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The effects of environment-based education on students' critical thinking skills and disposition toward critical thinking

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This study examined the relationship between environment-based education and high school students' critical thinking skills and disposition toward critical thinking. Four hundred four 9th and 12th grade students from 11 Florida high schools participated in the study. A Pretest-Posttest Nonequivalent Comparison Group Design (9th grade) and a Posttest Only Nonequivalent Comparison Group Design (12th grade) were used. Interviews of students and teachers were used in the classic sense of triangulation. Data collection took place over the 2001–2002 school year. When controlling for pretest score, grade point average (GPA), gender, and ethnicity, environment-based programs had a positive effect on 9th grade students' critical thinking skills ($p=.002$). When controlling for GPA, gender, and ethnicity, environment-based programs had a positive effect on 12th grade students' critical thinking skills ($p < .001$) and disposition toward critical thinking ($p < .001$). The results of this study support the use of environment-based education for improving critical thinking and can be used to guide future implementation.

Introduction

Despite many years of state and national attention, legislation, and discussion, student achievement in core subject areas remains at unacceptable levels throughout the United States (National Commission of Excellence in Education, 1983; National Research Council, 1999). Various efforts are in progress to improve student achievement, including national and state standards and assessments, as well as incentives for improvement and sanctions for continued low performance. At the same time, a number of well-researched reform models and instructional strategies are

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being implemented to reorganize and revitalize schools. The use of the environment as an integrating context for learning has the potential to serve as one of these comprehensive improvement strategies.

Gerald Lieberman and Linda Hoody's 1998 study, *Closing the achievement gap: using the environment as an integrating context for learning*, suggests that students learn more effectively within an environment-based context than within a traditional education framework. According to their study, the benefits of these environment-based programs can include improved performance on standardized measures of academic achievement, reduced classroom management problems, and increased enthusiasm for learning (Lieberman & Hoody, 1998). A report by the National Environmental Education and Training Foundation (NEETF), *Environment-based education: creating high performance schools and students*, and a State Education and Environment Roundtable (SEER) study of schools in California further support the premise that environmental-based education improves academic performance across the curriculum (NEETF, 2000; SEER, 2000).

There is, however, limited research documenting a connection between environment-based education and academic achievement. To date, much of the evidence has been qualitative or anecdotal. The National Environmental Education and Training Foundation has called for more stringent research documenting improvements in student achievement and effective implementation (NEETF, 2000). Concerns regarding the use of standardized test scores and grade point averages to document improvements in learning also support the need for additional research. Although widespread, the use of achievement tests has been criticized for providing an indication of current or past achievement, rather than assessing knowledge and skills in terms of their constructive use for future learning (Glaser, 1990). Many educational researchers argue that assessments should provide information on whether or not students 'can use their current achievement to gather further information, evaluate evidence … weigh alternative courses of action, and articulate reasoned arguments and decisions' (Glaser, 1990, p. 480). In addition, some environmental educators have further questioned such a narrow measure of student learning—standardized test scores and grade point averages—which limits the ability of environment-based education to satisfy the needs of stakeholders in both the formal education community and the environmental education community.

Critical thinking skills and disposition toward critical thinking are alternative indicators of achievement, providing information on students' abilities as future learners and problem solvers. Critical thinking is the process of purposeful, self-regulatory judgment, which drives problem-solving and decision-making (American Philosophical Association [APA], 1990). At the core of critical thinking are the following cognitive skills:

- Interpretation: categorization, decoding significance, clarifying meaning;
- Analysis: examining ideas, identifying and analyzing arguments;
- Evaluation: assessing claims and arguments;
- Inference: querying evidence, conjecturing alternatives, drawing conclusions;

- Explanation: stating results, justifying procedures, presenting arguments; and
- Self-regulation: self-examination, self-correction (APA, 1990).

Beyond these core cognitive skills, a set of attributes is used to describe a person inclined to use critical thinking when faced with problems to solve, ideas to evaluate, or decisions to make. This disposition toward critical thinking can be understood in terms of open-mindedness, inquisitiveness, cognitive maturity, truth-seeking, analyticity, systematicity, and critical thinking self-confidence (APA, 1990). The basis of this construct is that it is not enough for a person to be able to think critically; the person has to be willing and inclined to use his/her thinking skills.

The goal of improving critical thinking is fundamental to American schooling, as increasingly complex societal challenges call for an improvement in the thinking skills used by decision-makers and citizens in their daily affairs (McTighe & Schollenberger, 1991). With the rapid increase of available knowledge, educators are realizing that the development of critical thinking skills is necessary to process this growing content base. Eighty percent of the teachers polled in the 1989 Annual Gallup Poll regarded the ability to think as the highest goal of education (Elam, 1989, as cited in McTighe & Schollenberger, 1991).

The goal of improving critical thinking is also fundamental to environmental educators' efforts to create an environmentally literate citizenry. In the face of complex environmental issues, environmental education does not advocate a particular solution or action, but instead facilitates a student's ability to draw on and synthesize knowledge and skills from a variety of subject areas to conduct inquiries, solve problems, and make decisions that lead to informed and responsible actions (UNESCO, 1978). Bright and Tarrant (2002) suggested that researchers can better measure the effectiveness of environmental education not by assessing environmental knowledge or perceptions regarding the truth about environmental information, but instead by examining their ability to think critically about complex issues. Thus, critical thinking and disposition toward critical thinking can be used as variables to evaluate environment-based education programs, as they satisfy interests of stakeholders in both the formal education and environmental education communities.

Research questions

The purpose of this mixed-methodology study was to examine the relationship between environment-based education and high school students' critical thinking skills and disposition toward critical thinking. The following questions were addressed in this research:

1. When controlling for pretest scores, achievement level, gender, and ethnicity, do 9th grade students who participated in environment-based education programs have higher critical thinking skills and a stronger disposition toward critical thinking than their peers in traditional instructional programs?

2. When controlling for achievement level, gender, and ethnicity, do 12th grade students who participated in environment-based education programs have higher critical thinking skills and a stronger disposition toward critical thinking than their peers in traditional instructional programs, including traditional environmental science?
3. Are any of the covariates (pretest score, achievement level, gender, and ethnicity) moderating the treatment effects or significantly influencing students' critical thinking skills and disposition toward critical thinking?
4. What program characteristics do students and teachers in environment-based programs identify as influencing critical thinking skills and disposition toward critical thinking?

Methods

Participants

Environment-based programs in 12 Florida high schools were selected for participation through operational construct sampling (finding manifestations of the theoretical construct of interest) and maximum variation sampling (purposefully picking a wide range of cases for external validity), as described by Patton (1990). Eleven programs completed the study. Environment-based programs selected met the defining characteristics of environment-based education, were in operation for at least two years, and were willing to participate in the study. In addition, these programs represented a range of socio-economic statuses and average achievement levels, as well as a range of geographic locations and program activities, which contributed to the external validity of the study. One hundred sixty-five 9th grade students and two hundred thirty-nine 12th grade students, ages 14 to 18, completed this study. These students agreed to participate and had parental permission through the consent process mandated by the University of Florida's Institutional Review Board. Participants were 42.9% male and 57.1% female; 56.5% were Caucasian, 33.2% were Non-Caucasian students, and 10.3% did not indicate their ethnicity.

Treatment

The treatment examined in this study was an established educational intervention–environment-based education. Environment-based education is a general term for describing formal instructional programs that adopt local environments as the context for a significant share of students' educational experiences. Its defining characteristics are interdisciplinary learning based on the local environment, project- and issue-based learning experiences, learner-centered instruction, and constructivist approaches. While environmental literacy is often an outcome of environment-based education, fostering student learning in all subject areas is its primary goal. A thorough

Table 1. Summary of participants

		Cornell Critical Thinking Test	California Measure of Mental Motivation
9th Grade[a]			
	Treatment	87	78
	Control	78	75
12th Grade[b]			
	Treatment	132	145
	Control	94	94

Note.
N=404.
[a]*n*=165. [b]*n*=239. (Twelve 9th grade students did not take the CM3; thirteen 12th grade students did not take the CCTT.)

description of environment-based education and its defining characteristics can be found in NEETF (2000) or in SEER (1998).

Design

To control for differences due to grade level, the 9th and 12th grade students were separated into two studies. A Pretest-Posttest Nonequivalent Comparison Group Design (Cook & Campbell, as cited in Rog, 1994) was used for the 9th grade study. Because many of the 12th grade students had participated in environment-based programs in previous years, a pretest was not possible. Thus, a Posttest Only Design with Nonequivalent Groups (Cook & Campbell, as cited in Rog, 1994) was used for the 12th grade study. The validity threat of selection differences was addressed with a pretest in the 9th grade study and through statistical controlling for pre-existing differences in achievement level, gender, and ethnicity in both the 9th and 12th grade studies. When possible, students from the same schools who were in traditional instructional programs or traditional environmental science courses served in the control group. Traditional instructional programs, including environmental science courses, lacked problem- or project-based instructional strategies, were teacher- rather than student-centered, and did not use an environmental context for integrating multiple subject areas. For schools that were unable to provide control students, schools with characteristics (average socio-economic status, average level of performance on the state assessment test, geographic setting) as similar as possible were used to provide students for the control group. (See Table 1 for a summary of participants.)

Research instruments

Cornell Critical Thinking Test

The Cornell Critical Thinking Test (CCTT), Level X (Ennis *et al.*, 1985), available

from the Critical Thinking Books and Software, was used to measure students' critical thinking skills. This test measures general critical thinking skills (as opposed to measuring only specific aspects of critical thinking or critical thinking in a specific content area), which is appropriate for the following reasons: environment-based programs' focus on fostering interdisciplinary learning; the inclusion of students who have not received the environment-based treatment in the study; and the need to justify programs to stakeholders in the formal education community, whose interest is in critical thinking is beyond that of the environmental content domain.

The CCTTX, designed for students in grades four through college, is a 76-item multiple-choice test requiring 50 minutes for completion. The items are scored '0' for incorrect responses and '1' for correct responses, yielding total test scores that could assume values between 0 and 76. Higher scores indicate higher critical thinking skills. The reliability coefficient (internal consistency) of the posttest data was .80 for the 9th grade study (n=165) and .88 (n=226) for the 12th grade study, as measured using Cronbach's alpha. The content validity of the use of the test for evaluating instruction designed to improve critical thinking was established by the test publisher as a part of the Illinois Critical Thinking Project (Ennis *et al.*, 1985).

California Measure of Mental Motivation

The California Measure of Mental Motivation (Giancarlo & Facione, 1998), available from the Insight Assessment Company, was used to measure disposition toward critical thinking. Level II of the CM3, designed for middle and high school students, is a 72-item inventory that takes approximately 20 minutes to complete. Each item has four response options, anchored by 'agree strongly' and 'disagree strongly.' Students receive a score on a scale ranging from 0 to 50, with higher scores representing a stronger disposition toward critical thinking.

Due to the scoring process required by the test publisher, item-level data were not available; thus, reliability coefficients for the data from the 9th and 12th grade students in this study could not be computed. The test publisher reports a reliability (internal consistency) range of .89 to .91, as measured using Cronbach's alpha, for scores on this instrument (Giancarlo & Facione, 1998). The CM3 was developed from the definition of disposition toward critical thinking generated through the 1990 Delphi Project, suggesting the content validity of the instrument for measuring disposition toward critical thinking (APA, 1990). Additional validity evidence provided by the test publishers is significant positive correlations between the CM3 and established measures relating to disposition toward critical thinking, including the Test of Everyday Reasoning and the Naglieri Non-Verbal Abilities Test (Giancarlo & Facione, 1998).

Quantitative procedures

All data collection took place over the 2001–2002 school year. Each school was visited to explain the data collection procedures. Teachers administered the instruments to

the 9th grade students as pretests within the first month of the school year and as posttests within the last month of the school year. Teachers administered the instruments to the 12th grade students as posttests within the last two months of the school year. In addition, information on students' gender, ethnicity, and achievement level was collected.

Qualitative procedures

The purpose of the qualitative investigation was to ensure that the participating programs met the defining characteristics of environment-based programs and to determine what students and teachers identified as factors influencing students' critical thinking skills and disposition toward critical thinking. These insights were used, in conjunction with the quantitative findings, to develop recommendations for future program implementation and further research. Consequently, the qualitative investigation was conducted exclusively with the treatment group. Each environment-based program was observed at least once for four to seven hours. Interviews were conducted with one teacher from 10 of the 11 participating programs, lasting 30–90 minutes each, according to techniques described by Lindolf (1995). The following questions were used to initiate discussion with the teachers:

1. What do you consider to be the most successful features of your program?
2. Do you think participation in this program builds students' critical thinking skills and makes them more disposed to use those skills? If the response is yes: What characteristics of your program would you identify as having the greatest impact on students' critical thinking?

Teachers were asked to select 3 to 6 'information-rich' students for in-depth interviews. Interviews were conducted with 44 students representing 10 of the 11 programs, each lasting 10–30 minutes. The following questions were used to initiate discussion with the students:

1. What do you do in this program?
2. What parts of the program do you like best?
3. Has this program helped you become a better thinker or problem solver? If the response is yes: What about this program has helped build those thinking skills or made you more likely to use those thinking skills?

Quantitative analysis and results

Multiple linear regression was used to determine if students in environment-based programs had higher scores on the CCTT and CM3 than students in traditional instructional programs, after controlling for the variance in scores due to students' initial critical thinking skill or disposition level, achievement level, gender, and ethnicity. The Type I error for each outcome variable was set at α=.05. Because each

Table 2. Summary of regression analysis for variables predicting students' critical thinking skills

Variable	b	SE	β	T	p	pr	sr
9th Grade[a]							
Pretest	0.452	0.092	.359	4.891	.000*	.361	.309
GPA	1.653	1.071	.115	1.544	.124	.121	.098
Gender	2.878	1.360	.135	2.116	.036	.165	.134
Ethnicity	5.122	1.404	.235	3.648	.000*	.277	.231
Treatment	4.331	1.360	.206	3.186	.002*	.244	.201
12th Grade[b]							
GPA	2.699	1.485	.125	1.818	.070	.121	.109
Gender	2.784	1.360	.127	2.047	.042	.136	.123
Ethnicity	3.751	1.424	.166	2.634	.009*	.174	.159
Treatment	5.544	1.516	.254	3.657	.000*	.238	.220

Note.
[a]n=165. [b]n=226.
[a]R^2=.361. [b]R^2=.195.
*$p < .025$.
pr=partial correlation; *sr*=semi-partial correlation.

outcome variable involved two inferential research questions (the effects of the treatment on 9th grade students and the effects on 12th grade students), the Bonferroni method (Cohen, 1988) was used to control for a spiraling Type I error rate. Thus, the explanatory variable, covariates, and interaction terms were tested using a Type I error rate of α=.05/2=.025. The following interactions were tested for each outcome variable before testing the significance of the treatment: treatment by pretest (9th grade only), treatment by GPA, treatment by gender, and treatment by ethnicity. Missing data was handled through excluding cases listwise.

Critical thinking skills

For the 9th grade study, the treatment was statistically significant, b=4.331, $t(159)$=3.186, p=.002 (see Table 2). These results indicate that when controlling for pretest score, GPA, gender, and ethnicity, there was a significant positive effect of the environment-based programs on students' critical thinking skills; 9th grade students in the environment-based programs score 4.33 points higher on the 76-point test than students in the control group. This effect was not a function of initial skill level (pretest), achievement level (GPA), gender, or ethnicity. While these variables were not moderating the effect of the environment-based programs, initial skill level and ethnicity were significantly influencing students' critical thinking test scores. Thus, students with higher critical thinking pretest scores and Caucasian students had systematically higher posttest scores, but the environment-based programs were not more effective (working differently) for students with higher pretest scores or for Caucasian students.

Table 3. Summary of regression analysis for variables predicting students' disposition toward critical thinking

Variable	b	SE	β	T	p	pr	sr
9th Grade[a]							
Pretest	0.767	0.056	.768	13.676	.000⋆	.747	.712
GPA	0.919	0.457	.109	2.013	.046	.163	.105
Gender	0.247	0.665	.020	0.371	.711	.030	.019
Ethnicity	0.399	0.701	.031	0.570	.570	.047	.030
Treatment	0.640	0.698	.052	0.916	.361	.075	.048
12th Grade[b]							
GPA	0.947	0.854	.076	1.110	.268	.072	.067
Gender	1.597	0.765	.130	2.087	.038	.135	.125
Ethnicity	1.050	0.806	.082	1.302	.194	.085	.078
Treatment	3.958	0.856	.318	4.624	.000⋆	.289	.277

Note.
[a]n=153. [b]n=239.
[a]R^2=.599. [b]R^2=.156.
⋆$p < .025$.

For the 12th grade study, the treatment was statistically significant, b=5.544, $t(221)$=3.657, $p < .001$ (see Table 2). These results indicate that when controlling for GPA, gender, and ethnicity, there was a significant positive effect of the environment-based programs on students' critical thinking skills; 12th grade students in the environment-based programs scored 5.54 points higher on the 76-point test than students in the control group. While GPA, gender, and ethnicity did not moderate the effect of the environment-based programs, ethnicity significantly influenced students' critical thinking test scores. Thus, Caucasian students' critical thinking test scores were systematically higher than Non-Caucasian students' posttest scores, but the environment-based programs were not more effective for Caucasian students.

Disposition toward critical thinking

For the 9th grade study, the treatment was not statistically significant, b=0.640, $t(147)$=0.916, p=.361 (see Table 3). These results indicate that when controlling for pretest score, GPA, gender, and ethnicity, there was no significant effect of the environment-based programs on 9th grade students' disposition toward critical thinking. For the 12th grade study, the treatment was statistically significant, b=3.958, $t(234)$=4.624, $p < .001$ (see Table 3). These results indicate that when controlling for GPA, gender, and ethnicity, there was a significant positive effect of the environment-based programs on students' disposition toward critical thinking; 12th grade students in the environment-based programs scored 3.96 points higher on the 50-point

inventory than students in the control group. None of the covariates were statistically significant, suggesting students' scores were not significantly influenced by GPA, gender, or ethnicity.

Qualitative data analysis and results

Data analysis consisted of analyzing the interview transcripts according to a general process of data reduction and interpretation. Inductive analysis, described by Guba (as cited in Patton, 1990), was applied to find themes or patterns, which emerged from the data. The criteria for the creation of a theme, suggested by Krueger (1998), was the frequency and extensiveness of responses, as well as the intensity and specificity of responses. As data were coded and sorted into these emerging themes, the meaningfulness and accuracy of the themes were judged by the extent to which the data that belonged in a certain theme held together in meaningful way and the extent to which differences among themes were clear.

Environment-based programs appeared to influence students' critical thinking skills and disposition toward critical thinking when they:

- *Integrated multiple disciplines using a common environmental theme.*

> We integrate five disciplines using the environment, and the benefit is that kids start to think about the connections. I can't recall hearing from my kids, 'Why are we learning this?' They know they are learning it because they see how it is applied to what's going on in the next class. They have to think about how it's related to what they've learned in the past and in what they're learning in their other classes. (Caucasian, Male Teacher)

Teachers and students consistently agreed that the using the environment as an integrating context is an important aspect of building critical thinking skills and disposition toward critical thinking. The interdisciplinary nature of the environment provided opportunities for coordinating learning between subject areas and exploring connections among natural and social systems. Further, students and teachers found the environmental context useful for blurring the lines between classroom learning and real-life applications, thus providing opportunities developing and using thinking skills through investigating the interactions among natural and social systems and the real world issues that stem from these interactions.

- *Involved open-ended projects that required hypothesizing, investigating issues, and conducting research.*

> We have to think about what we are finding from our water quality studies in this river and compare it to what we are finding in the other rivers and why we are getting differences. It makes us think about our town's main industry and pay more attention to where we live. Our town needs the industry for jobs. But we also see what's happening to the water. (Caucasian, Female, 12th Grade Student)

Students' and teachers' responses indicate the importance of learning activities that involved more than traditional teacher-centered instruction, as none of them attributed strategies such as memorization of content or classroom-focused learning as being conducive to building and encouraging critical thinking. Instead, all of the

students interviewed believed their thinking skills were improved and they were more likely to use these thinking skills when they had opportunities to be engaged in the learning process through posing and solving problems, investigating issues, and building understandings—opportunities that were learner- rather than teacher-centered.

- *Empowered students' to be responsible for their own learning.*

> It's because we, the students, plan the projects. You have to do a lot of research, and you have to know what you are talking about in order to do a project. You have to make an outline, plan everything out, and think through the whole project and what you'll have at the end. It's a lot of thinking involved. (Non-Caucasian, Female, 12th Grade Student)

The students in the environment-based programs were given the responsibility for their own learning through selecting their projects, developing goals and action plans, and making decisions regarding what data to collect, what equipment to bring, and what to do when something did not work. In several programs, students were responsible for documenting how the projects they selected and completed met state education standards, and in other programs, students developed individualized learning plans that addressed how they would learn the targeted content and skill areas. Teachers and students consistently attributed this responsibility for learning as a key factor in critical thinking, particularly in students' disposition toward critical thinking.

- *Provided opportunities for students to reflect on what they have done or learned, helping them make the connection to the real and local purpose of their efforts.*

> You know there's that saying that people learn by doing. No. People learn by reflecting on what they've done. My students have to write reflective essays, explaining why they picked the project, what they would do differently, what their partners should have done differently, and what the significance of their work is. It's the reflecting that encourages thinking and solidifies the learning. (Caucasian, Male Teacher)

Through reflective essays and verbal debriefings, teachers encouraged students to thoughtfully consider what they did and learned. All of the programs involved reflection in some format, typically going beyond verbal or written reflections and encouraging students to communicate the significance of their findings through reports, presentations, or publications to classmates and others within their schools and communities. This reflection and sharing appear to be important, as many students and teachers emphasized the key role these activities played in stimulating thinking and ultimately learning.

Discussion

The results of this research suggest students who participated in environment-based programs were more skilled in critical thinking than their peers, including peers who were in traditional environmental science classes. The data further suggest that the 9th and 12th grade students in environment-based programs had critical thinking skill levels that were comparable to or exceeded those of college students in several American universities, as reported by test norms in Ennis *et al.* (1985). The results

also indicate that one year of environment-based education did not improve 9th grade students' disposition toward critical thinking. This may be related to the duration of treatment; while 9th grade students' in the environment-based programs may have developed critical thinking skills, one year may not be enough time for them to develop an inclination to use these new skills. Multiple years of environment-based education, however, may have improved students' disposition, as 12th grade students who had participated in the environment-based programs were more disposed toward critical thinking then their peers.

Teachers' and students' perceptions of what program characteristics influenced critical thinking skills and disposition toward critical thinking suggest that the defining characteristics of environment-based education—the interdisciplinary environmental context, project-based or issue-based instruction, and the learner-centered, constructivist approaches—played a key role in the success of these environment-based programs. These findings are consistent with the research literature, which suggests building critical thinking skills by encouraging students to pose and solve problems, investigate issues, examine alternative perspectives, incorporate thinking skills across subject areas, act on what they are thinking through authentic tasks, and reflect on what they are learning (Berman 1991; Costa, 1991). These findings are also consistent with the research literature on improving disposition toward critical thinking which suggests the following:

> exposing students to situations where there are good reasons to exercise critical thinking, particularly through real-life situations; providing opportunities for students to practice critical thinking, first through situations that are artificially simple, and then culminating in situations that are realistically complex; and providing students with opportunities for the development and use of thinking skills over time and throughout the curriculum, as this tends to produce more effective thinking than unplanned or short-term emphasis (Howe & Warren, 1989; APA, 1990).

The following are recommendations for future implementation of environment-based programs, which stem from the results of this study:

- *Include students of all achievement levels in the environment-based education programs.* The effects of the environment-based programs were not a function of achievement level (as measured by GPA), indicating the treatment worked well for all achievement levels. Teachers suggested that including students of varying abilities provides lower achieving students with role models and challenging standards and higher achieving students with the opportunity for peer teaching. Teachers also emphasized the effectiveness of environment-based education in highlighting the different strengths and skills of all students, making it less obvious who the 'best' students are.
- *Structure environment-based programs so that students can participate in them for multiple years, particularly if improvements in disposition toward critical thinking are desired.* Multiple years in environment-based programs are likely needed in order for students to practice their critical thinking skills in increasingly complex situations and be able to use these skills willingly and independently.

- *Provide educators with the freedom and flexibility to choose to use environment-based education.* Each environment-based program in this study was initiated and implemented by a teacher or team of teachers and administrators, as opposed to being mandated from an external agent. According to research on school reform success, schools where educators felt they were 'forced' to adopt a reform model showed lower levels of implementation and lower levels of success (McChesney, 1998).
- *Recognize the importance of the systemic nature of environment-based education in program implementation.* Students in environment-based programs outperformed their peers in traditional instructional programs, including traditional environmental science classes. Thus, it may be that the local environment, when confined to traditional teaching methods, does not improve critical thinking. However, when combined with the other characteristics of environment-based education, an environmental context can be influential. Consequently, the environmental context is not only a good integrator of subject areas, but also a good integrator of best practices in education.

This study also raises important questions that should be answered with additional research:

- *How does program variation affect the desired outcomes?* This study involved 11 schools, each implementing environment-based education in slightly different ways. To better understand how program variation influences the outcomes, additional research is needed involving enough schools (at least 20) to use Hierarchical Linear Modeling (HLM) to capture the 'nested' situation of students within classrooms within schools. The results of the qualitative investigation suggest the following variables representing program variation for incorporation into further research: the amount of time (hours per day and number of years) students participate in the program, the selection process for participation in the program, the quality of inquiry-based activities, and the academy ('school within a school') setting. These variables, as well as other variables capturing program variation, could be incorporated into the regression equations for the HLM analyses to better predict the effects of program variation and to generate additional guidelines for future implementation.
- *What makes a teacher able and motivated to implement environment-based education programs?* Once these attributes have been determined, professional development opportunities should be designed to encourage and support these attributes in pre-service and in-service programs. Without exposure to and training in environment-based education, particularly integration of subject areas and project-based instructional approaches, new teachers and even experienced teachers may be hesitant to use this approach, and widespread implementation is unlikely.

Conclusion

While this study may not be entirely conclusive, the results are consistent with

theoretical predictions in the critical thinking literature and previous studies on the efficacy of environment-based programs (Lieberman & Hoody, 1998; NEETF, 2000; SEER, 2000). Collectively, this evidence can be used to raise awareness among the public and policy-makers of the valuable role the environment can play in improving student learning. In addition, these results can be used by teachers and administrators to justify their environment-based programs to stakeholders in the formal education community, helping assure parents, superintendents, and policy-makers that these programs can produce desired and valued educational outcomes.

This involvement in the formal school setting and education reform is not to suggest that environment-based education should replace traditional environmental education activities. The environment-based programs in these Florida high schools are improving students' critical thinking skills and helping them become more disposed toward using these skills—skills and habits that are essential to managing the increasingly complex environmental issues that face our global society. The effectiveness of environment-based programs in building other aspects of environmental literacy is, however, unknown, as these aspects are not the focus of environment-based education and were not measured in this study.

Environmental educators may instead view their involvement in environment-based education as one piece of what they do. Their support is often essential to the success of these programs, as environmental educators in agencies, parks, and nature centers can be the source of connections between teachers and students and the actual contexts, issues, and projects that become the foundation for their learning. Environmental educators can further support environment-based education through their expertise in particular environmental issues, content, or skills, and by working with students on individual or group research projects, providing teachers with professional development opportunities, and connecting programs with funding opportunities and other resources.

As the search for effective ways to improve the quality of schools continues, the results of this study are encouraging. In essence, this study highlights common ground between the formal education and environmental education communities—shared goals that can drive program development and implementation with results that are important to both groups. When the goal of improving student learning is viewed as complementary with building environmental literacy, environmental educators can help the formal education community understand that environment-based education is simply good education. This will go a long way in ensuring that, in the midst of education reform and its high-stakes standards and assessment, environmental education does not get lost in the shuffle.

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