

THE IMPACT OF ENVIRONMENTALLY-RELATED EDUCATION ON ACADEMIC ACHIEVEMENT

A Literature Survey

Nicki Norman
Anne Jennings
Lisa Wahl

Funded by:

StopWaste.Org
August 2006

Community Resources for Science

practical support for great science teaching



1375 Ada Street, Berkeley, CA 94702 • (510) 527-5212 • www.crs-science.org

LITERATURE SURVEY OF THE IMPACT OF ENVIRONMENTALLY-RELATED EDUCATION ON ACADEMIC ACHIEVEMENT

August 2006

EXECUTIVE SUMMARY	i
SECTION I: PURPOSE AND PROCESS	1
PURPOSE AND CRITICAL DEFINITIONS	1
SEARCH METHODS	2
ANALYSIS PROCESS.....	3
SECTION II: RESULTS OF LITERATURE SEARCH	7
LITERATURE SEARCH RESULTS	7
OVERVIEW OF STRONGEST RESEARCH	8
OVERVIEW OF LESS DEFINITIVE RESEARCH.....	13
OVERVIEW OF RELATED OUTCOMES RESEARCH.....	15
SECTION III: ANALYSIS	17
IMPACTS ON ACADEMIC ACHIEVEMENT	17
IMPACTS ON RELATED OUTCOMES	21
SECTION IV: FINDINGS	23
SUMMARY	23
STRENGTHENING EE'S CONTRIBUTION TO ACADEMIC ACHIEVEMENT	23
REACHING MORE STUDENTS	24
USING RESEARCH AND EVALUATION TO EXPAND EE'S POTENTIAL	25

APPENDICES

- A: STRONGEST RESEARCH
- B: LESS DEFINITIVE RESEARCH
- C: RELATED OUTCOMES RESEARCH
- D: LITERATURE COMPILATIONS AND ANALYSES
- E: ARTICLES AND REPORTS
- F: ORGANIZATIONS AND PEOPLE
- G: EDUCATIONAL RESEARCH AND EVALUATION GUIDELINES

BIBLIOGRAPHY

Executive Summary

Introduction

Environmental education program providers are eager to help teachers incorporate environmental principles and experiences into their teaching. However teachers are faced with extremely crowded schedules, strict curriculum requirements, and intense pressure to improve academic achievement. K-12 environmental education will be valued more if it is perceived by teachers, administrators, parents, and community members as contributing to academic achievement for students. The purpose of this survey was to determine whether meaningful evidence exists that shows a connection between environmentally-based education programs and improvements in academic achievement. The project was undertaken in winter and spring of 2006, and was funded by StopWaste.Org.

The survey looked for English-language documents published between 1990 and 2006 that addressed the academic outcomes of environmentally-based, K-12 education programs. Sources included websites, online databases, university libraries, peer-reviewed dissertations, and references from persons and organizations concerned with environment, horticulture, science, and education.

Results of Literature Search

There is a large body of research, meta-analysis literature, and related articles and reports about a wide variety of environmentally-based programs studying specific learning outcomes. Approximately 200 documents were discovered that fulfilled one or more of the search terms. Further review identified 100 original research papers, literature compilations, and related articles to be analyzed. Upon closer analysis, some of these documents were determined to be non-relevant materials focused on non-academic outcomes or programs that took place outside of a K-12 educational context. Some documents provided interesting meta-analyses of combined research or were descriptive articles.

A total of 24 documents contained comparable, original research data that could be used for analysis. The research documents selected for analysis focused on:

- Studies with comparable quantitative data measuring change in traditional curriculum subjects
- Or quantitative data for related outcomes that might contribute to academic achievement

Analysis of Original Research

The collective research studied a range of environmentally-related programs in schools across the U.S. and in widely different student populations (urban to rural, affluent to underserved, diverse to homogeneous). Studies were found investigating specific curriculum initiatives as well as more immersive or integrated approaches, in grades ranging from elementary to high school. Studies looked at variety of quantitative and qualitative data.

The analysis of original research documents used seven criteria: two relevance criteria to determine alignment with survey goals and five research quality criteria to determine the strength of the research. The quality criteria were informed by the Education Science Reform Act of 2002 (see Appendix G) and the work of the Department of Education and other groups to improve the quality of educational research. Applying the quality criteria to the existing body of research revealed widespread methodological flaws. Since the federal guidelines are relatively new, and the range of studies provides interesting insights into different aspects of EE programs and research approaches, this survey includes studies that cover a range of relevance and conclusiveness.

Collective Evidence of Academic Outcomes

The eight strongest studies addressed all of the criteria used for analysis. Four studies actually did statistical significance tests, meeting the more rigorous requirements for possible evidence by eliminating chance results. The other four strongest studies provided suggestive evidence because their results were still likely to be significant due to the size of the populations and outcomes reported.

These studies focused on programs that were generally longer, integrated curriculum approaches that studied natural environmental areas regularly and used a range of best educational practices. The research showed a variety of results across the targeted subject areas, with significantly positive outcomes in general:

Summary of Strongest Research

Curriculum Subject Area	Possible Evidence	Suggestive Evidence
Writing/Language Arts	2 of 2 studies positive	2 of 2 studies positive
Reading	2 of 3 studies positive, 1 of 3 studies slight negative	1 of 1 studies positive
Math	3 of 3 studies positive	3 of 4 studies positive 1 of 4 studies negative
Science	1 of 1 studies no impact	3 of 3 studies positive
Social Studies		2 of 2 studies positive

These results show meaningful evidence of positive impacts on academic achievement across many curriculum subjects as a result of environmentally-related programs using best educational practices. Results of the less definitive studies also showed positive outcomes, although the methodological shortcomings of these ten studies in terms of the guidelines for evidence indicate that their conclusions may be erroneous. Nonetheless, the continuing positive trend in these documents lends support to the overall picture.

Research showing possible evidence of academic achievement tends to study results in terms of standardized tests, the most widely established measure of academic outcomes. However, some educators and researchers question whether these tests are reliable indicators of either achievement or ability to achieve. The results of the remaining research pieces showed positive impacts on a broader set of outcomes that might contribute to academic gains, including attendance, behavior, and a range of skills from critical thinking to collaboration. While not analyzed in terms of their research quality, these studies are included in the report to illustrate the interest in and need for a deeper understanding of how to measure impacts on academic achievement and contributing behaviors and skills.

Association with Particular Characteristics and Practices

This cumulative positive trend does not necessarily mean that all environmentally-related teaching experiences will have a positive impact on academic achievement. The results show strong correlation with many different educational best practices, revealing the complexity of proving a causal relationship for any overall approach involving multiple factors.

The one exceptionally strong study that looked at a broader set of data to isolate causal relationships did find that the environmental nature of the experience was a significant factor in the positive academic outcomes measured. Additionally, all of the programs showing strong results used natural environments regularly. Some other teaching practices that were more frequently associated with

suggestive results in this analysis include: project-based, interdisciplinary teaching that uses learner-centered, constructivist methods in both cooperative and independent experiences. Some teacher support practices, including training, curriculum, collaborative planning and teaching, and facilitating community involvement, were also commonly mentioned in strong research descriptions.

Findings and Implications

Based on the literature surveyed here, there are four main findings:

- There is meaningful evidence that environmentally-related education, using best educational practices, can increase academic achievement across curriculum subjects.
- Study of natural environments can be a significant factor in academic achievement gains
- Certain teaching practices and teaching support in EE programs appear to strengthen academic outcomes
- More and better research is needed to reach conclusive results and verify the most important practices and support.

The results of this literature analysis can be used to build the capacity of the environmental education community both to reach K-12 students and provide stronger support for academic achievement. The survey indicates that the study of natural areas combined with best teaching practices and teaching support can improve academic performance. The challenge to us all – community, businesses, school districts, EE providers and classroom educators – is to make use of that potential for our students by: 1) using best teaching practices and support, 2) reaching more students, and 3) building our understanding of the important factors that produce academic achievement. The literature analysis suggests a variety of actions that could be taken in these three areas. These actions are summarized briefly below and explained more fully in “Findings”, Section IV of the report.

Strengthening EE’s Contribution to Academic Achievement

The EE community can strengthen the academic contributions of their programs in several ways:

- Follow current educational research and incorporate best practices where possible:
 - use of natural environments for longer, interdisciplinary teaching
 - cooperative, project-based learning
 - inquiry-based, learner-centered teaching
- Extend the contribution of shorter programs with teacher-based extensions that use best practices, links to other EE programs, and involving the community

Reaching More Students

More students need access to this potential for academic improvement. A key proposition of this study is that research-based results can help influence school decision-makers about incorporating EE programs and curriculum. Suggestions for reaching more students include:

- Build community awareness and confidence in connections between EE, best practices, and achievement by sharing credible research and evaluation that meets federal guidelines
- Develop program descriptions that focus on academic outcomes that are important to educators and show credible relationships between program practices and these outcomes.

- Make it easier for schools and educators to use EE programs with research-based teacher support, flexibility in program design, and response to previously identified barriers to EE (confidence, funding, administrative support, materials)

Using Research and Evaluation to Expand EE's Potential

In addition to programmatic implications, this study also points to the need for additional research that investigates further questions in depth, while improving the quality of research and evaluation methods in response to guidelines from the Department of Education and other agencies. It will be important for the field to improve both the relevance (what is studied) and the significance (methodologies applied) of EE studies. In addition, the community in general, and educators in particular, must improve their ability to use research results effectively.

- Deepen understanding of links between EE, specific practices and academic achievement
 - Do more evaluation and research causal relationships
 - Programs and administrators must work together to evaluate academic as well as other outcomes of environmentally-based education.
 - Develop broader range of accepted tools to measure academic achievement and skills.
- Contributions to relevance include studies that:
 - Select outcomes to study based on information needs
 - Address factors that might affect outcomes to reduce error and identify strong practices
 - Choose appropriate data collection tools, using accepted, standardized instruments where possible.
 - Study impacts of shorter-term interventions and sustainability of results
- The significance of studies may be improved by consulting education research guidelines (Appendix G), and incorporating:
 - Carefully matched test and control groups, studied over time
 - Extended length and/or breadth of studies to allow for statistical analysis
 - Isolation of specific variables (program experiences or characteristics) for targeted testing, including baseline conditions of study population
 - Complete descriptions of research methods and conditions, including characteristics of test and control groups, differences between test and control teaching experiences

In order to develop a basis for specific, targeted research, it would appear to be most beneficial for EE programs to consider developing partnerships with specific programs or schools in order to test longer interactions over time and in the context of a range of environmental and/or academic goals.

LITERATURE SURVEY ON THE IMPACT OF ENVIRONMENTAL EDUCATION ON ACADEMIC ACHIEVEMENT

SECTION I: PURPOSE AND PROCESS

Purpose and Critical Definitions

In the face of continuing efforts to reach basic curriculum goals for public school students, the ability to support academic achievement, as well as accomplishing the goals of environmental education, is an important part of gaining access to public schools. Many individual studies have been undertaken by individual programs, environmental education organizations, school reform initiatives, and educational institutions to look at the outcomes of different programs related to the environment in some way. In addition to documenting support for main curriculum goals, looking at the outcomes, best practices, and research approaches in these research projects can improve the practice of environmental education.

Community Resources for Science (CRS) was asked by StopWaste.Org to complete a literature survey of research that attempted to measure the impact of environmental education on academic achievement. The purpose of this survey was to determine whether there was sound evidence that environmental education could support academic curriculum goals and to identify program trends that could inform the environmental education programs in Alameda County. CRS undertook this work in a three step process:

- 1) Collecting a broad group of research results that study the connections between environmental experiences and academic achievement;
- 2) Reviewing the research for both relevance and quality; and
- 3) Analyzing the outcomes in order to provide recommendations for ongoing programs and to support opportunities for further research or analysis.

The search was conducted on literature published in the English language from 1990 to the present. Search parameters were defined quite strongly in terms of the academic experience: studies were selected about environmental education experiences offered to K-12 students during the school day. Academic achievement was also defined strictly in terms of measurable change in test scores in curriculum subject areas (i.e. math, language arts, social studies, science).

By contrast, environmental education (EE) was defined quite broadly to include: environmental education, place-based education, environment as an integrating context for overall education, garden-based education, and other outdoor experiential or hands-on education. Because these terms are often used interchangeably, but have distinct meanings for people in the field, it is worth taking the time to describe their unique characteristics.

Environmental Education: During the 1970's two different United Nations conferences held in Belgrade, Serbia, and Tbilisi, Republic of Georgia, defined EE as a learning process that:

- Increases people's knowledge and awareness of the environment and associated challenges.
- Develops the necessary skills and expertise to address the challenges.
- Fosters attitudes, motivations, and commitments to make informed decisions and take responsible action.

The National Project for Excellence in Environmental Education, an initiative of the North American Association for Environmental Education (www.naaee.org), defined the overall educational goal of environmental literacy in terms of four facets:

- Personal and civic responsibility.
- Knowledge of environmental processes and systems.
- Skills for understanding and addressing environmental issues.
- Questioning and analysis skills.

By these definitions, EE is focused on building knowledge, skills and attitudes that will lead to responsible action. EE is delivered in a variety of formats and specific focuses by both informal education programs and classroom teachers. Writing about best practices in environmental education brings in ideas of different teaching approaches or pedagogies such as using outdoor settings, focusing on issues relevant to the learner, inquiry-based experiences, interdisciplinary skills, and supporting standards-based curriculum. (Archie, 2001) (The National Environmental Education Advisory Council, 2005)

Environment as an Integrating Context (EIC): Attention to pedagogy and an increased focus on academic outcomes possible through study of the environment has come to the forefront for some researchers and practitioners. Using the Environment as an Integrating Context for learning (EIC) is a term coined by the State Education and Environment Roundtable. As defined in SEER publications, EIC-based learning is “not primarily focused on learning about the environment, nor is it limited to developing environmental awareness.” (Lieberman and Hoody, 1998) EIC uses natural and community settings to engage students while applying some fundamental educational strategies: interdisciplinary instruction, hands-on experiences combined with problem solving and project-based activities, a team teaching approach, student-centered, constructivist methods that adapt to individual student skills and abilities, and a combination of independent and cooperative learning experiences.

School Gardening/Schoolyard Habitat Projects: The School Gardening movement is an outgrowth of EE, encouraging teachers in urban schools to develop an outdoor classroom within school grounds as a setting for learning across the curriculum while building student awareness and stewardship of the natural world. More than 1,000 schools nationwide have joined the Garden in Every School Registry maintained by the National Gardening Association. Another 1,100 schools have launched Schoolyard Habitat projects, organized by the National Wildlife Federation. (Boss, 2001)

Place-Based Education: Place-Based Education is a newer term that encompasses EE in a similar fashion to EIC. It includes investigation of surrounding bioregions, concern for the local human and natural environment, and may consider the geography, ecology, sociology, politics and other dynamics of a region. Place-Based Education is experiential and multidisciplinary. (Woodhouse & Clifford, 2000)

Experiential/Project-Based Learning: These terms describe teaching strategies that range from individual hands-on activities to long-term, cross-curriculum projects addressing specific questions or issues. Project-based learning often uses the environment or local issues to engage students, but is not restricted to outdoor settings or environmental topics. It is a strong teaching technique with an issue-based, inquiry-based, and interdisciplinary approach similar to the pedagogies used in place-based education and EIC programs.

Search Methods

The literature search looked first for any abstracts, articles, dissertations, reports, and other documents reporting original research on the relationship of school day environmentally-based education practices to academic achievement in curriculum subject areas. This research also incidentally produced a second group of studies focused on outcomes that might contribute to academic achievement, such as building a willingness to learn or critical thinking skills.

References were obtained from websites, online databases, university libraries resources, and from persons and organizations concerned with environment, horticulture, science, and education.

Databases included:

- Dissertation Abstracts (Index to Theses, WorldCat, and ProQuest Digital Dissertations)
- Education Full Text (Wilson Web)
- Educational Resource Abstracts/ Taylor & Francis Online Journals
- ERIC- Education Resources Information Center
- HighBeam Research

Search words used included “environmental education”, “outdoor education”, “place-based education”, “school gardening”, and “project-based learning”, combined with “achievement” and/or “evaluation”. Published journal articles that are not currently available in electronic form were researched through the Biological Sciences Library at the University of California, Berkeley. Personal requests for references were made to people and organizations involved in environmental education both locally and nationally.

Analysis Process

Selecting Documents for Review

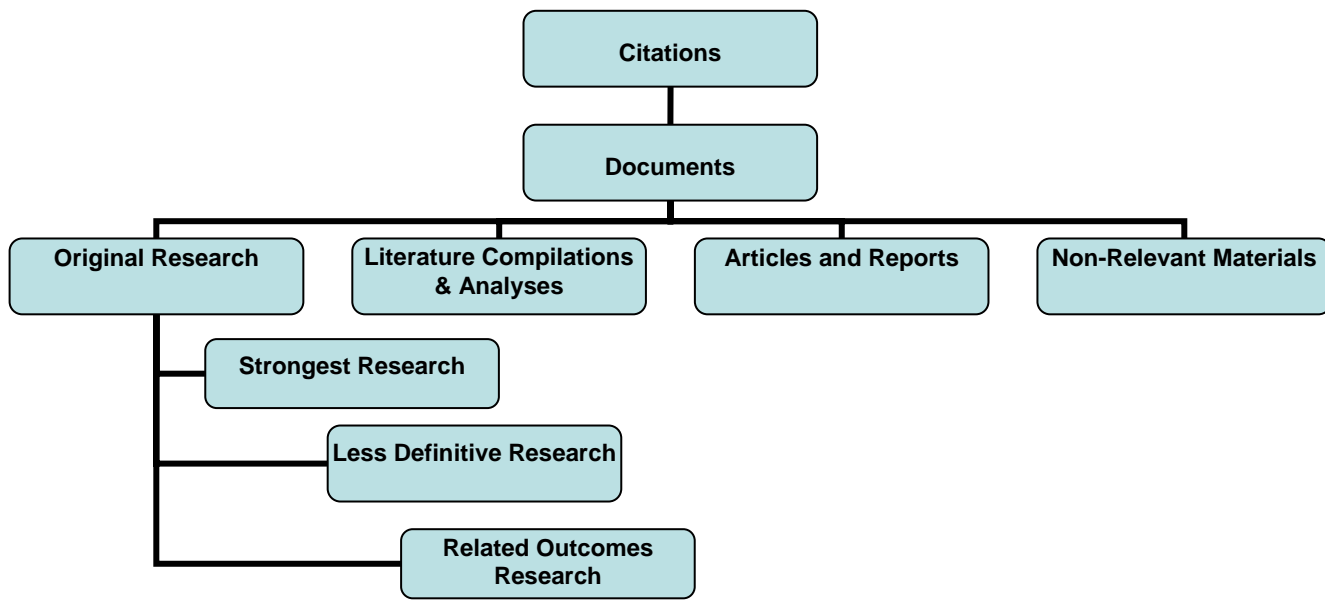
Approximately 200 citations were collected in an initial search, and 100 documents were selected as potentially relevant for review. These documents were initially sorted into four groups: 1) original research, 2) literature compilations and analyses, 3) related articles, and 4) unrelated materials. All of the documents reviewed are listed in the complete bibliography to provide context for the results.

Original research consists of analytical studies that connect environmental experiences and academic achievement. These studies are the primary focus of this survey, and are further divided into categories of “strongest research”, “less definitive research”, and “related academic outcomes research”, based on review criteria for both relevance and quality.

Literature compilations and analyses were used primarily as resources for references to original research documents, since methods and focus in these overview documents varied widely from our search parameters and research guidelines. Meta-analyses and overviews were also used for insight into trends and practices in environmental education.

Articles and reports provide additional context for the results of the survey, but do not provide specific results or analysis.

Non-relevant materials were focused on non-academic outcomes, after-school or summer programs, or were otherwise unrelated to the search parameters.



Review Criteria for Original Research

The original research documents discovered by the survey were reviewed to sort the studies into the three research categories shown in the diagram above. Review criteria were developed to look at both the *relevance* of the study to the search directives and the *quality* or strength of the research results.

In order to look at the evidence related to support for academic achievement through the same lens as educators and administrators making decisions about environmental education, the review focused on *two relevance criteria*:

1. Studies of changes in academic achievement as measured by widely-used standardized tests in core curriculum areas: writing, reading, math, science, or social studies.
2. Studies of programs that were delivered as part of a K-12 school program.

Any documents, including research, which did not meet the relevance criteria were added to non-relevant materials.

The *quality criteria* were guided on the standards for evidence-based research listed in H.R. 3801, the Education Sciences Reform Act of 2002 (Appendix G). The U.S. Department of Education, the Institute of Education Sciences, The National Center for Education Evaluation and Regional Assistance, and the National Science Foundation have all been involved in efforts to clarify how to use scientifically-based research methods to improve education research and practice. The key idea is to be able to identify clear causal relationships using methods of data collection and analysis that can be understood by peers and outside experts. The *five quality criteria* used in this literature review were developed from a combination of the original legal language in H.R. 3801 and the work of these agencies:

1. Research used randomized control or other technique to avoid group bias
2. Peer-reviewed report contains description of intervention and participants
3. Study included at least 300 students or 50 classrooms/schools
4. Study used valid outcome measures related to conclusions (standardized tests)
5. Study performed statistical tests on significance of impact measured (size/chance of impact)

There are two practices in these criteria, randomized control studies and statistical analysis, which are often missing in educational research and had to be more carefully considered in this survey.

Randomized control studies are studies that randomly assign individuals to an intervention group or control group in order to measure effects of an intervention. In the studies reviewed in the literature search, two principal techniques were used to address the requirement for randomized control trials: large scale studies of relative performance change over time within test and control populations with acknowledged differences (achievement gap analysis), or direct comparisons of performance between EE student test groups and closely matched non-EE student groups. The best research of this latter type made strenuous efforts to ensure comparability of test and control groups through correlation with demographics, past test scores, location, and socio-economics factors. However, it is important to note that results from matched comparison studies can differ widely (and even contradict) results with randomized controls. Because of the strong effect of self-selection in education programs, outcomes are often less convincing from a scientific perspective.

Statistical analysis is used to determine whether results are “significant” rather than the result of chance or random variation. The best studies reviewed in this survey applied statistical tests and/or regression analysis to look at the size of the impact in context, eliminating chance and sometimes identifying other statistical correlations that indicated stronger explanations. It is important to point out that some researchers noted that their efforts to secure funding to do the additional statistical analyses on initial results were not successful.

Applying the quality criteria to the existing body of research revealed that there are few studies in environmentally-related education that use either randomized control trials or statistical analysis to evaluate the significance of the impact of EE experiences. Rather than eliminate interesting studies that did not completely meet the standard, we used our relevance and quality factors as guidelines to help us create three groups for analysis: 1) strongest research, 2) less definitive research, and 3) related outcomes research. Relevant research documents that contained missing, non-quantitative, or non-comparable data were considered non-comparable research and were included in the report as related articles and reports.

The strongest research includes the studies that came closest to the seven listed review criteria, with at least partially positive answers to all of the seven review criteria.

Most of the less definitive research had one or more of the following flaws:

- Measured only a subsection of academic curriculum or particular skill
- Focused on a small study populations (fewer than 300 test subjects)
- Had limited description of intervention or participants, and/or
- Used a unique or non-standardized test to gather data

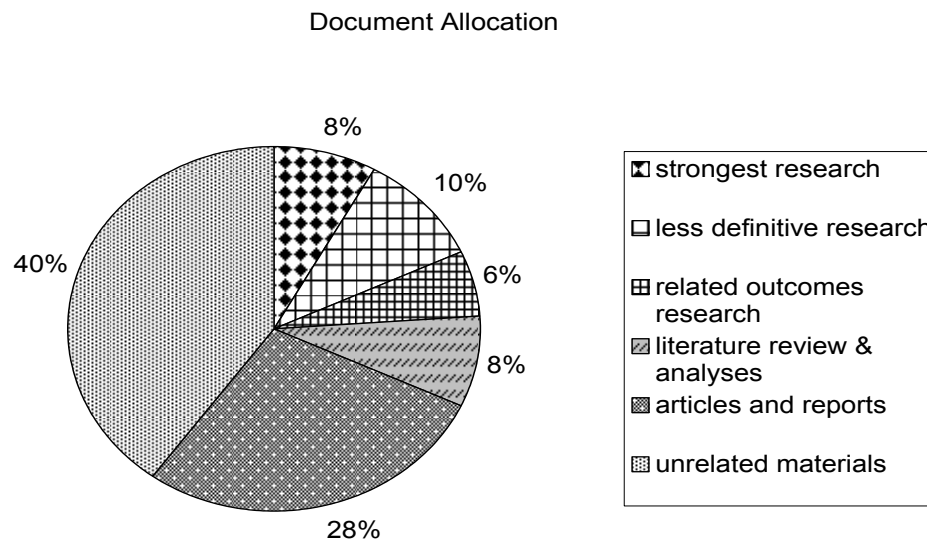
The related outcome research is comprised of studies that were discovered while searching for studies on environmentally-based programs' impacts on academic outcomes in specific curriculum areas. These studies focus on outcomes in related areas that might be contributing factors to academic success such as willingness to learn or attendance. It is important to note that since these contributing factors were not the main focus of this survey, the included list is not comprehensive in this category. This research was summarized, but not used in the findings, since the actual academic outcomes are not measured.

SECTION II: RESULTS OF LITERATURE SEARCH

Literature Search Results

Document Allocation

Using the criteria described above, a total of 86 of the 100 documents were analyzed to inform our conclusions. The remaining 14 were found to be unrelated materials. The 24 pieces of original research were reviewed using the criteria described in the previous section. Of the 24, eight studies fell into the strongest research category, providing meaningful results about the academic outcomes of environmentally related education. These studies are described briefly in this section and in more detail in Appendix A. A total of ten studies were determined to be less definitive when compared to the review criteria and six concentrated primarily on other outcomes that might have an impact on academic achievement (such as motivation to learn, or critical thinking skills, or attitudes toward science). An overview of the less definitive research and related outcomes research is included below and the studies are summarized in Appendices B and C respectively. The 35 remaining research documents did not provide comparable data, lacking the descriptions and/or data necessary for analysis. These documents are included in the bibliography as background.



The rest of the documents reviewed in the literature search are described in [Appendix D: Literature Compilations and Analyses](#), and [Appendix E: Articles and Reports](#). These documents summarized and interpreted original research documents for a variety of different outcomes and with varying levels of research rigor. While for the purposes of this survey these studies were used primarily as references to find existing research, they are included here for background and different insights into research needs and best practices. Some organizations and people who provided useful reference points in the environmental education field are listed in [Appendix F: Organizations and People](#).

Survey Summary

The strong message from the breadth of studies discovered by the search is that there are widespread efforts at making strong connections between environmental education and academic achievement. From the smallest evaluation study to the most comprehensive and longitudinal research, investigators are working to establish causal relationships and to understand factors for “successful” in-school environmental education. Studies were found from states across the U.S., investigating specific curriculum initiatives as well as more immersive or integrated approaches, in grades ranging from elementary to high school, and in students of diverse populations from a range of socio-economic backgrounds. Moreover, the focus of this literature survey on K-12 in-school programs and academic outcomes related to standardized tests limits the results within a much larger field. Almost all the studies collected for this survey show positive connections, leading readers to conclude that EE may provide a powerful vehicle for improving academic achievement.

However, despite the substantial number of studies making positive connections between EE and academic achievement, this survey also points to methodological shortcomings in many of the studies that make the conclusions less substantive. As noted in a report to Congress on the Status of Environmental Education in the United States, “a significant body of research exists on various aspects of environmental education, including: the effectiveness of environmental education in improving student achievement and meeting education reform goals. The scope of this research, however, tends to be limited (particularly in terms of focus, methodology, geography, and populations), leaving gaps in what is truly known about the field.” (NAAEE, 2005)

Overview of Strongest Research

The survey found eight research documents that at least partially met all seven of the relevance and quality criteria. These studies ranged from a curriculum-based program lasting less than a year for one grade level to long-term studies of K-12 schools using the environment as a vehicle for integrated, project-based teaching. These projects encompassed a wide variety of teaching practices and teacher support techniques and used different methodologies to measure their results. An overview of the strongest research projects is provided in [Table 1: Overview of Strongest Research](#). The table lists the research author and title and describes the participants, program being studied, and research quality in relation to the quality criteria.

Of these eight, four studies performed the statistical analysis necessary to show “possible evidence” that their results are significant: Bartosh 2003, Clavijo 2002, Danforth 2005, and Lieberman et. al 2005. Statistical analysis is a key part of the scientific research guidelines outlined by the U.S. Department of Education based on the Education Science Reform Act of 2002. The other four (Emekauwa 2004-AK, Emekauwa 2004-LA, Lieberman et. al. 2000, and Sterbinsky 2002) contain methods that could lead to erroneous conclusions, but are still strong enough to provide “suggestive” results.

The studies showed meaningful, predominantly positive academic outcomes related to the environmentally-based programs that they studied as shown in [Table 2: Academic Outcomes Measured in Strongest Research](#). The particular curriculum areas measured varied in terms of the goals of the program and the particular test instrument used.

Table 1: Overview of Strongest Research

[Research producing possible evidence that meets survey criteria or suggestive evidence]

Research Author	Participants/ Age Tested	Program Experience	Research Methodology and Strength
<p>Bartosh 2003 <i>Environmental Education: Improving Student Achievement</i></p>	<p>K-12, Washington</p> <p>77 paired EE and non-EE schools, 700 students/school</p> <p>47 elementary schools</p> <p>21 middle schools</p> <p>9 high school</p> <p>5 years multiple curriculum test data over multiple grades</p>	<ul style="list-style-type: none"> ▪ Environment-based 5 yr programs, with > 20% of teachers ▪ Receive EE more than 33% of year, and regular use of natural areas ▪ Variable integration ▪ Project-based, constructivist, inquiry, cooperative/indep ▪ EE training, collaborative planning <p>Community support</p>	<p><u>Possible Evidence</u></p> <p>5 years quantitative test data from two statewide annual tests over very large group of carefully matched pairs. Statistical and longitudinal tests showed significant results. Extended analysis of extensive qualitative data showed clearer causal relationships with broad range of factors.</p>
<p>Clavijo 2002 <i>The Impact of Environmental Education of 6th Grade Science Achievement</i></p>	<p>K-6, Kentucky</p> <p>4 elementary, 3 middle schools</p> <p>Testing 5th & 6th grade science performance of students in EE and non-EE schools;</p>	<ul style="list-style-type: none"> ▪ Environment as a context for science learning ▪ At least 2 years experience, regular use natural areas ▪ Project-based, inquiry, and problem solving ▪ Focus on local issues ▪ Broad support in school 	<p><u>Possible Evidence</u></p> <p>Analyzed change in science scores compared with previous performance of same students in 4th grade. While test did not eliminate all factors with randomization, some contributing factors were addressed in analysis and matching, including earlier science knowledge and socio-economic status. Applied statistical tests for significance.</p>
<p>Danforth 2005 <i>An Evaluation of NWL's Schoolyard Habitat Program-Houston</i></p>	<p>4th grade, Houston.</p> <p>3 paired elementary schools; matched by demographics</p> <p>306 students in Schoolyard Habitat Program</p> <p>108 students traditional</p> <p>Testing 4th grade reading and math performance on statewide tests.</p>	<ul style="list-style-type: none"> ▪ EE elementary class program ▪ Less than one year, based on outdoor study ▪ Variable integration, stronger math connection ▪ Project-based, problem solving ▪ Local habitat improvement ▪ Curriculum and training 	<p><u>Possible Evidence</u></p> <p>Measured relative changes between students' 3rd and 4th grade data in matched school pairs. Study used data from pretest, posttest, statewide achievement tests, and attendance records. While pair matching may introduce some error, statistical analysis demonstrated that results were significant.</p>
<p>Emekauwa 2004. <i>The Star with My Name - Alaska</i></p>	<p>K-12, Alaska</p> <p>18,982 students in 176 schools, 90% of state's native Alaskan students</p> <p>Testing math performance at 8th, 10th, 11th grade compared to 28 other non-AKSRI rural schools and total Native Alaskan student population</p>	<ul style="list-style-type: none"> ▪ Place-based, systemic initiative, 10 years ▪ regularly studied environment ▪ Integration with emphasis on cultural and scientific subjects ▪ Inquiry-based, project-based, career & role models ▪ Culturally relevant, strong community involvement, collaborative teaching ▪ Curriculum development and training 	<p><u>Suggestive Evidence</u></p> <p>Comparing relative change in math performance between targeted test group and other rural schools and total Native Alaskan student population (gap analysis). Although no statistical analysis and some possibility of method error, the large population in the study, the focus on changes within populations, and size of the increases sustained over time suggest that results are significant.</p>

Research Author	Participants/ Age Tested	Program Experience	Research Methodology and Strength
Emekauwa 2004 <i>They Remember What They Touch - LA</i>	K-8, Louisiana 2000 students, in 5 middle or elementary schools Testing 4th grade math, science, social studies performance	<ul style="list-style-type: none"> ▪ Place-based, 3 year, systemic program ▪ Study of local natural areas ▪ Variable integration across subject, starting in math and science ▪ Hands-on, small projects ▪ Local place connection ▪ Training, modeling, mentoring for teachers 	<p><u>Suggestive Evidence</u></p> <p>Study compared changes in % of students with unsatisfactory performance over 3 years with state-wide changes (gap analysis). Although no statistical analysis and some possibility of method error, the large population in the study, the focus on changes within populations, and size of the increases sustained over time give strong indications that the results are significant.</p>
Lieberman, Hoody & Lieberman, 2000 <i>CA Student Assessment Project</i>	K-12, California 8 paired programs or schools classes Tested at 3 successive years in different grades depending on school; multiple curriculums with variety of tests	<ul style="list-style-type: none"> ▪ EIC school or class programs, at least 3 year ▪ Regularly study local environment ▪ Varying curriculum and integration ▪ Project- and issue-based, constructivist, cooperative/independent ▪ Collaborative teaching 	<p><u>Suggestive Evidence</u></p> <p>Compared performance of matched pairs on variety of standardized and non-standardized tests over a three-year period, totaling times EIC outperformed traditional programs. Analytical approach and lack of statistical analysis make significance of results less certain, but still suggestive.</p>
Lieberman, Hoody & Lieberman, 2005 EE student achievement	K-5, California 3500+ students in 4 paired k-5 schools Tested a total of 20 times for multiple curriculum areas over 5 years at grades 2, 3, 4	<ul style="list-style-type: none"> ▪ EIC school programs, at least 5 years ▪ Regularly study local environment ▪ Varying integrated curriculum ▪ Project- and issue-based, constructivist, cooperative/independent Collaborative teaching, authentic assessment	<p><u>Possible Evidence</u></p> <p>Compared performance of API matched pairs on standardized tests over a five-year period, totaling # of times EIC students scored significantly higher based on statistical analysis. Collected qualitative data to compare instructional practices.</p>
Sterbinsky 2002 Rocky Mtn Expeditionary School	3-12, Colorado 300+ students self-selected for EE compared with adjusted test scores in feeder schools. 54 test results for 3 rd through 10 th grade with state standardized tests for multiple curriculum areas over 5 year period	<ul style="list-style-type: none"> ▪ Outdoor Learning program, long term, multiple years ▪ Routinely study natural environment ▪ Integrated curriculum ▪ Project-based 	<p><u>Suggestive Evidence</u></p> <p>Compared scores on state achievement tests of RMSEL students with scores of weighted control group to adjust for differences in RMSEL and feeder group student populations in terms of previous achievement. Although analytical approach and lack of statistical analysis make significance uncertain, results are suggestive due to size of group and sustained results.</p>

Table 2: Academic Outcomes in Strongest Research

Possible Evidence from Strongest Research						
Research Author	Writing	Reading	Math	Science	Social Studies	Summary Results
Bartosh 2003	<u>Positive</u> EE schools <i>significantly</i> better than paired school in 56 of 77 pairs	<u>Positive</u> EE schools <i>significantly</i> better than paired school in 51 of 77 pairs	<u>Positive</u> EE schools <i>significantly</i> better than paired school in 50 of 77 pairs			EE outperformed non-EE in <u>math, reading, writing, listening</u> in one test; and <u>math and reading</u> on 2 nd test.
Clavijo 2002				<u>No Impact</u> No correlation with any difference in science achievement		No correlation with EE. Earlier science knowledge and socio-economic status were significant predictors in later performance in <u>science</u> .
Danforth 2005		<u>Negative</u> Overall drop in test and control groups, but slight added negative correlation for tested environ program.	<u>Positive</u> Significant gain when compared to students in traditional program			Negative results in <u>reading</u> for all with slight negative impact correlation demonstrated for total test group* Significant, positive improvement in <u>math</u> scores. <i>*some indication of slight positive impact for African American students, but significance unclear.</i>
Lieberman Hoody & Lieberman2 005	<u>Positive</u> EIC groups significantly higher in 40% of tests, while control only scored significantly higher in 5% of tests.	<u>Positive</u> EIC groups significantly higher in 46% of reading tests, while control only scored significantly higher in 0% of tests.	<u>Positive</u> EIC groups significantly higher in 48% of math tests, while control only scored significantly higher in 8% of tests.			EIC students scored significantly higher on more state tests in <u>math, reading and writing</u> .
Suggestive Evidence from Strongest Research						
Emekauwa 2004. <i>The Star with My Name - Alaska</i>			<u>Positive</u> significantly closed gap in top math performance vs. other rural schools and whole native population (11.7% to .8%			Over 7 years AKRSI schools had large net gain over non-AKRSI rural schools in the percentage of 8th graders scoring in the upper quartile on <u>math</u> Also outperformed state's Alaska Native population as a whole.

Suggestive Evidence continued

Research Author	Writing	Reading	Math	Science	Social Studies	Summary Results
Emekauwa 2004 <i>They Remember What They Touch - LA</i>			<u>Positive</u> High relative decrease in unsatisfactory performance in math vs. state-wide scores. <i>14.1 pt decrease vs. 3.6 pt drop state-wide</i>	<u>Positive</u> High relative decrease in unsatisfactory performance in science vs. state-wide scores. <i>8.1 pt decrease vs. 3.7 drop state-wide</i>	<u>Positive</u> High relative decrease in unsatisfactory performance in science vs. state-wide scores. <i>11.3 pt decrease vs. 3.2 pt drop state-wide</i>	Over 3 year program, test schools in parish had at least double the statewide decrease in percentage of 4 th grade students scoring unsatisfactory on state tests in <u>math, science and social studies.</u>
LiebermanH oody & Lieberman2 000 <i>CA Student Assessment Project</i>	<u>Positive</u> EIC schools outperformed traditional paired group in 69 of 71 language arts assessments (76%) (Mix of standardized and non-standardized)	See writing.	<u>Positive</u> EIC schools outperformed traditional paired group in 17 of 27 math assessments (63%) (Mix of standardized and non-standardized)	<u>Positive</u> EIC schools outperformed traditional paired group in 7 of 11 science assessments (64%) (Mix of standardized and non-standardized)	<u>Positive</u> EIC schools outperformed traditional paired group in 8 of 11 social studies assessments (73%) (Mix of standardized and non-standardized)	Positive results in <u>language arts, math, science and social studies.</u>
Sterbinsky 2002 Rocky Mtn Expeditionary School	<u>Positive</u>	<u>Positive</u>	<u>Negative</u> RMSEL test group did less well than traditional schools in math.	<u>Positive</u>		RMSEL students do slightly better than the comparison group in <u>reading, writing, and science.</u> RMSEL test group did less well than traditional schools in <u>math.</u>

Only two of the strongest research studies, Bartosh 2003 and Clavijo 2002, extended their analysis beyond the statistical significance of the environmental experience to look at other factors that might have influenced the outcomes. Clavijo, 2002, found that previous scientific knowledge as measured by previous test scores of the same students and socio-economic factors had a more significant impact on academic gains than the program experience.

Bartosh did a full statistical analysis on an extensive set of quantitative and qualitative data for 77 carefully matched pairs of schools in Washington State, including five years of standardized test data. Bartosh went on to analyze the similarities and differences between the school pairs in order to identify critical differences that might be related to the positive outcomes measured. In summary, the strongest causal factors for the better performance of the EE schools appeared to be the environmental aspect of the experience, the specific EE training for teachers, and a belief that the chosen teaching approach was valuable by the teachers, administrators, and community.

Bartosh’s longitudinal analysis also indicated that the scores for both EE and control schools were rising over time, showing the positive impact of some shared factors. The analysis of qualitative data showed that the test and control school were similar in terms of their: student and teacher characteristics, teaching and planning practices, and policies and needs that affected the practice of EE in the classroom. The similarities in some key teaching practices such as amounts of integrated teaching, collaborative planning and teaching, and project-based and constructivist approaches, may account for the parallel increases in academic outcomes for both the test and control groups.

Overview of Less Definitive Research

The ten studies that fell into the category of less convincing research on academic achievement are summarized in Appendix B. The significance of these studies is limited by research methodology, insufficient background information on the experiences or groups tested, or size of the study sample. As shown in Table 3 below, all of these studies assert that different kinds of environmentally-related experiences can have a positive impact on academic achievement in core curriculum areas. Six of the ten studies are longer-term programs and four are shorter units lasting three months or less. There are a variety of program descriptions, but the uneven program information in these reports makes comparison of pedagogical practices difficult. However, nine of the ten studies mention hands-on or project-based experiences and four refer to EIC or integrated curriculum approaches. Seven of the ten studies involve learning in natural settings.

Table 3: Overview of Less Definitive Research

Author, year	Type program	Size of test group/age	Impact on Academic Achievement
Abrams, 1999	3 yr variable hands-on experiences & integration, EE curriculum, training and resources, regular use of natural environment.	4 schools of 11 completed data 4 th grade	Saw different increases in percent of 4 th grade students meeting/exceeding standards at four schools, principal impact in <u>writing</u> , slight impacts in <u>math</u> , <u>reading</u> . Behavior/attendance.
Basile, C.G., 2000	7 week unit with walk, looking at ability to transfer knowledge.	45 students Primary	Positive impact on ability to transfer procedural knowledge (process skills) Non-standardized test

Beard, L. J., 1998	3 yr outdoor classroom experience, hands-on, interdisciplinary	104 students	EE group mean score in ITBS (<u>std state test</u>) significantly higher
Blake, A. (2004)	Unit linking rock cycle with recycling program, studying limited content and use of analogy method	60 students Upper Primary age	Students showed gains in specific <u>earth science</u> content targeted. Non-standardized test.
Falco, E., 2004	EIC program, One year study of impact on GPA for groups of students	1400 students 5 th through 8 th grade	Suggestive results of large <u>GPA</u> increases within same group of students. More information needed.
Hitz, W. H Jr., 2000	Study of three month project-based instruction in math looking at immediate testing scores and later testing	95 students 10 th grade	Traditionally taught students showed higher <u>math</u> scores on immediate tests, but project-based student had greater level of retention after three weeks. Non-standardized tests.
Klemmer, C. D., Waliczek, T. M., & Zajicek, J. M., 2005	Study of impact of school garden program on science achievement looking at comparative performance on state test between test and control groups. Integrated curric, project-based	647 students 3 rd , 4 th , 5 th grades	Measured statistically higher science test results for students participating in hands-on gardening. Results limited by unmatched test and control groups, lack of information about demographics and other factors, and comparison of only post-experience tests across these different groups.
Parish, D. & Phillips, G., 2005	Used Science Knowledge Scale to test for educational impact of one yr hands-on EE programs on at risk ELL students	255 students 6 th grade	Results suggest positive impacts on <u>science</u> knowledge. Lack of control group and study methodology reduce impact.
Randall, J.M., 2001	5 lesson unit combining biodiversity and writing skills. Used rubric from state test to score pre- and post- writing samples.	132 students 9 th and 10 th grade	Pre and post tests show positive impact on <u>writing</u> skills. Limited significance due to sample size, lack of information, and methodology to exclude other factors
Zwick, T.T. & Miller, K.W., 1996	Compares one yr outdoor, hands-on science teaching approach vs classroom, textbook-based science on American Indian students	49 students total, 22 test 4 th grade	American Indian and non-native students in outdoor classes showed better performance on <u>state test scores</u> . Limited by size and information.

Along with academic outcomes, a few of these studies also note improvements in other outcomes that are related to achievement. Two studies noted improvements in attendance and less behavior management. Two studies noted better retention of what was learned. One study reported increased enthusiasm for learning, greater pride of ownership, increased interest in reading, and “greater volumes of higher quality writing.”

Overview of Related Outcomes Research

The six studies listed in Appendix C are those documents discovered during the literature search that focused on quantitative measures of outcomes related to academic achievement, rather than specific achievement measures for core curriculum areas. Although not a focus of the literature search, these research results touch on a growing interest in the educational community to expand the way we measure both academic achievement directly, and the skills or attitudes that are indicators or prerequisites for future academic achievement. Outcomes related to academic achievement that have been discussed in educational research include: willingness or motivation to learn, interest in particular subjects, critical thinking skills, problem-solving skills, ability to transfer knowledge, process or procedural skills, reflection skills, and collaboration skills.

While the documents presented here are only the tip of the iceberg, they provide some interesting ideas for expanding research discussions. As shown in Table 4, all of these studies assert that different kinds of environmentally-related experiences can have a positive impact on outcomes related to academic achievement. They all studied programs using natural environments and were oriented towards hands-on or project-based experiences. These particular studies looked at increases in motivation to learn, critical thinking, analytical skills, interest in science careers and knowledge of science methodology.

Several existing test instruments for these related outcomes were mentioned in the research, including:

- Critical Thinking Test of Environmental Ed
- Cornell Critical Thinking Test
- CA Measure of Mental Motivation
- School Attitude Measurement test.

Table 4: Overview of Related Outcomes Research

Author, year	Type program	Size of test group/age	Related Outcome Impacts
Athman, J. & Monroe, M., 2004	EIC program, long-term. Env themes, project- and issue-based, student voice, connection to community, learner-centered	400 students 9 th and 12 th grade	Raised achievement motivation and critical thinking scores on surveys. Results controlled for GPA, gender and ethnicity.
Barnett, et al, 2005	Urban youth, unknown age, project-based, scientific field investigations	Pretest: 418 randomly selected test, 228 control Post-test: 335 randomly selected test, 184 control	Starting from comparable levels with control group, test group showed significant increase in interest in being a scientist and increased knowledge of investigative methodologies. Control group lost interest in science careers. Significance limited by lack of information.
Cheak, M., Hungerford, H., & Volk, T., 2002	Unclear, EE program. Assessments with Environmental Literacy Inventory and Critical Thinking Test of Env Ed (CTEE)	38 students in test group 5 th & 6 th grade	Compared to control group, test group using a wider, more challenging group of reading materials, were skilled analysts of complex issues, had improved writing skills, and were more motivated learners.
Ernst, J., & Monroe, M., 2004	Environment-based program. Tested with Cornell Critical Thinking Test & CA Measure of Mental Motivation	404 students from 11 schools 9 th and 12 th grade	Student in environment-based programs more skilled in critical thinking than peers, even those in traditional env science classes. Suggest critical thinking connection to outdoor, project-based program, but need more information on experience.
Nava-Whitehead, S., 2002	Nature's Classroom EE program, 5-day residential program. Gains measured using School Attitude Measurement test.	110 students 6 th graders	Indicates that even short EE program positively affects a student's disposition to learn.
Von Secker, C., 2004	3-year EE program, problem-solving projects related to watershed	Unknown # 3 elementary schools 2 middle schools	Found that test students had increased engagement in learning compared to students at same school with less intense EE experiences.

SECTION III: ANALYSIS

This section combines the results of the research documents described in Section II to look at the collective evidence related to academic achievement outcomes of environmentally-related learning experiences. Because some of the research also quantitatively measures some outcomes that might be related to academic achievement, the section is divided into two parts, Impacts on Academic Achievement and Impacts on Related Outcomes.

Impacts on Academic Achievement

The survey analyzed impacts of environmentally-based education on academic achievement that were measured in terms of performance on well-established standardized tests applied in a similar fashion in both test and control groups. The research studies were focused on outcomes in different curriculum areas depending on their goals and the tests used.

In addition to this direct result, the research literature also contained other information worth analyzing. Each report contained varying descriptions of different experiences, teaching practices, and teaching support, being studied by the research, and some researchers tried to determine which factors were most important. This information was used to identify particular practices or factors that were commonly associated with positive academic outcomes in the strongest research.

The impacts on academic achievement are discussed below in terms of 1) impacts by curriculum subject area, 2) the significance of the environmental factor, and 3) practices that support academic achievement.

Impacts by Curriculum Subject

The eight strongest studies showed a variety of results across the particular subject areas targeted by the specific research, with significantly positive outcomes in general:

Summary of Strongest Research

Curriculum Subject Area	Possible Evidence	Suggestive Evidence
Writing/Language Arts	2 of 2 studies positive	2 of 2 studies positive
Reading	2 of 3 studies positive, 1 of 3 studies slight negative	1 of 1 studies positive
Math	3 of 3 studies positive	3 of 4 studies positive 1 of 4 studies negative
Science	1 of 1 studies no impact	3 of 3 studies positive
Social Studies		2 of 2 studies positive

Results of the less definitive studies also showed positive outcomes, although the methodological shortcomings of these studies in terms of the guidelines for evidence indicate that their conclusions are possibly erroneous. Nonetheless, the strong positive trend lends support to the overall picture. The ten less definitive studies are summarized here:

Summary of Less Definitive Research

Curriculum Subject Area	<i>Less Definitive Results</i>
Writing/Language Arts	<i>3 of 3 studies positive</i>
Reading	<i>1 of 2 studies positive 1 of 2 slight positive</i>
Math	<i>1 of 3 studies positive 1 of 3 slight positive 1 of 3 short-term negative but long-term positive</i>
Science	<i>3 of 3 studies positive</i>
Standardized Tests Mean/GPA	<i>3 of 3 studies positive</i>

In addition to these positive results using well-established standardized test instruments, several researchers noted the need for expanding our ability to measure academic ability and, by connection, a program’s impacts on academic achievement beyond standardized subject tests. Critics pointed at the limited capacity of multiple choice tests for measuring more complex thinking and analytical skills. Researchers are working on a range of other measures and test instruments that could be used in future EE research and evaluation projects as the education community comes to value and accept this deeper look into achievement.

To summarize, the research reviewed in this survey suggests that there is meaningful evidence supporting positive impacts on academic achievement across many curriculum subjects as a result of environmentally-based education. It is important to note, however, that this is not the same as asserting that all EE teaching has had or will have a positive impact on academic achievement. Because the results also show strong correlation with many educational best practices, the research also reveals the difficulty of proving a causal relationship between an overall approach like environmental education and positive academic outcomes.

However, it is possible to look for causal relationships between academic gains and particular factors that might influence academic outcomes – including factors that are unique to environmentally-based experiences. There are many factors that might influence academic outcomes. In a model developed by A.W. Austin, and reported by Bartosh, these factors can be divided into “Inputs,” including initial characteristics of the students, teachers and schools, and the teaching and learning “Environments” in the program or school, including confidence, pedagogies, assessment practices, teacher support and training, planning time and approach, district policies, and funding. (Austin 1991; Bartosh 2003) These interacting factors are shown in Figure 1. Addressing and understanding these factors will make it possible to address them in research and draw clearer relationships between causes and effects.

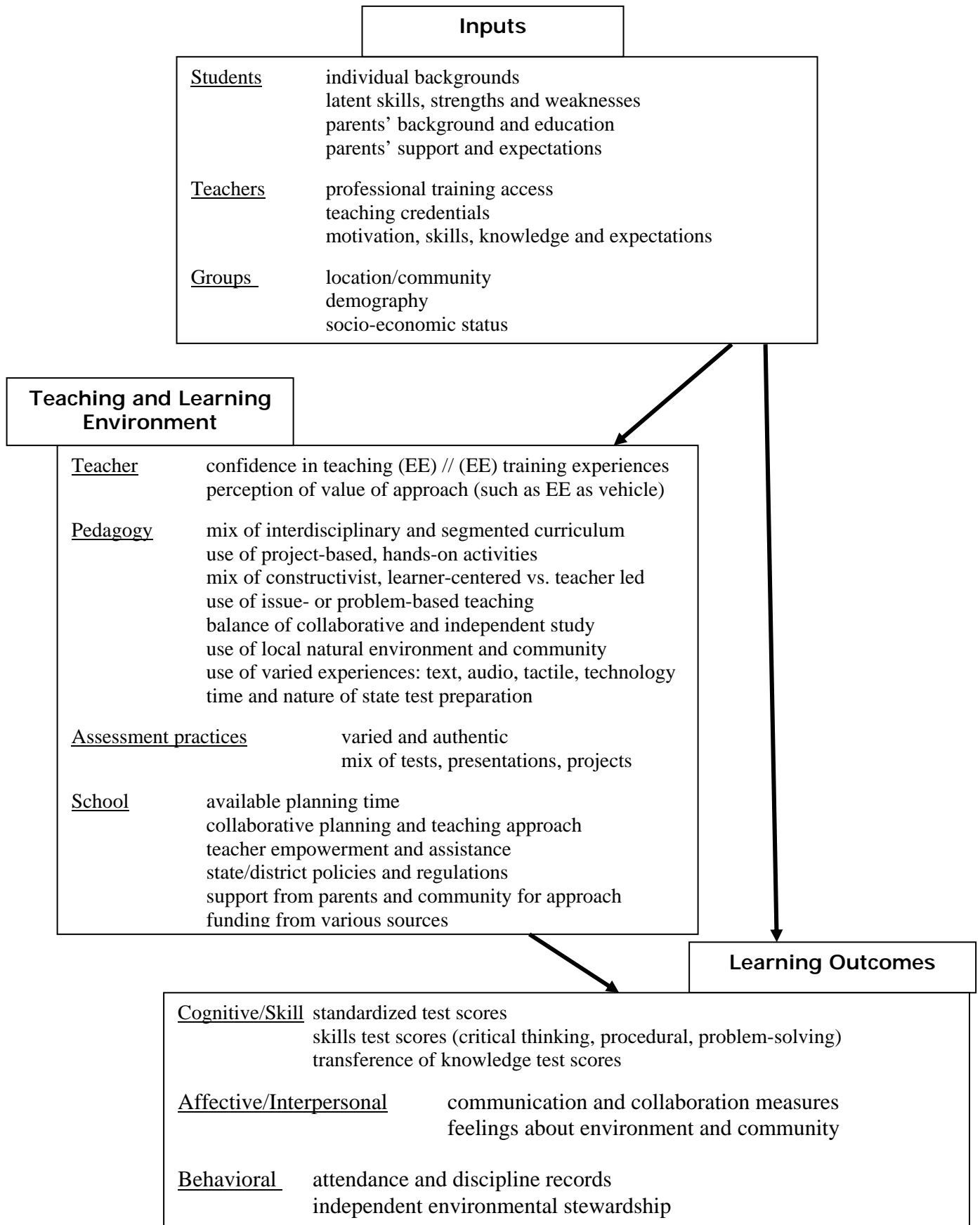
In addition to creating a stronger case for environmentally-based education, studying the variety of factors that might be influencing academic outcomes may help educators to identify and replicate practices that have helped EE programs make positive impacts on academic achievement. The following findings look at what the literature survey revealed about the impacts of specific factors.

Significance of the Environmental Factor

Only two studies looked at the statistical significance of the environmentally-related results they were asserting and also began to separate the relative impacts of different factors within the overall experience. (Bartosh, 2003, Clavijo, 2002.) Clavijo found that while there was no correlation between

Figure 1: Input-Environment-Outcome Model for Educational Research

[adapted by Community Resources for Science from Austin (1991) and Bartosh (2002)]



a two-year science-based EE program and scores on a standardized science test, previous science knowledge and socio-economic indicators were significant predictors of performance. This suggests that participation in learning experiences that differed in terms of an EE-based experience may not have been as important in improving performance as other factors. (Clavijo, 2002)

Bartosh, however, did find that the environmental nature of the experience was a significant factor in the positive academic outcomes measured using a much broader set of experiences, schools, and statistical analyses to eliminate competing explanations. The research was a more extensive study over 77 carefully matched pairs of schools, looking at five years of test data and a large set of factors related to performance. The strongest causal factors for the better performance of the EE schools were the environmental aspect of the experience and a belief among the teachers, administrators, and community, that the environmental teaching approach would improve academic performance.

Practices that Support Academic Achievement

The programs described in the original research documents include everything from short-term environmental education programs focused on a single core curriculum area to long-term EIC programs focused on overall learning outcomes, including changes in behavior and attitude. They all describe their participants, length, and goals, but vary in their attention to the practices they used or the actual differences between the teaching and learning environment in the test and control groups. Consequently, this analysis can only provide indications of best practices by identifying those most commonly associated with positive academic outcomes.

Seven of the eight strongest studies document programs that are at least two years in length. However, one program showing possible evidence for positive impacts in math was less than a year long. In general, longer experiences that involve the classroom teacher as the primary educator were more frequently associated with gains in academic achievement.

The programs studied reported a range of teaching techniques and teaching support practices that are being researched and applied in both EE and non-EE schools to improve academic outcomes.

Pedagogies and teaching practices mentioned in the research include:

- **Regular study of natural environments**
- Challenging, engaging subject matter
- **In-depth, longer-term investigation of topics**
- **Integrated, interdisciplinary curriculum**
- **Active learning** (from hands-on activities to more intensive project-based learning experiences)
- **Problem-solving and inquiry experiences**
- Connection to relevant issues leading to problem-based teaching
- **Constructivist, student-centered and student-led teaching**
- **Mix of cooperative and independent study**
- Varied student experiences: text, audio, tactile, technology
- Authentic, on-going assessment

Teaching support practices mentioned in the research include:

- **Professional training and support for new practices**
- Curriculum support and/or development
- **Collaborative planning and teaching**
- **Administrative and community support and involvement**
- Expectations of student performance from teacher and parents
- Safe school and home climate

The practices shown in bold were more frequently mentioned in association with the positive outcomes measured in the strongest research. All of the programs described in the strongest research used local natural environments regularly and were active-learning, project-based experiences. Most of the less definitive research was also either hands-on or project-based and used natural environments. Although seven of the eight strongest studies mention using EE to integrate teaching across subject as a teaching practice, the actual level of integration being practiced is not well described and quite variable. The one study that actually compared the amount of subject integration between the control and test schools found that they used similar proportions of integrated teaching and traditional single discipline teaching, associating this factor with a parallel positive rise in both control and test schools. (Bartosh, 2003) Some other factors that are commonly associated with positive academic results in this analysis include: the use of learner-centered, constructivist methods to help students build their own knowledge, inquiry and problem solving experiences, cooperative and independent learning experiences, and collaborative planning and teaching. Most of the strongest research outcomes were for programs that included training and/or curriculum support for the classroom teacher and involved the community and administration.

All of these practices for teaching and teaching support have been and continue to be the subject of educational research nationally and internationally in all kinds of schools and learning settings. As research improves, there will be more and better evidence about the effectiveness of different techniques. Both EE and non-EE educators need to build their capacity to access and weigh different educational research results in order to choose a set of “best practices” that can maximize their ability to support academic achievement.

The overall results of this literature survey analysis indicate that the academic achievement impacts of EE can be strengthened by drawing on the best educational practices while preserving strong connections to natural environmental experiences. It is important for the EE community to stay abreast of current research on educational practices and put these practices into their own programs whenever possible.

Impacts on Related Outcomes

As described in the search methods in Section 1, some of the research also studied other outcomes that might contribute to academic achievement, such as motivation to learn, problem-solving skills or critical thinking skills. Although this was not a primary focus of this literature search, these results are interesting in terms of broadening the ability to measure other skills and behaviors that may contribute to academic achievement.

All of the research included in this report that looked at attendance, behavior, motivation to learn, critical thinking skills, analysis of complex issues, or other outcomes reported positive results from student involvement in environmentally related experiences. Although the results are all limited by gaps in information on experiences, testing instruments, and methodology, the uniformity of the response is suggestive. The gaps also make it difficult to determine what parts of the experiences – unique environmental aspects, different teaching approaches, or other factors - affect these outcomes. It is interesting to note that positive results were found for everything from five-day programs to multi-year EIC programs underscoring the need for improved research methods in general.

Future research on how environmental education affects these contributing factors could help to clarify these relationships. The few studies collected incidentally in this survey reveal that many different test instruments exist to measure these types of behaviors and skills. The possible contributions of different behaviors and skills to academic achievement have been a topic of research in the academic community for years. Since improving academic achievement is the primary goal, future research on the impact of environmental education on particular contributing factors should be guided by evidence of established connections with academic improvement, using the same kind of research standards applied in this report.

SECTION IV: FINDINGS

Summary

Using U.S guidelines for scientifically-based education research, there is meaningful evidence that:

- Environmentally-based education using best educational practices can improve academic performance across curriculum subjects
- The use and study of natural environments is a significant factor in academic achievement gains

This literature survey also reveals that:

- Certain teaching practices and teaching support in EE programs appear to strengthen academic outcomes
- More and better research is needed to reach conclusive results and verify the most important practices and support.

The results of this literature analysis can be used to build the capacity of the environmental education community both to reach K-12 students and provide stronger support for academic achievement. The survey indicates that the study of natural areas combined with best teaching practices and teaching support can improve academic performance. The challenge to us all – community, businesses, school districts, EE providers and classroom educators – is to make use of that potential for our students by: 1) designing EE programs that respond to changing knowledge of best teaching practices and support, 2) reaching more students, and 3) continuing to build our understanding of the important factors that produce academic achievement through better evaluation and research. The literature analysis suggests a variety of actions that could be taken in these three areas.

Strengthening EE's Contribution to Academic Achievement

The contribution of environmental education to academic achievement can be strengthened by the use of teaching practices and teacher support practices that have been associated with the positive outcomes documented by valid research. While our understanding of the impact of specific practices continues to change and grow, current research studied in this survey indicates several directions for educators to pursue in their own environmental teaching or EE program design.

- **Maintain strong connection with studying the natural environment**
- **Follow current educational research and incorporate best practices where possible**
 - Focus on active, project-based learning
 - Promote longer, integrated curriculum approaches to environmental study
 - Maintain relevance to local environmental issues and culture of target audience
 - Use constructivist, learner-centered methods that respond to knowledge of students
 - Use inquiry and problem-solving experiences to promote critical thinking
 - Include cooperative and independent learning experiences

- **Extend the contribution of shorter programs**
 - Promote effective teacher extensions of programs with training, curriculum, and materials that incorporate best teaching practices
 - Link with other environmental education and professional development providers using best practices to provide longer, richer environmental experiences
 - Promote administrative, community and parent involvement in experiences and outcomes

Reaching More Students

Academic performance is the primary measure of success for school-based education programs. Therefore, the key issue in gaining access to public school students is making it clear the specific ways in which EE programs will support improved academic performance. This can be accomplished through a combination of education, program outreach, and program design. The general public and educational decision-makers need more information about the possible connection between EE and academic achievement. Program outreach materials must both refer to valid research results and show how the specific program uses this research. Program design must make it easier for different schools and communities to use EE programs in a meaningful way.

- **Build community awareness and confidence in connections between EE, best practices, and achievement**
 - Educate program providers, parents and school decision-makers in conferences, District meetings, articles, and on websites
 - Be scrupulous in selecting the research used and quoted – using quality as a guide rather than favorable conclusions.
 - Share results of valid evaluations linking effective practices and outcomes

- **Develop outreach that connects the program with outcomes important to educators**
 - Explain the link between current research results and specific program design
 - Include academic results from program evaluation , as well as other outcomes in environmental knowledge and behaviors
 - Focus on characteristics important to educators in program descriptions:
 - Academic achievement: *“We support the following specific curriculum goals and academic skills....”*
 - Best education practices: *“We use teaching practices that support academic achievement, including”*
 - Teaching support practices: *“We help you make the most of our program by providing...”*
 - Flexibility: *“We can be an engaging enrichment for existing units or part of collaborative teaching approach with our extended program offerings.”*

- **Make it easier for schools and educators to use EE programs**
 - Provide support based on research results, including: professional training with opportunities for collaborative planning and facilitation of community involvement.
 - Respond to the needs and time constraints of different teachers and schools by considering different ways to offer your program: short-term enrichments with more limited outcomes and as longer experiences with more impact on academic achievement.
 - Continue to address barriers such as background knowledge, confidence, limited funds, and classroom support that have been previously identified in teacher research by CRS and other organizations.

Using Research and Evaluation to Expand EE's Potential

Information from scientifically-based research and evaluation is critical to both creating more access to students and improving EE's contribution to academic achievement. In order to develop a basis for specific, targeted research, it would appear to be most beneficial for EE programs to consider developing partnerships with specific programs or schools in order to test longer interactions over time and in the context of a range of environmental and/or academic goals.

Additional research could provide conclusive evidence that environmentally-based approaches improve academic performance and improve the likelihood of this positive outcome in practice by illuminating other important teaching and learning factors. Carefully-designed program evaluations can also help education decision-makers see the connection between specific programs and academic outcomes. Research and evaluation studies could increase their effectiveness by improving in relevance (what is studied) and significance (what methodology is used). Finally, and perhaps most importantly, the community in general, and educators in particular, must improve their ability to use research results effectively.

- **Expand and deepen knowledge of the links between EE and academic achievement**
 - Do more evaluation and research to look for strong causal relationships between environmental study and achievement, and across the range of other factors
 - Programs and administrators must work together to evaluate academic as well as other outcomes of environmentally-based education.
 - Develop broader range of standardized and accepted tools to measure academic achievement and skills.
- **Improve relevance of studies**
 - Carefully choose outcomes to measure in program evaluations or research, considering the audience for results. Funders should encourage positive overall results that are supported by sound research approaches. Educators should look for evidence that a specific EE approach will have a positive outcome on achievement in core curriculum areas, attendance, discipline, or key academic skills.

- Understand different factors that might affect results. Appendix I lists different factors that may affect the outcomes of research or evaluation. Understanding these factors can help the design of effective studies
 - Select and design appropriate tools for collecting needed data. Determine quantitative and qualitative data needed to measure targeted outcomes and address as many possible contributing factors as possible. Use accepted standardized instruments to measure targeted outcomes whenever possible.
 - Do more studies related to shorter-term interventions and the sustainability of the results
- **Improve significance of studies**
 - Follow U.S. guidelines for scientific educational research and evaluation when undertaking any studies of these kinds. (Appendix G)
 - Carefully match control and test groups in terms of as many baseline input factors (teacher experience, previous test performance, socio-economic factors) and learning environment factors as possible, whether the groups were selected randomly or not. Even randomly selected test and control groups should be compared to avoid bias introduced by chance.
 - Look at relative scoring over time between paired test and control groups, since an increase or decrease in test group performance may be due to factors other than the studied program.
 - Do statistical analysis of results to eliminate effects of chance and increase significance of results. If needed, combine data sets to extend length and breadth of data.
 - Address all factors that could have influenced results with either careful matching of groups initially or analysis of qualitative and quantitative data. This will help isolate particular program experiences or characteristics to study. (See Bartosh, 2003 for an interesting model for using a combination of data to address multiple factors affecting outcomes.)
 - Provide complete descriptions of the characteristics of the test and control groups, the specific differences between a test experience and the traditionally-taught experience, any other differences learning environments, and methodology for data collection.
 - **Use research results effectively**
 - Develop ability to weigh and compare research results to determine strength of assertions. The Institute of Education Sciences, National Science Foundation, and other teacher support organizations provide resources and support.
 - Stay abreast of current research and use applicable results to inform teaching practices, EE program design for students and teachers, and general community education.