Real life examples and the link between content, social issues, and environmental issues was the second most frequent response, reported by three teachers. The most frequent response for the course strength related to pedagogy, reported by seven teachers, was the use of hands-on activities in the course. The use of community resources (5 teachers), teaching materials (4 teachers), and the connection of course content to real life and current issues (3 teachers) were the most frequent responses to the strength of the course in regard to classroom teaching.

In response to the question of how their participation in the course will help improve their students' learning, ten of the teachers reported that their students would learn more content, five reported that their students would become more involved in activity-based learning and thus learn more, four reported that their students would experience more real life learning, three reported that their students would utilize an increased number of resources in their learning, and two reported that their students would learn more about human impact and responsibility and would become more excited and positive because their teacher was.

While six of the teachers reported that there were no barriers to teaching the course content in their classrooms, the other teachers reported barriers related to taking their students on field trips and issues related to curriculum. The barriers identified by teachers to utilizing field trips in their classroom teaching included the lack of usable sites that are safe and near the school (3 teachers), the difficulty of obtaining permission slips for all students to participate in field trips (1 teacher), limited ability to take field trips based on scheduling constraints (1 teacher), and the difficulty presented by large class sizes (1 teacher).

Barriers to implementing the course curriculum in the classroom were identified by five of the 16 teachers. A barrier reported by two of the teachers was the lack of a match between the curriculum taught during the course and the subject matter that they teach in the classroom. Other barriers reported were a limited amount of time devoted to the 5th grade science curriculum due to a focus on the social studies and math state assessment (1 teacher), the difficulty of adapting the course content to the level of elementary students (1 teacher), and the requirement to teach from a science kit that leaves little time to teach other activities (1 teacher).

Discussion

The results of this study support findings and recommendations of previous studies that incorporating several tenets of place-based education in training programs has the potential to improve educational outcomes. Educational benefits have been reported in the literature for the use of experiential education practices (Chawla, 1998; Chawla, 1999; Heimlich & Daudi, 2002; Reeder, 1998); utilizing different expertise in program leadership, building relevancy into the program by using a local setting and involving community-based experts (Bouillion & Gomez; 2001; Ciffone, et. al., 2002; Jakowska; Niesenbaum & Gorka, 2001; O'Neill & Gomez, 1998; Rhoton, et al., 1999); allowing time for participants to reflect about their learning (Clark, 1994; Ginsbury & Clift, 1990; Henson, 1996; Meichtry, (1998); Reynolds, 1992; Rhoton, et al., 1999; Shulman, 1986); and establishing means of ongoing support for the participants (AAAS, 1998; NRC, 1996; Powers, 2004; Rhoton, et al., 1999). In addition to these studies, which focus on the use of a single tenet of place-based education, Lieberman and Hoody (1998) found that using a comprehensive set of place-based teaching strategies when using the environment as an integrating context yielded positive educational outcomes for K-12 students.

For K-12 students to realize the benefits of place-based education, it is critical that classroom teachers be effectively trained in the use of place-based teaching strategies. Studies such as this are thus needed to determine the impact of educational programs that focus on teacher education and that utilize the comprehensive set of teaching strategies which constitute place-based education. These studies are necessary to help guide the design, implementation, and evaluation of teacher education courses and professional development programs that utilize a comprehensive set of place-based teaching strategies.

The comprehensive set of place-based education strategies used in this study as the basis for the teacher education course design and implementation resulted in a course that positively impacted the confidence levels of teachers to use place-based classroom practices. The areas impacted were the use of instructional technologies, the use of standards-based in teaching, the use of community resources and the natural environment in teaching, the use of field-based investigation in teaching, and the teaching of water quality, science, and societal topics.

There was a statistically significant gain evidenced in the areas of using Excel and the Internet as instructional technologies, the use of inquiry-based teaching, and the teaching of water quality topics and the connection between science and real life. While the statistical significance of classroom use measures was not evidenced in the majority of item measures, there were other results that revealed positive impacts of the course on the teachers' use of classroom practices. These results included an increase in 25 of 28 item means from pre-survey to delayedpost-survey and the responses of teachers to the delayed post-survey open-ended questions. Given the small sample size of 16 participants, the amount of time and support needed to enact change, and obstacles that existed within the school setting as reported by teachers, it was encouraging that the direction of the change in means indicated a positive change in classroom teaching practices.

Research design recommendations based on this study relate to the results of the delayedpost-measure, conducted nine months after the summer course ended. The fact that the measures were so specifically related to course activities lessened the likelihood that other interventions would have impacted the long-term positive outcomes of this study. The results of a repeated measures design, with the delayed post-measure analysis, revealed the extent to which positive impacts on teachers' confidence and use of classroom practices were sustained over time.

An analysis of the results of the open-ended questionnaire indicated that the teachers learned content, revealed areas of pedagogy that were learned and could be applied in their classroom teaching, and revealed areas of student learning that would be and were impacted due to the participation of teachers in the course. The questionnaire results also revealed barriers that made it difficult for some of the teachers to implement aspects of the course in classroom teaching. Knowledge of these barriers, which related to taking K-12 students on field trips and curriculum issues in this study, are important to ascertain so that instructors may plan ways to address barriers faced by teachers in future course sessions.

Instructors addressed the lack of opportunity faced by teachers for taking their students on field trips by conducting lessons during the course that demonstrated alternative ways to teach the same or similar field trip content in the classroom. These lessons demonstrated ideas for classroom experiments, simulations, outdoor education at the school site, role playing activities, the use of models for demonstration purposes, powerpoint presentations with digital photos of field trip sites, Internet websites, and community guest speakers. Resources that were necessary for these activities were made available by the instructors on a loan basis to the teachers.

It is recognized that providing support for teachers to make and sustain changes in their teaching is an important component of training programs (AAAS, 1998; NRC, 1996; Powers, 2004; Rhoton, et al., 1999). The types of support for teachers provided in this course were a network of university faculty, community-based experts and teachers, print and electronic media resources for classroom use, resources for loan, a course website, and a group email list. Other types of support to help teachers make classroom changes included the requirement that teachers develop a unit of study aligned with state science standards and share these units with one another. The degree to which the teachers used the types of support made available during the course over time was not measured as part of this study. However, a review of the units of study developed by the teachers to be taught in upcoming and future years indicated that teachers were using a variety of types of these support tools. Four of the 16 teachers used community speakers who spoke during the course as guest speakers in their classrooms, two teachers conducted field trips to community sites they were connected to during the course, seven teachers checked out resources for loan, and virtually all of the teachers made use of print and electronic resources provided during the class. The group email list continues to be used by the instructors to update the teachers on opportunities and resources related to the course topics.

While the results of this study indicated that the course had a positive impact on teachers' confidence levels, classroom practices, and potential impact on student learning, these results also revealed that the statistically significant gains in confidence levels of teachers did not translate into statistically significant gains in classroom practice for the majority of teaching areas measured. Follow-up qualitative studies are thus recommended to: 1) determine whether the reasons the teachers are not using particular classroom practices to a significantly greater degree are factors that can be addressed in future training programs; and 2) whether increases in the confidence level of teachers nine months after the program were based on aspects of the summer program, the experience of applying the summer learning to classroom teaching, or factors unrelated to the program. It is also recommended that follow-up studies be conducted to determine whether the reasons the teachers are using classroom practices to a greater degree than indicated on the pre-survey are related to the course.

Recommendations for the design, teaching, and evaluation of the course, based on the results of this study, are to increase the likelihood that classroom practices will be implemented by teachers through the following means:

Alignment of Course Content with State Science Standards and School Curriculum

- develop clearly stated objectives that are linked to the state and/or school standards that teachers are required to address.;
- explicitly connect course learning to K-12 classroom teaching, state standards, and school curriculum;
- design instruction to be explicitly connected to classroom practice by requiring units of study to be developed by teachers for use in their classroom teaching;
- help elementary teachers to adapt the course learning to their grade levels.

Course Teaching Strategies

- model effective teaching strategies for use with K-12 students in the teaching of the course;
- use assessment methods that model how teachers should asses their own students;
- build relevancy into the program by using the local environment and community as a context for integrating course topics, and by using investigation protocols and equipment used by the state or local government and citizen groups.

Support for Teachers

- provide classroom resources to teachers and/or develop a lending library;
- provide information on a website that teachers can utilize over time;
- provide a formal means for participants to establish networks with each other and with community experts;
- provide ideas for ways to overcome field trip barriers in K-12 schools.

Program Evaluation

- conduct program evaluation that is directly aligned to the program objectives and use the results to improve the course over time;
- conduct interviews and classroom observations of teachers as a means to improve the validity of the self-reported survey and open-response questionnaire data;
- collect demographic data such as prior teaching experience, advanced degrees held, type of school setting (rural, suburban, urban, private, public), and analyze these data to determine potential impacts to different classroom settings and across teaching contexts;
- measure the degree to which participants use the ongoing support components that were established throughout the course.

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Appendix A: Confidence Measures for Pre, Post, and Long-Term Post

Please rate your <u>confidence</u> in your own ability to use the following technologies:	Very Low	Low	Average	High	Very High
1. Water quality sampling kits.					
2. Labware, probes, CBLs, and graphing calculators.					
3. Internet websites for research and support materials.					
4. Microscopes.					
5. Videoscopes and/or display monitor.					
6. Presentation technologies (slides, power point, etc.)					
7. Digital camera.					
8. Geographic Positioning System (GPS)					
Please rate your <u>confidence</u> in your own ability to:	XXXX	XXXX	XXXXX	XXXX	XXXXX
9. Use hands-on instructional strategies.					
10. Use inquiry-based teaching strategies.					
11. Address gender and minority equity through instruction.					
12. Integrate the sciences (physical, life, earth) in teaching.					
13. Integrate science as a subject with other subject areas.					
Please rate your <u>confidence</u> in your own ability to use the following community resources:	XXXX	XXXX	XXXXX	XXXX	XXXXX
14. Guest speakers (local, university, county, and/or state).					
15. Natural environment **<u>field</u>** sites related to watershed studies.					
16. Field trips to watershed related community resource sites (Museum, historical society, fish hatchery, farm site, etc.)					
Please rate your <u>confidence</u> in your own ability to conduct the following field based investigations:	XXXX	XXXX	XXXXX	XXXX	XXXXX
17. Water chemistry					
18. Macroinvertebrate study					
19. Habitat assessment					
20. Fish study					
21. Plankton collection					
22. Geology study with topo maps					
Please rate your <u>confidence</u> in your own ability to teach:	XXXX	XXXX	XXXXX	XXXX	XXXXX
23. about watershed topics.					
24. about connections between science & real life.					
25. connections between science & societal issues.					
26. connections between science & science-related careers.					
Please rate the general enthusiasm of the following groups of students for science:	XXXX	XXXX	XXXXX	XXXX	XXXXX
27. All student in my classes					
28. Male students					
29. Female students					
30. Minority students					
	0-10%	11-25%	26-50%	51-75%	76-100%
31. What percentage of your curriculum do you believe is aligned with the core content for assessment?					

Appendix B: Classroom Practice Measures for Pre and Long-Term Post

To what extent have you used the following types of technology in and/or for classroom instruction?	Never	1-2 Times a Year	3-4 Times a Year	5-6 Times a Year	Over 6 Times a Year
1. Water quality sampling kits.					
2. Labware, probes, CBLs, and graphing calculators.					
3. Internet websites for research and support materials.					
4. Microscopes.					
5. Videoscopes and/or display monitor.					
6. Presentation technologies (slides, power point, etc.)					
7. Digital camera.					
8. Geographic Positioning System (GPS)					
To what extent do you:	XXXX	XXXX	XXXXX	XXX	XXXXX
9. Use hands-on instructional strategies.					
10. Use inquiry-based teaching strategies.					
11. Address gender and minority equity through instruction.					
12. Integrate the sciences (physical, life, earth) in teaching.					
13. Integrate science as a subject with other subject areas.					
To what extent do you use the following community resources in your teaching:	XXXX	XXXX	XXXXX	XXX	XXXXX
14. Guest speakers (local, university, county, and/or state).					
15. Natural environment **field** sites related to watershed studies.					
16. Field trips to watershed related community resource sites (Museum, historical society, fish hatchery, farm site, etc.)					
To what extent do you incorporate the following types of field-based investigations in your teaching:	XXXX	XXXX	XXXXX	XXX	XXXXX
17. Water chemistry					
18. Macroinvertebrate study					
19. Habitat assessment					
20. Fish study					
21. Plankton collection					
To what extent do you teach:	Never	Rarely	Sometimes	Often	Always
22. about watershed topics.					
23. about connections between science & real life.					
24. connections between science & societal issues.					
25. connections between science & science-related careers.					