Literacy and Arts-Integrated Science Lessons Engage Urban Elementary Students in Exploring Environmental Issues

P. GRAY[*], C.F. ELSER[†], J.L. KLEIN[‡], A.C. RULE[§]

ABSTRACT: This descriptive case study examined student attitudes, writing skills and content knowledge of urban fourth and fifth graders (6 males, 9 female) during a six-week literacy, thinking skill, and art-integrated environmental science unit. Pre- and post-test questions were used to address knowledge of environmental problems and student environmental actions. Students expressed knowledge and suggestions for positive action of youth through four essays throughout the unit, the final essay being accompanied by a pop-up construction. Writings showed steady growth in number of words, sentences, suggested environmental actions for youth, and instances of discussing consequences and sequels of actions. Students were engaged, collaborative, and reported implementing positive environmental actions.

KEY WORDS: Environmental education; Writing in science, Thinking skills, Urban students, Art integration into science

INTRODUCTION

Today's elementary students are soon to be adults shaping society through their families' attitudes and actions. The elementary years are particularly important because, at this time, students are most receptive to messages and information about human impact on the environment (Stohr, 2013). Engaging students early in their educational studies in real world environmental issues may help to solve the current crisis in science education of negative student attitudes toward learning science and enrolment in science electives resulting in a shortage of science-qualified workers and teachers (Tytler, 2007). Involving students in community environmental projects that include analysis, problem-solving and

[*] Department of Curriculum & Instruction, University of Northern Iowa, Cedar Falls, Iowa, USA. E-mail: pg212497@uni.edu
[†] Department of Teaching, University of Northern Iowa, Cedar Falls, Iowa, USA. E-mail: caroline.elser@uni.edu
[‡] Department of Curriculum & Instruction, University of Northern Iowa, Cedar Falls, Iowa, USA. E-mail: jk218100@uni.edu
[§] (Corresponding Author), Department of Curriculum & Instruction and Center for Educational Transformation, University of Northern Iowa, Cedar Falls, Iowa, USA. E-mail: audrey.rule@uni.edu

planning, as in the current project described here, may help children have agency in affecting the welfare of the global environment and commit to lifelong environmental stewardship (Strife, 2012), improving their overall attitude and conscience regarding science education (Laughter & Adams, 2012).

Students in urban neighbourhoods have fewer opportunities to explore natural places than students who live in the suburbs or in rural areas. Thus, the positive environmental attitudes that arise when a child spends time outdoors exploring nature are often lacking in urban students (White, 2006). However, students in the current study had opportunities to observe nature. Homes close to the school in which the study took place are two-story apartment buildings, duplexes, or single family houses on small lots, often with large trees and bushes. Additionally, the recently rebuilt elementary school has grassy areas and new tree plantings on the grounds. The study drew participants from a high-poverty community in which families moved frequently to seek employment or less expensive living arrangements, resulting in a high turn-over rate in students attending the school.

Ecologically informed concerns centred on cultural causes of pollution, deforestation, climate change, and loss of habitat impacting species, coupled with the need to develop an ecologically based consciousness as an alternative to the modern, individually-centred structure of existence (Bowers, 2003) formed the foundation of this project. Besides providing an awareness of environmental issues, this project sought to provide resources that might inspire students to implement positive changes in themselves, their families, and their community to help solve these problems, thereby avoiding feelings of hopelessness, frustration, and powerlessness (Barratt & Barratt Hacking, 2003; Sobel, 2008; Strife, 2012). Offering opportunities for urban students to examine environmental issues and to relate them to their community and own daily practices is seen as critical to the health of the planet as cities grow and populations become more urban. More than half of the world's population is urban; three-fourths of Westerners live in urban areas, with most of the world's population growth for the next decades projected to occur in cities (Cohen, 2004). Human interaction with the environment through local community decisions, lifestyle choices, and consumption of resources has strong effects necessitating that urban students develop an understanding of environmental concepts, positive attitudes, and effective actions.

The way that environmental issues are approached in the science classroom can determine whether students feel overwhelmed, helpless, and tuned-out, resulting in eco-phobia (Strife, 2012); or engaged and excited about their projects with potential impacts on the problem. Several aspects of environmental education need to be addressed early for effective learning: valuing protection of the environment, knowledge of environmental interactions, and belief that one can make a difference (Hungerford & Volk, 1990).

The current study involved fifteen upper elementary students in an interactive environmental protection unit, focusing on what elementary students can do to help and documenting those ideas through essay writing. Facts about

problems and solutions associated with various environmental facets were presented through illustrated and captioned pop-up scenes (three-dimensional displays in which images stand as the page or folder is opened), and also through reading of juvenile non-fiction trade books to build a pertinent knowledge base. Ideas were analysed and developed by using Edward de Bono's (2000), Cognitive Research Trust (CoRT) Breadth system of ten thinking skills. The small group thinking skill work allowed students to develop a sense of personal and group competency in evaluating environmental problems, as well as in creating solutions they could implement. The students refined their expressed knowledge and regard for the environment through four essays, spaced across the unit. The final essay was accompanied by student-made, pop-up constructions that highlighted each student's chosen topic through images cut from magazines, telling ways youth can positively affect the planet. These displays were showcased in the school's lobby to further impact parent and peer audiences. The following section highlights previous work that supports the current project's approach to teaching elementary students about environmental science.

Nature Deficit Disorder

During the past century, as the American population migrated from farms to cities, many people lost their connectedness to the environment, causing some to be dismissive of the role that nature plays in keeping the planet alive. Discussion of local environmental issues among families, valuing of nature, and actions to help the environment have been seen as evidence of biophilia (Kahn & Lourenco, 2002), love of nature (Wilson, 1984). Unfortunately, youth separated from nature by growing up in sanitized, air-conditioned homes spending their time engaged in video games or playing sports on mowed grass fields may develop apathy toward nature, viewing it as a commodity to be exploited (White, 2006).

The lack of connection between youth and nature has been called 'nature deficit disorder' (Louv, 2005). Educators can work to change this negative attitude. Valuing of the environment can occur through educational programs that have these three essential components (Malone & Tranter, 2003): learning about environmental interrelationships; discussions of actions leading to environmental stewardship, and having experiences with the environment. The current study employed these three principles as students learned content about environmental issues, used thinking skills to guide discussions of ecological solutions, and wrote about how they were implementing the ideas in their communities. For example, after reading about deforestation, planting trees, and providing habitats for wildlife, students reported that they spent more time outdoors noticing the trees and bushes in their neighbourhoods along with the squirrels and birds that inhabit them. Students organized themselves to pick up litter at school and around their neighborhoods. Students learned how plastics tend not to decompose, are blown into streams, find their way to the ocean, are broken into small parts, and ingested by sea life, leading to the animals' demise. At the start of the next school year,

students formed collection centres for recycled items at school to reduce discarded plastics in the environment.

Studies about Elementary Students and the Environment

While many quantitative studies have investigated children's knowledge about environmental issues, few have examined youth's feelings about environmental problems, indicating a need for more research in empowering students to solve these problems. A qualitative study involving in-depth interviews of 50, ten-to-twelve-year-old students revealed that a majority expressed fear, sadness, anger, and apocalyptic or pessimistic feelings about the Earth's environment (Strife, 2012). Frustration and powerlessness can occur when the weight of the world's problems is given to children before they feel able to influence positive change (Barratt & Barratt Hacking, 2003; Sobel, 2008). Environmental disaster films and current news programs about tornado, flood and wildfire crises may scare elementary children, who are not developmentally prepared to cope with more abstract global issues (Sobel, 2008). Although most children's knowledge of environmental issues is derived from television, news media and movies, information about solutions to those problems has been shown to originate from parents and teachers (Strife, 2012). Elementary students' attitudes toward the environment are guided by enjoyment of nature, empathy for creatures, sense of oneness with nature, and a sense of responsibility (Cheng & Monroe, 2012). Teaching strategies that empower elementary students with solutions they can implement are necessary to counter such negative effects of fear, guilt and regret concerning environmental issues. These positive teaching strategies are important, but many teachers find they have difficulty fitting them into an already-crowded curriculum of required lessons, which, especially in the United States, focuses on literacy.

Youth Literature and Writing Help Students Delve Deeply

A trend in solving today's overcrowded school curriculum is to implement subject integration addressing several concept areas in the same lesson, while highlighting connections (Shoemaker, 1989). In the current study, environmental science was integrated with language arts through essay writing, reading of trade books, and discussions guided by a system of thinking skills. Participation in scientific activities with integrated thinking skills was useful in enhancing logical thinking (Abrami et al., 2008) and facilitating cognitive development in student learners (Piaget, 1969). Using youth literature to suggest ways elementary students could impact on the environment also introduced important vocabulary (Kolstø, 2001).

Tang (2015) presented a three-part model of integrating new literacies with science: "(a) harnessing youth cultural resources, (b) scaffolding multimodal practices, and (c) hybridizing a third space" (p. 315). Tang advocated that youths' cultural experiences be leveraged as resources to connect their personal lives with

school science. This was accomplished in the current project by incorporating images and words from popular magazines and images of the students themselves ("selfies"). The multimodal aspects of the project were the pop-up scenes students made that incorporated popular nature images from the magazines and repurposed found article titles, advertising slogans, and clichés to the environmental literacy project. This repurposing of images and texts from the cultural environment to serve the science classroom topic created Tang's "third space," thereby allowing students to see symbolic representations from competing points of view. This reinterpretation of aspects of popular culture utilizing environmental concepts from the science classroom integrated both perspectives, making the learning more meaningful.

The lessons, incorporating reading of juvenile trade book literature, reinforced the *Next Generation Science Standards* (Achieve Inc., 2013), a recent set of science standards being adopted by many United States school districts. The lessons supported environmental education standards for fourth and fifth grade students. The sources of many environmental problems were discussed, such as the origin of petroleum and its transport through pipelines, ships, and trucks, its use as a fuel and lubricant, and air or water pollutants resulting from its use, supporting Standard 4-ESS3-1: "Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment" (Achieve Inc., 2013, p. 36). Many environmental issues addressed in the lessons centred on fossil fuel energy sources and their effects on water, air quality, and habitats. For example, the devastating effects of oil spills on marine organisms and shore life were discussed, along with ways people have rescued animals and helped in clean-up operations. Local actions that could reduce pollution, such as riding bikes or walking to school rather than riding in a car, and disposing of used oil at a car service facility rather than pouring it down a drain or street sewer, were offered. Human Impacts on Earth Systems were considered with this standard, "Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space, but individuals and communities are doing things to help protect Earth's resources and environments (5-ESS3-1)." Students learned that prairies have been reduced to a fraction of their former extent and many animal populations dwindled as land was changed into agricultural fields. Local efforts, in which students might participate to restore natural prairies, were highlighted. The essays students wrote, and the pop-up scenes they made, identified environmental problems and what youth could do to mitigate, or solve them.

Using CoRT Thinking Skills to Enhance Critical Thinking

Encouraging students to use critical thinking skills is currently being emphasized in schools, as part of the 21st Century Skills movement (e.g., Partnership for 21st Century Skills, 2011). Critical-thinking lessons, in which students are encouraged to think scientifically, allow students to be more active participants in their learning (Torff, 2006). In a study conducted by Al-Shaibani and Daoud (2011),

a course on thinking skills increased students' academic self-efficacy and improved confidence in problem solving.

The current study incorporated into lessons the CoRT (Cognitive Research Trust) *Breadth* (the first of six thinking skill sets of the system) thinking skills, designed by Edward de Bono (2000), to actively engage students in creating ways to solve environmental problems. These thinking skills included *Plus, Minus, Interesting; Consider All Factors; Other People's Views; and Consequence and Sequel*; among others to total ten distinct skills. These skills encouraged the thinker to consider viewing the problem from a variety of perspectives "beyond the obvious, immediate, and egocentric" (de Bono, 2013, para. 1).

De Bono's thinking skills have been utilized worldwide to give participants an outline for examining problems in unique and diverse ways. Other studies of the CoRT Breadth set of skills with participants have been conducted: Rule and Barrera (2006) found that the CoRT Breadth thinking skills encouraged elementary students to elaborate on ideas, positively impacting on students' questioning skills. Well-designed integration of these thinking skills into discussions creates opportunities for in-depth conversation (Rule & Stefanich, 2012). Using the thinking skills in the current study provided the researchers a guide for discussing environmental problems with the students in a thorough, thoughtful way and allowed these urban students to problem solve and work together. A major goal of environmental education is improvement of environmental literacy, meaning not just more knowledge, but an improved attitude toward the environment with a higher incidence of pro-environmental behaviours (Spínola, 2015); thinking skills can help students see aspects of the situation they had not previously considered, allowing them to change attitudes and actions.

Learning through Art: Pop-up Constructions Motivate Students

Arts integration, the incorporation of art into a non-art subject area (Eisner, 2002), through pop-up constructions, was another component the researchers included in the current study. Art integration across curriculum areas builds cognitive and behavioural skills, while increasing content learning and achievement (Appel, 2006). Arts integration adds depth to the curriculum, while increasing student engagement (Mason, Steedly & Thormann, 2008). Guiding students to take a student-centred inquiry approach and to transform what they know into art, encourages them to organize and make meaning of new knowledge as they express their ideas in creative ways (Eisner, 2002). Additionally, Trnova (2014) found that inquiry-based science education supported creativity for teachers and their students by engaging them in connecting learned information to a meaningful context, through exercising critical thinking, by advancing positive attitudes towards science and through increasing motivation.

Pop-up constructions were used during the presentation of environmental science content in the lessons and also as part of the culminating student product. Pop-ups are three-dimensional representations with images that stand vertically

as the page is opened, a type of moveable book (Montanero, 2005). The Figures in appendix 1 show different views of pop-up boxes, made by the instructors, to serve as examples of pop-up constructions, while teaching basic information about several environmental problems. This arts integrated format was chosen to allow students to represent their understandings of problems and youth solutions in a unique manner. Olsen, Zhbanova, Parpucu, Alkouri, and Rule (2013) found that pop-up creations motivated students, fostering a focused and collaborative environment.

Research Question

The main research question addressed by this study is:
How do urban, upper elementary students' regard their own

1) attitudes of their ability to positively impact the environment,
2) skills of writing about environmental issues, and
3) content knowledge evolving as they explore environmental problems and their possible contributions to solving these issues through literacy- and arts-integrated science lessons concerning the environment?

METHOD

This study was a descriptive case study involving pre- and post-test measures, repeated measures of student essay writing, teacher observation, and student pop-up constructions.

Participants

This study was conducted with fifteen elementary students (6 males, 9 females; 4 African-American, 10 Euro-American, 1 Asian-American; 9 fourth graders, 6 fifth graders) who were attending an urban Midwestern elementary school in the United States. This research investigation was approved by the Human Subjects Committee of the overseeing university, the associate superintendent of the school district and the school principal. All students and their parents gave written consent to participate in the study.

Lesson Procedures

Eight, approximately one-hour lessons, occurred over a six-week period. Table 1 presents the main content of each lesson. Appendix 2 shows the order and application of the de Bono CoRT thinking skills during the unit.

Table 1   **Outline of Lesson Activities during the Environmental Education Unit**

Lesson	Activities
1	Pre-Assessment: Pre-test with content and attitude questions that included writing an essay about environmental issues and what youth can do to help was administered. Students were given an overview of the unit topic.
2	Pop-up Box Work: Each student was given a pop-up box focused on a different environmental problem. After examining the different scenes of the box, each student reported the most important information to the class. Students then switched pop-up boxes to explore them all. Students began to consider which environmental issue was most interesting for further investigation.
3	Second writing sample: Students reviewed what they learned from the pop-up boxes. Students completed a writing sample about what can youth do to help the environment. Students then practiced the first de Bono skill of Consequence and Sequel.
4	Thinking skill work: The next four de Bono CoRT Breadth skills were taught in relation to what kids can do for the environment.
5	Thinking skill work: Four additional de Bono thinking skills were used to discuss environmental issues and what youth can do to help the Earth.
6	Third Writing Sample: Before engaging in writing, students used the final de Bono skill to address environmental concerns. Then they wrote about "What can kids do to help the environment." After writing, students perused and read juvenile trade books (Amsel, 2009; Earthworks Group, 2009; O'Sullivan, 2009; Scott, 2004) that had suggestions of what youth can do to solve environmental problems.
7	Final writing sample and pop-up constructions: Students began making a pop-up construction in a folder to portray a chosen environmental issue and what students can do to remedy it. They had access to the youth literature at this time to gain additional ideas. The final writing sample concerning "What can kids do to help the environment" was written.
8	Students completed their pop-up constructions and responded to the post-assessment. The post-assessment did not have a writing sample included, as students completed the final essay during the previous lesson.

Data Collection

The data collected to evaluate this project came from several sources: a pre- and post-test instrument, student essay writings, teacher observations of student comments and behaviours, and student pop-up constructions. The pre- and post-test contained content questions about environmental issues and questions about environmental actions. Students wrote essays about environmental problems and what youth can do to solve them on four occasions. These were typed into a spreadsheet so that environmental issues and suggested youth actions could be identified and tallied. The number of words and sentences in student writings

were determined with the help of the spreadsheet. The number of instances of the de Bono skill of stating a consequence, or sequel to an action was also counted with the organizational help of the spreadsheet. Also graphs of the mean number of instances per student of these measures of student essays were produced with the spreadsheet.

The pre- and post-test had identical content questions:

- <u>List</u> as many environmental problems as you can.
- Underline the problems you listed above that occur in your neighbourhood or city.
- <u>List</u> as many things as you can that kids can do to help the environment.
- Underline the things above that you are <u>actually doing now</u> to help the environment.

Student responses to these questions were listed and tallied on the spreadsheet.

The researchers kept notes on student behaviours and reactions during the lessons. These were reviewed and discussed by the researchers after each lesson and prior to composing this report. Student pop-up constructions were analysed for instances of creative thinking skills.

RESULTS

Environmental Science Content Learning

Table 2 shows environmental issues of which students expressed awareness at the times of the pre- and post-test. At first, students remarked mainly on litter/trash issues and general environmental problems, but later changed to describing more specific problems. Students independently stopped writing about issues (kidnapping, snow in streets) that are not usually classed as environmental concerns on the post-test, as they developed a better understanding through readings and class discussions. New environmental issues that students addressed on the post-test were: water pollution, polar ice cap melting, prairie loss, soil contamination, and rainforest destruction.

Student Awareness and Agency Regarding the Environment

Table 3 shows pre- and post-test student responses to what students, such as themselves, may be able to do to help the environment and the actual actions they are taking in this regard. Most students list more than one action; sometimes students list several actions that are grouped into one category. On the post-test, students are able to identify a greater number of actions youth can take to solve environmental problems and report an increase in the number of actions in which they are currently engaged. This indicates that students are actually applying the ideas learned in class to their daily lives.

Table 2   Student-Identified Environmental Issues on the Pre- and Post-test

Category	Example Terms Used by Students	New Terms Used on Posttest	Pretest Issues in the World	Pretest Issues my Area	Posttest Issue in the World	Posttest Issue my Area
Trash	Littering, not recycling, not reducing, not reusing, dumping, garbage, landfills, wasting stuff, throwing stuff in lakes, too much electronics	Not reducing, not reusing, too many electronic devices	20	16	23	15
Generic Pollution	Pollution, factories		13	7	0	0
Global Climate Change	Global warming, heat wave, greenhouse gasses	Greenhouse gases	7	0	5	0
Endangered Animals	Extinction, hunting, killing, destruction of wildlife grasslands, not careful about running over, endangered, loss of habitats, poaching	Loss of habitats, poaching	7	3	20	9
Air Pollution	Air pollution, chemicals in air, car exhaust, gas fumes, people burning stuff, toxic air, too much transportation	Too much transportation	7	8	14	9
Loss of Forests	Cutting down/ killing trees, less trees	Deforestation	6	3	10	1
Human Issues	Highways/streets, too much snow, kidnapping, not a lot of help to people, less population		6	3	0	0
Wild fires	Wild fires		5	2	0	0
Oil spills	Oil spills		5	0	2	0
Energy Issues	Gasoline, too much energy used, energy usage, energy	Too much energy used, energy usage, energy	1	1	5	6
Flood	Flood		1	0	0	0
Ice Age	Ice age		1	0	0	0
Earthquake	Earthquake		1	0	0	0
Water Pollution	Water Pollution	Water Pollution	0	0	13	7
Polar Ice Cap Melting	Polar Ice Cap Melting	Polar ice cap melting	0	0	10	0
Prairie Loss	Prairies disappearing, prairie farms disappearing	Prairies disappearing, prairie farms disappearing	0	0	4	2
Soil Contamination	Soil Contamination	Soil contamination	0	0	2	1
Rainforest Destruction	Rainforest destruction	Rainforest destruction	0	0	1	0

Table 3   **Ideas about What Kids Can Do to Solve Environmental Problems and What Actions Students Report They Are Doing**

Category	Specific Actions Identified by Students	Pre-test Actions Kids Can Do	Pre-test Reported Actions Taken	New Actions Identified by Students	Post-test Actions Kids Can Do	Post-test Actions Reported Taken
Trash	Help clean up litter and pick up trash, don't dump stuff in lakes, eat healthier food to reduce wrappers, help their parents recycle, recycle, reduce, reuse, kids use less paper	26	18		21	21
Generic Pollution	Don't use toxic things,	1	0		0	0
Actions Unrelated to a Specific Environmental Problem	Do a service job, influence the laws, inform people what they can do/what are doing, learn more to know how to help, tell other people what is happening and what you notice	6	7	Ask to stop chemical factories, encourage parents, friends, family not to smoke, enjoy nature, don't ask for/consume a lot, spread awareness, stop, teach others	11	6
Endangered Animals		0	0	Adopt an arctic animal, don't make clothes of animals, make/find animal homes, make bird feeders, don't hunt or poach and raise awareness, kill only animals needed like deer or ducks, save the animals	9	3
Air	Do not burn stuff unless it is wood, encourage parents not to smoke, not drive as much	3	0	Don't smoke, walk or ride bikes instead of cars, use your cars less often	8	4
Human Roads	Shovel more snow	1	0		0	0
Wild fires	Make sure that cigarette butts are not hot enough to start a fire, try to make sure wild fires stop, don't play with matches	3	0		0	0
Oil spills	Keep oil away from water	1	0		0	0
Energy Issues	Turn everything off when you are done, use less gas, walk to school	3	1	Use less electronics, use energy wisely	5	4
Water Pollution		0	0	Stop polluting the water	1	0
Prairie Loss	Plant prairies	0	0		1	0
Soil Contamination		0	0	Don't spray so many chemicals in the soil	1	0
	Total	44	26		57	38

The language used on the post-test becomes more specific; for example, the generic word "stuff" appears several times on the pre-test in response to these items, but not on the post-test. Example actions students start to take that are inspired by the lessons include: teaching others about the environment, enjoying nature, riding bikes rather than traveling in cars, walking to school, encouraging adults not to smoke, and conserving energy.

This project took place near the end of the school year. The next fall, students resumed their environmental protection efforts and initiated a recycling program at the school.

Student Essays about How Youth Can Impact the Environment

Table 4 shows the development of student writing over the course of the unit from general, shorter paragraphs to more detailed writings on varied topics with specific actions students can implement. Figure 1 shows the trends for more words, sentences, actionable ideas, and instances of the de Bono thinking skill of Consequence & Sequel as the project unfolded.

Development of Students' Ideas for Taking Action.

A dramatic increase in actionable ideas occurred in the last segment of the study. On the pre-test, most students' essay writings focused on helping the environment by collecting litter. An example pre-test response was: "Help clean the earth by picking up trash and trying to influence other kids to do it, too." There were a few other specific ideas. After students had gained knowledge from examination of the teacher-made pop-up boxes, students again wrote essays. Instead of focusing the writing on just one topic, students mentioned several environmental problems such as factory pollution, poaching of endangered animals, deforestation and loss of habitats. In this example excerpt, a student mentioned several issues i.e. "And there are also problems such as tree cutting, smoking, air pollution, and energy waste like leaving the light on when you're not using it." Students expanded their ideas about litter to overflowing landfills, dumping, and plastic trash in the ocean.

The third student essay writing was made after the lesson in which the ten de Bono Breadth skills had been applied to environmental issues. Students concentrated their efforts by choosing one environmental topic and exploring it more thoroughly. For example, one student focused on reducing the amount of trash sent to landfills:

> "Some things kids can do to help landfills is to start using your own grocery bag to go shopping with and recycle old newspapers or magazines around your home; take a soup can and clean it out to be used as a marker/pencil holder in your room; use old paper to colour on and make a welcome sign to greet visitors at your house."

The last essay writing was completed to accompany pop-up constructions the students had made and occurred after students had spent time reading the environmental trade books. The tone of the final essays switched from informational to persuasive, showing student passion for particular issues and convincing others to help. For instance, a student remarked, "Some people don't care about the Earth. Others really do. I know I care. Do you?" Another student suggested:

> "… look on the Internet or in books to learn more of the problems so you can know how to help or teach your family, classmates, and neighbours. Look for ways to help. Ask your teacher if, when there's spare time, she/he could talk about it. Start a nature club. Join groups that help the environment, such as water pollution filtering clubs. Get others interested to help. Create a project on ideas to help, including reasons."

Students were motivated to seek additional sources of information about Earth problems and what they might do to alleviate them. One student wrote about the problem of too much packaging on products: "… [D]on't buy tiny, tiny packages. Buy big ones and use them well because the longer you use stuff, the longer you keep them out of landfills and bulk-buying reduces packaging and often saves you money!"

Evidence of Growth in Student Thinking Skills

Evidence of several de Bono thinking skills that were taught during lessons 4, 5, and 6 was found in the student writings: Plus, Minus, Interesting; First Important Priorities; Other People's Views; Alternatives, Possibilities, Choices; and Consequence & Sequel. For example, a student considered the pluses of conserving electricity and the interesting idea of having more time to explore nature:

> "Saving electricity helps sharpen the saw (Covey Habit 7), heart, mind, body, and soul. We would probably use more sunlight, which you need. Since I'm using less electricity, I could have more time to explore nature and learn things about it."

Another student applied First Important Priorities to determining an initial key action: "I would save animal habitats by first of all persuading families to save animal habitats with me. I would do that by making signs…" Students applied Other People's Views by considering the viewpoint of wildlife: "Without prairies, a lot of animals like buffalo could lose their habitats. It is just as important to them as our home is to us." Many students used Alternatives, Possibilities, Choices in their writing. For example, a student noted ways to restore or preserve prairies: "To help with a comeback for prairies disappearing

is: Plant your own prairie at home or school. Make a club to get people to work as a group so we have prairies… Try to build fewer buildings…"

Table 4 **Characteristics of Student Essays about What Kids Can Do to Solve Environmental Problems**

| Timing	Mean Number of Words per Essay	Mean Number of Sentences per Essay	Mean Number of Ideas of What Kids Can Do per Essay	Mean Number of Instances of Consequence and Sequel per Essay
Pretest	47.8 (12.9)	3.9 (1.0)	2.8 (1.2)	0.6 (0.9)
After examining environmental pop-up boxes	83.7 (36.0)	6.1 (3.0)	3.6 (2.7)	4.1 (2.1)
After practicing the 10 de Bono thinking skills	92.5 (38.5)	7.5 (2.3)	4.3 (1.4)	5.3 (3.3)
After making the pop-up constructions and reading juvenile trade books on what youth can do to help the environment	120.8 (57.2)	9.6 (5.1)	7.5 (3.7)	7.5 (5.2)

The thinking skill most heavily employed by students was Consequence and Sequel. Many examples appeared in student writings, such as: "People should stop throwing stuff out their windows, because it's probably going to end up in the rivers or lakes." "Stop saying I want so much, because then the companies make them and the factories dirty the air."

Figure 1 (below) shows how use of Consequence and Sequel increased dramatically over the duration of the project. This skill helped students organize their thoughts into cause and effect arguments, making the persuasive aspects of their writings more effective. The fact that very few students used this thinking skill initially, but eventually almost all employed it many times in their work by the end of the unit indicates important growth in logical thinking.

Teacher Observations

The teachers observed that students were most excited about being able to complete a hand-made craft involving scissors and glue. The moment that students saw the pop-up boxes made by teachers, they began asking for the opportunity to make a pop-up construction. Once students began making the pop-up scenes, they were reluctant to stop work for lunch, suggesting that lunch be skipped while they continue to work. Students seldom did homework on other

projects, but reported that they had spent time at home looking for additional images to enhance their pop-up constructions.

Mean Number of Words

Mean Number of Action Ideas

Mean Number of Sentences

Mean Number of Instances of Consequence & Sequel
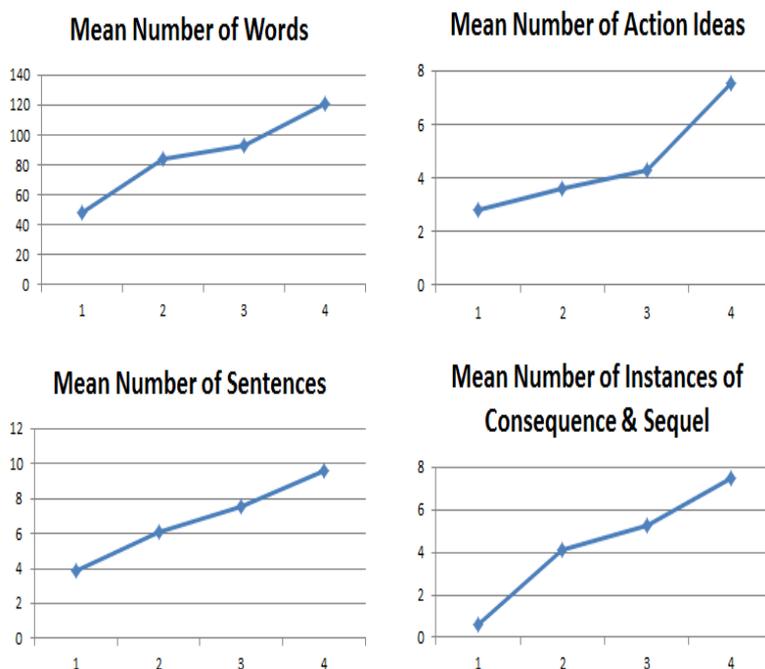
* The horizontal x axis shows the time of the writing sample: (1) pre-test, (2) second writing, (3) third writing, and (4) final essay. The vertical y-axis shows the mean count of words, sentences, action ideas, and number of instances of consequence of sequel for each of the graphs respectively.

Figure 1   **Graphs of Changes in Number of Words, Sentences, Action Ideas, and Instances of Consequences and Sequels in Student Writings.**

Students developed scientific attitudes of stewardship of the environment as they learned more information about interrelationships between human actions and natural systems. They reported they felt empowered that they could influence others' behaviours and knowledge of the environment. Students expressed a desire to continue projects such as organizing litter pick-up, planting trees, and having an ecology club, showing their attitudes of believing they could positively impact on the environment. In the next school year, they initiated a recycling centre at the school. They were happy that their pop-up scenes would be put on display for classmates and school visitors to see in the lobby.

Student Pop-up Constructions

Figure 2 and Figure 3 show student pop-up constructions. Figure 2a shows the cover and inside scene of a construction about polar ice cap melting; Figure 2b

shows the cover and enclosed scene related to recycling, reducing and reusing. The student who made the scene in 4a used magazine phrases in a new context. He cut out a picture of a baby to voice concern for future generations. The student who made the scenes in 2b used photos of herself to highlight her agency in affecting the environment. She used an image of money to symbolize fundraising.
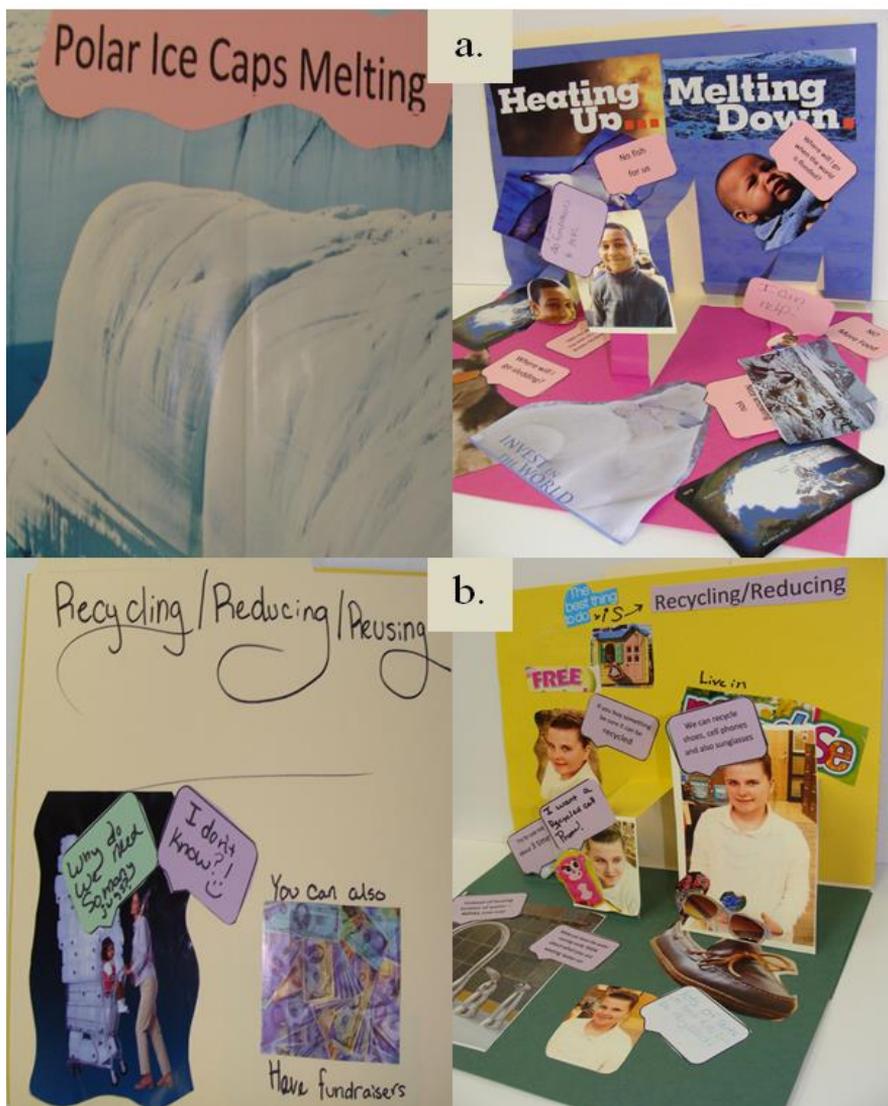
Figure 2   Student Pop-up Constructions Concerning Melting of Polar Ice Caps and Recycling, Reducing, Reusing

Figure 3 shows the internal views of four different scenes. The student who made 3a used talking animals to express the issues affecting them. The student in

3b chose negative images from around the world to illustrate his point. He crowded the images around the words "No Room to Run" to show how animals are losing their habitats. The student who made the display in 3c took appealing images and used contrast to make her point. The work of a final student is shown in 3d. He used humour and a mixture of photographs and cartoons to make his work interesting.

Figure 3   Interior Scenes of Student Pop-up Constructions Concerning Animal Habitats

Summary of Results

The first outcome of the study was that students became more aware of environmental issues, especially specific problems with solutions youth can implement. The traditional science classroom of urban schools follows a strict, scripted, teacher-centred, outcome-based protocol in which students memorize correct responses to prompts; students are denied the opportunity to devise solutions to emerging problems through group work, a natural aspect of their home culture (Emdin, 2010). The current project allowed students to demonstrate their strengths in solving environmental problems through reading and group interaction. Secondly, students expressed that they thought about the environment more often, wanted to learn more through lessons concerning how they could solve environmental problems, and actually implement the ideas they were learning about, such as riding bikes to school, picking up trash, and initiating a school recycling program. They believed they could positively affect people's actions for a healthier environment, supporting the views of many recent investigators (Barratt & Barratt Hacking, 2003; Hungerford & Volk, 1990; Sobel, 2008; Strife, 2012) that students needed to know how to help solve environmental problems or they might develop negative attitudes and tune out. Calabrese Barton, Ermer, Burkett, & Osborne (2003, p. 25) called for science literacy in urban schools in which students engaged in "deep thoughtful acquisition of key concepts and ideas, habits of mind, attitudes toward science, and the scientific skills necessary for individuals to be effective members of a technologically and scientifically democratic society." Developing a positive attitude toward being part of environmental solutions, practicing thinking skills, and taking personal actions, as nurtured through the current project, supported such thoughtful engagement in science literacy.

Third, writing skills improved with students composing longer, detailed, more specific essays. Writing about holistically integrated real-world topics that students could impact through their actions was engaging (Shoemaker, 1989). Students incorporated the thinking skill of consequence and sequel, showing growth in critical thinking. Emdin (2010) stated that the culture of urban students supported critical thinking, but teachers seldom recognized students' ability to problem solve and think logically. In our study, we supported students' reasoning process by directly teaching the de Bono thinking skills; students readily grasped the concepts, incorporating many of the thinking skills in their writings, especially consequence and sequel.

Finally, students were excited to make a pop-up construction as part of arts integration with environmental science. Integration of the arts increased student motivation and engagement with the project as seen in other studies (Mason, et al., 2008; Olsen, et al., 2013). Students evidenced much creativity in their pop-up constructions and scenes. Hursh (2007, p. 304) noted that in many urban schools, "respect for students' intelligence, creativity, and human individuality completely disappeared." The students in our study complained that they seldom had the

opportunity to construct creative works of art outside of their formal art class; they especially enjoyed being creative in their pop-up constructions.

CONCLUSION

Urban students' knowledge of environmental issues as exemplified in the pre- and post-test responses, expanded environment-related vocabulary, and number of environmental actions suggested in the essay writings, increased from the beginning to end of the unit. Students chose environmental topics that related to problems in their community. Students' agency concerning their perceived ability to positively impact on the environment was evidenced by persuasive remarks made in later essays, during lessons, and in implementation of actions to help the environment.

Although the study was limited in its duration and number of students involved, participants showed an increase in the number of reported personal activities to help the environment. The school at which this study took place implemented a new student leadership program in the school year following the study. Many students became involved in tackling local environmental, social, and community problems as part of the curriculum through this new program. A recycling project was implemented at the school connected to students' concern for the environment, sparked by the project described in this study.

ACKNOWLEDGEMENT

REFERENCES

Abrami, P. C., Bernard, R. M., Borokhovski, E., Wade, A., Surkes, M. A., Tamim, R., & Zhang, D. (2008). Instructional interventions affecting critical thinking and dispositions: A stage 1 meta-analysis. *Review of Educational Research, 78*(4), 1102-1134.

Achieve Inc. (2013). *Next Generation Science Standards.* Washington, DC: Achieve Inc.

Al-Shaibani, Y. A., & Daoud, J. I. (2011). Thinking Skills Course and Student's Academic Self-efficacy. *Australian Journal of Basic and Applied Sciences*, *5*(6), 403-415.

Amsel, S. (2009). *365 Ways to live green for kids: Saving the environment at home, school, or at play – every day!* Avon, MA: Adamsmedia.

Appel, M. P. (2006). Arts integration across the curriculum. *Leadership, 36*(2), 14-17.

Barratt, R., & Barratt Hacking, E. (2003). Rethinking the geography national curriculum: A case for community relevance. *Teaching Geography*, *18*(2), 29–33.

Bowers, C. A. (2003). Can critical pedagogy be greened? *Educational Studies, 34,* 11-21.

Calabrese Barton, A., Ermer, J., Burkett, T., & Osborne, M. (2003). *Teaching science for social justice*. New York, NY: Teacher's College, Columbia University.

Cheng, J. C.-H., & Monroe, M. C. (2012). Connection to nature: Children's affective attitude toward nature. *Environment and Behavior, 44*(1), 31-49.

Cohen, B. (2004). Urban growth in developing countries: a review of current trends and a caution regarding existing forecasts. *World Development*, *32*(1), 23-51.

de Bono, E. (2000). *Edward de Bono's CoRT thinking lessons.* Oxford, England: Cavendish Information Products, Ltd.

de Bono, E. (2013). Thinking tools: The art and science of thinking. Edward de Bono – CoRT thinking lessons – CoRT 1 – Breadth. Retrieved from http://www.edwdebono.com/debono/cort11.htm

Earthworks Group. (2009). *The new 50 simple things kids can do to save the earth*. Kansas City, KS: Andrews McMeel Publishing.

Eisner, E. (2002). *The arts and the creation of mind*. New Haven, CT: Yale University Press.

Emdin, C. (2010). What is urban science education? In S. R. Steinberg (Ed.) 19 Urban questions: Teaching in the city. New York, NY: Peter Lang.

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

Hursh, D. (2007). Exacerbating inequality: the failed promise of the No Child Left Behind Act. *Race, Ethnicity, and Education*, *10*(3), 295-308.

Kahn, P. H., Jr., & Lourenco, O. (2002). Water, air, fire, and earth: A developmental study in Portugal of environmental moral reasoning. *Environment and Behavior, 34*, 405–430.

Kolstø, S. (2001). Scientific literacy for citizenship: Tools for dealing with the science dimension of controversial socioscientific Issues. *Science Education, 85*(3) 291–310.

Laughter, J. C., & Adams, A. D. (2012). Culturally relevant science teaching in middle school. *Urban Education, 47*(6), 1106-1134.

Louv, R. (2005). *Last child in the woods: Saving our children from nature deficit disorder*. Chapel Hill, NC: Algonquin Books.

Malone, K., & Tranter, P. (2003). Children's environmental learning and the use, design and management of schoolgrounds. *Children, Youth and Environments*, *13*(2), 87-137.

Mason, C. Y., Steedly, K. S., & Thormann, M .S. (2008). Impact of arts education on voice, choice and access. *Teacher Education and Special Education: The Journal of the Teacher Education Division on the Council for Exceptional Children*, *31*(1), 36-46.

Montanaro, A. (2005). A concise history of pop-up and movable books. Retrieved from *http://www.libraries.rutgers.edu/rul/libs/scua/montanar/p-intro.htm*

O'Sullivan, J. (2009). *101 Ways you can help save the planet before you're 12*! New York, NY: Lark Books.

Olsen, B. D., Zhbanova, K. S., Parpucu, H., Alkouri, Z., & Rule, A. C. (2013). Pop-Up Constructions Motivate and Reinforce Science Learning for Upper Elementary Students. *Science Activities, 50*(4), 1-15.

Partnership for 21st Century Skills. (2011). *Framework for 21st century learning.* Retrieved from http://www.p21.org/overview/skills-framework

Piaget, J. (1969). *Psychology of intelligence.* Totowa, NJ: Littlefield, Adams.

Rule, A. C., & Barrera, M. T., III, (2006). CoRT thinking skills guide PBL science. *Academic Exchange Quarterly, 10*(4), 145-149.

Rule, A. C., & Stefanich, G. P. (2012). Using a Thinking Skills System to Guide

Discussions during a Working Conference on Students with Disabilities Pursuing STEM Fields. *Journal of STEM Education: Innovations and Research, 13*(1), 1-12.

Scott, N. (2004). *Reduce, reuse, recycle: An easy household guide.* White River Junction, VT: Chelsea Green Publishing Company.

Shoemaker, B. (1989). Integrative education: A curriculum for the twenty-first century. ERIC Document Reproduction Service No. ED 311 602.

Sobel, D. (2008). *Childhood and nature: Design principles for educators*. York, ME: Stenhouse Publishers.

Spínola, H. (2015). Environmental literacy comparison between students taught in Eco-schools and ordinary schools in the Madeira Island region of Portugal. *Science Education International, 26*(3), 395-416.

Stohr, W. (2013). Coloring a green generation: The law and policy of nationally-mandated environmental education and social value formation at the primary and secondary academic levels. *Journal of Law and Education, 42*(1), 1-111.

Strife, S. J. (2012). Children's environmental concerns: Expressing ecophobia. *The Journal of Environmental Education, 43*(1), 37-54.

Tang, K. S. (2015). Reconceptualising science education practices from New Literacies research. *Science Education International, 26*(3), 307-324.

Torff, B. (2006). Expert teacher's beliefs about use of critical-thinking activities with high- and low-advantage learners, *Teacher Education Quarterly, 33*(2), 37-52.

Trnova, E. (2014). IBSE and creativity development. *Science Education International, 25*(1), 8-18.

Tytler, R. (2007). *Re-imagining science education: Engaging students in science for Australia's future.* Camberwell, Victoria: Australian Council for Educational Research.

Wilson, E. O. (1984). *Biophilia*. Cambridge, MA: Harvard University Press.

White, R. (2006). Young children's relationship with nature: Its importance to children's development and the Earth's future. *Taproot, 16*(2), 1-5.

Appendix 1-a   Instructor's Pop-up Box Showing Problems Related to Endangered Animals and What Kids Can Do to Help

Appendix 1-b Instructor's Pop-up Box Showing Problems Related to Greenhouse Gases and What Kids Can Do to Help

Appendix 2   Outline of Lesson Activities during the Environmental Education Unit De Bono Thinking Skills Used in the Lessons with Examples of Student Responses

De Bono Skill	Question for Students	Example Student Responses			
Consequences and Sequel (C&S)	What may be consequences and results of continuing to pollute our planet: immediate effects; short-term consequences (1-5 yrs.); medium-term effects (5-25 yrs.); and long-term effects (more than 25 yrs.).	C&S	Animals	Air Pollution	Trash
		1-5 years	Animals are slowly disappearing.	You could see the pollution in the air.	Overflow and spread across town, cities, and water/oceans.
		5-25 years	Earth not in good shape, because some animals that are important and help us are gone.	We as humans and animals could die.	Animals could eat garbage they see and get poisoned. Population of humans and animals will drop.
		More than 25 years	Few animals left.	Our state would be a landfill.	Places will stink and no wild life would be around.
Plus, Minus, Interesting Ideas (PMI): Find the good and bad points along with insights.	Rate a specific idea about helping the environment by listing the plusses, the minuses, and interesting ideas that are neutral.	Plus: Planting more trees at school will provide more oxygen and homes for animals. Minus: Planting trees at school will cost money. Minus: Planting trees at school will mean someone will need to take care of them such as watering. Interesting Idea: We studied trees in another class.			
Consider All Factors: List all the aspects or elements affecting the problem	Tell all the factors you need to consider related to your pop-up project.	Newscasters would say that working on the environment is amazing. Ice caps are melting. Saving electricity can save money and also encourage people to exercise outside. Whose habitat should we save? Do we need money to do this?			
First, Important, Priorities (FIP) Put components in order according to value.	According to you, what is the most important environmental problem to study?	1. Deforestation; 2. Landfills; 3. Air pollution; 4. Save animal habitats; 5.Water pollution; 6. Fields and prairies disappearing			
Other People's Views (OPV): Explore the issue	What are various human, animal, or environmental	Animals: Don't hurt my home. Sidewalk: Stop littering on me; don't spray on me. Elementary School: I need more trees!			

from different perspectives	objects' views on how to help the environment?	Trash Can: Make sure all your litter gets inside me except for reusable items. Paper: Use both of my sides, recycle me, erase mistakes on me; stop cutting down trees to make me; I want to stay a tree. School bus: I to run on cleaner fuel; walk to school when you can.
Rules Write guidelines for implementation	If you could make rules to help the environment what rules would you make?	Stop poaching and hunting No more oil rigs Take your own grocery bag to the store Factories must clean the air before they return it to the atmosphere
Planning Organize and tell steps of project.	Create a plan of how you could work to solve this environmental problem.	Educate classmates. Inform people to start recycling. Create billboards, flyers, brochures about the problem. Have contests to raise money. Reduce, Reuse, Recycle
Aims, Goals, and Objectives (AGO) Determine direction, accomplishments, and criteria for project.	Determine the aims, goals, and objectives you have for creating a pop-up picture.	To recycle and use things more than once. My pop-up box will be really informative. To teach how animal habitats disappear. People will understand what I am saying.
Alternatives, Possibilities, Choices (APC): Determine all potential variables	Determine at least two topic choices for your pop-up and then list alternatives or possibilities.	Polar Ice Cap Melting: put a giant cork in the ice cap; cut down on greenhouse gasses; plant more trees; stop polluting the air; stop using coal. Landfills: take your own grocery bag; post on Internet how much garbage is in landfills; tell others about landfill problems at local places such as the grocery store; create a job where person goes through landfill and removes harmful items; use computers more instead of paper; make art out of trash.
Decisions Determine the best course of action.	Decide what ideas about your environmental problem are important to include in your pop-up construction.	Loss of prairies: Loss breaks the food chain. Water Pollution: Most things people throw away can be reduced or recycled rather than leaked into water. Start an eco-friendly club. Animal Habitat Destruction: Plant trees to save habitats. We can't live without some of the animals.