Evaluating the effectiveness of environmental education essential elements in school field trip programming

Mariam Futer

Department of Integrated Studies in Education

McGill University, Montreal

May, 2005

A thesis submitted to McGill University in partial fulfillment of the requirements of the degree of Masters of Arts in Education

Your file Votre référence
ISBN: 0-494-12719-8
Our file Notre référence
ISBN: 0-494-12719-8

Abstract

This thesis investigated the apparent effectiveness of environmental education essential elements in school field trip programming. First, the elements essential to environmental education field trips were identified from the literature. Second, these elements were incorporated into a questionnaire that was administered as a pre/post test to elementary school students visiting an extensive indoor environmental education facility located in Montreal. Finally, 24 environmental education programs at eight institutions in Montreal were observed to investigate the extent and methodology of implementation of the essential elements. With regard to the chief institution, it was concluded that 1) the educational programming appeared to significantly increase environmental knowledge, and 2) the environmental attitudes were most strongly correlated with student background. Program observation at the eight institutions demonstrated that a wide array of environmental topics was presented, but there was insufficient instruction of environmental issues and action strategies. The list of observed implementation methodologies and the study conclusions could prove useful as a research-based foundation for effective environmental education field trip program development.

Sommaire

Ce travail de thèse vise à explorer l'efficacité apparente de l'éducation des éléments essentiels relatifs à l'environnement dans la programmation des sorties éducatifs scolaires. Premièrement, les éléments essentiels requis lors au sorties éducatifs scolaires relatifs à l'environnement ont été identifiés dans la littérature professionnelle. Deuxièmement, ces éléments étaient intègres dans un questionnaire pré/post visite qui a été administré à des étudiants d'école primaire visitant une vaste installation intérieure d'éducation de l'environnement a Montréal. Finalement, 24 programmes d'éducation en lien avec l'environnement ont été suivis au sein de huit institutions à Montréal pour déterminer le niveau et la méthodologie d'implantation des éléments essentiels. A propos de l'institution principale, il a été conclu que 1) la programmation éducative semble contribuer significativement a augmenter les connaissances environnementales, et 2) les attitudes face à l'environnement étaient plus fortement corrélées avec l'expérience préalable de l'étudiante. L'analyse des programmes des huit institutions a démontré qu'un grand nombre de thèmes ont été présentés, mais qu'il n'y avait pas suffisamment de détails relatifs aux problèmes environnementaux et aux actions qu'il est possible d'engager. La liste des méthodologies d'implantation observée et les conclusions de l'étude pourraient être utile comme base scientifique pour un développement efficace des programmes de sorties éducatifs scolaires en lien avec l'environnement.

Acknowledgements

This work would not have been possible without the assistance of numerous individuals. I would like to thank my supervisor, Dr. Brian Alters for his guidance and support in getting my thesis from its infancy through to completion, and all of the Faculty of Education professors who allowed me to explore environmental education from different perspectives in their courses. I would like to acknowledge the invaluable assistance of Mme. Clair Lépine and all of the Montréal Biodôme animators, as well as all of the teachers who administered questionnaires to their students. I am also incredibly grateful to all of the dedicated directors and staff at the participating Montreal environmental education institutions for letting me observe their programs.

A sincere thank you to Dr. Marcus Lieberman for his assistance with statistical analysis, Dr. Helen Amoriggi for ensuring the appropriateness of the reading level and vocabulary use of the student questionnaires, Dr. Catherine Le Maistre for reading the manuscript and providing very helpful feedback, Ms. Lorraine Pilon for translating all of the documents into French, and Dr. Spencer Boudreaux for looking over all of the French documents.

Finally, I would like to thank my friends and family for all of their encouragement throughout this journey, and my husband for his undiminished support.

Table of Contents

Chapter 1: Introduction

1.0 Introduction

The industrial, green, and technological revolutions of the preceding centuries have drastically improved the human quality of life. However, this improvement has often been at the expense of the environment. Different strategies have been used to deal with the global environmental degradation that has ensued. Some have chosen to seek further technological solutions to the problems, while others have placed emphasis on conservation and preservation. Environmental education strives to mitigate human impact on the environment through the dissemination of information and creation of an active and involved citizenry (Stapp, 1969). Both educators and educational researchers have worked towards this goal by implementing and examining best practice strategies. The work in this thesis strives to investigate and evaluate the essential elements of environmental education with the ultimate purpose of contributing knowledge to the field and potentially helping increase educational program effectiveness.

1.1 Working definition of environmental education

Environmental education is a holistic approach to instruction about, in, and for the environment. It aims to increase knowledge of natural processes as well as human interactions with, and influences on, the environment. In 1970, the World Conservation Union (IUCN) defined environmental education as

> The process of recognizing values and clarifying concepts in order to develop skills and attitudes necessary to understand and appreciate the inter-relatedness among man, his culture, and his biophysical surroundings. Environmental education also entails practice in decision-making and self-formulation of a code of behavior about issues concerning environmental quality. (as cited in Palmer, 1998 p. 7)

While the above definition provides a good general idea, definitions of environmental education have often been disputed (Disinger, 2001; Vidart, 1978). A more widely cited and accepted mission statement was adopted at the 1976 United Nations conference in Belgrade, Yugoslavia

> The goal of environmental education is to develop a world population that is aware of, and concerned about, the total environment and its associated problems, and which has the knowledge, attitudes, skills, motivation, and commitment to work individually and collectively towards solutions of current problems and the prevention of new ones. (UNESCO-UNEP, 1976 p. 2)

Achieving the goals of this statement has become the benchmark for best practice strategies in both program design and implementation. These goals can be realized in three distinct venues. The most traditional form of environmental education takes place in nonformal institutions such as nature centers and aquaria and is aimed at the general public. Formal environmental education takes place in the regular school setting, where both classroom teachers and external instructors can present information. Finally, classroom teachers can choose to take their students on a field trip to a nonformal institution where instruction is lead by the site's docents. The third category blends formal and nonformal instruction, and is the focus of this thesis investigation.

1.2 History of environmental education

Environmental education has taken on many forms over time. In the late 1800s and early 1900s John Muir and Enos Mills sought to understand nature through direct observation and inquiry. They shared their passion for the outdoors and its conservation with others, thus becoming some of the first environmental educators. John Muir became one of the greatly respected backcountry guides for the Sierra Mountains of California and exposed the likes of Theodore Roosevelt to their splendor (Muir, 1997). Mills explored the Rocky Mountains in great detail, and is often called the father of Rocky Mountain National Park (Mills, 1921). The nature study movement, as it later became known, has played an important role in elementary education that often strives for first-hand discovery (Athman & Monroe, 2001).

Later in the 20th century Aldo Leopold witnessed the disappearance of the prairies in favor of fields of wheat and corn. He saw the resultant widespread floods and dust storms, and wrote of detrimental forestry practice and soil erosion (Leopold, 1966). The disappearance of natural places coincided with their greater use as an educational tool. Organizations such as the YMCA promoted outdoor education within their recreation activities, and legislation in the U.S. was passed granting land for natural purposes to schools (Athman & Monroe, 2001). However, outdoor education and environmental education have diverged from each other over the years. The focus of outdoor education is the instructional venue, while environmental education is content driven (Adkins & Simmons, 2000). Furthermore, a study of campers' attitude change as a result of an outdoor education program revealed that outdoor education alone is insufficient for realizing the critical goal of improved environmental attitudes (Shepard & Speelman, 1986).

Rachel Carson was another highly influential figure in the middle of the 20th century. The 1956 publication of *Sense of Wonder* became the foundation for early childhood education in environmental education, and validated the need for intimate experiences in and with nature (Corcoran, 1997). Significant life experiences research picked up on the potential for instilling environmentally positive values in young children by replicating formative events in the lives of current environmentalists first in 1980 (Tanner, 1980), and also more recently (Chawla, 1998a; Gough, 1999). Furthermore, Carson's *Silent Spring* exposed evidence of environmental effects on human and animal health (Carson, 1962), and became the cornerstone of the environmental movement's fight against commercial toxins (Corcoran, 1997).

Environmental education as a field began to gain momentum at the end of the 1960s. The Journal of Environmental Education was founded in 1969, with the first issue publishing a keystone article entitled "The concept of environmental education." In this work William Stapp provided environmental education with a clear set of goals to be realized in teaching the global population. The population needed to have a clear understanding of the biophysical environment, and a comprehension of the interconnection of man and nature. Secondly, the citizenry needed to be exposed both to environmental problems, and their potential solutions. Finally, to ensure that action will be taken, motivation and environmentally positive attitudes are necessary (Stapp, 1969).

After the slow climb to gain insight into the consequences of environmental degradation and the need for action, 1970 saw two monumental events for environmental education. First, people came together to celebrate the first ever Earth Day, thus communally accepting the necessity to preserve our planet. Secondly, the United States Environmental Quality Education Act was passed in Congress (NAAEE, 2003). By signing the bill, President Nixon acknowledged the need for communication on the subject of the "man's relationship with his natural and manmade surroundings" (U.S. Public Law, 1970). While the original law was repealed in 1981, in 1990 the National Environmental Education Act was signed into law, providing substantially more concrete support for the movement. The new law called for the establishment of an office within the Environmental Protection Agency, teacher training programs, and funding opportunities for research in and execution of environmental education (Marcinkowski, 1991).

In Canada there is no specific legislation mandating environmental education, yet the government has demonstrated a commitment to the environment, and the necessity for education in order for that commitment to be successful. Since the ratification of the Kyoto protocol in December of 2002 (Government of Canada, 2002), a government-sponsored advertisement has aired on National television. It urges for the insulation of drafty windows and the use of efficient light bulbs. This educational campaign reaffirms the notion that an informed political body is not enough; it is also necessary to have an informed citizenry, and that simple day-to-day actions can mitigate global problems.

International actions have been key to promoting and validating environmental education. Extensive deliberations started with the United Nations Conference on the Human Environment which was held in Stockholm, Sweden, in 1972 (NAAEE, 2003). As a result of the Stockholm conference, a small number of staff were placed at the Paris UNESCO headquarters with the mandate of working with the international community to involve educators and governments in the infant field (Fensham, 1978). The end result of the deliberations was the 1976 Belgrade Charter that spelled out the mission of environmental education (UNESCO-UNEP, 1976). The text of the charter mirrors the mandates and goals first proposed by Stapp in 1969. The Tbilisi Declaration followed the Belgrade charter in 1977, and broke down the objectives of environmental education into five distinct categories of awareness, knowledge, attitude, skills, and participation (UNESCO-UNEP, 1978).

The UN summit on environment and development in Rio de Janeiro in 1992 pulled environmental education into the greater mandate of the environmental movement, recognizing it as a critical component to achieving sustainable development. Agenda 21, the document produced by the summit, included a chapter of recommendations to governments on how to incorporate environmental education into all spheres of society ranging from entertainment and leisure activities to formal curriculum planning (UN Department of Economic and Social Affaires, 2003). However, the issue of education for sustainable development created a rift within the environmental education community. While some saw education for sustainability as a newly evolved name for environmental education, others proposed it as an independent field. The later group reasoned that teaching about sustainability involves more social and economical issues, in addition to the scientific issues covered under environmental education (Paden, 2000). Still other researchers were outright opposed to education for sustainable development, arguing that its goal-oriented stance (educating *for* something) involved too much advocacy, teaching learners what to think and not how to think (Jickling, 1992).

Environmental education today is a blend of preceding movements and mandates. It has maintained its uniqueness while borrowing from past ideologies and giving rise to sister fields. As described above, environmental education and education for sustainability are not synonymous. However, the NAAEE's (North American Association for Environmental Education) curriculum guide includes such topics as human culture and economics (NAAEE, 2000a). Similarly, experiences in the outdoors are still considered essential (Harvey, 1990), yet a clear distinction remains between environmental education and outdoor education (Adkins & Simmons, 2000; Hungerford, 2001).

As environmental education has struggled to maintain its identity, researchers have attempted to evaluate the effectiveness of environmental education activities at realizing the stated goals. These studies have focused on evaluating learner knowledge gain (Benton, 1993), attitude shift (Jaus, 1984), reported behavior changes (Ramsey, 1993), realized behavior changes (Asch & Schore, 1975), as well as transfer of knowledge and attitude to family members (Ballantyne, Fien, & Packer, 2001). The target audience has ranged from pre-schoolers (Cohen & Horm-Wingerd, 1993) to adults (Linn, Vining, & Feeley, 1994), while the treatments have included formal class instruction (Kinsey & Wheatley, 1984), short visits to nonformal institutions (Knapp & Poff, 2001), as well as longer summer camp (Dressner & Gill, 1994) and residential program stays (Dettmann-Easler & Pease, 1999).

The findings of the numerous studies have varied almost as much as the methodologies. For example, a meta-analysis of studies that evaluated behavior change as a result of an environmental education program demonstrated that a large proportion of the investigations proved the intervention to be ineffective, while others were highly effective with statistically significant changes (Zelezny, 1999). The wide disparity in findings has made researchers investigate what is necessary for an effective program (Hungerford & Volk, 1990), how such a program should be conducted (Athman & Monroe, 2001), and the extent to which effective techniques are being implemented (Boerschig & De Young, 1993; Simmons, 1991). These findings provide a solid base for further research in the field.

1.3 Thesis organization and goals

Three areas of environmental education research were identified at the end of the preceding section. These areas can be broadly defined as: evaluating program content; evaluating the effectiveness of program implementation at one institution; and evaluating the extent of effective implementation at multiple institutions. This thesis builds upon these research areas in order to evaluate the effectiveness of environmental education essential elements in school field trip programming and satisfy the following three goals

1. identify and synthesize the essential elements of environmental education
2. examine the effectiveness of the identified essential elements
3. examine the extent of essential element implementation

The essential elements that have been identified for goal one appear in Chapter 2. Each element is supported with extensive explanations based on the primary literature. The remainder of the thesis is devoted to the methodology (Chapter 3), results (Chapter 4), and discussion and conclusions (Chapter 5) of the research that was conducted for the above goals two and three.

1.4 Research questions

The studies conducted for this thesis attempted to answer the following primary and secondary research questions

Primary:

1. To what extent does the implementation of the essential elements of environmental education at natural history centers appear to affect a visiting child's ecological knowledge, grasp of environmental issues, and environmental attitude?

Secondary:

1.1 To what extent is the ecological and environmental knowledge and environmental attitude different after students visit an environmental education institution as compared to before the visit?

1.2 To what extent are there differences in environmental knowledge of students with positive environmental attitudes as compared to students with negative environmental attitudes?

1.3 To what extent do differences exist in answers to environmental knowledge and attitude questions provided before and after a visit to an environmental education institution by students with a strong environmental background as compared to students without such a background?

2. What differences and trends can be observed in the implementation of essential elements at environmental education institutions?

Secondary:

2.1 To what extent are the essential elements being implemented at individual environmental education institutions?

2.2 What methodologies are used in essential element implementation?

2.3 To what extent are essential educational themes being implemented at a regional level?

2.4 What methodologies are used in implementing essential educational themes?

Chapter 2: Identifying the Essential Elements

2.0 Introduction

While the implementation of environmental education has varied, the goals of a knowledgeable, aware, and responsible citizenry as spelled out in the Belgrade charter (UNESCO-UNEP, 1976) have remained the same. Prominent researchers have pointed out that too many environmental education programs are developed through intuition, rather than being grounded in sound research (Hungerford, 2001; Hungerford & Volk, 1990). Today's environmental educators need to know which content and implementation techniques are still considered essential, and which are best at realizing the specified goals of environmental education.

Two bodies of literature were investigated to identify the essential elements. The first set included publications pertaining to school science field trips, though not exclusively environmental in content. Some of the elements discussed under this section pertain to general good pedagogy, and are applicable, although not unique to the field trip setting. The second set of literature focused on studies specific to environmental education.

2.1 The essential elements of school science field trips

Millions of students visit nonformal science education institutions as part of a school field trip every year. Researchers have promoted the use of science field trips to increase both the knowledge of scientific information and student attitudes towards science (Falk, Koran Jr., & Dierking, 1986; Finson & Enochs, 1987; Tressel, 1980). The mandate for the use of field trips has spurred a body of literature on factors influencing trip effectiveness. The focus of this thesis is on the implementation of environmental education within school field trips, and many of the components of achieving an effective field trip are universal. Thus, the literature from the broader area of science education is a useful tool for this environmental education investigation. This use of science education literature within environmental education research is further supported by the recent call for closer interactions between the two fields (Gough, 2002). A discussion of seven essential elements pertaining to field trips follows, with supporting evidence from environmental education literature wherever appropriate.

2.1.1 Reduction of novelty

A major component of effective field trips is the preparedness of students, often referred to as the novelty factor. It is hypothesized that if children are parachuted into a new environment with little or no preparation for what they are likely to encounter, too much of their energy is devoted to exploration, and very little remains for on-task learning. Falk and Balling (1980) paralleled this behavior to a dog unable to perform tricks in an environment where it has not yet had the chance to sniff in the corners. An unfamiliar setting can cause anxiety or act as a distracter from the field trip goals, while novelty reducing activities can act to focus the student's attention and increase trip effectiveness (Howe & Disinger, 1988; Rudman, 1994). Melber (2000) suggests that to allow for more in-depth learning it is best to spend more time at fewer exhibits allowing students to acclimate to each, rather than attempting to view everything. Similarly, Yerkes and Haras (1997) state that urban students participating in outdoor education activities need more adjustment time than campers from rural areas.

Orion (1993) broke up the *novel space* into three factors: psychological, geographic and cognitive. Psychological novelty refers to the factors such as duration of the trip, expected weather conditions, timing of breaks, and expectations of the students. To reduce geographic novelty a student would need to know the specific path the trip is going to take. This is especially important for outdoor excursions. Finally, cognitive preparedness involves knowledge of basic concepts and skills which will be used as a foundation for further learning on the trip (Orion, 1993; Orion & Hoftein, 1994).

Numerous researchers have tested the hypothesis of reducing novelty to maximize field trip benefit. Falk was one of the first investigators. In a study with Martin and Balling (1978) the authors compared the learning of two sets of students following a visit to the wooded area of a nature center. The *unfamiliar* group had never visited the center, and lived in an urban setting, whereas the *familiar* group lived in a development surrounded by woods, and had participated in an earlier activity at the center's estuary facility. The findings showed that while knowledge gain on questions pertaining to the setting were similar in both groups, the familiar group's conceptual learning substantially exceeded that of the unfamiliar group. The authors speculated that the *setting-oriented* learning of the unfamiliar group overpowered the *task-oriented* conceptual learning since all aspects of the environment were new. These findings demonstrate both the benefits of the home environment and those of a repeat visit, even if the visit is to a different area of the same facility.

Following Falk and colleagues' findings, researchers attempted to simulate the novelty-reducing agents such as a repeat visit. Kubota and Oltad (1991) exposed the treatment group to a video and slides of other students exploring the facility to be visited while the control group viewed images of a different facility. Increases in both on-task exploration and cognitive gains were especially high in boys. Similarly, Barshinger and Ray (1998) found that video-conferencing with an interpreter of the science museum to be visited was helpful in orienting students to the novel environment. In both of these studies the video interaction substituted for a pre-visit, with the actual field trip being viewed as, and receiving the benefits of a repeat visit.

If one was to look at the three studies discussed above from the perspective of Orion's (1993) novelty space taxonomy, they all focus on geographic and psychological novelty, increasing the learner's comfort in the novel environment. Pre-visit instruction on the topic to be covered in the field trip or positioning the trip at an appropriate point within the curriculum provided a foundation of conceptual knowledge needed to reduce cognitive novelty. Orion and Hofstein (1994) demonstrated that greatest learning occurred in students who had substantial preparation, but had not yet completed the topic in class. Others have similarly argued for the use of the field trip as an integral part of the curriculum, rather than a concluding reward (Keown, 1984; Millan, 1995). While nonformal educational institutions do not have control over when a teacher chooses to take his or her class on a field trip, the institutions can provide instructional materials to be used in preparatory activities. Gennaro (1981) compared the knowledge gain as the result of a field trip of two groups, one that had received pre-visit instruction and the other that had not. Having the lesson accounted for 7% of the overall variance in the data.

It has been speculated that too much novelty reduction leads to boredom and decreased learning potential (Falk & Balling, 1980). Anderson and Lucas (1997) examined this hypothesis by comparing the learning as the result of a science center visit of students who had previously visited the facility, and those that had not. All students had received pre-visit novelty-reducing preparation. The authors demonstrated that the prior visit experience was not a hindrance, but rather an aid in student learning, with the experienced students scoring significantly higher. These finding further reiterate the detrimental effect that novel space can have on student learning, and the need to maximize potential through all possible preparatory activities.

2.1.2 Local relevance

An alternative to active novelty reduction is to choose a field trip location that the students are already familiar with. Using a schoolyard or a local wooded area can provide for a highly educational biology lesson (Falk & Balling, 1980), while earth systems are best understood if the investigation starts with the local environment before expanding to regional, national, and global levels (Goto, 2002). Learning from the local environment increases the student's link with both the subject matter and the surrounding.

These ideas fall directly in line with the theory of place-based learning. One of the origins for the word *place* is from the Latin *planta*, meaning the sole of one's foot, while the word *ecology* comes from the Greek for *the study of house* (Morris, 1981). The word place implies an earthy connection to one's environment while the study of ecology necessitates an understanding of the immediate surrounding (Arenas, 1999; Heimlich, 1994). Combining these two linguistic derivations provides an environmental foundation for place-based learning. For example, Heilmlich (1994) suggests using water or energy use in a child's home to teach about the global issues of natural resources and consumption. Similarly, Trisler (1993) provides an example of investigating global biodiversity through a case study of local species distribution.

The ideas of locally relevant education were first advocated by John Dewey in the early 1900s. He argued that education should be part of life rather than preparation for it, and that the curriculum should comprise a continuum of experiences that link student interests (Apple & Teitelbaum, 2001). Dewey argued against the dualities that separate the school from the community that surrounds it. In his laboratory school he aimed to teach through the democratic interactions, with the school functioning as a society (Tanner, 1997). Today's field trips stand to learn from Dewey's century old theories. By having students understand science through experience in their immediate surrounding rather than museum specimens that have little relevance to every-day life, students can make a much deeper connection with the content (Woodhouse & Knapp, 2000).

2.1.3 Active participation

Active involvement with the instructional material is important for maximized learning (Tobin & Fraser, 1989). A field trip provides a special opportunity to interact with the environment both cognitively and physically, and researchers have understood the need to make good use of this (Millan, 1995). Rudman (1994) promoted the active manipulation of objects, citing Piaget's 1964 work in support: "to know an object is to act on it" (p. 140). MacKenzie and White (1982) demonstrated the need for interactive learning by comparing the retention of knowledge and skills of students who participated in active versus passive excursions. Although students in the passive group showed higher gains than control students who did not participate in an excursion at all, students in the active group showed substantially higher cognitive gains than the passive group students.

An educator is not only interested in the acquisition of the information delivered through direct instruction, but also in the learner's ability to transfer the acquired knowledge and skills to a novel situation. Basile (2000) demonstrated that active involvement through a skill-based curriculum provided greater levels of transfer than more traditional classroom instruction. In studying habitats, the treatment group gained transferable skills and knowledge as they took on scientific roles and actively searched for solutions to proposed problems based on their immediate schoolyard environment. Although the control group took a weekly walk through the schoolyard, findings demonstrated that they had a lower ability to transfer learning. The transfer of learning is highly important in environmental education as the learner needs to be able to make environmentally conscious choices independently of direct instruction. Other environmental education researchers have likewise pointed to the need for active participation in issues investigation (Hines, Hungerford, & Tomera, 1986; Iozzi, 1989b; Ramsey, 1993).

An alternative to the quantitative comparison of a treatment and a control group is a qualitative investigation that identifies which specific concepts have been retained by the learner, not just how much knowledge was acquired. Knapp and Poff (2001) interviewed fourth grade students following a visit to a U.S. Forest Service site. During the visit the students had engaged in games and listened to more traditional interpretation on environmental topics pertaining to the forest. The interviews revealed that students had excellent recall of the game rules and concepts, but only a vague recollection of the information presented in the lecture format. The best-retained content was acquired through cognitive and physical active involvement.

2.1.4 Multi-sensory learning

Howard Gardner's outline of the theory of multiple intelligences promotes the idea that different people have different intellectual strengths (Gardner, 1993). By stimulating the learner's different senses it is possible to target the various intelligences and reach a larger proportion of the class more effectively. These ideas build on the above discussion of active participation and hands on learning.

The process-oriented approach to field trips asks students to observe, touch, identify, measure, and compare aspects of the exhibit (Orion, 1993).

Peart (1984) demonstrated the benefits of multi-sensory learning through an investigation of exhibit design. Museum visitors viewed an exhibit that consisted of just text; text and a photograph; just a three-dimensional display; text and a three-dimensional display; or text, a three-dimensional display and appropriate sound effects. The greatest amount of learning resulted from the exhibit that incorporated sound. Furthermore, the holding power was greater for exhibits that had a combination of text and image, with the sound exhibit again scoring highest. This study was conducted with adults, and the findings are likely to be even more striking for children who have lower attention spans. Stimulating the tactile sense, for example, by providing objects for manipulation can substantially increase the amount of time spent at an exhibit (Rudman, 1994).

2.1.5 Cooperative learning

Today's society is moving away from the environment of extreme interpersonal competition. While competition has long been the norm, the work place is requiring greater and greater amounts of collaboration both locally and globally between individuals of different educational, cultural, and ethnic backgrounds. It is essential that the learner is prepared for this environment (Brandt, 1987; Fortner, 2002). In environmental education cooperation is especially critical as the Belgrade Charter points out the need to work "individually and collectively towards the solutions of ... problems" (UNESCO-UNEP, 1976, p. 2). Furthermore, it has become increasingly evident that, similarly to the wastefulness of competition in biological systems (Hofbauer & Sigmund, 1998), in human interactions it is likewise not conducive to highest productivity (Johnson, Maruyama, Johnson, Nelson, & Skon, 1981; Swain, Monk, & Johnson, 1999).

Instruction in the field trip setting fits in naturally with cooperative learning. As with laboratory experiments, field experiences often require the sharing of materials. Numerous researchers have investigated the benefits of a cooperative learning environment for student achievement and behavior. Through experimental studies both Watson (1991), and Chung and Son (2000) demonstrated higher learner achievement in collaborative student groups as compared to the traditional classroom setting. These findings are supported by an earlier meta-analysis that demonstrated higher achievement and productivity in groups learning through cooperation as compared to competition and individual efforts (Johnson et al., 1981). It is likely that these findings can be extrapolated to student investigation of exhibits or participation in docent-mediated field trip activities.

Cooperative learning is also beneficial to non-academic aspects of learning. On-task behavior is increased through small group interactions (Lazarowitz, Hertz, Baird, & Bowlden, 1988). As field trips provide endless opportunities for learner distraction, methodology for maximizing on-task behavior and maintaining focus is essential. Furthermore, cooperation can lead to a positive chain of events that will help realize the goals of environmental education. Lazarowitz and colleagues (1994) showed cooperative learning can increase learner self-esteem. The self-esteem of child participating in nature activities is in turn positively correlated with their desire to take environmental actions (Dressner & Gill, 1994). Thus, cooperative learning can be useful in effective environmental instruction to realize the goals of environmentally active citizens.

2.1.6 Constructivism

Constructivism is the educational theory stating that the purpose of the educator is to help extract and build on the experiences that are already within the student. In order for true knowledge acquisition to occur, not only must each part be comprehended, but also, each part must be viewed in relation to the whole. If a child does not understand the founding framework of a concept, learning will become fragmented. Such fragmentation can create incomplete understanding and misconceptions. Through hands-on constructivist instruction the learner is challenged to create their own understanding of the phenomenon. Such personal experience can reverse previously ingrained misconceptions. Thus, the educator must work from the baseline of knowledge for each child to achieve a continuum of experiential learning (Fosnot, 1996).

The application of constructivist strategies is not restricted to science field trips. However, the reasoning behind the essential elements of effective field trips that were discussed above can be better understood from the perspective of constructivism. One of the main premises of constructivism is that knowledge is created through experience. Constructivist methodologies can increase the benefits of cooperative learning environments (Marinoloulos & Stavridou, 2002). Furthermore, a field trip that engages students in active participation and multi-sensory activities will create a rich set of experiences that can be taken back to the classroom. The teacher can then refer back to those experiences in future instruction.

Hands-on experiences also provide the student with opportunities to reevaluate their prior beliefs. A contradiction between prior beliefs and current experiences forces students to construct new knowledge that can overthrow existing misconceptions (Lawson, 1994). Thus, active constructivism instruction can not only help student attain new knowledge, but also revise prior misconceptions. Cole (1995) builds on constructivist ideals to encourage museum docent and curators to "inform through participation," and applauds the increased popularity of interactive open-ended exhibits.

The benefits of reduction of novelty can be explained through the constructivism lens as well. It has been demonstrated that pre-visit activities benefit field-trip learning (Barshinger & Ray, 1998; Falk et al., 1978; Gennaro, 1981; Kubota & Olstad R. G., 1991; Orion & Hoftein, 1994). Rather than attributing this benefit to the reduction in anxiety, the preparation can be seen as providing a foundation upon which the actual field trip learning can be built. The same is true of the timing of the field trip within the curriculum. A trip that is integrated into the learning continuum benefits from the prior cognitive preparation of the students and serves as a foundation for their further learning.

Furthermore, a trip that takes place in a local outdoor setting or focuses on local issues allows students to integrate prior experiences into their learning structure.

An environmental education study outlines how a constructivist approach can benefit not only knowledge gain, but also the construction of more positive environmental attitudes. Ballantyne and Packer (1996) examined the development of environmental conceptions. They proposed that the conception of a phenomenon integrates relevant knowledge, attitude, and behavior. As was discussed above, understanding the learner's foundation of knowledge is needed for further cognitive gains. Similarly, it is important to understand a learners pre-conceived attitudes. The authors suggest that by understanding why a given learner would want to protect the environment, the instructor can be better equipped with appropriate materials that could address issues of interest to the learner (Ballantyne & Packer, 1996). This study demonstrates that constructivism is applicable not only to the cognition, but also to the affective domain.

2.1.7 Attitude towards learning

An educational experience has many overlapping goals. While increased knowledge often takes first priority, a positive attitude towards the experience is critical, as a child who views a field trip negatively will not want to repeat the trip, engage further in the subject, or pursue science as a career (Tressel, 1980). Environmental education strives for life-long learning (NAAEE, 2000b), and thus continued learner interest and positive attitude are essential. Several studies have demonstrated higher learner attitudes when more effective field trip methodologies were implemented. More positive learner attitudes were observed as the result of pre-visit preparation (Barshinger & Ray, 1998), more appropriate timing of the visit within the curriculum (Orion & Hoftein, 1994), cooperative learning (Chung & Son, 2000; Nicol, Kane, & Wainwright, 1994), and participation in interactive activities as compared to text exhibits and lecture-style lessons (Flexer & Borun, 1984; Knapp & Poff, 2001; Washburne & Wagar, 1972).

2.2 The essential elements of environmental education

The North American Association for Environmental Education has published a set of guidelines for practitioners in the field (NAAEE, 2000a; NAAEE, 2000b). Grounded in international charters discussed earlier (UNESCO-UNEP, 1976; UNESCO-UNEP, 1978), it is viewed as the state of the art for implementing and designing both formal and nonformal environmental education programming. Thus, it was used as the foundation for identifying the essential elements of environmental education. The following discussion reviews the studies from the primary academic literature supporting these elements as the basis for best practice in environmental education field trip programming.

Prior to identifying the essential elements of environmental education per se, it is important to reexamine the goals for a successful environmental education program. Unlike science education with the primary focus on knowledge gain, environmental education aims to both induce environmentally positive attitudes, and teach towards a responsible and active citizenry (UNESCO-UNEP, 1978). Some researchers have proposed that knowledge will lead to attitude (Fortner & Teates, 1980; Moore, 1981) which will in turn lead to appropriate behavior (Callicott, 1987). Simmons (1991) showed that two-thirds of the 1,225 environmental and nature centers surveyed believed this to be true. If this was the case, it would be sufficient to examine essential elements that maximize environmental knowledge gain. However, the "knowledge to attitude to behavior" model has been repeatedly critiqued and shown to be incorrect (Borden & Schettino, 1979; Hungerford & Volk, 1990; Ramsey, Hungerford, & Tomera, 1981; Sia, Hungerford, & Tomera, 1986). Much more complex interactions of many interdependent factors, only some of which are within direct control of an educator, have been shown to drive an individual's behavior (Hines et al., 1986). Thus, the following discussion will attempt to present the components that are within the scope of an educational program, as well as acknowledging other relevant factors that effect environmentally responsible behavior.

As was stated earlier in defining environmental education, it strives to teach *in*, *about*, and *for* the environment. These three perspectives play independent roles in the ultimate behavior choice of the learner, and thus will be used as organizing subsections below.

2.2.1 Teaching in the environment

2.2.1.1 Exposure to nature

Just like it is hard to learn art history without seeing art, it is hard to learn about the environment without experiencing it first hand. However, the theoretical reasoning for exposure to nature goes deeper. In the 1956 publication of *Sense of Wonder*, Rachel Carson argued that for a young child it is most important to be exposed to nature and gain an appreciation for it. Once the child becomes curious about his surrounding, he would pursue further study, and acquire the necessary factual knowledge (Carson, 1956). Research on the formation of environmental sensitivity of leaders in environmental professions supports this assertion. A review of the significant life experience literature demonstrated that 64%-91% of individuals surveyed attributed their environmental interests to outdoor experiences (Chawla, 1998b). Furthermore, outdoor recreation has been shown to correlate positively with environmental concern (Dunlap & Hefferman, 1975).

The benefits of outdoor experiences can be seen immediately following the exposure, not just many years later in adulthood. Students participating in a residential program that allowed for substantial amount of time in nature had more positive attitudes toward wildlife, than students who received an in-class program on the same topic (Dettmann-Easler & Pease, 1999). Ramsey (1993) hypothesized that an environmental education program designed for in-class instruction failed to achieve the goal of environmental sensitivity, while being effective at realizing cognitive goals, because it lacked the outdoor component necessary to build sensitivity (Ramsey, 1993; Ramsey & Hungerford, 1989). More positive self-esteem and self-concept have likewise been reported as the result of outdoor programs (Dressner & Gill, 1994; Hattie, Marsh, Neill, & Richards, 1997; Palmberg & Kuru, 1998). Self esteem effects an individual's perception of their ability to have an impact on a problem (internal locus of control will be discussed in greater detail below), and was shown to be a major influence on learner desire to take further environmental actions (Dressner & Gill, 1994).

Experiences in nature not only produce more positive attitudes, but also allow for intuitive learning. Harvey (1989) examined the effect of schoolyard vegetation on botanical knowledge and attitude of 8-11 year old students. She found not only a positive correlation of attitude with past and present experiences with vegetation, but also a correlation of knowledge with the same factors. Environmental complexity further benefited learning.

2.2.2 Teaching about the environment

All of the essential elements presented up until now have been primarily concerned with how education would proceed, focusing on the *education* component of environmental education. In teaching *about* the environment, program content becomes the focal point. The program content can be viewed hierarchically, starting with environmental literacy and basic scientific knowledge, continuing to issues investigation, and concluding with knowledge of action strategies and strategy implementation skills (Hungerford, Peyton, & Wilke, 1980). Each will be discussed independently, however only when all components are included will the program be truly effective (Hines et al., 1986; Hungerford & Volk, 1990).

2.2.2.1 Learning themes

Environmental education takes a holistic approach to learning, and is not restricted to any particular component of either the natural or manmade environment. The whole curriculum as proposed by the North American Association for Environmental Education is most easily viewed in four subcategories. The first two categories pertain to earth and life sciences, whereas categories three and four deal with the interaction between human societies and the environment. Category three approaches interactions from the social science perspectives, covering topics such as culture and economic systems. Category four, on the other hand, covers human interactions with natural systems such as resource use, technology, and concrete human-induced environmental issues (NAAEE, 2000a). While program duration limits the content that can be covered by any one educational field trip, a learner should have the opportunity to be exposed to all components of the complete curriculum. Thus, a set of programs delivered by educational institutions catering to the same population should address all four of the identified categories.

2.2.2.2 Environmental literacy

Environmental literacy forms the foundation of environmental education, covering different topics from the themes discussed above. While the need for literacy seems self-evident, several studies performed with participants of different ages have indicated substantially lacking environmental knowledge. When asked to define the *nature set*, the responses of elementary school students in Italy varied widely, with only one student relying on scientific concepts, even though all had covered ecological topics (Mortari, 1997). Only 57% of grade 12, and 51% of grade 10 U.S. high school students were able to answer more than half of the questions correctly on an environmental knowledge scale (Gambro & Switzky, 1996). In defining the concept of *life*, only 12.8% of responding students relied on biological aspects, whereas the remainder used aesthetic, religious, or emotional values to structure the definition (Schaefer as cited in Grace & Ratcliffe, 2002). In a survey of adults, 73% were unfamiliar with "loss of biological diversity." Even more troubling were the findings that many of the adults belonging to environmental organizations were also unfamiliar with the concept (Pennisi, 1993). A well-designed environmental education program can have a significant and substantial effect on learner knowledge gain (Bradley, Waliczek, & Zajicek, 1999).

The lack of knowledge presented above is exacerbated by the misconceptions and attempted actions of mal-informed individuals. Grace and Ratcliffe (2002) showed that high school students relied more heavily on values than on scientific concepts when forming opinions about conservation issues. Fifth and six grade students in Greece scored high on a survey of environmental attitudes towards local sea turtle conservation, but received low scores on knowledge about the same issue (Dimopoulos & Pantis, 2003). While positive environmental values are crucial, alone they can lead to poor decision making. Blaikie (1993) investigated ecological world views and actions of Australian university students. Although many students expressed an interest in avoiding purchasing environmentally harmful products, only 11% were able to correctly identify 3 or more such products. Similarly, Gigliotti (1990) argued that values and behavior of citizens is often based on environmental myths rather than facts. Further challenge is added to the job of the environmental educator by the prevalence of factual errors in instructional materials (findings of the Independent Commission on Environmental Education as reported in Salmon, 2000). Therefore it is imperative for educators not to loose sight of the need for accurate and comprehensive factual information in the effort to meet environmental education mandates.

2.2.2.3 Knowledge of environmental issues

The knowledge of environmental issues and their consequences builds on factual information, and acts as a stepping stone toward the comprehension of action strategies. It is only logical that action strategies can not be learned without first learning the issues to which they pertain. Knowledge of issues was first proposed as an integral part of an individual's intention to act on an environmental problem as a result of a meta-analysis of 128 studies conducted prior to 1986 (Hines et al., 1986). In 1990 "in-depth knowledge about issues" was incorporated into the set of "ownership variables" in a linear progression towards citizenship behavior (Hungerford & Volk, 1990). Ownership variables are critical to personal identification with a particular problem, and were still considered a driving factor in a recent review (Culen, 2001). Furthermore, there are general pedagogy benefits to the study of issues. Learning through issues investigation in the field allows for students to be actively engaged with the material and involved with the subject matter (Keown, 1984). The benefits of active participation were highlighted earlier both specifically, and from the perspective of constructivist teaching.

2.2.2.4 Knowledge of action strategies and implementation skills

Once an individual has the required knowledge of the environment and associated issues, he/she needs to know what to do and how to do it in order to help resolve the problem. Knowledge of action strategies and implementation skills are one of the final "empowerment variables" in achieving citizenship behavior (Hungerford & Volk, 1990). This assertion was based on three doctoral dissertations conducted in the 1980's that have consistently reported that "perceived knowledge of environmental action strategies" and "perceived skill in using environmental action strategies" are significant predictor variable of responsible environmental behavior in members of environmental organizations such as the Audubon Society, Ducks Unlimited, or Sierra Club (reviewed recently in Marcinkowski, 2001). A similar investigation of both rural and urban secondary school teachers in Taiwan again showed knowledge and skill of action strategies to be significant predictors of behavior (Hsu & Roth, 1998). Furthermore, Hwang and colleagues (2000) hypothesized that in their study knowledge had little effect on an individual's intention to act because they only tested knowledge of an issue, not the associated action strategies. Knowledge of action strategies and implementation skills would have likely had a significant effect.

The above studies all focused on adult behavior as predicted by knowledge acquired over many years of experience. One might wonder if it is feasible to teach children the necessary information. Several studies have demonstrated that issues investigation and action training can positively affect junior high school students' knowledge of action strategies and skills, and lead to more environmentally responsible behavior (Culen & Volk, 2000; Ramsey et al., 1981; Ramsey & Hungerford, 1989; Ramsey, 1993). Similarly, high school workshop participants who were exposed to both issues and action strategies instruction reported more responsible environmental behaviors than did participants learning only about the issues (Jordan, Hungerford, & Tomera, 1986). The effect of teaching action strategies can even be seen in elementary school children. Third grade students exposed to a skills-based curriculum were highly successful at applying environmental problem-solving skills to novel situations (Basile, 2000). These findings demonstrate that the environmental education goal of teaching towards an environmentally responsible citizenry is a realistic one.

2.2.2.5 Skill building

The importance of skills specifically related to investigating issues and implementing environmental action strategies was discussed above. However, learners participating in an environmental education program also need to be exposed to a broad range of skills that could help make them become the environmental leaders of tomorrow. "Emphasis on skill building" was identified as one of six key characteristics in reviewing environmental education materials for the "National Project for Excellence in Environmental Education" (Simmons, 2001). Both Keown (1984) and Palmer (1998) have pointed to the benefits and importance of developing effective communication skills in the learner, while the need for cooperative learning skills was highlighted earlier. Furthermore, using a variety of inquiry tools ranging from magnifying glasses to simple thermometers can help build investigation skills, as well as peaking student interest, and exposing hidden aspects of the surrounding (NAAEE, 2000a).

2.2.3 Teaching for the environment

Teaching for the environment is concerned with the learner's affective domain. While researchers have been interested in the function that affect plays in learning (Meredith, Fortner, & Mullins, 1997), the role of education in directly influencing attitudes is unclear (Iozzi, 1989a; Iozzi, 1989b). However, beliefs and attitudes do have a strong effect on behavior (Hines et al., 1986), and thus warrant discussion as they need to be controlled for in this and other environmental education studies.

2.2.3.1 Environmental role models

It has been shown that adult models can influence the environmental attitudes and values of children (Knapp, 1972). Sixth grade students who talked about the environment at home had significantly higher environmental attitudes then students who did not. However, there was no significant effect of engaging in classroom discussion (Eagles & Demare, 1999). Research on determinants of environmental sensitivity in adult environmental leaders supports these finding. As many as 77% of survey respondents identified family members as a significant factor of environmental interests, but only 31% identified teachers as an influence (Chawla, 1998b). These findings suggest that while teachers and environmental institution instructors can occasionally influence the attitudes of the learner, much stronger influence comes from the home. Thus educators still need to set an environmentally conscience example and present knowledge in an unbiased form, but researchers need to be aware of the influence of relatives.

2.2.3.2 Attitude

Attitudes are an individual's feeling, values, and beliefs towards a particular issue. Attitudes, however, do not bind the holder to action. For example, an individual might like the idea of swimming in a clean lake, but that attitude might only be expressed verbally if a polluted lake is more accessible (Knapp, 1972). This hypothetical situation demonstrates why attitude is not the sole determinant of behavior, and hints at the role it plays in decision making. The meta-analysis conducted by Hines and her colleagues (1986) placed attitude with other "personality factors" that in turn effect an individual's "intention to act." According the authors' meta-analysis based model, final behavior is also influenced by knowledge as discussed earlier, and "situational factors," such as lake accessibility in the above example. Hwang and colleagues (2000) showed a slight effect of attitude both on intention to act, and on personal responsibility. The review by Hungerford and Volk (1990) identified attitudes towards pollution, technology, and economics as a minor "entry-level" variable in determining citizenship behavior. These studies demonstrate that while the strength of attitude effect on behavior varies depending on research methodology, it is a consistent influencing factor.

The need for positive environmental attitudes in obtaining responsible environmental behavior is fairly clear, but the effect that education can have on attitude is questionable. Several researchers have shown improved learner attitudes as the result of an environmental education program through quantitative (Bradley et al., 1999; Jaus, 1982; Jaus, 1984; Leeming, Porter, Dwyer, Cobern, & Oliver, 1997) and qualitative (Knapp & Poff, 2001) investigations, as well as a meta-analysis (Zelezny, 1999). However, the results are not consistent. For example, Leeming and colleagues (1997) found that while attitude increased in grade 1-3 students, it decreased in students in grades 4-6. The authors considered that the intervention was still successful because the attitudes of the control group decreased more than those of the treatment group. Others have reported no effect on attitude (Armstrong & Impara, 1991; Kostka, 1976; Kinsey & Wheatley, 1984; Zelezny, 1999). Given the general reluctance towards the reporting of negative findings, these results could be more widespread. As reported by an earlier review (Iozzi, 1989a), the relationship between education and attitude change is at best inconclusive.

The above inconsistency in findings calls for a deeper examination of the source of learner attitudes. There have been several proposed reasons as to why an environmental program might fail to produce the desired attitude change. Eagles and Demare (1999) showed that children's environmental attitudes are more strongly influenced by family and media than by school interactions, while Iozzi (1989a) suggested that a decrease or lack of change in learner attitude can result from greater pessimism toward the problem as knowledge is acquired. Ma and Bateson (1999) demonstrated a significant positive correlation between attitude toward science and attitude toward the environment. These studies suggest complex interaction of which environmental education is only one component. For example, the improvement in environmental attitudes could be hindered by pre-conceived negativity toward science (Ma & Bateson, 1999). The issue is further complicated as it is neither the goal nor ethically acceptable educational practice for environmental educators to directly teach what a learner's attitudes or values should be (Hungerford, 2001). Thus, the educator is left to walk the fine line of issues and action strategies instruction without indoctrination, while the researcher must be aware of both the limitations of an educational program in altering attitude, and the other variables that affect it.

2.2.3.3 Locus of control and personal responsibility

Locus of control refers to an individual's beliefs in their ability to have an impact on a given problem. Somebody with an internal locus of control believes that they can have a direct effect, and would thus be reinforced for their actions either extrinsically or intrinsically. An individual with an external locus of control, on the other hand, believes that power to cause change lies with luck, fate, or other more powerful individuals. These people feel that the consequences of their actions would be too minor for noticeable change, and thus reinforcement (Hamilton, 1986). This definition is easily extrapolated to an intuitive link between locus of control and behavior. Only those individuals who think they are capable of catching a fish are likely to go fishing. A similar analogy can be made with external locus of control and the outcomes of the "Tragedy of the Commons". In this theory public resources such as common grazing grounds are overexploited because individuals feel that their reduction in resource use will not mitigate overexploitation (Hardin, 1968). Individuals with an external locus of control are unlikely to cut back personal consumption when using public resources, while those with an internal locus of control would feel that even small actions can make a difference and would reduce consumption to benefit the greater good.

Experimental environmental education research supports the locus of control – behavior link. In a survey of Greek fifth and six grade students, the measure of the locus of control was positively correlated with verbal commitment to take action (Dimopoulos & Pantis, 2003). Trigg and her colleagues (1976) found that individuals with an internal locus of control engaged in more pro-environmental anti-pollution behaviors than external locus of control individuals. Several reviews and meta-analyses have presented similar findings. Hungerford and Volk (1990) placed locus of control into the concluding category of empowerment variables in the path to behavior. Hines and colleagues (1986) identified locus of control, along with attitudes and personal responsibility, as a personality factor effecting "intention to act." Hwang and colleagues (2000) demonstrated that locus of control has a significant effect on both "intention to act" and the sense of "personal responsibility." The connection between locus of control and personal responsibility is logical, as somebody who does not feel that they *can* do something, is unlikely to think that they *should* do it.

As with environmental attitudes, the connection to behavior is strong, but the link between education and an internal locus of control is tentative. Several researchers have demonstrated a significant positive correlation between the level of environmental knowledge, and an internal locus of control (Dimopoulos & Pantis, 2003; Hamilton, 1986). Smith-Sebasto (1995) showed positive gains in locus of control as the result of a university environmental studies course. However, the results are not always as clear. An issues investigation and action training module for eighth grade students produced positive gains in group locus of control (the belief in the collective ability to produce change), but not individual locus of control (Ramsey, 1993). Conversely, an extended case study focusing on wetlands failed to effect the group locus of control, but had a positive effect on individual locus of control of junior high school students (Culen & Volk, 2000).

The variation in the above findings suggests a difference in the type of education being presented. Earlier discussion pointed to the importance of knowledge of action strategies and skills. When somebody knows *how* to cause change, it is much more likely that they will believe that they *can* cause change. The factors interaction model of Hwang and colleagues (2000) demonstrated a significant effect of locus of control on precursors of behavior, but failed to show an effect of knowledge on locus of control. The authors hypothesized that this was because the knowledge under investigation was "general knowledge about an issue," not action strategies or skills. On the other hand, Dimipoulos and Pantis (2003), who showed a significant correlation between knowledge and locus of control, investigated both general biological knowledge and knowledge of "existing protective measures" as related to turtle conservation. Similarly, the environmental studies course reported by Smith-Sebasto (1995) to cause significant gains presented not only environmental content, but also extensive issues investigation and action strategies instruction. These findings suggest that locus of control might be one of the more easily influenced affective domain variables. While pre-conceived beliefs and attitudes will still play a role in determining whether somebody possesses an internal locus of control, a holistic education program can help to empower learners and instill a sense of personal responsibility.

Chapter 3: Methodology

3.0 General approach

The previous chapter identified the essential elements, while this chapter will present the research approach to their evaluation. As demonstrated by the two primary research questions, two perspectives were used in the investigation. The first involved an experimental survey to evaluate the apparent effect of essential elements on student learning and attitudes, while the second required extensive program observation to identify trends in essential element implementation across several environmental institutions. Due to this duality in the research study, specific methodology will be described separately for each component. However, together the two approaches provide a comprehensive view of environmental education in school field trip programming.

3.1 Research location

The research took place at informal environmental education institutions in Montreal, Quebec. While the location choice was largely a choice of convenience, Montreal makes for an appropriate study location. As a large metropolitan center, it has an ethnically and socio-economically diverse population base. This allows for large variation in the backgrounds of study participants, and enables a greater level of generalizability of the findings than if the population had been more homogeneous. Furthermore, the number of environmental institutions located within the metropolitan area boundary (the Island of Montreal) is both large enough to allow for a diverse sample, and small enough to allow for a manageable study without the need for sub-sampling.

3.2 Age focus

The time limitations imposed on this investigation permitted the inclusions of all the informal environmental education institutions in the designated geographic area, but not all of the learners visiting these institutions as part of a school field trip. The research focused on environmental education programs designed for grade 5 and 6 students. Extensive research literature support exists for this age group choice. Environmental attitudes often form prior to adolescence, and are solidified by the time students reach later years in high school (Bradley et al., 1999), while the largest change in children's political attitudes occurs as they go into fifth grade (Knapp, 1972). Furthermore, based on responses to a knowledge scale, it was shown that lower elementary school students relied primarily on guessing in their answer choice, while upper elementary and middle school students possess a substantial level of environmental knowledge (Leeming, Dwyer, & Bracken, 1995). While knowledge would continue to increase through maturation, the 5/6 grade level provides an ideal middle ground of sufficient knowledge, yet open-minded opinions. Experimental researchers have used similar findings for support in conducting studies with upper-elementary age students (Dimopoulos & Pantis, 2003; Jaus, 1982).

The identified age group is also appropriate from the perspective of the goals of environmental education. An investigation of intergenerational transfer demonstrated that upper-elementary school learners can be effective at influencing the environmental behaviors of other members of the household (Ballantyne et al., 2001). Learning from their children might be a more effective way of influencing adults, as direct interventions have a greater effect on children than adults (Zelezny, 1999). It is thus most worthwhile to focus an investigation of environmental educational essential elements on children, as they can have the greatest long term effect on the environmental education goal of a knowledgeable and active citizenry.

3.3 Survey methodology

3.3.1 Procedure

The Director of Educational programming at the Montréal Biodôme (an environmental education institution, description to follow) was contacted by the researcher in October 2002 to solicit initial support for the study and familiarize the researcher with Biodôme's educational programs. In the summer of 2003 the survey instrument was compiled, and a research proposal was submitted for

McGill ethics committee review (see Appendix 11 for ethics certificate). That fall teachers interested in participating in the study were identified through the Biodôme's registration records and the researcher's professional contacts. Interested teachers were mailed sufficient copies of the survey instrument (see Appendices 1-5 and detailed description below), survey administration instructions (Appendix 6), a brief questionnaire (see Appendix 7 and detailed description below), and an informed consent form (Appendix 8). All materials were made available in both English and French, and corresponded to the language of science class instruction. Completed surveys, questionnaires and consent forms were returned to the researcher also by mail.

Biodôme visits took place between November 2003 and March 2004. Identical surveys were administered by the teachers in the regular classroom setting within one week prior to the visit, and again within one week following the visit. Teachers were instructed to follow the survey administration procedure as closely as possible, and to conduct any preparatory activities prior to pre-visit survey administration and follow-up activities after post-visit administration to avoid confounding the visit effect. Data returned to the researchers was collated and analyzed statistically with professional assistance.

3.3.2 Sources of data

Montréal Biodôme is one of four museums that make up the "Scientific Institutions Direction" known by the French acronym, D.I.S. The D.I.S. abides by the mission statement, and describes itself as follows

> D.I.S. is a museum complex devoted to familiarizing the general public with the natural sciences and nature itself, sparking visitors' interest and teaching them about the world around them.
>
> In this way, the D.I.S. helps to make people aware of the importance of protecting our natural heritage and of the relationships between humans and the environment. (Montréal Biodôme, 2004)

The Biodôme specifically "strives to deliver an essential message: we are all part of nature and we can help protect it" (Montréal Biodôme, 2004). The Biodôme consists of four indoor artificially-controlled ecosystem replicas representing the Amazonian tropical rainforest, Quebec Laurentian forest, gulf of the St. Lawrence River marine area, and Polar regions. The ecosystems are natural representations that include live flora and fauna.

The Biodôme receives on the order of 1 million visitors annually, with 9,500-11,500 coming as part of a school group. In 2001, 953 cycle 3 (grade 5/6) students participated in a guided ecosystem visit. Each school program focuses on one of the four ecosystems, and includes a classroom introduction, activity in the ecosystem, and classroom wrap-up. Program duration is approximately 90 minutes. Following the guided component students visit the remaining facility with their classroom teacher. This research was conducted with students participating in the Tropical forest, St. Lawrence marine, and Laurentian forest programs.

Intact classes of students visiting the Montréal Biodôme were surveyed. A total of 393 students in 17 different classes participated, with 338 of the students completing both a pretest and posttest questionnaire. Six classes participated in the Tropical forest program, eight in the Laurentian forest program, and three in the St. Lawrence marine program. Five of the classes were grade 5, six were grade 6, four were grade 5/6 split, and two were grade 4/5 split (all classes participated in programs designed for cycle 3 [grade 5/6] students). Seven of the classes were part of a French immersion program, and conducted activities and responded to survey questions in French. The remainder of the classes conducted activities and responded to survey questions in English. Two of these English program classes consisting of students predominantly from Francophone households, with English instruction from kindergarten onwards, while the rest came from Anglophone or other first language households. The classes came from seven different schools with representation from both suburban neighborhoods and urban areas.

3.3.3 Instrument

3.3.3.1. Introduction

The instrument was compiled by the researcher with the aim of evaluating student learning and attitude, as well as extent of environmental background, with questions designed to assess as many of the previously identified essential elements as possible. The survey consists of 28 multiple choice questions sub-divided among three categories. The first section focused on the background of the learner, the second on learner feelings with regard to the environment, and the third on specific content-related knowledge. Since content varies depending on the program (Tropical forest, Laurentian forest, or St. Lawrence marine), the third section was designed specifically for each program, while the first two sections remained the same throughout the study. For the sake of maximized legibility, font size and margins were adjusted such that each of the three sections was printed on a separate page. A practice question was provided at the beginning of the survey to familiarize students with the multiple-choice format. Overall reading level and vocabulary use was evaluated and adjusted with the help of an expert.

In addition to the student survey, the instrument included a brief questionnaire completed by each classroom teacher. The purpose of this questionnaire was both to provide additional information and check student responses with relation to student environmental background. The teacher questionnaire is discussed in greater detail below, followed by a detailed description of each of the three student survey sections.

3.3.3.2 Teacher questionnaire (Appendix 7)

The teacher questionnaire was designed to address essential elements that could be more accurately assessed through teacher rather than student responses. It consisted of seven multiple choice questions, but respondents were encouraged to add open-ended comments wherever applicable. Three of the questions directly addressed essential elements, three acted as controls of student prior knowledge and field trip experience, while the final question gave teachers the opportunity to request a copy of the findings. Two of the questions mirrored those of the student survey to allow a self-check mechanism. Table 3.1 below lists the teacher questions, the essential elements that they address (if applicable), and the student questions with which they are correlated (if applicable). The complete questionnaire can be seen in Appendix 7 in the form that was presented to teachers.

Table 3.1: Teacher questions and associated essential elements and student questions

Teacher question	Essential element	Student question
1. How often do you take your students for a class outside?	Exposure to nature; Environmental role model	6. Does your teacher ever take your class for a lesson outside?
2. What are the school grounds like?	Exposure to nature	
3. What sorts of recycling facilities are available for your students at school?	Environmental role model	9. Does your school have bins for recycling?
4. How much time did you spend exploring the Biodôme with your class outside of the framework of the guided visit?	N/A (control)	
5. How much pre-visit preparation did you do with you students?	Reduction of novelty; (control)	
6. When did you conduct pre-visit preparation (if applicable)?	N/A (control)	
7. Would you like to receive a copy of the compiled results once the study is completed?	Teacher attitude toward study	

3.3.3.3 Survey section 1: Background (Appendix 1)

The purpose of the first section of the student survey was to assess learner environmental background, and evaluate the level of environmental exposure prior to the participation in the environmental education program. It consisted of nine multiple choice questions. The first two questions obtain broad information on student age and gender, while the remaining seven addressed such themes as the level of environmental involvement of family role models and the extent of exposure to the outdoors. While responses to these questions are not expected to change as the result of exposure to an environmental education program, these themes have been shown to effect attitudes and environmentally responsible behavior (as was described in Chapter 2). Thus, responses to questions in this section are important covariates in the overall analysis of the results. Table 3.2 below presents the questions for this section and associated essential elements, while questions and response options can be seen in Appendix 1.

Table 3.2: Student survey section 1 (student background) questions and associated essential elements

Question	Essential element
1. I am a: boy/girl	N/A (gender)
2. How old are you	N/A (age)
3. Have you ever been to the Montreal Biodôme?	Reduction of novelty
4. How often do you spend time doing nature activities (such as hiking, camping, fishing, canoeing, or walking in a park)?	Exposure to nature
5. Do you participate in nature activities with your family?	Exposure to nature; Environmental role model
6. Does your teacher ever take your class for a lesson outside?	Exposure to nature; Environmental role model
7. Is there a garden either at your school or at home?	Exposure to nature
8. How often does your family recycle at home?	Environmental role model
9. Does your school have bins for recycling?	Environmental role model

3.3.3.4 Survey section 2: Affective domain (Appendix 2)

The second section of the student survey was designed to assess aspects of learner affective domain. The ten four-point Likert scale questions addressed the domain's following components: overall environmental attitudes, level of internal locus of control, and sense of personal responsibility toward the environment. Prior studies attempting to evaluate similar factors with similar age groups were used to gain ideas for question content (Horvat & Voelker, 1976; Jaus, 1982; Siemer & Knuth, 2001; Leeming et al., 1995; Morrone, Mancl, & Carr, 2001), while the final wording was decided by the researcher. It was necessary to include these questions because based on the literature review (see Chapter 2) learner affective domain has a strong influence on environmentally responsible behavior, and could be affected by exposure to an environmental program. Furthermore, responses could be used to evaluate the effect of learner prior environmental attitudes on knowledge and learning. Table 3.3 below presents the questions and associated essential elements (affective domain components).

Table 3.3: Student survey section 2 (environmental attitudes) questions and associated essential elements

Question	Essential element
10. By taking part in environmental activities such as planting of trees or helping start a recycling program, I can help to protect natural areas.	Locus of control
11. I can help to protect the environment by turning off water and lights when they are not in use.	Locus of control
12. If I see somebody wasting water, I feel I should tell him or her to stop.	Personal responsibility
13. I would spend some of my own money to help protect wild animals.	Personal responsibility
14. It makes me feel good to know I am helping the environment.	Locus of control
15. People's actions affect the environment.	Overall attitude
16. Natural resources (such as wood for making paper, water for drinking and washing, and gasoline for driving cars) should be carefully conserved and recycled.	Overall attitude
17. To help reduce pollution, people should drive cars less, and walk or ride bicycles more.	Overall attitude
18. People must know more about the environment in order to help protect it.	Overall attitude
19. As a member of my community, it is my job to pick up litter at school, even if it is not mine.	Personal responsibility

3.3.3.5 Survey section 3: Knowledge (Appendices 3-5)

The purpose of the final section of the student questionnaire was to evaluate specific content-based knowledge. It was designed by the researcher based on information obtained by observing a typical program. The nine multiple choice questions were different for each of the three programs (Tropical forest, Laurentian forest, and St. Lawrence marine), but wherever possible, similar themes were retained. For example, each survey asked students to identify the ecosystem based on a list of animals that live there. The response options for each of the questions included one correct answer, three incorrect answers, and an "I do not know" option. This technique has also been used by other researchers to minimize error due to random guessing (Dimopoulos & Pantis, 2003).

In composing the questions for the third section of the student survey, an attempt was made to address all three components of essential knowledge (environmental literacy, knowledge of environmental issues, knowledge of action strategies). However, only the Tropical forest program presented information in the "knowledge of action strategies" category, while the Laurentian forest and St. Lawrence marine programs only taught general environmental literacy and some associated issues. Table 3.4 on the next page presents the questions in each survey that are associated with each category (essential element). Complete questions as they were presented to the students are in Appendix 3 for Tropical forest, Appendix 4 for Laurentian forest, and Appendix 5 for the St. Lawrence marine program.

3.3.4 Data analysis

The data obtained from the Biodôme survey was analyzed statistically with professional assistance to evaluate student knowledge and attitude from three perspectives. First, to assess survey reliability, the Cronbach Alpha coefficient was calculated for the knowledge scores of the three ecosystem programs, and the overall attitude score. Thematically similar student questionnaire and teacher questionnaire responses were also compared. The second goal of the data analyses was to gain an understanding of what drives pre-visit knowledge and attitude scores. The final goal was to evaluate the extent of knowledge gain and attitude change, and to assess what could be influencing them. A combination of correlation, t-test and general linear model techniques were implemented to test the relationships outlined in table 3.5 on the following pages.

Table 3.4: Student survey section 3 (environmental literacy) questions for three programs by essential element

Essential element	Tropical forest questions	Laurentian forest questions	St. Lawrence marine questions
Environmental literacy	20. The roseate spoonbill, capybara, and piranha all live in which ecosystem?	20. The porcupine, river otter, common loon, and lake sturgeon all live in which ecosystem?	20. The starfish, blue whale, green-winged teal, and halibut all live in which ecosystem?
	21. What kind of animals have scales, lay eggs, and breathe with lungs?	21. Which of the following is NOT a characteristic of the beaver?	21. The sea-urchin, lobster, whelk, and starfish all belong to which group of animals?
	22. Which of the following is NOT a bird?	22. Which of the following are parts of the ecosystem?	22. Which of the following animals does NOT use a suction foot or suction feet to stick to a rocky surface?
	23. Where can tropical forest be found in the world?	23. Which of the following is an example of an interrelation between living things?	23. How would you describe the water in the St. Lawrence marine region?
	24. Which of the following are parts of the ecosystem?	24. Where can the Laurentian forest be found in the world?	24. What do the starfish and sea urchin have in common?
		25. Which of the following events is NOT a result of seasons?	25. What are the lobsters' claws used for?
		26. What can you tell by looking at the skull of an animal?	26. Why are the feathers of green-winged teal females brown?

Table 3.4 continued: Student survey section 3 (environmental literacy) questions for three programs by essential element

Essential element	Tropical forest questions	Laurentian forest questions	St. Lawrence marine questions
Knowledge of environmental issues	25. Why is it important to protect the tropical rain forest?	27. Why is it important to protect animals such as lynx?	27. Which species has disappeared from the estuary and the gulf of the St. Lawrence River?
	26. In which of the following groups of foods do all three come from the tropics?	28. What would happen in a part of the Laurentian forest where there were no trees?	28. What effect(s) does pollution have on the St. Lawrence marine ecosystem?
	27. Where does aluminium come from?		
Knowledge of action strategies	28. How can the recycling of aluminium (such as from soda cans) in Montreal help protect the tropical rain forest?	N/A	N/A

Table 3.5: Relationships evaluated in analyzing survey results

Primary variable	Secondary variables
Knowledge pretest	Student background
	Teacher
	Attitude pretest
Attitude pretest	Student background
	Teacher
Knowledge gain	Knowledge pretest
	Student background
	Teacher
	Attitude pretest
Attitude change	Attitude pretest
	Student background
	Teacher
	Knowledge pretest
	Knowledge gain

3.4 Program observation methodology

3.4.1 Procedure

In the fall of 2003 the observation instrument was compiled based on previously identified essential elements of environmental education, and a research proposal was submitted for McGill ethics committee review in January 2004 (see Appendix 12 for ethics certificate). At the same time the researcher began contacting potential environmental education institutions that provide environmental education programs for school groups and could be interested in participating. The researcher met with appropriate institution personnel to solicit further support and obtain schedules of programs to be conducted during the winter and spring. A copy of the instrument (Appendix 9) was made available to each institution prior to the observations. All of the observations were conducted by one researcher, and took place from late January through early June of 2004. The program instructor was asked to sign an informed consent form (Appendix 10) at the start of each program observation. Once the program began, the researcher remained at the back of the group in the least obtrusive manner possible, to allow the instructor to proceed with the program in a natural fashion. The researcher took notes on both the presence of essential elements, and on the method of their implementation. Upon completion of the observation the data were compiled in a spreadsheet, and grouped for presentation by essential element.

3.4.2 Sources of data

A total of eight environmental education institutions participated in the study. Initially ten were contacted, but one did not offer appropriate programming, and another was not willing to participate. An analysis of the programming at eight out of the nine institutions that offer age and content appropriate programming on the Island of Montreal provides a comprehensive view of the state of environmental education in this area.

Due to ethical considerations, it is not possible to name the participating institutions, or talk about their individual characteristics. However, an overview of the group as a whole provides an idea of the similarities and differences between the participating institutions. All of the institutions have an environmental education agenda in their mission statements, emphasizing nature conservation and teaching about environmental protection. While education is the sole focus of some of the institutions, others also include scientific research or environmental conservation programs. Some of the institutions have extensive indoor facilities; others combine indoor and outdoor activities; while some focus exclusively on outdoor programming. The total number of visitors is also starkly different. The total number of visitors per year ranged from under 1,000 to just over 1 million, with guided group visits making up 43,000 visitors at one institution. Together the eight environmental education institutions greet approximately 2.5 million visitors annually.

A total of 24 different programs were observed in the study with anywhere from one to seven programs per institution. All efforts were made to observe each program twice to help account for differences in program instructor or slight content variation. However, given the limited number of registered groups at some institutions, this was not always possible. Of the 24 programs, 16 were observed twice, and 8 once, for a total of 40 observations conducted in the study. Programs ranged in duration from 1 to 5 hours, with most being 1.5 or 2 hours long. The age group focus was grade 5/6 to correspond to the Biodôme survey study. In instances where either a grade 5/6 program was not available for observation or observing programs for other age groups would provide a much better understanding of institution operations, other age groups were observed. The overall program observation age range was grade 3-8.

3.4.3 Instrument

The observation guide instrument (Appendix 9) was designed based on previously identified essential elements with the aim of creating a list of key program components and topics. During program observation the researcher used the observation guide to identify essential element presence or absence, and take notes on methodology of essential element implementation. For maximized ease of use during observations, the instrument was printed as two columns on one side of one landscaped page.

The key program components of the instrument were divided into four levels. Levels 1, 2, and 3 reflect essential elements of an environmental education program that were discussed in Chapter 2. Level 1 groups those essential elements that involve program development decision-making at the institutional level, while level 2 presents the elements that are under the control of each individual program instructor and reflect teaching methodologies. In level 3 the proportion of time spent on gaining factual environmental knowledge, learning about environmental issues, or acquiring environmental action strategies was evaluated.

Level 4 of the observation guide differs slightly from the other three groups. It is aimed at identifying the specific learning themes that might be presented during a program. As it is not possible for any one program to cover all the topics, the goal of this section is to identify the themes covered on a regional, rather than single program basis. The theme categories were identified based on a publication of the North American Association for Environmental Education (NAAEE, 2000a), and are described in more detail in Chapter 2.

3.4.4 Data analysis

The results of the observation of the 24 different programs at eight Montreal environmental education institutions can be loosely grouped into two categories. The first set of findings is numerical in nature, indicating either presence or absence of the essential elements in the programs. For each of the essential elements in levels 1 and 2, each program received a score of 1, 0.5, or 0. A score of 1 indicates that the essential element in question was covered well. A score of 0 indicates that it was not covered at all, while a score of 0.5 indicates that the element was touched upon, but does not satisfy the criteria for a full score of 1. In the case of level 3, the score for each program was the percentage of the amount of time spent on each type of learning. Finally, for level 4, a program received a 1 for each of the themes that it covered. For programs that were observed twice, the results were averaged prior to any further analyses.

Descriptive statistics were conducted on these data sets to identify which of the essential elements are being widely implemented, and which are underrepresented in Montreal environmental education programming.

The second category of data is based on researcher notes on how particular essential elements are implemented and which topics are discussed. These results are grouped by essential element, and describe the various possible implementation methodologies. The findings could prove useful for environmental education program design as educators could use the examples of the essential element implementation techniques as guidelines for future program development.

For level 4 of the instrument (learning themes) the list of possible topics that could be covered for each theme is broken down further beyond the categories listed in the instrument to facilitate analysis and legibility. The subheadings are based on the same NAAEE document (NAAEE, 2000a) that was used to design the initial instrument, and reflect both themes that are appropriate for the K-4 grade level, and the 5-8 grade level. Since the observed programs ranged from grade 3-8, it was possible to use the grade level division of the themes to also judge the age-appropriateness of Montreal environmental education programming.

Chapter 4: Results

4.0 Introduction

The previous chapters have explained the rationale and methodology of this research study. This chapter will present the findings, while the final chapter of the work will discuss the results and bring forth conclusions. The results are organized similarly to the methodology, with the findings of the survey study conducted at the Montréal Biodôme presented separately from the observation study of the 24 environmental education programs at eight Montreal institutions. The two sets of findings will be combined into a unifying conclusion in the final chapter.

4.1 Survey results

The following results are based on statistical analysis of the survey questionnaires administered to students visiting the Montréal Biodôme. The findings are divided into three categories. The first presents the reliability of the survey instrument. The second presents factors influencing student knowledge and attitude prior to the Biodôme visit. The final section addresses the observed gains in knowledge and change in attitude, and factors that affect these parameters. The relationship between gain in knowledge and change in attitude is also presented in the final section. In all of the following tables, St. Lawrence Marine ecosystem will be referred to as St.Law, the Laurentian Forest will be referred to as Lauren, and the Tropical Forest will be referred as Trop. Significant relationships are indicated with asterisks (*), while significant relationships with counter-intuitive findings are identified with the pound (#) sign. Further discussion of the findings is presented in Chapter 5.

4.1.1 Survey reliability

The reliability of the survey findings was tested in two ways. First, the Cronbach Alpha coefficient was calculated for each of the survey components (table 4.1). Secondly, a self-check mechanism built into the instrument was used to compare responses to thematically similar teacher and student questions (table 4.2).

Table 4.1: Cronbach's Alpha coefficient of survey reliability for the pre and posttest questionnaires for each ecosystem and the attitude scores.

	Trop	Lauren	St.Law	Attitude
Pretest	α (N=9) = .479	α (N=8) = .285	α (N=9) = .341	α (N=10) = .798
Posttest	α (N=9) = .688	α (N=8) = .561	α (N=9) = .163	α (N=10) = .830

Table 4.2: The relationship between teacher and student responses to thematically similar questions.

Student question	Teacher questions	χ^2 relationship
6. Does your teacher ever take your class for a lesson outside?	1. How often do you take your students for a class outside?	$\chi^2(1, N=379) = 6.56$**
9. Does your school have bins for recycling?	3. What sorts of recycling facilities are available for your students at school?	$\chi^2(1, N=399) = 0.74$

** indicates a significant relationship ($p < .01$)

4.1.2 Pre-visit knowledge and attitude

Knowledge and attitude pretest scores were found to be correlated with some teacher questionnaire responses and student background responses (section 1 of the student questionnaire). These findings are in tables 4.3, 4.4, 4.6 and 4.7 on the following pages. Furthermore, some knowledge and attitude pretest scores were statistically significantly correlated with each other (table 4.5).

Table 4.3: Results for the comparison of student background (for each questions, and grouped thematically) to knowledge pretest scores. Equal variance could not be assumed for the t-test conducted for Tropical forest question #6.

Student Q. #	Trop pretest	Lauren pretest	St.Law pretest
1	F(1,148)= 0.82	F(1,170)=0.48	F(1,66)=0.01
2	F(3,147)= 1.69	F(3,168)=1.21	F(3,64)=1.55
3	t(148)= 2.43*	t(169)=1.42	t(66)=1.05
4	r(150)= .04	r(172)= -.16*	r(68)= -.08
5	t(147)= 1.36	t(169)=0.84	t(65)=-0.98
6	t(122)= -1.96 %	t(169)=0.88 %	t(66)=0.71 %
7	t(146)= -0.49	t(170)=-0.74	t(66)=-1.60
8	r(151)= -.04	r(172)= .002	r(68)= .14
9	F(2,148)= 0.21 %%	F(2,169)=2.97 %%	F(2,65)=1.38 %%
Exposure to nature	r(147)= -.15	r(171)= .08	r(68)= -.04
Role model	r(147)= -.04	r(165)= .08	r(66)= -.10

* indicates a significant relationship (p < .05)

% run as a comparison to thematically similar teacher Q. # 1; results are inconclusive because sample size should equal the number of teachers, not the number of students

%% variance is too small for conclusive findings

Table 4.4: Results for the comparison of teacher questionnaire responses to student knowledge pretest scores. Since question 4 reflects time spent at the Biodôme, it is not applicable to pre-visit knowledge.

Teacher Q. #	Trop pretest	Lauren pretest	St.Law pretest
1	r(6)= -.20	r(7)= .70	%
2	r(6)= -.20	r(7)= -.40	%
3	r(6)= -.35	r(7)= .70	%
4	N/A	N/A	N/A
5	r(6)= .27	r(7)= -.23	r(3)= .98
6	r(4)= .61	r(6)= -.05	%
7	F(1,4)= .04	F(1,5)=1.12	F(1,1)=21.23
Exposure to nature	r(6)= -.22	r(7)= .42	%
Role model	r(6)= -.33	r(7)= .82*	%

* indicates a significant relationship (p < .05)

% could not be computed due to lack of variance

Table 4.5: Pearson correlation results for the comparison of student attitude pretest scores (for each question, for all responses, and grouped thematically) to student knowledge pretest scores.

Student Q. # (pretest)	Trop pretest	Lauren pretest	St.Law pretest
10	r(148)= -.06	r(172)= .24**	r(68)= -.14
11	r(148)= -.02	r(172)= .09	r(67)= -.19
12	r(149)= .04	r(172)= .06	r(65)= -.03
13	r(149)= .01	r(172)= -.02	r(68)= .05
14	r(149)= -.04	r(172)= .06	r(68)= -.03
15	r(147)= .24**	r(171)= .24**	r(68)= .04
16	r(148)= .05	r(172)= .27***	r(67)= -.09
17	r(149)= .06	r(172)= .12	r(67)= .09
18	r(150)= .00	r(170)= -.06	r(68)= -.19
19	r(150)= .05	r(172)= .01	r(65)= .12
All Questions	r(138)= .05	r(168)= .16*	r(61)= -.06
Locus of control	r(145)= -.05	r(171)= .17*	r(67)= -.19
Personal responsibility	r(148)= .05	r(172)= .02	r(62)= .08
Overall attitude	r(144)= .14	r(169)= .22**	r(66)= -.03

*** indicates a significant relationship ($p < .001$)
** indicates a significant relationship ($p < .01$)
* indicates a significant relationship ($p < .05$)

Table 4.6: Results for the comparison of student background responses (for each questions, and grouped thematically) to attitude pretest scores.

Student Q. #	Attitude pretest
1	F(1,372)=16.61***
2	F(2,371)=15.12***
3	t(370)=0.80
4	r(373)= -.17***
5	t(370)=5.25***
6	t(371)=2.33* %
7	t(369)=1.00
8	r(374)= -.17***
9	F(2,371)=0.74 %%
Exposure to nature	r(369)= .18***
Role model	r(363)= .30***

*** indicates a significant relationship ($p < .001$)
* indicates a significant relationship ($p < .05$)
% run as a comparison to thematically similar teacher Q. # 1; results are inconclusive because sample size should equal the number of teachers, not the number of students
%% variance is too small for conclusive findings

Table 4.7: Results for the comparison of teacher questionnaire responses to student attitude pretest scores. Since question 4 reflects time spent at the Biodôme, it is not applicable to pre-visit attitude.

Teacher Q. #	Attitude pretest
1	r(16)= .09
2	r(16)= -.29
3	r(16)= -.19
4	N/A
5	r(16)= .06
6	r(13)= -.31
7	F(1,14)=0.54
Exposure to nature	r(16)= -.10
Role model	r(16)= -.11

4.1.3 Knowledge gain and attitude change

Substantial knowledge gains were found following a visit to the Montreal Biodôme. Table 4.8 presents the percent increase in the number of questions answered correctly when comparing pre-visit and post-visit questionnaire results. In addition to comparing the overall questionnaire results, gains for the knowledge subcategories of environmental literacy, environmental issues, and environmental action strategies were evaluated. Tables 4.9-4.12 present relationships with factors that could potentially influence gain in environmental knowledge.

The change in environmental attitude was less consistent than the gain in environmental knowledge. The results for the change for the entire sample population, and by ecosystem are presented in table 4.13. Several factors were shown to be correlated with attitude change. These findings are in tables 4.14-4.18 on the following pages.

Table 4.8: The percent gain in knowledge (for all questions, and grouped thematically) for each ecosystem, and corresponding t-test values for the difference between the pretest and posttest scores.

Knowledge group	Trop	Lauren	St.Law
Overall gain	23% t(121)=11.99***	12% t(160)=6.61***	18% t(54)=6.38***
Literacy gain	21% t(121)=9.83***	15% t(160)=7.45***	23% t(54)=7.39***
Issues gain	23% t(121)=7.53***	4% t(160)=1.15	1% t(160)=0.17
Strategies gain	31% t(121)=6.89***	N/A	N/A

*** indicates a significant relationship ($p < .001$)

Table 4.9: The relationship between student pretest scores and score gain for all questions, and grouped thematically.

Knowledge group	Trop	Lauren	St.Law
Overall gain	r(122)= -.29***	r(161)= -.42***	r(55)= -.64***
Literacy gain	r(122)= -.36***	r(161)= -.46***	r(55)= -.61***
Issues gain	r(122)= -.40***	r(161)= -.53***	r(55)= -.73***
Strategies gain	r(122)= -.30***	N/A	N/A

*** indicates a significant relationship ($p < .001$)

Table 4.10: Results for the comparison of student background (for each questions, and grouped thematically) to knowledge gain scores. The ANCOVA calculations were run with knowledge pretest as a covariate.

Student Q. #	Trop gain	Lauren gain	St.Law gain
1	R^2= .12 F(1,118)=4.55*	R^2= .17 F(1,157)=0.002	R^2= .40 F(1,51)=0.45
2	R^2= .10 F(1,118)=0.71	R^2= .22 F(1,157)=4.91**	R^2= .40 F(1,50)=0.27
3	R^2= .11 F(1,118)=2.54	R^2= .17 F(1,156)=1.04	R^2= .41 F(1,51)=1.43
4	r(121)= -.06	r(160)= .16*##	r(54)= -.06
5	R^2= .13 F(1,118)=6.53*	R^2= .17 F(1,156)=0.01	R^2= .39 F(1,50)=0.86
6	R^2= .20 F(1,119)=17.43***# %	R^2= .18 F(1,156)=2.08 %	R^2= .53 F(1,51)=14.4* %
7	R^2= .13 F(1,118)=5.70*	R^2= .20 F(1,157)=4.03*	R^2= .39 F(1,51)=0.04
8	r(122)= -.26***	r(160)= -.12	r(54)= -.02
9	R^2= .10 F(1,118)=1.01 %%	R^2= .18 F(1,157)=1.06 %%	R^2= .44 F(1,50)=1.96 %%
Exposure to nature	r(120)= -.04	r(158)= -.13	r(54)= .22
Role model	r(120)= -.001	r(155)= -.06	r(52)= .31*

*** indicates a significant relationship (p < .001)
** indicates a significant relationship (p < .01)
* indicates a significant relationship (p < .05)
# students who do not go outside with their teachers had greater gains
students who spent less time doing activities in nature had greater gains
% run as a comparison to thematically similar teacher Q. # 1; results are inconclusive because sample size should equal the number of teachers, not the number of students
%% variance is too small for conclusive findings

Table 4.11: Results for the comparison of teacher questionnaire responses (for each questions, and grouped thematically) to knowledge gain scores. The ANCOVA calculation was run with knowledge pretest as a covariate.

Teacher Q. #	Trop gain	Lauren gain	St.Law gain
1	r(6)= .19	r(7)= -.40	%
2	r(6)= .23	r(7)= -.10	%
3	r(6)= -.37	r(7)= -.80*#	%
4	r(5)= .94*	r(7)= .27	%
5	r(6)= .09	r(7)= .35	r(3)= -.73
6	r(4)= .47	r(7)= -.08	%
7	R^2= .99 F(1,3)=133.84***	R^2= .92 F(1,4)=11.42*	F(1,1)=1.16
Exposure to nature	r(6)= .23	r(7)= -.59	%
Role model	r(6)= -.20	r(7)= -.69	%

*** indicates a significant relationship (p < .001)
* indicates a significant relationship (p < .05)
# students who have fewer recycling facilitates available to them had greater gains
% could not be computed due to lack of variance

Table 4.12: Pearson correlation results for the comparison of attitude pretest scores (for each question, for all questions combined, and grouped thematically) to knowledge gain for each ecosystem.

Student Q. # (pretest)	Trop gain	Lauren gain	St.Law gain
10	r(119)= .05	r(160)= .05	r(54)= .24
11	r(119)= .04	r(160)= .05	r(53)= .14
12	r(120)= -.04	r(160)= -.06	r(51)= .01
13	r(120)= -.02	r(160)= -.01	r(54)= -.12
14	r(120)= .07	r(159)= .13	r(54)= .14
15	r(118)= -.01	r(159)= -.04	r(54)= .21
16	r(120)= -.06	r(159)= -.08	r(54)= .24
17	r(121)= -.04	r(160)= .02	r(53)= .23
18	r(121)= .04	r(158)= -.01	r(54)= .05
19	r(121)= .06	r(160)= .05	r(52)= -.09
All Questions	r(111)= .03	r(156)= .02	r(48)= .26
Locus of control	r(116)= .06	r(159)= .11	r(53)= .25
Personal responsibility	r(119)= -.01	r(160)= -.01	r(49)= -.05
Overall attitude	r(117)= -.03	r(157)= -.04	r(53)= .28*

* indicates a significant relationship (p < .05)

Table 4.13: The change in student attitude (for each question, for all questions combined, and grouped thematically) for the entire sample population and by ecosystem.

Student Q. #	Trop change	Lauren change	St.Law change	All change
10	t(118)=2.41*	t(164)=-0.52	t(55)=1.83	t(339)=2.05*
11	t(116)=0.63	t(163)=0.35	t(54)=-1.63	t(335)=0.15
12	t(118)=0.34	t(161)=-0.19	t(51)=-2.47*#	t(332)=-0.63
13	t(116)=0.40	t(163)=-1.62	t(55)=0.89	t(336)=-0.59
14	t(118)=0.71	t(161)=0.65	t(55)=0.00	t(336)=0.87
15	t(116)=-0.79	t(162)=-0.42	t(55)=3.83***	t(335)=0.74
16	t(118)=0.74	t(160)=-2.11*#	t(55)=-1.23	t(335)=-1.29
17	t(120)=1.43	t(162)=-0.92	t(54)=-2.51*#	t(338)=-0.50
18	t(120)=0.71	t(161)=0.65	t(55)=-0.81	t(337)=0.22
19	t(119)=1.82	t(162)=2.48*	t(53)=0.20	t(336)=2.94**
All Questions	t(104)=2.11*	t(149)=-0.29	t(48)=-1.02	t(303)=1.03
Locus of control	t(112)=1.58	t(159)=0.43	t(54)=0.12	t(327)=1.43
Personal responsibility	t(114)=1.18	t(158)=0.53	t(49)=-0.51	t(323)=0.96
Overall attitude	t(114)=1.20	t(157)=-1.60	t(54)=-0.09	t(327)=-0.34

*** indicates a significant relationship (p < .001)
** indicates a significant relationship (p < .01)
* indicates a significant relationship (p < .05)
# indicates significant decrease in attitude

Table 4.14: Pearson correlation results for the comparison of attitude pretest scores (for each question, for all questions combined, and grouped thematically) to the change in attitude.

Student Q. # (pretest)	Attitude change
10	r(304)= -.23***
11	r(304)= -.28***
12	r(304)= -.20***
13	r(304)= -.18***
14	r(304)= -.32***
15	r(304)= -.05
16	r(304)= -.17**
17	r(304)= -.19***
18	r(304)= -.21***
19	r(304)= -.18***
All Questions	r(304)= -.34***
Locus of control	r(304)= -.36***
Personal responsibility	r(304)= -.24***
Overall attitude	r(304)= -.24***

*** indicates a significant relationship (p < .001)
** indicates a significant relationship (p < .01)

Table 4.15: Results for the comparison of learner background (for each question, and grouped thematically) to attitude change scores. The ANCOVA calculations were run with knowledge pretest as a covariate.

Student Q. #	Attitude change
1	R^2= .11 F(1,301)=0.60
2	R^2= .12 F(1,300)=1.07
3	R^2= .11 F(1,300)=1.37
4	r(303)= .01
5	R^2= .12 F(1,300)=3.33
6	R^2= .11 F(1,300)=0.39 %
7	R^2= .11 F(1,300)=0.81
8	r(304)= .06
9	R^2= .11 F(1,300)=0.30 %%
Exposure to nature	r(301)= -.04
Role model	r(297)= -.08

% run as a comparison to thematically similar teacher Q. # 1; results are inconclusive because sample size should equal the number of teachers, not the number of students

%% variance is too small for conclusive findings

Table 4.16: Results for the comparison of teacher questionnaire responses (for each questions, and grouped thematically) to attitude change scores. The ANCOVA calculation was run with knowledge pretest as a covariate.

Teacher Q. #	Attitude change
1	r(16)= .24
2	r(16)= .01
3	r(16)= .03
4	r(16)= .02
5	r(16)= -.17
6	r(13)= .31
7	R^2= .22 F(1,13)=1.01
Exposure to nature	r(16)= .16
Role model	r(16)= .11

Table 4.17: Pearson correlation results for the comparison of attitude change scores (for each question, for all questions combined, and grouped thematically) to the knowledge pretest for each ecosystem.

Student Q. # (change)	Trop pretest	Lauren pretest	St.Law pretest
10	r(119)= .19*	r(157)= -.22**#	r(56)= .15
11	r(117)= .09	r(156)= .07	r(55)= .13
12	r(119)= .06	r(154)= -.01	r(52)= .00
13	r(117)= -.06	r(156)= -.10	r(56)= .09
14	r(119)= .15	r(154)= .06	r(56)= -.08
15	r(117)= .03	r(155)= -.10	r(56)= .00
16	r(119)= .09	r(154)= -.14	r(56)= .32*
17	r(121)= -.10	r(155)= .03	r(55)= -.07
18	r(121)= .11	r(153)= .09	r(56)= .21
19	r(120)= -.09	r(155)= -.05	r(54)= -.22
All Questions	r(105)= .10	r(143)= -.08	r(49)= .21
Locus of control	r(113)= .20*	r(152)= -.08	r(55)= .10
Personal responsibility	r(115)= -.06	r(151)= -.07	r(50)= -.09
Overall attitude	r(115)= .04	r(151)= -.05	r(55)= .21

** indicates a significant relationship ($p < .01$)
* indicates a significant relationship ($p < .05$)
# students with higher knowledge pretest scores had lower attitude scores

Table 4.18: Pearson correlation results for the comparison of attitude change scores (for each question, for all questions combined, and grouped thematically) to the knowledge gain for each ecosystem.

Student Q. # (change)	Trop gain	Lauren gain	St.Law gain
10	r(119)= .09	r(155)= .10	r(53)= -.10
11	r(117)= .10	r(154)= .02	r(52)= .03
12	r(119)= .08	r(152)= .25**	r(49)= .05
13	r(117)= .01	r(154)= .09	r(53)= -.09
14	r(119)= .06	r(152)= .01	r(53)= .06
15	r(117)= .13	r(153)= .12	r(53)= -.03
16	r(119)= .09	r(153)= .26***	r(53)= -.24
17	r(121)= .10	r(154)= .11	r(52)= .02
18	r(121)= .05	r(152)= .03	r(53)= -.05
19	r(120)= -.12	r(154)= .05	r(51)= .21
All Questions	r(105)= .16	r(142)= .21*	r(46)= -.10
Locus of control	r(113)= .13	r(150)= .04	r(52)= .01
Personal responsibility	r(115)= .01	r(150)= .20*	r(47)= .03
Overall attitude	r(115)= .16	r(150)= .25**	r(52)= -.14

***indicates a significant relationship ($p < .001$)
** indicates a significant relationship ($p < .01$)
* indicates a significant relationship ($p < .05$)

4.2 Observation results

4.2.1 Descriptive statistics of essential element presence/absence

The results in tables 4.19-4.23 on the following pages present the relative frequencies of implementation of the essential elements and learning themes under investigation in Montreal environmental education. The tables refer to the four levels of the observation instrument which were described in the previous chapter.

Table 4.19: The essential elements associated with institutional decisions (level 1) and instructor implementation (level 2) and their relative frequencies of implementation in Montreal environmental education programming. Scores of 1 indicate full coverage, 0.5 represents incomplete coverage, and 0 no coverage at all. Of the possible 18 essential elements there was an average of 11 elements covered per program, with a maximum of 16 and a minimum of 5.

Category		Essential element	% of programs with score=1	% of programs with score=0.5	% of programs with score=0	Average score
Institutional decisions Level 1	Reduction of novelty	on location	79	17	4	0.89
		preparatory activities	63	0	38	0.63
		follow-up activities	67	0	33	0.67
		local relevance	75	8	17	0.79
		exposure to nature	29	29	42	0.44
		apply skills	58	17	25	0.66
		inquiry tools	29	4	67	0.31
		multi-sensory learning	21	17	63	0.29
		hands on learning	38	25	38	0.49
		active discovery	54	29	17	0.69
	Skills	issues investigation	29	4	67	0.31
		cooperative learning	67	13	21	0.73
		communication	54	38	8	0.73
Instructor implementation Level 2		balanced approach / model behavior	100	0	0	1.00
		model inquiry	33	0	67	0.33
		foster curiosity	100	0	0	1.00
		empower learners	17	17	67	0.25
		engage all learners	67	33	0	0.83

Note: Due to averaging of scores for programs observed twice, there were a total of five instances of scores of 0.25 or 0.75, in cases where the two observations did not receive the same score on a particular essential element. All of these cases were counted in the 0.5 category.

Table 4.20: The relative amount of time spent on presenting the components of environmental knowledge (level 3) by Montreal environmental education programs. The average total program duration was 126 minutes.

Component of environmental knowledge (level 3)	% of programs spending no time	Average % of time spent	Average amount of time spent (minutes)
Literacy	0	84	105
Environmental issues	17	14	18
Environmental action strategies	54	2	2.4
Issues and action strategies combined	8	17	21

Table 4.21: The proportion of Montreal environmental education programs covering the various learning themes (level 4).

Broad Category	Concept area and grade level	Learning theme	% of programs covering theme
Earth science	Processes that shape the Earth (K-4)	Erosion	17
		Landforms	25
		Climate	25
		Seasons	42
	Processes that shape the Earth (5-8)	Global patterns	25
		Phenomena	13
		Solar system interactions and associated patters	8
	Matter (K-4)	Materials	13
		Change of state	8
		Hydrologic cycle	13
	Matter (5-8)	Chemical reactions	8
		Molecular properties	4
		Compositions / formation of matter	8
	Energy (K-4)	Forms	13
		Production / use	13
	Energy (5-8)	Path / flow	4

Table 4.21 continued: The proportion of Montreal environmental education programs covering the various learning themes (level 4).

Broad Category	Concept area and grade level	Learning theme	% of programs covering theme
Life science	Organisms, populations, communities (K-4)	Similarities and differences	8
		Classification	33
		Basic needs	71
	Organisms, populations, communities (5-8)	Levels of organization (species, population, ecosystems)	38
		Physiology to habitat link	75
		Extreme adaptations	25
		Differences in energy use	8
	Heredity and evolution (K-4)	Evolved vs. adapted traits	33
		Plants and animal trait variation	79
		Fossil vs. living animals	17
	Heredity and evolution (5-8)	Advantageous variation	8
		Natural selection	8
		Extinction	8
		Implications of loss of species	4
	Systems and connections (K-4)	Link between organism behavior and the environment	25
		Organisms causing environmental change	13
		Organism interactions	4
	Systems and connections (5-8)	Food web links	42
		Scavengers, decomposers, predators	33
		Competition / mutualism	17
		Abiotic / biotic effect on the ecosystem	21
	Flow of matter and energy (K-4)	Reliance on the sun	13
		Life to decomposition cycle	13
	Flow of matter and energy (5-8)	Transform of matter in food webs	8

Table 4.21 continued: The proportion of Montreal environmental education programs covering the various learning themes (level 4).

Broad Category	Concept area and grade level	Learning theme	% of programs covering theme
Humans and societies	Culture (K-4)	Favorite place	4
		Reaction of people to place	4
		Life in different regions	13
	Culture (5-8)	Culture view of environment	4
		Spread of culture	21
	Political and economic systems (5-8)	Public / private goods	8
		Local economy and politics	4
		Government laws for environmental protection	21
	Global connections (K-4)	Trade	8
		Effect of product use on other regions	4
	Global connections (5-8)	Trade and resources	4
		Individual effect on global environment	4
		Effect of change in one area on another	8
		Global links	8
	Change and conflict (K-4)	Generational change	25
		Change in environmental rules	4
	Change and conflict (5-8)	Patterns of change	8
		Effect of change on people	8

Table 4.21 continued: The proportion of Montreal environmental education programs covering the various learning themes (level 4).

Broad Category	Concept area and grade level	Learning theme	% of programs covering theme
Environment and society	Human/ environment interactions (K-4)	Human dependency on environment	38
		Human-induced change	79
		Environmental effects on humans	4
	Human/ environment interactions (5-8)	Consequences of technology use	38
		Effects of actions on other places	38
		Effects of restoration	17
	Places (K-4)	Important local places (landmarks)	33
		Creating places	8
		Differentiating places	38
	Places (5-8)	Physical and human characteristics of places	25
		Differentiating regions based on criteria	4
	Resources (K-4)	Natural resources	42
		Renewable / nonrenewable resources	4
		Use of resources	38
		Sources	21
	Resources (5-8)	Distribution	4
		Resources key to society	8
	Technology (K-4)	Technology as a tool	29
		Technology change over time	8
		Pro /con of technology	25
		Technological systems (i.e. agriculture, transportation)	21
	Technology (5-8)	Technological issues	17
	Issues (K-4)	Universal issues	29
	Issues (5-8)	Conflicting views	29
		Difficulty in resolution	4

Table 4.22: Learning themes (level 4) not covered by any of the Montreal environmental education programs.

Broad Category	Concept area and grade level	Learning theme
Earth Science	Energy (5-8)	Solar energy effects on air masses
		Life needs of energy
Life science	Flow of matter and energy (K-4)	Recycling of matter
	Flow of matter and energy (5-8)	Energy in food webs
		Transfer of solar energy
Humans and society	Individuals and groups (K-4)	Causes of individual behavior
		Belonging to groups
		Benefit of group to community and the individual
	Individuals and groups (5-8)	Development of identity
		Effect of group on individual
		Stereotyping
	Culture (5-8)	How technology effects view of culture
	Political and economic systems (K-4)	What if there were no laws?
		Natural resource jobs
		Infrastructure
	Global connections (K-4)	Individual vs. community
		Technology and global communication
	Change and conflict (K-4)	Conflict resolution
	Change and conflict (5-8)	Individual vs. society
		Group conflict resolution (government)
Society and environment	Places (5-8)	Influence of culture, and technology on perception of place
	Resources (K-4)	Link between settlement patterns and resource patterns
	Resources (5-8)	Resource conflicts
	Technology (5-8)	Technological revolutions
		Use of technology in environmental influence
	Issues (K-4)	Local disputes
	Issues (5-8)	Other places with same issues

Table 4.23: The number of learning themes (level 4) covered by Montreal environmental education programs in each broad category, and the percentage of the total covered by each category.

	Category	Min. # themes	Min. % total	Max. # themes	Max. % total	Average # themes	Average % total
All	All	6	N/A	33	N/A	16.04	N/A
Science	All Science	1	11	14	100	8.42	57
Science	Earth Science	0	0	9	47	2.38	13
Science	Life Science	0	0	11	100	6.04	44
Humanities	All Humanities	0	0	19	89	7.63	43
Humanities	Humans and Societies	0	0	7	26	1.63	8
Humanities	Environment and Society	0	0	13	89	6.00	35

Table 4.24 The age appropriateness of the learning themes (level 4) covered by Montreal environmental education programming. Themes appropriate for grades K-4 were counted for all programs presented to students younger than grade 5 (total=9 programs, average grade level=3.7), and themes appropriate for grades 5-8 were counted for all programs presented to students grade 5 or older (total=15 programs, average grade level=5.8).

Grade level	Min. # themes	Min. % total	Max. # themes	Max. % total	Average # themes	Average % total
K-4	3	43	15	89	9.11	64
5-8	2	29	14	62	7.20	42

4.2.2 Essential element implementation methodology

The following list presents the various methods of implementing each of the essential elements based on researcher program observations. It is organized by the essential element categories that were described in the previous chapter. Levels 3 and 4 present the concepts and topics covered for each learning theme and area of environmental knowledge.

4.2.2.1 Level 1: Institutional decisions as they relate to program content

- Reduction of novelty
  - On location
    - classroom introduction before exposure to live animals/ecosystem
    - slide show
    - introduction of instructor, facility, and site rules

- preview of the visit
- review of prior knowledge, preparatory activities, or past visits
- site set up such that students are exposed to area prior to formal instruction (seeing animals through window, walking through woods)

Preparatory activities
- activities on web site
- activity package mailed by site to teacher to be done in the classroom (some extensive knowledge, others draw picture intro)
- create name cards and draw pictures
- more than one visit in one school year (build information)

Follow-up activities
- activities on web site
- empower learners to take further action
- activities provided by site (quizzes, puzzles, crosswords, drawings, etc.)
- take living specimen back to classroom to care for, and as a reminder
- binder of addition information on the topic
- more than one visit in one school year (build information)

Local relevance
- focus of study on local environment, local issues, or local industry
- outdoor exposure to local environment
- focus on distant areas of same province
- map location of study area to create connectivity to local
- use local flora or fauna species as examples

Exposure to nature
- activity conducted in the outdoors
- outdoor observation of wild fauna
- activity conducted in indoor ecosystem replica with live flora and fauna
- observation of captive fauna or cultivated flora

Apply skills
- "treasure hunt" type information search activities (active investigation, observation)
- scientific "lab" experimentation activities
- identify flora/fauna with the help of guides and drawings
- draw flora/fauna that is observed
- matching games (birds to nests, food to beak type etc.)
- jeopardy type games to remember information presented

Inquiry tools
- thermometer
- tape measure
- magnifying glass
- scale

- binoculars
- dissecting microscope
- color light filter
- kaleidoscope
- anemometer

Multi-sensory learning
- touch animal specimens (furs, bird nests, stuffed birds, antlers)
- listen to recorded forest sounds, bird songs
- examine tree rings, bark
- grind grains with bird gizzard replica
- identify small objects based on touch or sound they make within a container
- active listening to forest sounds, bird songs
- dig for insects
- touch live captive animals

Hands-on learning
- examine animal specimens
- take ecosystem measurements
- conduct lab experiments
- grind grains with bird gizzard replica
- identify and search for forest objects
- dig for insects
- matching/labeling games using pieces with Velcro on the back

Active discovery
- information "treasure hunt"
- multi-sensory learning activities (feeling, listening, observing)
- interact with information and instructor
  - multimedia presentation (requires participation, not just passive observation)
  - laboratory experimentation
  - use of computers to search for information
  - engage student creativity
  - draw visual observations
- matching/labeling games using pieces with Velcro on the back

Skills
- Issues investigation
  - search for question responses in information "treasure hunt"
  - answer questions through laboratory investigation
  - hypothesis testing through video observation
- Cooperative learning
  - conduct activities in teams / pairs
  - division of labor within the team / pair
- Communication
  - verbal responses to instructor questions
  - share activity findings / project design with rest of class
  - gather information during course of activity

- drawing of observations
- hypothesis testing
- written quiz

4.2.2.2 Level 2: Teaching methodology (implementation)

- Balanced approach / model responsible behavior
  - hard to give examples, due to varying instructor styles
- Model inquiry
  - provide guidance during investigation
- Foster curiosity
  - engaging, energetic style
- Empower learners
  - encourage to write letters, involve parents
  - reduce, reuse, recycle, and tell others to do the same
  - students can be scientists
  - methods to decrease personal greenhouse gas emission
  - demonstrate how other students have made a difference
  - instill personal responsibility through effect of environmental issues on Montreal
  - help over-wintering birds with a bird feeder
- Engage all learners
  - conduct hands-on and multi-sensory activities that foster inquiry and active participation such that each student has an opportunity to engage with the subject (more direct interaction, less lecture or demonstration)
  - work performed in pairs or small groups
  - personalized question and answer (student wear name tags)
  - students pick topic discussion order (personal stake in learning)

4.2.2.3 Level 3: Program evaluation

- Literacy (topics covered)
  - Laurentian forest
  - Gulf of St. Lawrence ecosystem
  - tropical forests
  - weather / climate
  - water (use, properties etc.)
  - St. Lawrence River ecosystems
  - birds and their adaptations
  - seasonal adaptations
  - carnivorous plants
  - garbage disposal and recycling
  - Quebec flora / fauna
  - maple syrup production
- Issues (topics covered)
  - hunting / over fishing / whaling
  - forestry / logging / tree age requirements
  - recreation in wild places

bioaccumulation / biomagnification
environmental degradation
loss of biodiversity / endangered species
pollution
mining
air pollution / smog / allergens
pollution effect on wild animals
sources of air pollution
eutrophication
climate change / green house gases / global warming
water conservation
invasive species (zebra mussels)
erosion
coastal development
fresh water resource
change in water levels
habitat degradation / restoration / filling in wetlands
garbage quantity
landfill pollutants
nature conservation
respect for nature
threats to bird migration (light pollution, agricultural pollution, habitat degradation)

Action strategies (topics covered)

being informed
letter writing
encouraging others (parents) to vote
reduce paper use
reduce fossil fuel use (bicycle, walk, recycle, turn off lights)
reduce littering
use biodegradable detergents
help increase citizen awareness
reduce, reuse, recycle
treat wild places with respect (don't feed animals, stay on trail, don't pick flowers, don't break branches etc.)
make a bird feeder

4.2.2.4 Level 4: Learning themes

Earth Science:

Processes that shape the Earth (K-4)

Erosion

Rocher Percé (pierced rock) of Gaspé, Quebec (wind and waves created whole)
coastal erosion and need for coastal vegetation
formation of Mt. Royal in Montreal from plutonic (magma) intrusion and subsequent erosion of surrounding sedimentary rocks

- effects of flooding
- Landforms
  - Rocher Percé
  - mountains in tropical regions
  - North/ South Pole
  - Mt. Royal
  - St. Lawrence River
  - river banks
  - groundwater formation
- Climate
  - Gulf of St. Lawrence has very cold water
  - climate of tropical regions / plants that grow there
  - process of climate change
  - Snowy owls live in cold climates
- Seasons
  - tree leaves changing color
  - tree rings
  - wet / dry seasonality in the tropics
  - what causes seasonality (Earth tilt)
  - winter weather
  - animal response to seasons
  - historical snow levels
  - reasons for bird migration (winter food availability)
  - effect of seasons on maple syrup production

Processes that shape the Earth (5-8)
- Global patterns
  - tides
  - distribution of tropical regions
  - wetland soil types
  - Monteregian Hills
  - St. Lawrence River sections
- Phenomena
  - ice storm
  - thunderstorms
  - tornadoes
  - flooding
- Solar system interactions and associated patters
  - pull of the Moon causes tides
  - simulating Green House effect with covered and open container

Matter (K-4)
- Materials
  - concentration of salt is in salt water
  - mass of atmosphere
  - efficient building construction
- Change of state
  - snow to water

- melting rate of ice in water and on land
- Hydrologic cycle
  - cloud types
  - snow to water to vapor to clouds to rain
  - path of water
- Matter (5-8)
  - Chemical reactions
    - acid rain
    - chemistry of leaf color change
  - Molecular properties
    - density of salt water vs. density of fresh water
  - Composition / formation of matter
    - which rock types work best as landfill liner
    - rocks of Mt. Royal
    - igneous, sedimentary rock forms
- Energy (K-4)
  - Forms
    - solar heat
    - fossil fuels
    - burning methane gas
  - Production / use
    - use for cars, factories
    - land-fill out-gassing as a source of methane
- Energy (5-8)
  - Path / flow
    - from local power-plant to homes

Life Science

- Organisms, populations, communities (K-4)
  - Similarities and differences
    - prey of carnivorous plants
    - comparison of raven and crow
  - Classification
    - vertebrates / invertebrates
    - animal groups and their characteristics (mammals, birds, reptiles, amphibians, fish)
    - different types of birds (what is a raptor)
    - differentiate birds based on beak type
    - types of fish reproduction
  - Basic needs
    - food
    - habitat / nesting sites / mating areas
    - water quality
    - bird food types
    - plant needs (water, sun, minerals, air)
    - what wetland provides to resident species
    - finding winter sources of food

Organisms, populations, communities (5-8)

- Levels of organization (species, population, ecosystems)
  - comparing diversity in different regions to overall global diversity
  - grouping / identifying species
- Physiology to habitat link
  - skulls / bird beaks determined by habitat and food type
  - which coastal animals live in which niche
  - difference in plants that grow in march versus a swamp
  - polar bears
  - woodpecker tongues to retrieve insects from small wholes
  - beaks and feet characterize bird habitat
  - carnivorous plans grow in nutrient-poor environments
  - bats use echolocation to fins insects at nights
  - physiology of an eye of a fly
  - spring flowers bloom before tree leaves come out
  - over-wintering animals need good fur / down
  - beak type determines food source, food source determines if bird needs to migrate in winter
  - physiology needed for migration (orientation, food reserves)
  - hibernation as an adaptation to winter
  - owls have ears at different heights to better locate source of sound
  - lynx have big feet to walk on snow
  - adaptation to flooded areas
  - hawks have good vision used for hunting
  - vultures have bald heads to avoid pests from carrion
  - camouflage
  - fish migration between fresh and salt water to spawn
  - fish gills to obtain dissolved oxygen from water
- Extreme adaptations
  - carnivorous plans eat insects
  - cacti needles are modified leaves
  - bat echolocation
  - owls have huge eyes and ears to hunt at night
  - animal winter survival
  - eel, salmon extreme migrations to spawn
- Differences in energy use
  - full hibernation vs. chipmunk over-wintering in burrow
  - over-wintering birds must eat body weight in food / migrating birds must double weight prior to trip

Heredity and evolution (K-4)

- Evolved vs. adapted traits
  - plants and animals evolve/adapt to their habitat (trees in cold areas loose leaves in winter etc.)
  - sand bittern has fake eyes pattern on wings to look bigger to predators

- sloth camouflages in trees
- buttress roots of trees in wet areas
- animal characteristics arise over millions of years (evolution)
- evolution of carnivorous plans
- traits that help to survive and reproduce are retained
- female snowy owl is speckled, arctic fox white for better camouflage
- evolution of feathers in birds from reptile scales (same as hair in humans)
- evolution of hollow bones in birds

Plant and animal trait variation
- differentiate mammal skulls, furs, and prints
- characteristics of marine invertebrates
- variety of tropical fauna
- differentiate birds by beaks, feet, song
- types of bird feathers (for coloration, insulation, camouflage, flight)
- parts of a carnivorous plant
- variety of butterflies
- sea gulls vs. pigeons
- urban wild mammals (skunks, groundhogs, foxes etc)
- variety in characteristics of animals (raccoons-agile, hawk-good eye sight, hare-big ears)
- types of plants (spring flowers), age of trees
- characteristics for tolerating cold winters
- traits of raptors, Quebec mammals
- differentiate plant leaf structure
- fish anatomy
- maple tree characteristics (leaf shape, sugary sap etc)

Fossil vs. living animals
- archaeopteryx vs. modern birds
- fossilized marine invertebrates

Heredity and evolution (5-8)

Advantageous variation
- evolution of carnivorous plants
- evolution of sternum in birds for attachment of flight muscles

Natural selection
- basics – best adapted individuals survive to reproduce

Extinction
- less that 1000 golden-lion tamarinds left in the world
- wild turkey was over-hunted to near extinction

Implication of loss of species
- biodiversity helps in ecosystem stability

Systems and connections (K-4)

Link between organism behavior and the environment

hibernation in cold climates
bird migration, nesting preference
Organisms causing environmental change
squirrel overpopulation
conifer needles acidify the soil
trees purify the air
beaver dams
Organism interactions
greater biological diversity increases ecosystem stability
Systems and connections (5-8)
Food web links
animal interrelations (who eats whom)
bioaccumulation / biomagnification
food web online preparatory activity
nutrient upwelling in river ecosystem
skunks are omnivores
sapsucker / tree interaction
in the winter hibernating animals don't need food
wood decomposition process
diet of zoo animals / wild counterparts
diet of different birds (grain, fish, insects, other birds)
Scavengers, decomposers, predators
lynx / hare interactions
tropical predators
insect log decomposers
owl predators (owl pellets)
Quebec predators (wolf, coyote, fox, etc)
raptor predators
flightless birds evolved without predators
sharks
Competition / mutualism
bird territoriality
cowbird parasitism of nests of other birds
competition for food in the winter (only 50% of over-wintering birds survive)
Abiotic / biotic effects on the ecosystem
an ecosystem includes both living and non-living components
effect of tides on ecosystem
few plants in conifer under-story because of acidified soil
hormonal contamination of river water makes male fish less fertile
Flow of matter and energy (K-4)
Reliance on the sun
sun is abiotic part of ecosystem
plants need sun to grow

- Life to decomposition cycle
  - nutrient upwelling in river ecosystem
  - decomposer insects
  - extra nutrient in water lead to algal blooms and increased sedimentation

Flow of matter and energy (K-4)

- Transformation of matter in food webs
  - use of insects at nutrient source by carnivorous plants
  - wood to nutrients by decomposing insects

Humans and societies

- Culture (K-4)
  - Favorite places
    - local parks
  - Reaction of people to place
    - original naming of Mt. Royal
  - Life in different regions
    - tropical tribal people
    - Native Americans
- Culture (5-8)
  - Culture view of environment
    - mythological story of Gilgamesh (control over weather)
  - Spread of culture
    - settlement of Montreal / Quebec city area by Europeans
    - Native Americans showed Europeans how to produce maple syrup
- Political and economic systems (5-8)
  - Public / private goods
    - effect of trees on surrounding city (produce oxygen, filter air, decrease summer temperature, decrease noise)
  - Local economy and politics
    - consequences of closed fishery
  - Governmental laws for environmental protection
    - Montreal protocol on the use of CFC's
    - Kyoto protocol on greenhouse gases
    - no building in Montreal can be taller than Mt. Royal
    - international migratory bird act restricts hunting
    - illegal to disturb bird nests or collect eggs
    - closed fisheries
- Global connections (K-4)
  - Trade
    - products produced in the tropics are used in North America
    - tropical food plants and global use
  - Effect of product use on other regions
    - aluminum used in North America is mined in the tropics
- Global connections (5-8)
  - Trade and resources
    - bauxite ore needed for aluminum production

- Individual effect on global environment
  - in bird migration hot spots such as Hawk Mt. one person can kill 1,000 birds in one day
- Effect of change in one area on another
  - effects on one part of river (pollution, damming) will cause change in other regions
- Global links
  - tropical products
  - exotic / invasive species (zebra mussels, carp)

- Change and conflict (K-4)
  - Generational change
    - increase in cattle farming in tropics has lead to more vampire bats
    - water level drop
    - climate change over last 100 years
    - traditional farming lifestyle
    - depletion of water resources
    - pollution
    - old vs. new methods of maple syrup production
  - Change in environmental rules
    - garbage used to be burned
- Change and conflict (5-8)
  - Patterns of change
    - deforestation
    - increase in cattle farming in tropics has lead to more vampire bats
    - riverbank location has changes with changing water levels
  - Effect of change on people
    - rising sea levels
    - flooding
    - closed fisheries

- Environment and society
  - Human / environment interactions (K-4)
    - Human dependency on environment
      - use of resources
      - jewelry made from animal products
      - water needs / use
      - fishing
      - food plants
      - space for landfills
      - use of wood for household products
      - Sanguinaria flower sap used as face paint
      - maple syrup production
    - Human-induced change
      - forestry practices
      - hunting

pollution leads to bioaccumulation in belugas leading to contaminating milk and declining populations
over-fishing leads to near-extinction / extirpation
bauxite mining decreases forested area
greenhouse gas emissions
pollution (water contamination, littering, frog population decline)
introduction of invasive species
draining of wetlands
problems resulting from garbage dumps
erosion due to mountain biking
effect of houses on wooden bridge
replanted trees easily broken if hikers not careful
habitat degradation / destruction
human-induced effects on birds (hunting, power lines, hit by cars, theft of eggs, pollution)
effect of introduced predators (cats, rats) on ground-nesting birds

Environmental effects on humans
weather

Human / environment interactions (5-8)
Consequences of technology use
pollution
deforestation / loss of mature forest
greenhouse gas emissions
over-fishing
introduction of invasive species
birds are hit by cars and collide with power lines

Effects of actions on other places
if hunt upper predator, prey populations increase
if remove prey food source, predators will decline
pollution has large scale effects
aluminum use in North America effects tropics where it was mines
climate change leads to melting of polar ice (loss of polar bear habitat), smog, more violent weather
pollution / damming in one part of river will effect other parts

Effects of restoration
remediation of landfill to create a park
use of old quarry as a landfill minimized need for new land
creating nesting habitat
stream remediation
bird feeders to help over-wintering birds

Places (K-4)
Important local places (landmarks)
Rocher Percé (pierced rock) of Gaspé, Quebec

St. Lawrence River
bridges over St. Lawrence river
Mt. Royal
Monteregian Hills
cross on top of Mt. Royal
Olympic stadium
local parks
Lachine rapids

Creating places

park from old landfill
migratory birds can over-winter if feeders available

Differentiating places

where is Laurentian forest on a map of Quebec and Ontario
where is the Gulf of St. Lawrence
where are the tropics in relation to Quebec
compass directions
sections of the St. Lawrence River
North and South Poles
temperature changes in different parts of Canada
where migratory birds go / come from

Places (5-8)

Physical and human characteristics of places

Laurentian forest has both deciduous trees and conifers
climate, flora, fauna, indigenous people of the tropics
characteristics of the sections of the St. Lawrence River
landfill will be turned into a park
marina only appropriate for shallow water boats
manages sugar woods for syrup production

Differentiating regions based on criteria

tropics are located around the imaginary equator line

Resources (K-4)

Natural resources

trees
fish
bauxite ore
water
limestone

Renewable / nonrenewable resources

trees need to be replanted after logging

Use of resources

trees for paper
bauxite ore for aluminum
fossil fuels
conservation of resources in economic construction
water for irrigation, drinking, washing
fish for food

Sources
- bauxite ore located in the tropics
- Great Lakes contain 20% of global fresh water
- groundwater as source of fresh water
- landfill out-gassing is a source of methane
- forest source of wood

Resources (5-8)
- Distribution
  - bauxite ore located in the tropics
- Resources key to society
  - fish to drive fisheries
  - water

Technology (K-4)
- Technology as a tool
  - weather measurement tools
  - inventions of building construction technology
  - landfill technology
  - recycling process
  - bird feeders can help over-wintering birds
  - maple syrup production and canning
- Technology changes over time
  - use of recycling to minimize garbage
  - old vs. new methods of maple syrup production
- Pro/con of technology
  - climate change results from greenhouse gas emissions due to technology
  - technological pollution
  - birds hit tall building, airplane engines on migration route
  - light pollution effect on bird migration
  - over-fishing
- Technological systems (i.e. agriculture, transportation)
  - transportation/ industry/ agriculture and greenhouse has emission
  - transportation and spread of invasive species
  - urban fresh water supply and location of reservoirs

Technology (5-8)
- Technological issues
  - water pollution
  - pollution from landfills
  - recycling
  - monitoring biogas emission
  - tall building, light pollution, power lines, airplane engines threats to bird migration

Issues (K-4)
- Universal issues
  - pollution
  - loss of biodiversity

climate change
fresh water shortage
changing water level
garbage production

Issues (5-8)

Conflicting views

clear-cutting vs. selective logging
coastal development
filling in wetlands for development
opinions on climate change causes and consequences
mountain bikes as sources of erosion
bird habitat used for development
hunting of birds, taking wild bird eggs vs. conservation
economic problems of closed fishery vs. conservation

Difficulty in resolution

where to put garbage

Chapter 5: Discussion and Conclusions

5.0 Introduction

The results presented in the previous chapter are discussed in this final chapter of the work. Connections will be made with other relevant research, trends in the findings will be identified, limitations presented, and conclusions drawn. As the goal of this discussion is to bring the survey and observation components of the study together, the discussion is structured around the essential elements presented in Chapter 2, incorporating both survey and observation findings. At the end of the chapter conclusions will be made with respect to the effectiveness of environmental education essential elements in Montreal field trip programming.

5.1 Discussion

The following discussion addresses the essential elements that were presented in Chapter 2, and investigated through the survey and observation components of the study. Wherever possible the essential elements were investigated through both methodologies, but for some only one was applicable. All relevant findings and appropriate past research literature are discussed for each essential element.

The discussion starts off with a presentation of factors that significantly influence learner pretest scores on knowledge and attitude. Having an understanding of these findings will help to put the discussion of the effects of the essential elements on knowledge gain and attitude change into context. The remaining order of the essential elements follows the order from Chapter 2, but for ease of discussion some essential elements are presented together.

5.1.1 Factors influencing knowledge pretest

Knowledge gain is a goal of all educators. However, it is also important to understand learner foundation and its influencing factors. These relationships were investigated through the pretest questionnaire, with several factors showing significant relationships. Prior visit to the Montréal Biodôme (student question 3) showed a significant relationship with Tropical Forest scores (table 4.3). Since the Tropical Forest ecosystem is most different from the students' natural surrounding it is possible that students gained knowledge about the St. Lawrence Marine or Laurentian Forest ecosystems under varied circumstances, only some of which would have involved a visit to the Biodôme.

The effect of the local environment is also likely the cause of the significant correlations of the Laurentian Forest pretest with participation in nature activities (student question 4, table 4.3) and the positive teacher role model effect (table 4.4). Since nature activities both with the teacher and with family members are most likely to take place in environments surrounding Montreal, students are likely to learn about the Laurentian Forest that is immediately to the north of the city. The St. Lawrence Marine ecosystem lies in between the Tropical Forest and the Laurentian Forest on the spectrum of familiarity, and was not significant for any of the mentioned questions. Thus, it is important to take the familiarity of the environment into account when designing program content (see also section 4 below for an applicable discussion on local relevance).

In addition to the effects of teacher and student background, student attitudes were found to be correlated with knowledge. Again the Laurentian Forest ecosystem stood out with the largest number of significant correlations (table 4.5). Only student question 15 was correlated with Tropical Forest pretest, and no significant relationships were found with the St. Lawrence Marine ecosystem pretest. While causality cannot be implied, it is possible that the students gained knowledge and attitude under the same circumstances, such as scouting activities or family events which would favor gains relevant to the local Laurentian Forest ecosystem.

5.1.2 Factors influencing attitude pretest

Student background was found to have a consistently significant relationship with attitude pretest scores. Although not all of the individual questions had a significant relationship with attitude, all questions showed the same trend, and both exposure to nature and environmental role model measures were positively correlated with the attitude score (table 4.6). However, no significant trends were identified with responses to teacher questions (table 4.7). This indicates the importance of prior experiences, especially those with family, on developing student environmental attitudes. Prior research has shown that many factors influence the slow formation of positive environmental attitudes over the course of maturation into adulthood (Chawla, 1998b; Tanner, 1980). The necessary repeated exposure is more likely to occur in the home than at school.

Student age and gender also significantly affected attitudes. Girls had significantly more positive attitudes than boys, and attitudes significantly decreased with age. Prior studies have found a similar gender difference, with girls having higher moralistic attitudes (Eagles & Demare, 1999), a greater perception of environmental risk (Riechard & Peterson, 1998), and generally more positive environmental attitudes (Iozzi, 1989a). With regard to age, it is possible that older students have become more jaded and reluctant to take action toward environmental problems. Leeming and colleagues (1997) showed similar findings, with an attitude increase as the result of an environmental education program for children in grades 1-3, and a decrease for older children in grades 4-6.

5.1.3 Reduction of novelty (and constructivism)

The use and effectiveness of reduction of novelty was evaluated in this study. It was observed that a large proportion of the environmental education centers in Montreal conduct novelty reducing activities (table 4.19). Of all of the programs observed, 79% provided well-structured (received score of 1 in the instrument) on-site introductory activities. Furthermore, 63% provided preparatory activities to be administered by the teacher prior to the field trip. This demonstrates that the majority of the Montreal environmental programs are conducting their activities in a way that is consistent with the research literature discussed in Chapter 2. For example, an on site introduction that includes a slide show of the facility would help to reduce the anxiety of visiting a novel environment, while a preparatory activity that requires students to engage with the topic prior to the visit provides a cognitive foundation upon which further learning can be constructed.

The findings of the quantitative evaluation of the effects of reduction of novelty are less conclusive. The correlations with question #3 of the student questionnaire assessed the effect of prior visits by the students to the Montréal Biodôme on knowledge gain (table 4.10) and change in environmental attitude (table 4.15). While having had a prior visit to the Biodôme did not significantly affect knowledge gain for any of the ecosystems, a positive trend was observed in all cases. A similar non-significant positive trend was observed for change in environmental attitude. While the findings are inconclusive, the consistent trend suggests that the reduction of novelty resulting from a prior visit could help students learn better during the structured field trip.

The extent of pre-visit preparation of the students, and subsequent effect of the preparation on knowledge and attitude was assessed through questions 5 and 6 of the teacher questionnaire. None of the relationships produced significant findings. Two factors come into play in interpreting these findings. First, the sample sizes for correlations with teacher questions are very small as the class rather than the individual student is the unit of measure. Secondly, it is hard to quantify the type of preparation that the teacher might have conducted. A more structured experiment, with consistently quantifiable field trip preparation methodologies would be necessary to reach a conclusion.

5.1.4 Local relevance

The exposure of elementary school students in Montreal to locally relevant environmental education programming was observed in a majority of environmental education programs (table 4.19). Of all of the programs observed, only 17% addressed topics which were not linked back to the local environment or local actions. In some instances maps or local flora and fauna examples were used to draw links with distant environments. These extension examples demonstrate that it is feasible to cover a variety of topics without creating a sense of detachment in the learner.

In the study conducted at the Montréal Biodôme, three ecosystems were used in the investigation, with varying levels of local relevance in the programming. The Laurentian Forest ecosystem reflects forests immediately to the north of Montreal, while the Tropical Forest ecosystem would be foreign to most visiting students. The St. Lawrence Marine ecosystem falls on the spectrum between the other two. Since it is not possible to judge the relative difficulty of questions used in the three separate questionnaires, a rigorous comparison of the learning from the three ecosystems is not possible. However, judging from the percent increase in knowledge (table 4.8), it is apparent that the students participating in the Tropical Forest program were not at a disadvantage.

The Biodôme instructors utilized two techniques that could have aided in bridging the local relevance gap. First, a map introduced at the beginning of the program would help learners to connect the location of the Tropics to that of their Montreal home. Secondly, in the program conclusions examples were given of how recycling in Montreal could help mitigate tropical forest destruction for construction of ore mines. These techniques provide a concrete example of how environmental education institutions conscious of the benefits of locally relevant programming can present a broad curriculum without compromising best practice strategies.

5.1.5 Active participation (and constructivism)

The methodology of this work did not allow for quantitatively assessing the effect of active participation on knowledge gain or change in attitude, but the extent of active participation of learners in Montreal environmental education programming was assessed through several observation criteria. The "apply skills," "hands on learning," and "active discovery" criteria reflect decisions made at the institution level that pertain to active participation, while "foster curiosity" and "engage all learners" reflect relevant instructor implementation methodologies. Overall these five criteria paint a fairly positive picture, with only "hands on learning" standing out with only 38% complete implementation (table 4.19). This suggests that while the learners are engaged in the activity through, for example, verbal interaction, they are not personally involved in experimentation, manipulation of objects, and data collection. From the perspective of constructivism, such limited interaction could hinder the learner's ability to break down misconceptions and construct new learning (Fosnot, 1996).

5.1.6 Multi-sensory learning

Multi-sensory learning techniques strive to move away from the traditional lecture format, and toward presentation of information in a manner that can actively engage all five senses. Few of the Montreal environmental programs observed provided an opportunity for this, with 63% not exposing learners to multi-sensory techniques in any manner (table 4.19). When some of the senses were engaged, most often it was to carefully listen to the sounds of a forest or forest birds, and in a few cases students were also encouraged to touch or examine artifacts. The senses of smell and taste were never used. In the modern world of lawsuits and food allergies it is reasonable to steer clear of taste. While a scent can also be an allergen, the richness of scents in the animal world should allow for choices that do not cause adverse effects. Incorporating smell into environmental programming could substantially enhance the experience.

5.1.7 Cooperative learning

Cooperative learning helps students learn from each other and prepare for lives and careers full of social interactions. Of the observed programs, 67% provided extensive opportunities for group or paired activities, and 13% encouraged such interactions for only a small amount of time (table 4.19). While the overall average score of 0.73 is encouraging, given the ease of implementing this technique, there is no reason why every program could not allow for some structured group work interspersed with other activities. It was observed that for the most part the programs scoring lower on cooperative learning also provided few opportunities for active discovery or hands-on learning. Thus, it can be hypothesized that the programs are not reluctant to pair up students, but rather lack the types of activities that make cooperative learning feasible and beneficial.

Of the programs that do implement cooperative learning, it was observed that groups are most likely to be formed based on random student placement, or according to student personal choice. Although such group work was sufficient for the purposes of the observation instrument, research has shown that greatest benefit is achieved from heterogeneous groups, with a diversity of achievement levels, sexes, and ethnicities (Lazarowitz et al., 1988; Pratt, 2003; Watson, 1991). Conscious choice in constructing student groups could help increase the educational value of the program.

5.1.8 Exposure to nature

Learning to understand and appreciate nature is a vital component of environmental education that is best achieved through direct exposure and interaction with the natural world (Dettmann-Easler & Pease, 1999; Dunlap & Hefferman, 1975; Harvey, 1990). Of the programs observed at Montreal environmental education institutions, only 29% provided learners exposure to wild nature, and an additional 29% incorporated captive animals or cultivated plants into their programming (table 4.19). The remaining 42% of the programs may have used images or non-living specimens in their instruction, but did not include any living components. The Montreal climate may be a reason, although not an excuse, for the reluctance to venture outdoors. A wealth of instructional content can be derived from the study and comparison of environments in various seasons. Programs can be structured to include short outdoor spurts followed by continued indoor learning, or allow for build-in flexibility to expand to the outdoors in the fall and spring months.

The use of a captive environment has both its drawbacks and its advantages. While it does not allow for the same holistic experience as the natural environment, captive replicas of wild environments enable greater program consistency. For example, in the case of animal observation, the behavior of caged animals will vary less from one day to the next than that of their wild counterparts. Likely the greatest benefit to replicated environment is the greater diversity of ecosystems that can be presented. Elementary school age children in

Montreal have few opportunities to experience the tropics first hand. A replicated environment can provide a taste of that experience. Thus, exposure to nature is best achieved through a combination of wild environments to teach about the local ecosystem, and replicated environments to focus on animal observation or explore distant ecosystems.

At the Montréal Biodôme all programs have the same level of exposure to nature. It is thus not possible to compare the exposure to nature within a program to learning or changes in environmental attitude. It was, however, possible to compare the level of prior exposure to nature of the students to attitude change and knowledge gained from Biodôme programming. Questions 4-7 of the student questionnaire (tables 4.10 and 4.15), and questions 1 and 2 of the teacher questionnaire (tables 4.11 and 4.16) pertained to exposure to nature. None of the comparisons with the individual questions or with the combined "exposure to nature" index produced consistent results, although several individual statistically significant relationships were identified with knowledge gain. Participating in nature activities with family (student question 5) had a significant positive effect on Tropical Forest knowledge gain, and exposure to a garden (student question 7) affected both Tropical Forest and Laurentian Forest knowledge gains (table 4.10).

In addition to the results presented above, two questions produced counter-intuitive findings. The extent of outdoor exposure (student question 4) was negatively correlated with Laurentian forest knowledge gains and a negative relationship was found between going outside with the teacher (student question 6) and Tropical Forest knowledge gains (table 4.10). Both of these are described further in the Limitations section below.

5.1.9 Learning themes

An individual program that offers a too wide array of learning themes would come across as disjointed and confusing. At the same time it is essential that students have the opportunity to learn about all aspects of our global environment. While a large number of themes and topics were covered, as presented in 4.2.2.4 (Level 4 of the list of the implementation methodologies), many of the themes were only covered by a small percentage of the programs (table 4.21). A student would need to participate in several environmental education programs at different institutions over the course of their education in order to learn the full scope of the available topics. As has been proposed in the general context by other researchers (Simmons, 2001), collaboration among Montreal environmental education institutions could help an educator achieve the goal of a broad curriculum for their students.

It is valuable to not only investigate which themes are covered, but also whether themes are receiving even coverage on the scale of Montreal as a whole. Science and humanities themes were fairly well balanced with 57% and 43% of the total respectively (table 4.23). However, the list of themes not covered at all is substantially skewed in the direction of humanities themes (table 4.22). Furthermore, within science, Life Science significantly outweighed Earth Science, and Environment and Society dominated the humanities. Humans and Societies themes represented only 8% of the total themes covered. It is interesting to note that some programs comprised solely of Life Science themes. Three Life Science themes were covered in over 70% of the programs (table 4.21). This is true for only one other theme of "human induced change" in Environment and Society. While it is easy to understand the desire to present charismatic furry creatures, learners need to be exposed to a more holistic curriculum. It is hard to study plants without understanding the soil from which they grow, and it is hard to understand human use of the environment without understanding the pressures that result from human interaction with each other. A greater overall balance is needed in Montreal environmental education programming.

The observed learning themes allowed to also evaluate the age appropriateness of the material being covered. Students in grade 3, 4 and 4/5 split classes received, on average, 64% of themes appropriate to grades K-4 (table 4.24). This number is adequate to allow a sufficient challenge to the older or more advanced students in the group while keeping in tune with the group mean. However, the older students in grades 5-8 only received 42% of age-appropriate material. This suggests that older students are under-challenged in Montreal programming. Since most Montreal environmental education institutions cater to both school groups and the general public, it is possible that curriculum is designed for a broad age range. These findings suggest that more attention needs to be given to age-appropriate programming, especially for older learners.

5.1.10 Environmental knowledge (environmental literacy, environmental issues, and environmental action strategies)

As was presented in Chapter 2, environmental knowledge is composed of environmental literacy, knowledge of environmental issues, and knowledge of environmental action strategies. In observing the programs at Montreal environmental education institutions, it was noted what proportion of the overall program time was spent on each of these components. On average 84% of the time was spent on environmental literacy and 54% of the programs did not devote any time to the discussion of environmental action strategies (table 4.20). Environmental issues and action strategies are discussed upon a foundation of environmental literacy so it is not surprising that the majority of time is spent on factual content. However, environmental education that lacks issues or action strategies discussion is nothing more than a course in environmental science. According to the goals of environmental education curriculum development, this satisfies only the primary ecological foundations level, leaving issues and values, investigation and evaluation, and action skills by the wayside (Hungerford et al., 1980). This form of instruction, although valuable in its own right, does not help to teach toward environmentally responsible behavior (Culen, 2001; Marcinkowski, 2001; Hungerford & Volk, 1990), or achieve the environmental education goals of an active and responsible citizenry (UNESCO-UNEP, 1976; UNESCO-UNEP, 1978).

In addition to investigating the proportion of time spent on discussion of environmental issues and action strategies, it is interesting to note which specific issues are being presented. The list of issues topics that were covered (4.2.2.3: Level 3) is quite comprehensive. However, there are two important issues missing: acid rain and ozone layer depletion. Politically, these are issues of the past, but environmentally they are by no means resolved. Environmental education institutions should present information that is environmentally relevant, not just politically en vogue.

The environmental learning of students visiting the Montréal Biodôme was investigated for overall knowledge gain, as well as categorized knowledge gain to reflect the goals of environmental education. The overall gain was educationally significant with increases that ranged from 12-23%, and statistically highly significant with $p < .001$ for all ecosystems (table 4.8). However, when the knowledge questionnaire was divided into the literacy, issues, and action strategies components, the gain remained significant for environmental literacy for all ecosystems but was no longer significant for environmental issues for either the Laurentian Forest or St. Lawrence Marine ecosystems. This suggests that while it was possible to compose content-specific environmental issues questions pertaining to those two ecosystems, there was more focus on presentation of scientific information. This is further supported by the fact that no environmental action strategies questions were incorporated into the questionnaire due to lack of relevant content.

In the case of the Tropical Forest ecosystem both educationally and statistically significant gains were observed for both environmental issues and action strategies questionnaire sections. Because it is not possible to gage the relative difficulty of the questionnaires prepared for the three different ecosystems, and the students participating in the three programs were not randomly assigned to their groups, it is not possible to directly compare the findings for the three ecosystems. However, all three programs are of equal duration, and follow the same class structure. Thus the positive findings of the Tropical Forest ecosystem may be extrapolated to suggest that it is possible to incorporate more environmental issues and action strategies content without compromising environmental literacy.

5.1.11 Relevant skills

The previous section discussed environmental knowledge and the importance of the knowledge of both environmental issues and action strategies. Once students process the necessary knowledge, they need appropriate skills to be able to implement that knowledge in a constructive manner. The majority of students gained an opportunity to practice communication skills and act cooperatively. However, it was observed that only 29% of the Montreal environmental education programs were inquiry-based, incorporating the use of inquiry tools and active issues investigation as a significant component of their instruction. An only slightly greater percentage (33%) had the instructor model active inquiry investigation (table 4.19). Thus, in the instances were students were learning about environmental issues, they were not gaining the tools necessary to act upon those issues. These findings fall directly in line with the result that on average only 2.4 minutes per program was spent on the discussion of environmental action strategies (table 4.20).

5.1.12 Environmental role models

The presence of environmental role models is important in developing positive environmental attitudes and conveying knowledge (Chawla, 1998b). Although the exposure of a student to an instructor of an environmental education institution is often brief, their behavior as a role model is nonetheless important. All of the instructors of the observed environmental education programs provided a balanced view of the environmental topics presented and modeled appropriate behavior (table 4.19). However, a larger problem was observed in modeling inquiry and empowering learners. The previous section addressed the lack of inquiry-based learning. Empowerment implies an opportunity for the learner to take even a small component of the issue into their hands, and take action to help resolve it. Since few environmental issues, and even fewer action strategies were covered in the environmental education programs (table 4.20), it left the instructors with few opportunities to empower the learners.

The quantitative effect of environmental role models on learner knowledge gain and attitude change was analyzed both through the student background and teacher questions of the Biodôme survey. None of the teacher questionnaire relationships produced substantive results on knowledge gain (table 4.11), and no significant relationships were found with attitude (tables 4.15 and 4.16), but both family (student questions 5 and 8) and school variables (student question 6) from the student questionnaire were significant in several instances for knowledge gain (tables 4.10). Furthermore, most of the non-significant trends followed the same patterns as the significant relationships. Most notably, the overall role model index was correlated with St. Lawrence Marine knowledge gain, and participating in outdoor activities with family (student question 5); and the extent of recycling at home (student question 8) had an effect on Tropical Forest knowledge gain (table 4.10). While several statistically significant counter-intuitive results were found, they can all be explained through secondary factors, and are examined in greater detail in the Limitations section below. Thus the overall findings point toward a positive trend between environmental role models and gain in environmental knowledge and attitude.

5.1.13 Affective domain (environmental attitudes, locus of control, personal responsibility)

Gains in environmental attitude, internal locus of control, and personal responsibility are essential for the ultimate goal of environmentally responsible behavior. However, they are also some of the hardest factors to influence and control. Attitudes are developed over many years through extended interactions with numerous individuals (Chawla, 1998b; Eagles & Demare, 1999). Statistically significant attitude change as a result of a visit to the Montréal Biodôme was observed for several of the questions, and for all questions combined only for students participating in the Tropical Forest program (table 4.13). In some instances a significant decrease in attitudes was found. Other researchers have cited similar findings (Newhouse, 1990) and some have attributed them to learner pessimisms or feeling of helplessness as a result of increased awareness of an environmental problem (Iozzi, 1989a). The lack of consistently significant relationships could also be due to the short duration of the program (Leeming et al., 1997).

Past literature has demonstrated that the link between knowledge and attitude is a tenuous one (Leeming, Dwyer, Portern, & Cobern, 1993; Zelezny, 1999). The results support that, with several significant positive correlations, although none of them consistent over all ecosystem programs. In evaluating the attitude pretest questionnaire, only one significant positive correlation between the overall attitude subcategory and St. Lawrence Marine knowledge gain was identified (table 4.12). Several significant positive relationships were also found between gains in attitude and knowledge gain for the Laurentian Forest program (table 4.18). Finally, knowledge pretest was positively correlated with attitude change in only three distinct cases (table 4.17). The one significant negative correlation in table 4.17 is best explained by secondary factors discussed in the Limitations section below. No substantial conclusions can be drawn with regard to the attitude-knowledge link based on these results.

5.2 Limitations

The survey and observation components of the study had separate methodologies, and thus separate limitations. The primary limitation of the observation component is the nature of the data collection. All of the findings were collected based on personal observations of the researcher. It is thus possible that an inherent observation bias crept into the data. However, the use of a consistent and research-based observation instrument would help to minimize the halo effect and maintain observer impartiality.

The survey component of the study had certain limitations but it also had factors that instill confidence in the reliability of the findings. The Cronbach Alpha coefficient was used to investigate the reliability of the survey component of the study (table 4.1). The coefficients were very high for the attitude component of the study thus demonstrating that the attitude section of the questionnaire consistently measures the same construct. The coefficients were lower for the knowledge component. This is not surprising since each question on the knowledge section of the questionnaire tests a different aspect of the curriculum presented to the students. The coefficient is especially low for the St. Lawrence Marine questionnaire, possibly due to fewer students participating in that program. However, the overall results from the Cronbach Alpha coefficient calculations suggest a sufficient level of reliability of the results.

In addition to the calculation of the Cronbach Alpha reliability coefficient, the significance of several control variables was investigated. Age and gender were evaluated as control variables for knowledge pretest and gain. Girls had significantly higher scores on Tropical Forest knowledge gain, and 11-year-old students had higher Laurentian Forest gains than students in the other age categories (table 4.10). No significant relationships were found with pretest scores. Age and gender were also evaluated for significance with attitude scores, and were discussed in greater detail earlier in "Factors influencing attitude pretest."

The teacher questionnaire had four additional control questions. Teacher question 4 evaluated the amount of time spent exploring the Biodôme outside of the structured program, and found to correlate significantly with Tropical Forest knowledge gain (table 4.11). The extent and timing of pre-visit preparation (teacher questions 5 and 6) did not influence any of the results. Finally, question 7 asked whether the teacher would like to receive a copy of the findings. While this question was initially designed to gain information for further dissemination of the results, it also hints at the level of teacher interest in the study. Teachers who are more interested in the study would be more eager to ensure that their students obtain high scores. A significant relationship was found both for Tropical and Laurentian Forest knowledge gains (table 4.11). The significant results of all of the control variables would have introduced noise into the overall data set making it harder to discern the relationships of interest.

In investigating trends in the data, of primary interest were effects of educational value. However, secondary effects were investigated as they can add error to the primary findings. In testing the correlation between learner pretest scores and learner knowledge gain, a significant negative relationship was identified (table 4.9). It is hypothesized that students with higher pretest scores had less room for gain, and thus had relatively lower knowledge gain scores. For example, in the case of the Tropical Forest, three students had a gain of seven points, but four students had room for only two points in gain based on their pretest score. Because of this relationship, pretest was used as a covariate in all knowledge gain analysis of variance calculations (tables 4.10 and 4.11).

The same trend of a negative correlation between pretest and gain scores was identified in attitude measures (table 4.14). Again, pretest was used as a covariate in all attitude change analysis of variance calculations (tables 4.15 and 4.16). The problem within the attitude scores was further exacerbated by the overall very high attitude scores. This is likely due to a socially desirable response set, with students aware of the more socially acceptable attitudes, and reflecting them in their responses rather than their true opinions. Rovira (2000) pointed out the danger of respondents adopting politically correct opinions, and older research on the new environmental paradigm demonstrated that members of the general public are quite likely to conform to the pro-environmental view (Dunlap & Van Liere, 1978). The consistently significant relationships identified between student background and attitude pretest (table 4.6) suggest that in cases where significant relationships are present at $p < .001$ trends will be identified despite the error, but if a relationship is weak it is more likely to remain hidden within the noise.

Unlike analysis of variance calculations, in correlation comparison it is not possible to use a covariate. In two instances a significant positive correlation was identified with a pretest score, and a negative correlation was identified with the relevant gain score. It is hypothesized that these relationships are the consequence of the overall negative relationship between pretest and gain scores. Thus the counter-intuitive relationships of student question 4 (table 4.10) with Laurentian Forest knowledge gain, and attitude gain for question 10 correlated with the Laurentian Forest pretest (table 4.17) are likely erroneous results. The same mechanism is likely the cause of the significant negative correlation between teacher question 3 and Laurentian Forest knowledge gain (table 4.11) since teacher question 3 was marginally positively correlated ($p < .08$) with the Laurentian Forest pretest score (table 4.4).

In two additional cases findings should be viewed with caution. Student question 6 (whether students go outside with their teacher) was evaluated using the number of students as the sample size and thus the degrees of freedom, and found to be significant in several instances (tables 4.3, 4.6, 4.10, and 4.15). However, because all students in the same class should have had the same answer with regard to their teacher, the de facto sample size was the much smaller number of teachers. The answers to the thematically similar teacher question 1, with the number of teachers as the sample size is likely a more accurate representation of the relationship in question (tables 4.4, 4.7, 4.11, and 4.16).

The second case pertains to student question 9, the availability of recycling facilities at school (tables 4.3, 4.6, 4.10, and 4.15). The variance for this question was very low, with only a small number of students answering that their school did not have recycling facilities, or that they did not know of their existence. While no significant relationships were found, again the more detailed thematically similar teacher question 3 is likely more accurate (tables 4.4, 4.7, 4.11, and 4.16). In both of the above cases the relationship between the student and teacher responses was evaluated for consistency. Responses to student question 6 were found to be statistically significantly consistent with those to teacher question 1, but the low variance of student question 9 prevented a significant relationship from being identified with teacher question 3 (table 4.2).

The final limitation in the survey component of the study was a mistake in the Laurentian Forest questionnaire. After the questionnaire had been administered it was discovered that more than one of the multiple choice answers to question 26 could be considered correct based on the content presented by Biodôme instructors. To resolve the problem the question was removed from all analyses. The Cronbach Alpha coefficient was slightly higher once question 26 was removed, at 0.285 for the pretest and 0.561 for the posttest, as compared to 0.271 and 0.531 for the pretest and posttest, respectively, for all 9 original questions.

5.3 Conclusions

This work set out to investigate environmental education essential elements in school field trip programming. It was determined that students obtain consistent knowledge gain as the result of a field trip program as measured by a content-specific questionnaire. Consistent change in environmental attitudes was not observed. On the other hand, it was found that pre-visit attitudes are consistently correlated with student background. Students who spend more time in nature and have more environmentally positive role models had higher attitude scores. Prolonged repeated exposure to environmental education programming would be necessary to replicate the effects of the home environment on attitudes.

Observation findings demonstrated that the knowledge presented in Montreal environmental education is focused on environmental literacy, and does not provide sufficient exposure to environmental issues and action strategies. While this form of content is acceptable for environmental science instruction, it does not meet the goals of environmental education and increasing environmentally responsible behavior. Increased attention on environmental issues and action strategies could also have the added benefit of prolonged learner empowerment and ultimately more environmentally positive attitudes.

The essential elements discussed in this work increase the benefits and effectiveness of environmental education programming. The list of implementation methodologies provides good examples of how the essential elements are put into action and can be a foundation for future environmental education program development.

Appendices

Appendix 1: Section 1 of Survey Instrument: Background

Students, please work on one page at a time. Read each question carefully. Circle the ONE best answer.

Sample question:
What is the colour of tree leaves in the summer time?
a. Blue b. Green c. Red d. Yellow e. I do not know

Please answer the following questions:
1. I am a:
a. Boy b. Girl

2. How old are you?
a. 9 b. 10 c. 11 d. 12 e. 13

3. Have you ever been to the Montreal Biodôme?
a. Yes b. No

4. How often do you spend time doing nature activities (such as hiking, camping, fishing, canoeing, or walking in a park)?
a. Weekly all year long
b. Weekly only during the summer
c. Monthly
d. Several times a year
e. Almost never

5. Do you participate in nature activities with your family?
a. Yes b. No

6. Does your teacher ever take your class for a lesson outside?
a. Yes b. No

7. Is there a garden either at your school or at home?
a. Yes b. No

8. How often does your family recycle at home?
a. All the time b. Sometimes c. Never

9. Does your school have bins for recycling?
a. Yes b. No c. I do not know

Appendix 2: Section 2 of Survey Instrument: Affective domain

Please answer the following questions based on your opinions. Do you agree or disagree with each of the following statements?

10. By taking part in environmental activities such as planting of trees or helping start a recycling program, I can help to protect natural areas.
a. Strongly agree b. Agree c. Disagree d. Strongly disagree

11. I can help to protect the environment by turning off the water and lights when they are not in use
a. Strongly agree b. Agree c. Disagree d. Strongly disagree

12. If I see somebody wasting water, I feel that I should tell him or her to stop
a. Strongly agree b. Agree c. Disagree d. Strongly disagree

13. I would spend some of my own money to help protect wild animals
a. Strongly agree b. Agree c. Disagree d. Strongly disagree

14. It makes me feel good to know that I am helping the environment
a. Strongly agree b. Agree c. Disagree d. Strongly disagree

15. People's actions affect the environment
a. Strongly agree b. Agree c. Disagree d. Strongly disagree

16. Natural resources (such as wood for making paper, water for drinking and washing, and gasoline for driving cars) should be carefully conserved or recycled
a. Strongly agree b. Agree c. Disagree d. Strongly disagree

17. To help reduce pollution, people should drive cars less, and walk or ride bicycles more
a. Strongly agree b. Agree c. Disagree d. Strongly disagree

18. People must know more about the environment in order to help protect it
a. Strongly agree b. Agree c. Disagree d. Strongly disagree

19. As a member of my community, it is my job to pick up litter at school, even if it is not mine
a. Strongly agree b. Agree c. Disagree d. Strongly disagree

Appendix 3: Section 3 of Survey Instrument: Knowledge (Tropical Forest)

Please answer the following questions based on what you know. Answering "I do not know" is fine.

20. The roseate spoonbill, capybara, caiman, and piranha all live in which ecosystem?
a. Desert b. Tropical forest c. Arctic d. Laurentian forest
e. I do not know

21. What kind of animals have scales, lay eggs, and breathe with lungs?
a. Fish b. Birds c. Amphibians d. Reptiles
e. I do not know

22. Which of the following is <u>NOT</u> a bird?
a. Bat b. Gull c. Ibis d. Penguin e. I do not know

23. Where can tropical rain forest be found in the world?
a. Far away from the equator
b. In areas where it is both hot and humid
c. In areas where there is lots of snow
d. In certain parts of Quebec
e. I do not know

24. Which of the following are parts of the ecosystem?
a. All living things
b. All non-living things
c. The air, water, and sun
d. All of the above
e. I do not know

25. Why is it important to protect the tropical rain forest?
a. Because it has a high diversity of species of plants and animals
b. Because humans use products that come from plants of the tropical forest.
c. Because tropical forests play an important role in maintaining climate stability
d. All of the above
e. I do not know

26. In which of the following groups of foods do all three come from the tropics?
a. Vanilla, molasses, and chocolate
b. Mangoes, pineapples, and apples
c. Wheat, corn, and maple syrup
d. Potatoes, tomatoes, and cabbage
e. I do not know

27. Where does aluminium come from?
a. Bauxite ore mined from rainforest areas

b. In its natural state in Quebec soils
c. Obtained from water distillation
d. Nuggets of aluminium found in tropical streams and rivers
e. I do not know

28. How can the recycling of aluminium (such as from soda cans) in Montreal help protect the tropical rain forest?
a. There will be less garbage going in the landfill
b. Recycling of aluminium will decrease the need for glass
c. Recycling will decrease the need for the mining of bauxite ore
d. By recycling, I will save money
e. I do not know

Appendix 4: Section 3 of Survey Instrument: Knowledge (Laurentian Forest)

Please answer the following questions based on what you know. Answering "I do not know" is fine.

20. The porcupine, river otter, common loon, and lake sturgeon all live in which ecosystem?
a. Desert b. Tropical forest c. Antarctic d. Laurentian forest
e. I do not know

21. Which of the following is <u>NOT</u> a characteristic of the beaver?
a. A flat tail for steering
b. Webbed feet for swimming
c. Long claws for climbing trees
d. Sharp teeth for cutting wood
e. I do not know

22. Which of the following are parts of the ecosystem?
a. All living things b. All non-living things c. The air, water, and sun
d. All of the above e. I do not know

23. Which of the following is an example of an interrelation between living things?
a. Beaver eat the bark of trees
b. Both lake sturgeon and river otter spend time in water
c. Both hare and lynx have large paws for running on snow
d. The colour of maple leaves changes at the same time as when bears get ready to hibernate
e. I do not know

24. Where can the Laurentian forest be found in the world?
a. In areas where all the trees are evergreen
b. In certain parts of Quebec and Ontario
c. All over Canada
d. In areas where it is hot and humid all year long
e. I do not know

25. Which of the following events is <u>NOT</u> a result of seasons?
a. The death of trees
b. Changing leaf colour
c. Changing snowshoe hare fur colour
d. Tree rings
e. I do not know

26. What can you tell by looking at the skull of an animal?
a. Where the animal likes to live
b. What the animal likes to eat
c. Whether the animal spends much time in the water

d. Animal skulls are too similar to be able to tell anything
e. I do not know

27. Why is it important to protect animals such as lynx?
a. If there are more lynx, there will be more beaver
b. If lynx are protected then they will leave the hare and porcupines alone
c. Without lynx there will be too many otters that will eat too much fish
d. Without lynx there will be too many hare that could eat too many plants
e. I do not know

28. What would happen in a part of the Laurentian forest where there were no trees?
a. The beaver would have no food
b. The number of hare would decrease in that part of the Laurentian forest
c. The lynx would be hungry
d. All of the above
e. I do not know

Appendix 5: Section 3 of Survey Instrument: Knowledge (St. Lawrence Marine)

Please answer the following questions based on what you know. Answering "I do not know" is fine.

20. The starfish, blue whale, green-winged teal, and halibut all live in which ecosystem?
a. St. Lawrence marine b. Tropical forest c. Arctic d. Open ocean
e. I do not know

21. The sea-urchin, lobster, whelk, and starfish all belong to which group of animals?
a. Vertebrates b. Amphibians c. Invertebrates d. Reptiles
e. I do not know

22. Which of the following animals does <u>NOT</u> use a suction foot or suction feet to stick to a rocky surface?
a. Sea-urchin b. Starfish c. Sea anemone d. Flounder
e. I do not know

23. How would you describe the water in the St. Lawrence marine region?
a. Fresh and warm
b. Salty and very cold
c. Salty and warm
d. Fresh and very cold
e. I do not know

24. What do the starfish and sea urchin have in common?
a. Their mouth is on the top of their body
b. They live in fresh water
c. They have a backbone
d. Their mouth is on the underside of their body
e. I do not know

25. What are the lobsters' claws used for?
a. As decoration
b. For feeling around
c. For cutting and "chewing"
d. For digging a home
e. I do not know

26. Why are the feathers of green-winged teal females brown?
a. To blend in with its environment
b. To be more attractive for the males
c. Brown feathers make it easier for baby ducks to find their mother
d. Brown feathers are more beautiful
e. I do not know

27. Which species has disappeared from the estuary and the gulf of the St. Lawrence River?
a. The winter flounder
b. The Atlantic sturgeon
c. The beluga whale
d. The stripped bass
e. I do not know

28. What effect(s) does pollution have on the St. Lawrence marine ecosystem?
a. The toxic chemicals go into the food chain
b. Animals get sick and sometimes die
c. People get sick
d. All of the above
e. I do not know

Appendix 6: Instructions for Teachers

Please read the following instructions, and follow them closely in explaining the procedures to your students. The uniformity in quiz administration is crucial to the research outcomes. Should you be uncertain as to any of the procedures, please do not hesitate to contact me.

Thank you again for all of your efforts.

Mariam Futer
mariam.futer@mail.mcgill.ca
(514) 398-3077

Time line of study participation

1. Receive forms, instructions , and a sample quiz
2. If you agree to participate in the study, sign the "informed consent" form, and receive quiz packet
3. Administer pre-visit quiz after all preparatory activities have been completed or 1 week prior to your class's scheduled Biodôme visit
4. Before you begin any follow-up activities or 1 week following the scheduled Biodôme visit, administer post-visit quiz and complete teacher questionnaire
5. Return completed quizzes, teacher questionnaire, and signed "informed consent" form to Ms. Mariam Futer at McGill

Detailed instructions for specific stages of the study

Before you administer the quizzes

1. Ensure that you have received enough copies of the quiz for all of your students.
2. Environmental activities are defined as: helping with a recycling project, doing a park cleanup, planting trees, informing other about environmentally conscious actions etc.
3. If you have any doubts as to the question content, please contact Ms. Mariam Futer for further clarification.

Instructions for quiz administration

1. Instruct students that they are not being graded for their work on this quiz.
2. Inform them that their diligence in answering the questions is very important for a person who wants to know how to better teach them.
3. If the students have not been previously exposed to the multiple choice question format, go over the sample question, and how one would go about picking the ONE best answer to the question.
4. Emphasize to the students that the "I do not know" answer is a legitimate option for which they will not be penalized. It is better to select "I do not know" then to guess on a question for which they do not know the answer.

5. Instruct students to work on only one page at a time, read each question carefully and select only one answer.
6. Instruct students that page two, with the strongly agree / strongly disagree questions is asking about their opinions. There is no right or wrong answer.
7. Students may write comments next to any question, if they choose to do so.

Please note: Even if a student was absent during the administration of the pre-visit quiz, they should still complete a post-visit quiz. If a student was absent on the day of the Biodôme field trip, they should still complete both quizzes, but their post-visit quiz should be labeled as "did not attend field trip."

While students are responding to the questions

1. Ensure that students understand what is being asked, but do not provide assistance if students do not know the correct answer.
2. For tropical forest only: for questions 27 and 28 you may inform students as to the definition of the word "ore" if they are not familiar with it. Ore can be defined as the rock deposits mined to extract metals of value.
3. While students are working on their post-visit quizzes, please complete the 7 brief questions for the teachers.

After students have completed answering the questions

1. Collect all of the student papers.
2. Assign a number to each student paper. Since the number has to be the same on the pre-visit and post-visit quiz, please keep a record of which number corresponds to which student. For your convenience, you might want to use the numbers already assigned in your grade book or other record keeping.
3. Cut off the student names from the tops of the quiz papers.
4. Please write "did not attend field trip" on the top of the papers of any student who was absent on the day of the field trip.
5. Once both the pre and post-visit quizzes have been completed, please place ALL quiz papers (with student names removed), the informed consent form, and the teacher questionnaire in the envelope provided, and mail it back to Ms. Mariam Futer at McGill University in the envelope provided.

Thank you again for your participation. All of your efforts are a tremendous help to the attaining of useful results in this research project. Please return all appropriate materials to Ms. Mariam Futer. If you need to contact me for any reason, please do not hesitate to do so at mariam.futer@mail.mcgill.ca or (514) 398-3077.

Appendix 7: Teacher Questionnaire

Please answer the following questions. Combining your answers with those of your students will be a great help in interpreting the overall outcomes of the research. Please provide additional comments for any of the questions where you feel it will further clarify the response.

1. How often do you take your students for a class outside?
a. Never
b. Several times a year
c. Often when the weather is nice
d. At least once a week

2. What are the school grounds like?
a. Urban setting with very little grass and few trees
b. Grassy field for sports, but few trees
c. Grassy field surrounded by trees
d. Has wild area (such as a small woodlot or forest) in addition to the sports fields

3. What sorts of recycling facilities are available for your students at school?
a. None
b. Paper only
c. Cans only
d. Both paper and cans
e. Full service that includes paper and cans, as well as plastics and glass

4. How much time did you spend exploring the Biodôme with your class outside of the framework of the guided visit?
a. Not at all, went back to school right after guided tour was over
b. Quickly walked through the remaining ecosystems
c. Spent about 15 minutes in each of the remaining ecosystems (about 45 minutes total) for students to observe the animals
d. Spent over 15 minutes in each of the remaining ecosystems, discussing what the students were seeing

5. How much pre-visit preparation did you do with your students?
a. None
b. Briefly explained what the students might see
c. Explained what students might see and devoted 1 lesson to closely related activities
d. Devoted 1-4 lesson to closely related activities
e. Devoted 5 or more lessons to closely related activities

6. When did you conduct pre-visit preparation (if applicable)?
a. 1-5 school days prior to the visit
b. More than one week before the visit
c. Ongoing throughout the term

7. Would you like to receive a copy of the compiled results once the study is completed?

a. Yes

b. No

Appendix 8: Teacher Informed Consent Form to Participate in Research

This is to request your participation in the research project entitled:
Effectiveness of Environmental Education Essential Elements in School Field Trip Programming
Conducted by: Ms. Mariam Futer and Dr. Brian Alters, McGill University

The primary goal of this project is to gain insight into educational approaches that lead to the greatest level of knowledge gain and are most effective at achieving a shift in environmental attitudes. The research is to be conducted with the groups visiting the Montréal Biodôme on a field trip program. By comparing student responses to science content quizzes prior to the visit to those following the visit, the researches hope to deduce the extent to which the techniques applied at the Biodôme have achieved an increase in knowledge and environmental awareness. Furthermore, the type of knowledge being retained is of interest.

Several international charters (i.e. UNESCO Belgrade Charter 1976, Tbilisi Declaration 1977) have set environmental education with the goal of increasing public awareness of the link between human actions and their effects on the surrounding world. The Montréal Biodôme has picked up on this task in its mission, striving to "deliver an essential message [that] we are all part of nature and can help protect it." This study should benefit the environmental education community by increasing the knowledge necessary for effective programming. Furthermore, the Biodôme will be able to gage the extent to which its educational mission is being realized. Finally, you, as a participating teacher, will be able to gage the knowledge gain of your students resulting from the Biodôme visit.

As a participant in this study, you will receive the science content quizzes upon your registration for a Biodôme visit. You will need to administer these prior to your scheduled Biodôme visit, and shortly following the visit. You are kindly asked to assign a numeric code to each student's name, and apply that code to his or her pre-visit and post-visit questionnaire. Neither the names nor any other personal information are to appear on any of materials returned to the researchers. This will insure your students' anonymity both within our records and in future dissemination of the results. Although the school name will be retained in the researchers' records, it will not appear on any published or otherwise disseminated documents.

The results may appear in journal publication. Furthermore, a copy of the analyzed results will be provided to the Montréal Biodôme and to the participating teachers. Thus the results will be accessible to the direct participant teachers of the study, as well as other interested educators and researchers.

Your participation in this study will be of great asset to this research project, to the goals of environmental education, and to the enhancement of environmental awareness. However, you are by no means obliged to participate.

Anyone is free to withdraw from the study at any point without any question, penalty, or prejudice.

Based on the information provided above, please consider the following statements. If you agree with them, please sign below. Should you have any further questions regarding this study, please do not hesitate to contact the researchers.

- I understand the purpose of this study and know about the risks, benefits and inconveniences that this research project entails.
- I understand that I am free to withdraw at anytime from the study without any penalty or prejudice.
- I understand that this research will not affect my grades or evaluation of my work.
- I understand how confidentiality will be maintained during this research project.
- I understand the anticipated uses of data, especially with respect to publication, communication and dissemination of results.

I have read the above and I understand all of the above conditions. I freely consent and voluntarily agree to participate in this study.

Name (please print) ____

Signature ____________________________________ Date ______________

Thank you for all of your time and efforts.
Mariam Futer
mariam.futer@mail.mcgill.ca
(514) 398-3077

Appendix 9: Observation Guide Instrument

<u>Level 1: Institutional decisions as they relate to program content</u>

Reduction of novelty:
- On location
- Preparatory activities
- Follow-up activities

Local relevance (link to familiar, then expand to global)
Link between delivery and provincial education standards
Relevance to agency mission
Time in nature
Opportunity to apply skills
Vary inquiry tools (magnifying glass, hygrometer etc.)
Vary implementation to address learning styles (use all senses to learn)
Hands on
Active discovery
Skills gained:
- Identifying, questioning, investigation issues
- Cooperative learning
- Communication skills:
  - Gather
  - Organize
  - Synthesize

<u>Level 2: Teaching methodology (implementation)</u>

Balanced approach (differing points of view), respectful behavior
Model process of inquiry and application of investigation
Foster curiosity
Empower learners
Engage all learners

<u>Level 3: Program evaluation</u>

A. Knowledge (literacy)
Topic: ______________________________
~Proportion of time spent: __________

B. Knowledge of issues
Issues discussed: ________________________________
~Proportion of time spent: __________

C. Knowledge of action strategies
Strategies discussed: _______________________________
~Proportion of time spent: __________
- Alternative solutions

<u>Level 4: Learning themes</u>

Earth Sciences

Processes and systems
Shaping of Earth (erosion, climate, seasons, landforms)
Changes in matter (hydrologic cycle, heating, cooling)
Energy (forms, production)

Life Science
Organisms, population, communities (basic needs, types)
Heredity and evolution (inheritance, variation, fossils)
Systems and connectedness (behavior, effect of change)
Flow of matter and energy
Interdependence

Humans and society
Culture
Political and economic systems
Global connectedness

Environment and society
Human/environment interaction (link to the systems)
Places (variation, uniqueness, landmarks)
Resources
Limiting factors
Technology
Concrete environmental issues

Appendix 10: Program Instructor Informed Consent Form to Participate in Research

This is to request your participation in the research project entitled: Implementation of Environmental Education Essential Elements in School Field Trip Programming

Conducted by: Ms. Mariam Futer and Dr. Brian Alters, McGill University

The primary goal of this project is to gain insight into educational approaches that lead to the greatest level of knowledge gain and are most effective at achieving a shift in environmental attitudes. The research is to be conducted by observing environmental programming at several Montreal environmental education institutions. By comparing the program content to environmental education essential elements identified from the literature, the researches hope to deduce the extent to which program implementation is linked to the theoretical foundations of the field. Furthermore, open-ended comments will enable to not only identify which essential elements are being implemented, but also gage the methodology of implementation.

Several international charters (i.e. UNESCO Belgrade Charter 1976, Tbilisi Declaration 1977) have set environmental education with the goal of increasing public awareness of the link between human actions and their effects on the surrounding world. Environmental education institutions have picked up on this task in an effort to educate the public. This study should benefit the environmental education community by possibly increasing the knowledge necessary for effective programming. Furthermore, the Montreal environmental institutions will be able to gage the extent to which their programs fit with the literature criteria.

As a participant in this study, you will be asked to participate prior to the observation of any programs that you might deliver. Upon consent, the researchers will observe your interaction with school groups to note any of the previously identified essential elements that you will implement, and record the method of implementation wherever possible. You are asked to maintain regular program delivery during observation. Your name and the name of your institution will be kept strictly confidential, and pseudonyms will be used in any published or otherwise disseminated documents.

The results may appear in journal publication. Furthermore, a copy of the analyzed findings will be provided to the participating Montreal environmental institutions. Thus the results will be accessible to the direct participants of the study, as well as other interested educators and researchers.

Your participation in this study will be of great asset to this research project, to the goals of environmental education, and to the enhancement of environmental awareness. However, you are by no means obliged to participate.

You are free to withdraw from the study at any point without any question, penalty, or prejudice.

Based on the information provided above, please consider the following statements. If you agree with them, please sign below. Should you have any further questions regarding this study, please do not hesitate to contact the researchers.

- I understand the purpose of this study and know about the risks, benefits and inconveniences that this research project entails.
- I understand that I am free to withdraw at any time from the study without any penalty or prejudice.
- I understand how confidentiality will be maintained during this research project.
- I understand the anticipated uses of data, especially with respect to publication, communication and dissemination of results.

I have read the above and I understand all of the above conditions. I freely consent and voluntarily agree to participate in this study.

Name (please print) ____

Signature ________________________________ Date ______________

Reference List

Adkins, C., & Simmons, D. A. (2000). Outdoor, experiential, and environmental education: Converging or diverging approaches? *ERIC Digest, August*, ED 467 713.

Anderson, D., & Lucas, K. B. (1997). The effectiveness of orienting students to the physical featured of a science museum prior to visitation. *Research in Science Education, 27*(4), 485-495.

Apple, M. W., & Teitelbaum, K. (2001). John Dewey. In J. A. Palmer (Ed.), *Fifty Major Thinker in Education: From Confucius to Dewey* (pp. 177-182). London: Routledge.

Arenas, A. (1999). If we all go global, what happens to the local? In defense of a pedagogy of place. *Annual Meeting of the Comparative and International Education Society: April 1999 Toronto, Canada,* ED 434 796.

Armstrong, J. B., & Impara, J. C. (1991). The impact of an environmental education program on knowledge and attitude. *Journal of Environmental Education, 22*(4), 36-40.

Asch, J., & Schore, B. M. (1975). Conservation behavior as the outcome of environmental education. *Journal of Environmental Education, 6*(4), 25-33.

Athman, J. A., & Monroe, M. C. (2001). Elements of effective environmental education programs. *Defining Best Practices in Boating, Fishing, and Stewardship Education,* 37-48, ED 463 936.

Ballantyne, R., Fien, J., & Packer, J. (2001). Program effectiveness in facilitating intergenerational influence in environmental education: Lessons from the field. *Journal of Environmental Education, 32*(4), 8-15.

Ballantyne, R. R., & Packer, J. M. (1996). Teaching and learning in environmental education: Developing environmental conceptions. *Journal of Environmental Education, 27*(2), 25-32.

Barshinger, T., & Ray, A. (1998). From volcanoes to virtual tours: Bringing museums to students through videoconferencing technology. *Proceedings of the Annual Conference of Distance Teaching & Learning, (14th, Madison, WI, August 5-7)*, 41-47, ED 422 841.

Basile, C. G. (2000). Environmental education as a catalyst for transfer of learning in young children. *Journal of Environmental Education, 32* (1), 21-27.

Benton, R. (1993). Does and environmental course in the business school make a difference? *Journal of Environmental Education, 24*(4), 37-43.

Blaikie, N. (1993). Education and environmentalism: Ecological world view and environmentally responsible behaviour. *Australian Journal of Environmental Education, 9*, 1-20.

Boerschig, S., & De Young, R. (1993). Evaluation of selected recycling curricula: Educating the green citizen. *Journal of Environmental Education, 24*(3), 17-22.

Borden, R. J., & Schettino, A. P. (1979). Determinants of environmentally responsible behavior. *Journal of Environmental Education, 10*(4), 35-39.

Bradley, J. C., Waliczek, T. M., & Zajicek, J. M. (1999). Relationship between environmental knowledge and environmental attitude of high school students. *Journal of Environmental Education, 30*(3), 17-21.

Brandt. (1987). Is cooperation un-American? *Educational Leadership, 45*(3), 3.

Callicott, J. B. (1987). "Just the facts, Ma'am." *Environmental Professional, 9*(4), 279-288.

Carson, R. (1956). *The Sense of Wonder*. New York: Harper & Row.

Carson, R. (1962). *Silent Spring*. New York: Mariner Book, Houghton Mifflin Company.

Chawla, L. (1998a). Research methods to investigate significant life experiences: Review and recommendations. *Environmental Education Research, 4*(4), 383-397.

Chawla, L. (1998b). Significant life experiences revisited: A review of research on sources of environmental sensitivity. *Journal of Environmental Education, 29*(3), 11-21.

Chung, Y.-L., & Son, D.-H. (2000). Effects of cooperative learning strategy on achievement and science learning attitudes in middle school biology. *Journal of the Korean Association for Research in Science Education, 20*(4), 611-623.

Cohen, S., & Horm-Wingerd, D. (1993). Children and the environment: Ecological awareness among preschool children. *Environment and Behavior, 25*(1), 103-120.

Cole, P. R. (1995). Constructivism - rediscovering the discovered. *Curator, 38*(4), 225-227.

Corcoran, P. B. (1997). Wonderment and wisdom: The influence of Rachel Carson (1907-1964) on environmental education. In P. J. Thompson (Ed.), *Environmental Education for the 21st Century: International and Interdisciplinary Perspectives*. New York: Peter Lang.

Culen, G. R. (2001). The status of environmental education with respect to the goal of responsible citizenship behavior. In H. R. Hungerford, W. J. Bluhm, T. L. Volk, & J. M. Ramsey (Eds.), *Essential Readings in Environmental Education* (2nd ed., pp. 37-45). Champlaign, IL: Stipes Publishing.

Culen, G. R., & Volk, T. L. (2000). Effects of an extended case study on environmental behavior and associated variables in seventh and eight-grade students. *Journal of Environmental Education, 31*(2), 9-15.

Dettmann-Easler, D., & Pease, J. L. (1999). Evaluating the effectiveness of residential environmental education programs in fostering positive attitudes toward wildlife. *Journal of Environmental Education, 31*(1), 33-39.

Dimopoulos, D. I., & Pantis, J. D. (2003). Knowledge and attitudes regarding sea turtles in elementary students on Zakynthos, Greece. *Journal of Environmental Education, 34*(3), 30-38.

Disinger, J. F. (2001). Environmental education's definitional problems. In H. R. Hungerford, W. J. Bluhm, T. L. Volk, & J. M. Ramsey (Eds.), *Essential Readings in Environmental Education* (2nd ed., pp. 17-31). Champlaign, IL: Stipes Publishing.

Dressner, M., & Gill, M. (1994). Environmental education at summer nature camp. *Journal of Environmental Education, 25*(3), 35-41.

Dunlap, R. E., & Hefferman, R. B. (1975). Outdoor recreation and environmental concern: An empirical examination. *Rural Sociology, 40*(1), 18-30.

Dunlap, R. E., & Van Liere, K. D. (1978). The "new environmental paradigm." *Journal of Environmental Education, 9*(4), 10-19.

Eagles, P. F. J., & Demare, R. (1999). Factors influencing children's environmental attitudes. *Journal of Environmental Education, 30*(4), 33-37.

Falk, J. H., & Balling, J. D. (1980). The school field trip: Where you go makes the difference. *Science and Children, 17*(5), 6-8.

Falk, J. H., Koran Jr., J. J., & Dierking, L. D. (1986). The things of science: Assessing the learning potential of science museums. *70*(5), 503-508.

Falk, J. H., Martin, W. W., & Balling, J. D. (1978). The novel field-trip phenomenon: Adjustment to novel settings interferes with task learning. *Journal of Research in Science Teaching, 15*(2), 127-134.

Fensham, P. J. (1978). Stockholm to Tbilisi - the evolution of environmental education. *Prospects, 8*(4), 446-455.

Finson, K. D., & Enochs, L. G. (1987). Student attitudes toward science-technology-society resulting from visitation to a science-technology museum. *Journal of Research in Science Teaching, 24*(7), 593-609.

Flexer, B. K., & Borun, M. (1984). The impact of a class visit to a participatory science museum exhibit and a classroom science lesson. *Journal of Research in Science Teaching, 21*(9), 863-873.

Fortner, R., & Teates, T. (1980). Baseline studies for marine education: Experiences related to marine knowledge and attitudes. *Journal of Environmental Education, 11*(4), 11-19.

Fortner, R. W. (2002). Chapter 5: Cooperative learning: A basic instructional methodology for global science literacy. In V. J. Mayer (Ed.), *Global Science Literacy* (pp. 79-92). Boston: Kluwer Academic Publishers.

Fosnot, C. T. (1996). *Constructivism: Theory, Perspectives, and Practice*. New York: Teachers College Press.

Gambro, J. S., & Switzky, H. N. (1996). A national survey of high school students' environmental knowledge. *Journal of Environmental Education, 27*(3), 28-33.

Gardner, H. (1993). *Frames of Mind: The Theory of Multiple Intelligences*. New York: BasicBooks.

Gennaro, E. D. (1981). The effectiveness of using previsit instructional materials on the learning for a museum field trip experience. *Journal of Research in Science Teaching, 18*(3), 275-279.

Gigliotti, L. M. (1990). Environmental education: What went wrong? What can be done? *Journal of Environmental Education, 22*(1), 9-12.

Goto, M. (2002). Chapter 14: How a Japanese science teacher integrated field activities into his curriculum. In V. J. Mayer (Ed.), *Global Science Literacy* (pp. 203-216). Boston: Kluwer Academic Publishers.

Gough, A. (2002). Mutualism: A different agenda for environmental and science education. *International Journal of Science Education, 24*(11), 1201-1215.

Gough, N. (1999). Surpassing our own histories: Autobiographical methods for environmental education research. *Environmental Education Research, 5*(4), 407-419.

Government of Canada. (2002) *Government of Canada ratifies Kyoto Protocol (News Release)* [Web Page]. URL <http://webapps.dfait-maeci.gc.ca/minpub/Publication.asp?FileSpec=/Min_Pub_Docs/105789.htm&Language=E> [2004, June 1].

Grace, M. M., & Ratcliffe, M. (2002). The science and values that young people draw upon to make decisions about biological conservation issues. *International Journal of Science Education, 24*(11), 1157-1169.

Hamilton, J. P. (1986). Environmental locus of control as a function of the perceived importance of environmental problems and environmental knowledge. *Journal of Interpretation, 11*(2), 15-31.

Hardin, G. (1968). The tragedy of the commons. *Science, 162*, 1243-1248.

Harvey, M. R. (1990). The relationship between children's experiences with vegetation on school grounds and their environmental attitudes. *Journal of Environmental Education, 21*(2), 9-15.

Hattie, J., Marsh, H. W., Neill, J. T., & Richards, G. E. (1997). Adventure education and outward bound: Out-of-class experiences that make a lasting difference. *Review of Educational Research, 67*(1), 43-87.

Heimlich, J. E. (1994). Using the child's environment to teach at home and at school. *ERIC Digest, September*, ED 172 968.

Hines, J. M., Hungerford, H. R., & Tomera, A. N. (1986). Analysis and synthesis of research on responsible environmental behavior: A meta-analysis. *Journal of Environmental Education, 18*(2), 1-8.

Hofbauer, J., & Sigmund, K. (1998). *Evolutionary games and population dynamics*. New York: Cambridge University Press.

Horvat, R. E., & Voelker, A. M. (1976). Using a likert scale to measure "environmental responsibility." *Journal of Environmental Education, 8*(1), 36-47.

Howe, R. W., & Disinger, J. F. (1988). Teaching environmental education using out-of-school settings and mass media. *ERIC Digest,* (1).

Hsu, S.-J., & Roth, R. E. (1998). An assessment of environmental literacy and analysis of predictors of responsible environmental behavior held by secondary teachers in the Hualien area of Taiwan. *Environmental Education Research, 4*(3), 229-249.

Hungerford, H. R. (2001). The myths of environmental education - revisited. In H. R. Hungerford, W. J. Bluhm, T. L. Volk, & J. M. Ramsey (Eds.), *Essential Readings in Environmental Education* (2nd ed., pp. 49-56). Champlaign, IL: Stipes Publishing.

Hungerford, H. R., Peyton, R. B., & Wilke, R. J. (1980). Goals of curriculum development in environmental education. *Journal of Environmental Education, 11*(3), 42-47.

Hungerford, H. R., & Volk, T. L. (1990). Changing learner behavior through environmental education. *Journal of Environmental Education, 21*(3), 8-21.

Hwang, Y.-H., Kim, S.-I., & Jeng, J.-M. (2000). Examining the causal relationships among selected antecedents of responsible environmental behavior. *Journal of Environmental Education, 31*(4), 19-25.

Iozzi, L. A. (1989a). What research says to the educator: Part one: Environmental education and the effective domain. *Journal of Environmental Education, 20*(3), 3-9.

Iozzi, L. A. (1989b). What research says to the educator: Part two: Environmental education and the effective domain. *Journal of Environmental Education, 20*(4), 6-13.

Jaus, H. H. (1982). The effect of environmental education instruction on children's attitudes towards the environment. *Science Education, 66*(5), 689-692.

Jaus, H. H. (1984). The development and retention of environmental attitudes in elementary school children. *Journal of Environmental Education, 15*(3), 33-36.

Jickling, B. (1992). Why I don't want my children to be educated for sustainable development. *Journal of Environmental Education, 23*(4), 5-8.

Johnson, D. W., Maruyama, G., Johnson, R., Nelson, D., & Skon, L. (1981). Effects of cooperation, competitive, and individualistic goal structures on achievement: A meta-analysis. *Psychological Bulletin, 89*(1), 47-62.

Jordan, J. R., Hungerford, H. R., & Tomera, A. N. (1986). Effects of two residential workshops on high school students. *Journal of Environmental Education, 18*(1), 15-22.

Keown, D. (1984). Let's justify the field trip. *American Biology Teacher, 46*(1), 43-48.

Kinsey, T. G., & Wheatley, J. H. (1984). The effects of an environmental studies course on the defensibility of environmental attitudes. *Journal of Research in Science Teaching, 21*(4), 675-683.

Knapp, C. E. (1972). Attitudes and values in environmental education. *Journal of Environmental Education, 4*(3), 26-29.

Knapp, D., & Poff, R. (2001). A qualitative analysis of the immediate and short-term impact of an environmental interpretive program. *Environmental Education Research, 7*(1), 55-65.

Kostka, M. (1976). Nature center program impact. *Journal of Environmental Education, 8*(1), 52-64.

Kubota, C. A., & Olstad R. G. (1991). Effects of novelty-reducing preparation on exploratory behavior and cognitive learning in a science museum setting. *Journal of Research in Science Teaching, 28*(3), 225-234.

Lawson, A. E. (1994). Research on the acquisition of science knowledge: Epistemological foundations of cognition. In D. L. Gable (Ed.), *Handbook of Research in Science Teaching and Learning* (pp. 131-176). New York: Macmillan.

Lazarowitz, R., Hertz-Lazarowitz, R., & Baird, J. H. (1994). Learning science in a cooperative setting: Academic achievement and affective outcomes. *Journal of Research in Science Teaching, 31*(10), 1121-1131.

Lazarowitz, R., Hertz, R. L., Baird, J. H., & Bowlden, V. (1988). Academic achievement and on-task behavior of high school biology students instructed in cooperative small investigative groups. *Science Education, 72*(4), 475-487.

Leeming, F. C., Dwyer, W. O., & Bracken, B. A. (1995). Children's environmental attitude and knowledge scale: Construction and validation. *Journal of Environmental Education, 26*(3), 22-31.

Leeming, F. C., Dwyer, W. O., Portern, B. E., & Cobern, M. K. (1993). Outcome research in environmental education: A critical review. *Journal of Environmental Education, 24*(4), 8-21.

Leeming, F. C., Porter, B. E., Dwyer, W. O., Cobern, M. K., & Oliver, D. P. (1997). Effects of participation in class activities on children's environmental attitudes and knowledge. *Journal of Environmental Education, 28*(2), 33-42.

Leopold, A. (1966). *A Sand County Almanac with Essays on Conservation from Round River*. New York: Ballantine Books.

Linn, N., Vining, J., & Feeley, P. A. (1994). Toward a more sustainable society: Waste minimization through environmentally conscious consuming. *Journal of Applied Social Psychology, 24*(4), 8-21.

Ma, X., & Bateson, D. J. (1999). A multivariate analysis of the relationship between attitude toward science and attitude toward the environment. *Journal of Environmental Education, 31* (1), 27-32.

MacKenzie, A., & White, R. (1982). Fieldwork in geography and long term memory structure. *American Educational Research Journal, 19*(4), 623-632.

Marcinkowski, T. J. (1991). The new National Environmental Education Act: A renewal of commitment. *Journal of Environmental Education, 22*(2), 7-10.

Marcinkowski, T. J. (2001). Predictors of responsible environmental behavior: A review of three dissertation studies. In H. R. Hungerford, W. J. Bluhm, T. L. Volk, & J. M. Ramsey (Eds.), *Essential Readings in Environmental Education* (2nd ed., pp. 247-276). Champlaign, IL: Stipes Publishing.

Marinoloulos, D., & Stavridou, H. (2002). The influence of a collaborative learning environment on primary students' conceptions about acid rain. *Journal of Biological Education, 37*(1), 18-25.

Melber, L. M. (2000). Tap into informal science learning. *Science Scope, 23*(6), 28-31.

Meredith, J. E., Fortner, R. W., & Mullins, G. W. (1997). Model of affective learning for nonformal science education facilities. *Journal of Research in Science Teaching, 34*(8), 805-818.

Millan, D. A. (1995). Field trips: Maximizing the experience. In *Experience and the Curriculum* (pp. 123-144 [ED 398-030]). Ontario, Canada.

Mills, E. A. (1921). *Waiting in the Wilderness*. Garden City, NY: Doubleday, Page & Company.

Montréal Biodôme. (2004) *Our Mission* [Web Page]. URL <http://www2.ville.montreal.qc.ca/biodome/e1-intro/ef1_miss.htm> [2004, August 3].

Moore, H. (1981). Energy related information-attitude measures of college age students. *Journal of Environmental Education, 12*(4), 30-33.

Morris, W. (1981). *The American Heritage Dictionary of the English Language*. Boston: Houghton Mifflin Company.

Morrone, M., Mancl, K., & Carr, K. (2001). Development of a metric to test group differences in ecological knowledge as one component of environmental literacy. *Journal of Environmental Education, 32*(4), 33-42.

Mortari, L. (1997). Children's ideas of nature: The social construction of a "Nature Set." In P. J. Thompson (Ed.), *Environmental Education for the 21st Century: International and Interdisciplinary Perspectives* . New York: Peter Lang.

Muir, J. (1997). *Nature Writings*. New York: Library of America.

NAAEE. (2000a). *Excellence in Environmental Education: Guidelines for Learning (K-12)*. Washington DC: North American Association for Environmental Education.

NAAEE. (2000b). *Guidelines for the Initial Preparation of Environmental Educators*. Washington DC: North American Association for Environmental Education.

NAAEE. (2003) *EE-link: Perspectives - Timeline* [Web Page]. URL <http://eelink.net/perspectives-timeline.html> [2003, April 10].

Newhouse, N. (1990). Implications of attitude and behavior research for environmental conservation. *Journal of Environmental Education, 22*(1), 26-32.

Nicol, D. J., Kane, K. A., & Wainwright, C. L. (1994). Case study: Improving laboratory learning through group working and structured reflection and discussion. *Educational and Training Technology International, 31*(4), 302-310.

Orion, N. (1993). A model for the development and implementation of field trips as an integral part of the science curriculum. *School Science and Mathematics, 93*(6), 325-331.

Orion, N., & Hoftein, A. (1994). Factors that influence learning during a scientific trip in a natural environment. *Journal of Research in Science Teaching, 31*(10), 1097-1119.

Paden, M. (2000). Chapter 1: Education for sustainability and environmental education. In K. A. Wheeler, & A. P. Bijur (Eds.), *Education for a Sustainable Future: A Paradigm of Hope for the 21st Century* (pp. 7-13). New York: Kluwer Academic / Plenum Publishers.

Palmberg, I., & Kuru, J. (1998). Outdoor activities as a source of environmental responsibility. In J. A. Palmer (Ed.), *Environmental Education in the 21st Century: Theory, Practice, Progress and Promise* (pp. 253-257). London: Routledge.

Palmer, J. A. (1998). *Environmental Education in the 21st Century: Theory, Practice, Progress and Promise*. London: Routledge.

Peart, B. (1984). Impact of exhibit type on knowledge gain, attitudes, and behavior. *Curator, 27*(3), 220-237.

Pennisi, E. (1993). What *is* Biodiversity, anyway? *Science News, 143*(26), 410.

Pratt, S. (2003). Cooperative learning strategies. *The Science Teacher, 70*(4), 25-29.

Ramsey, J. M. (1993). The effects of issue investigation and action training on eighth-grade student's environmental behavior. *Journal of Environmental Education, 24*(3), 31-36.

Ramsey, J. M., & Hungerford, H. R. (1989). The effects of issue investigation and action training on environmental behavior in seventh grade students. *Journal of Environmental Education, 20*(4), 29-34.

Ramsey, J. M., Hungerford, H. R., & Tomera, A. N. (1981). The effects of environmental action and environmental case study instruction on the overt environmental behavior of eight-grade students. *Journal of Environmental Education, 31*(1), 24-29.

Riechard, D. E., & Peterson, S. J. (1998). Perception of environmental risk related to gender, community socioeconomic setting, age, and locus of control. *Journal of Environmental Education, 30*(1), 11-19.

Rovira, M. (2000). Evaluating environmental education programs: Some issues and problems. *Environmental Education Research, 6*(2), 143-155.

Rudman, C. L. (1994). A review of the use and implementation of science field trips. *School Science and Mathematics, 94*(3), 138-141.

Salmon, J. (2000). Are we building environmental literacy? *Journal of Environmental Education, 31*(4), 4-10.

Shepard, C. L., & Speelman, L. R. (1986). Affecting environmental attitudes through outdoor education. *Journal of Environmental Education, 17*(2), 20-23.

Sia, A. P., Hungerford, H. R., & Tomera, A. N. (1986). Selected predictors of responsible environmental behavior: An analysis. *Journal of Environmental Education, 17*(2), 31-40.

Siemer, W. F., & Knuth, B. A. (2001). Effects of fishing education programs on antecedents of responsible environmental behavior. *Journal of Environmental Education, 32*(4), 23-29.

Simmons, D. A. (1991). Are we meeting the goal of responsible environmental behavior? An examination of nature and environmental education center goals. *Journal of Environmental Education, 22*(2), 16-21.

Simmons, D. A. (2001). Epilogue or some further thought on "Are we meeting the goal of responsible environmental behavior?". In H. R. Hungerford, W. J. Bluhm, T. L. Volk, & J. M. Ramsey (Eds.), *Essential Readings in Environmental Education* (2nd ed., pp. 350-351). Champlaign, IL: Stipes Publishing.

Smith-Sebasto, N. J. (1995). The effects of an environmental studies course on selected variables related to environmentally responsible behavior. *Journal of Environmental Education, 26*(4), 30-34.

Stapp, W. B. (1969). The concept of environmental education. *Journal of Environmental Education, 1*(1), 30-31.

Swain, J., Monk, M., & Johnson, S. (1999). A quantitative study of the difference in ideas generated by three different opportunities for classroom talk. *International Journal of Science Education, 21*(4), 389-399.

Tanner, L. N. (1997). *Dewey's Laboratory School: Lessons for Today*. New York: Teacher's College Press.

Tanner, T. (1980). Significant life experiences: A new research area in environmental education. *Journal of Environmental Education, 11*(4), 20-24.

Tobin, K., & Fraser, B. (1989). Case study of exemplary science and mathematics teaching. *School Science and Mathematics, 89*, 320-334.

Tressel, G. W. (1980). The role of museums in science education. *Science Education, 64*(2), 257-260.

Trigg, L. J., Perlman, D., Perry, R. P., & Janisse, M. P. (1976). Anti-pollution behavior: A function of perceived outcome and locus of control. *Environment and Behavior, 8*(2), 307-313.

Trisler, C. E. (1993). Global issues and environmental education. *ERIC Digest*, (June), ED 359 051.

U.S. Public Law. (1970). The Environmental Quality Education Act: Bill #91-516.

UN Department of Economic and Social Affaires. (2003) *Agenda 21, Chapter 36: Promoting Education, public awareness and training* [Web Page]. URL <http://www.un.org/esa/sustdev/documents/agenda21/english/agenda21chapter36.htm> [2004, June 1].

UNESCO-UNEP. (1976). The Belgrade Charter. *Connect, 1*(1), 1-2.

UNESCO-UNEP. (1978). The Tbilisi Declaration. *Connect, 3*(1), 1-8.

Vidart, D. (1978). Environmental education - theory and practice. *Prospects, 8*(4), 466-479.

Washburne, R. F., & Wagar, J. A. (1972). Evaluating visitor response to exhibit content. *Curator, 15*(3), 248-254.

Watson, S. B. (1991). Cooperative learning and group educational modules: Effects on cognitive achievement of high school biology students. *Journal of Research in Science Teaching, 28*(2), 141-146.

Woodhouse, J. L., & Knapp, C. E. (2000). Place-based curriculum and instruction: Outdoor and environmental education approaches. *ERIC Digest,* (December), ED 448 012.

Yerkes, R., & Haras, K. (1997). Outdoor education and environmental responsibility. *ERIC Digest,* (October).

Zelezny, L. C. (1999). Educational interventions that improve environmental behaviors: A meta-analysis. *Journal of Environmental Education, 31* (1), 5-14.