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FIELD STUDIES IN GEOGRAPHY AND ENVIRONMENTAL SCIENCE AS A VEHICLE FOR TEACHING SCIENCE AND MATHEMATICAL SKILLS

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ABSTRACT: *A summer training program designed to show teachers how to use urban parks for teaching a variety of math and science concepts was implemented and evaluated. Seven 5th and 6th grade teachers from the Jersey City School District in New Jersey were trained during a 10-day residential experience at Montclair State University's School of Conservation. During the following academic year, the performance of students from the experimental classes was compared to a control group of students at two and 23 weeks after the end of the academic program. Students exposed to the experimental program scored significantly higher on posttest assessments.*

INTRODUCTION

Science education is among the six national priorities outlined by educational leaders to prepare America to face the economic, political and technological challenges of the 21st century (Yager, 1993). As a result, our teacher training institutions are faced with the challenge of reforming science teacher education (Yager et al, 1996). The National Science Education Standards (National Research Council, 1996), which sets both science teaching and professional development standards, has called for "inquiry-based science programs" (p.4). In response to this lead, a number of states, including New Jersey, have set up or revised their science education standards.

Unfortunately, the national and state standards have not outlined a systematic plan for the implementation of science teaching and professional development standards. This puts the implementation phase of these standards squarely on the shoulders of science teacher educators. The restructuring of science teacher education programs is essential to meeting state and national programs. Reform should include a variety of new training strategies including field-based teacher preparation (Kumar, 1999).

Field-based teacher training is critical to preparing effective classroom teachers who will then use field-based teaching strategies themselves. It can be argued that science concepts are best understood when they are encapsulated within relevant real world experiences. Concepts related to the natural sciences are particularly well suited to field-based outdoor teaching experiences. Experiential/environmental educators have advocated for many years the use of field-based programs rooted in real life experiences as an alternative to tradition classroom instruction (Simmons, 1988, Simmons & Young, 1991; Young & Simmons, 1992).

The benefits of field-based teaching strategies can also be extended to other subject areas, including mathematics. Mathematic concepts can be easily integrated into field-based natural science studies given the inherent quantitative nature of such studies. Mathematics applied to real world situations in outdoor settings illustrates to students the value of acquiring math skills.

In spite of the purported advantages of taking students into the field to teach science and math concepts, many educators, particularly those teaching in urban areas, feel that there are limited opportunities for outdoor educational experiences and continue to teach these concepts within the confines of their classrooms. Perceived barriers to taking students into the field include time constraints, costs, transportation limitations, parental permission, liability, and the need for additional supervision (see Ham & Sewing, 1988; Simmons & Young, 1991; Young & Simmons, 1992).

This pilot study investigates the effects of a field-based teacher-training program on the subsequent performance of 5th and 6th grade students engaged in outdoor science and math studies using the urban park system in Jersey City, New Jersey. In addition to measuring the cognitive growth in students, the study will also address how students perceive the study of math and science (i.e. do students enjoy learning about science and math). This field-based program employs a wide variety of field-oriented science and math teaching strategies involving the "hands-on" participation of students in the urban parks.

The author predicts that the students participating in the experimental field-based program will score significantly higher on the posttests when compared to a control group participating in a traditional classroom-learning environment. The investigator also predicts that a within-group analysis of pre- and posttest scores will demonstrate the effectiveness of the field-based program. Furthermore, a second posttest will show that the effectiveness of the experimental program continues over an extended time period.

METHODS

One hundred and thirty-eight students (64 5th graders and 74 6th graders) made up the experimental group in this pilot study. All of the students in this group were taught by teachers who were previously trained in field-based teaching at MSU (see below). An additional 158 students (52 5th graders and 106 6th graders) acted as controls. The control group was subjected to the same unit of instruction using traditional classroom teaching strategies. Both groups of teachers and students were from the Jersey City School District, Jersey City, New Jersey. The science and math concepts evaluated were consistent with the learning objectives of both groups of teachers.

Each of the seven teachers in the experimental program participated in a 10-day residential program specially designed to train the teachers how to implement the field-based program back in Jersey City. This 10-day teacher-training program was based at Montclair State University's field center, the New Jersey School of Conservation, in Stokes State Forest, Branchville, New Jersey.

The first five days of training at the Montclair State University (MSU) field center focused on the skills needed to carry out the field-based lessons. These skills included soil, water and air testing, tree/shrub/herb identification, identification of common urban animals and their signs, types of pond and soil invertebrates, etc. Each of these skills was linked to a specific lesson that correlated with the unit objectives. The next five days of training showed the teachers how to apply the skills and teaching strategies they developed at MSU back in Jersey City using the urban parks closest to the teacher's individual elementary schools.

Field-based lessons centered on 10 related geography and environmental science topics: air quality (acid rain evidence, measurement of carbon dioxide levels, nylon deterioration, vegetation indicators, shade determination, and transpiration calculations); water quality (pH, dissolved oxygen, odor, turbidity, and plant and animal indicators); soil quality (pH, nitrates, phosphorous, potassium, humus, soil texture, and size of area covered by soil); plant diversity (diversity of trees, shrubs, and herbaceous plants); animal diversity (diversity of animals based on direct observations and the presence of animal signs, and diversity of invertebrates in soil, water and air); reproduction (signs of plant and animal reproduction based on a scavenger hunt for seeds on the ground, nests in trees or on the ground, eggs along the pond shoreline, and reproductive structures made by insects); succession (inventory of plants found on land and in the pond followed by a discussion on the succession of land areas and ponds); nutrient cycling (recording of the presence and quantity of organic – humus- layer of soil, evidence of organic topsoil layer, evidence of nutrient recycling biota in soil); vegetation abundance (quantity of overall vegetative cover, proportion of cover types); and human impacts (presence of litter, evidence of soil compaction, excavation and displacement of soil, signs of pollution in air, water and soil). Each of these topics included the basic concepts that were to be covered in their science and math units for the first half of the academic year.

Each field-based lesson was carried out in an urban park located near the elementary school. Once in the park, students were divided into study teams and each team was given specific tasks to perform relating to the topic of the day. Instructions for each task were written out on laminated cards and given to each study team. Once the teams collected the information they were responsible for, the class was brought together to share results and to discuss the relevance of the findings. Typically, each of the 10 topics covered during the park visits lasted approximately 2 hours.

For example, during the activity to determine *plant species diversity*, students were given a simple dichotomous picture key (specifically tailored for their park by the investigator) and directed to a specific part of the park to collected data. After the data collection was completed, the entire class visited each tree/shrub/herb where he teacher went over the identification process, correcting any mistakes. This activity stressed the importance of vegetation to human populations and concluded with a discussion on the significance of maintaining biodiversity.

The students from both groups were administered an 18 question pretest prior to the onset of the course of study. The test was divided equally into two portions: the *cognitive portion* to ascertain their level of understanding of nine key concepts covered in the unit of study and the *affective portion* to determine whether or not they viewed studying science and math in a favorable light. The cognitive portion of the test included questions on soil composition, food chains, trophic levels, plant communities, animal diversity, decomposition/nutrient cycling, habitats, averaging numbers, and computing land area. The affective portion of the test asked students to indicate their level of interest in science, mathematics, the natural environment, and the outdoor classroom. Students received one point for each correct answer on the cognitive portion of the test and one point for each answer on the affective portion that indicated a positive attitude toward science, math, the environment, and learning in an outdoor setting.

Two weeks after the completion of the course of study by both groups, a posttest (posttest-1) was administered to each group to measure cognitive growth and student perceptions of studying science and math. Twenty-three weeks after the first posttest, a second posttest (posttest-2) was administered to all groups to document retentive differences, if any.

Although pre and posttests were identical within each grade level, the 5th grade tests were slightly different from the 6th grade tests to address the differences in their science and math units. Due to the limited scope of this pilot investigation, the instrument used was not tested for reliability or validity. However, the investigator is fairly confident that the instrument is both reliable and valid since its form and function are typical of other instruments that have been tested for reliability and validity and used in similar assessments.

Pre- and post-tests were compared using standard t-tests with the significance level set at 0.05. Since the investigator made no prediction about which group would perform better on pretests, two-tailed distributions were used to analyze the results. One-tailed distributions were used to compare posttest results, since the author was predicting directionality: the experimental group was predicted to score higher than the control group. The data analysis package within Microsoft EXCEL was used to analyze the results.

Sample sizes between tests and within each grade level fluctuated greatly due to problems associated with teachers administering the tests. Some teachers in both the experimental and control groups either did not administer one or more of the three tests at all, or they administered them at inappropriate times (e.g. gave pretest after unit became and so the tests were discarded). For example, one teacher in charge of an experimental class administered the pretest after her first visit to the park and did not administer the second posttest at all. For this class, only the results of the first posttest were used in the data analysis. Even though sample sizes fluctuated greatly due to testing problems, the statistical analysis took into account these sample size differences.

RESULTS

Between Group Results

The results of the pretest comparing the 5th and 6th grade control and experimental groups are given in Table 1. There was no difference in student performance on the test when considering the entire test (5th $p=0.648$; 6th $p=0.813$), the cognitive portion (5th $p=0.533$; 6th $p=0.069$) or the affective (5th $p=0.768$; 6th $p=0.143$) portion of the test.

The results comparing the pretest with the first posttest for both grades are given in Table 2. The experimental group scored significantly higher than the control group on the entire test (5th $p=0.0001$; 6th $p<0.0001$) and the cognitive portion of the test (5th $p<0.0001$; 6th $p<0.0001$). However, the two grade levels diverged on the affective portion of the posttest, with the 5th graders showing no difference between the pretest and posttest-1 ($p=0.154$), while the 6th grade experimental group scored significantly higher than the control group ($p=0.047$).

Table 3 gives the results of posttest-2 for both grade levels. The 6th grade experimental group continued to outperform the control group in both phases of the test (cognitive $p<0.0001$; affective $p=0.0139$). The 5th graders, however, only scored higher on the cognitive portion of posttest-2 ($p=0.001$).

Within Group Results

Table 4 compares the within-group results for the 5th graders who participated in the experimental program. When comparing the scores on the pretest with posttest-1 and posttest-2, both posttests yielded highly significant results in the cognitive portion.

Within the 6th grade experimental group, significantly higher scores were posted on both posttests for both the cognitive and affective portions of the tests (Table 5).

TABLE 1: Pretest scores for 5th and 6th graders. These tests were given prior to the onset of the project. The results are not significant indicating that the experimental and control groups are from the same population. Results are partitioned into cognitive and affective domains.

		5TH GRADE PRETEST				
		Cognitive portion of pretest				
Group	**Count**	**Mean Score**	**Variance**	**df**	**t-Stat**	**Prob (2-tail)**
Control	47	3.217	1.451			
Experimental	23	3.043	1.085	68	-0.626	0.533
		Affective portion of pretest				
Group	**Count**	**Mean Score**	**Variance**	**df**	**t-Stat**	**Prob (2-tail)**
Control	47	4.652	1.265			
Experimental	23	4.532	1.73	68	-0.296	0.768
		6TH GRADE PRETEST				
		Cognitive portion of pretest				
Group	**Count**	**Mean Score**	**Variance**	**df**	**t-Stat**	**Prob (2-tail)**
Control	30	3.4	2.248			
Experimental	26	4.115	1.866	54	1.855	0.069
		Affective portion of pretest				
Group	**Count**	**Mean Score**	**Variance**	**df**	**t-Stat**	**Prob (2-tail)**
Control	30	4.967	2.24			
Experimental	26	4.385	2.006	54	-1.488	0.1426

TABLE 2: First Posttest scores for 5th and 6th graders. These tests were given immediately after exposure to the experimental and classroom programs. The results are highly significant for both grades except for the fifth grade affective domain. Results are partitioned into cognitive and affective domains.

Fifth Grade Posttest 1

Cognitive portion of Posttest 1

Group	Count	Mean Score	Variance	df	t Value	Prob (1-tail)
Control	46	3.174	1.391			
Experimental	38	4.658	2.555	82	4.89	<.0001

Affective portion of Posttest 1

Group	Count	Mean Score	Variance	df	t Value	Prob (1-tail)
Control	46	4.674	2.625			
Experimental	38	5.026	2.243	82	1.027	0.1538

TABLE 2 Continued

6th Grade Posttest 1

Cognitive portion of Posttest 1

Group	Count	Mean Score	Variance	df	t Value	Prob (1-tail)
Control	76	4.132	3.369			
Experimental	68	5.588	3.559	142	4.692	<.0001

Affective portion of Posttest 1

Group	Count	Mean Score	Variance	df	t Value	Prob (1-tail)
Control	76	4.855	2.685			
Experimental	68	5.279	1.816	142	1.685	0.0471

TABLE 3: Second Posttest scores for 5th and 6th graders. These tests were given 23 weeks after the students were exposed to the experimental and classroom programs. The results are highly significant for both grades except for fifth graders in the affective domain. Results are partitioned into cognitive and affective domains.

Fifth Grade Posttest 2

Cognitive portion of Posttest 2

Group	Count	Mean Score	Variance	df	t Value	Prob (1-tail)
Control	28	4.821	2.004			
Experimental	40	5.875	1.599	66	3.219	0.001

Affective portion of Posttest 2

Group	Count	Mean Score	Variance	df	t Value	Prob (1-tail)
Control	28	4.821	2.374			
Experimental	40	4.4	1.938	66	-1.176	0.122

6th Grade Second Posttest

Cognitive portion of Posttest 2

Group	Count	Mean Score	Variance	df	t Value	Prob (1-tail)
Control	80	4.4	3.534			
Experimental	57	6.088	3.653	135	5.144	<.0001

Affective portion of Posttest 2

Group	Count	Mean Score	Variance	df	t Value	Prob (1-tail)
Control	80	4.963	2.366			
Experimental	57	5.544	2.145	135	2.224	0.0139

TABLE 4: Results from the 5th grade EXPERIMENTAL group.

Test	Count	Mean Score	Variance	df	t Value	Prob (1-tail)
			Cognitive portion			
Test	**Count**	**Mean Score**	**Variance**	**df**	**t Value**	**Prob (1-tail)**
Pre	47	3.043	1.085			
Post-1	38	4.658	2.555	83	5.612	<0.0001
Post-2	40	5.875	1.599	85	11.456	<0.0001
			Affective portion			
Test	**Count**	**Mean Score**	**Variance**	**df**	**t Value**	**Prob (1-tail)**
Pre	47	4.532	2.993			
Post-1	38	5.026	2.243	83	1.39	0.084
Post-2	40	4.4	1.938	85	-0.387	0.35

TABLE 5: Results from the 6th grade EXPERIMENTAL group.

Test	Count	Mean Score	Variance	df	t Value	Prob (1-tail)
			Cognitive portion			
Test	**Count**	**Mean Score**	**Variance**	**df**	**t Value**	**Prob (1-tail)**
Pre	26	4.115	1.866.			
Post-1	68	5.588	3.559	92	3.628	0.0002
Post-2	57	6.088	3.653	81	4.732	<0.0001
			Affective portion			
Test	**Count**	**Mean Score**	**Variance**	**df**	**t Value**	**Prob (1-tail)**
Pre	26	4.385	2.006			
Post-1	68	5.279	1.816	92	2.839	0.0028
Post-2	57	5.544	2.145	81	3.378	0.0006

DISCUSSION

The investigator found no difference in pretest scores within each grade level, indicating that the control and experimental groups came from the same population (Table 1). Obviously these results are a prerequisite for the meaningful comparison of any of the between group posttest scores.

As predicted both 5^{th} and 6^{th} graders in the experimental group were able to exhibit a greater understanding of the science and math concepts covered in the unit, outperforming the control group on the cognitive portion of posttest-1 (Table 2). In addition, the 6^{th} graders in the experimental group rated science and math studies in a more favorable light than did their counterparts in the control group, indicating a positive attitude related to these subject areas. Thus, it appears that students benefited greatly by participating in the field-based program when compared to a traditional classroom program of study.

Even after twenty-three weeks from the end of the unit of study, the benefits of the field-based experimental program remained the same: 5^{th} and 6^{th} graders in the experimental group continued to outperform their peers in the control group on the cognitive portions of the test. In addition, 6^{th} graders in the experimental group viewed science and math studies in a more favorable light when compared to their classroom-taught peers (Table 3).

The results of within-group comparisons were consistent with the between-group comparisons: Posttest scores were significantly higher than pretest scores *within* experimental groups, except for 5^{th} graders in the affective portion of the test (see Tables 4 & 5). These findings further illustrate the benefits of the field-based program, using the urban park system, over the classroom program.

The lack of a significant positive impact of the field-based program on 5^{th} grade student's perception of science and math studies is perplexing. Perhaps the younger 5th graders felt uneasy about a learning environment without walls in the inner city. Maybe the weather was not favorable or there were too many flying insects on the days they visited the park (neither of these factors were recorded). Regardless of the reasons, the data did not indicate a positive change in attitude toward learning about science and math in an outdoor setting.

Although sample sizes were small and the instrument was not evaluated for reliability or validity, this pilot study strongly suggests that field-based science and math programs are superior to tradition classroom teaching strategies.

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