Science Education International
Vol. 15, No. 1, January 2004

ICASE International Council of Associations in Science Education

The Effect of Teaching an Environmentally-oriented Science Unit on Students' Attitude and Achievement

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ABSTRACT *The purpose of this study was to investigate the effects of teaching an environmentally oriented science unit related to water on students' achievement in science and on their attitude toward the environment. The subjects in the present study were 63 students enrolled in two sections of a Grade 7 class at a private school in Beirut. The two sections were taught science by the same teacher and were heterogeneous in terms of achievement, socio-economic status, and gender. The design of the study was a pretest-treatment-posttest two-group design with intact groups. Since the study used intact groups, students' grades in math and science as well as scores on the achievement test prior to treatment were used as covariates. In addition, an attitude questionnaire was administered before treatment, and its scores were used as covariates. Dependent variables in the study were general achievement in science, achievement in science at the comprehension level and above, and students' attitude toward the environment. Results indicated that students' in the experimental group achieved significantly higher and developed significantly more positive attitudes toward the environment than students in the control group.*

KEY WORDS: *Environment, attitudes, achievement*

Introduction

Environmental awareness is actualized in students in a developing country, like Lebanon, through many mechanisms. These mechanisms can be informal and formal. Informal education is accomplished by the visual and auditory media, governmental institutions, non-governmental organizations (NGOs), and United Nations agencies. These sources, however, may not be available to all students. The formal mechanism to disseminate environmental information, raise awareness, improve attitudes, and nurture pro-environment behaviors is actualized in classrooms where young people are reached. This is especially important, because studies indicate that the foundations of pre-adult attitudes toward the environment are formed during childhood and that these attitudes govern behavior throughout adult life (Pomerantz, 1984). One way through which environmental concerns are addressed in the classroom is by integrating environmental issues in the science curriculum.

Integrating environmental studies in the science curriculum seems reasonable, since, in real life, science and environment are interdependent. This integration has at least two benefits. First, it is an efficient mechanism to introduce the majority of students to environmental issues, and help them acquire knowledge and develop skills and attitudes needed to address environmentally based everyday problems (Bybee, 1991; Lorson, Heimlish, & Wagner 1993; Pomerantz, 1984). Second, it contextualizes science, and makes it more meaningful and socially and culturally relevant to students' lives, thus, helping them to improve their science achievement (Ferguson, Angell & Tudor, 2001; Gough, 2002, The National Environmental Education & Training Foundation, 2000).

Actually, research has shown that students achieve higher in science when it is integrated with environmental studies at the high school (Hassard & Weisburg, 1992; Simon, 1992), middle school (Hassard & Weisburg, 1992), and upper elementary levels (Powell & Wells, 2002; Williams & Reynolds, 1993). Furthermore, research demonstrated that using environmental education improves achievement in other subject areas, such as language arts (Simon, 1992), and increases children's perception of biodiversity (Lindermann-Matties, 2002).

Dillon and Scott (2002) suggest that environmental education has the potential to transform science education by introducing social and scientific issues into the classroom. In addition, environmental education and inquiry teaching may complement each other, thus, making inquiry more relevant and authentic (Dory & Herscovitz, 1999; Gough, 2002); Herried, 1994). Moreover, Dillon and Scott (2002) propose that environmental education, because of its nature, challenges the notion that science education is value-free, and may be used to introduce values into the science curriculum in line with modern conceptions of scientific literacy (BouJaoude, 2002; Grace & Ratcliffe 2002; Hart, 2002).

Contradictory results have been reported in studies investigating the relationship between using environmental education in the classroom, or integrating it in science, and attitudes toward the environment. Showers and Shrigley (1995) established that high school students' nuclear knowledge and attitudes correlated highly. Similarly, DeFina (1991, 1995) found that using integrated science-environment activities improved high school students' attitudes toward and awareness about the environment. Armstrong and Impara (1991) determined that fifth- and seventh-grade students, using Nature Scope as a curriculum supplement, developed more positive attitudes than those who did not. Conversely, Kinsey and Wheatley (1984) found that there were no significant differences between university students who took an environmental studies course, and those who did not, in terms of supporting their stated attitudes toward the environment. Along similar lines, Ryan (1991) suggested that a conservation education program used with fifth-grade students resulted in insignificant improvement in their attitudes. Similarly, Quinn (1976) found that short lessons on environmental problems accompanied by a series of personally involving questions did not improve students' attitude toward the environment.

Many of the attitude scales that were used in research studies failed to consider Fishbein and Ajzen's (1975) suggestion that the immediate precursor to behavior is intention rather than attitude toward an object, and that attitudes had three components: Beliefs, affect, and behavioral intentions. Consequently, the contradictory results may be a function of the instruments used to measure attitude. Moreover, the measures used in various research studies focused on measuring knowledge rather than higher-level objectives. Yet, if integrating environmental issues and science is to have a lasting impact, it must improve performance on higher cognitive level items rather than just the knowledge level. This makes it necessary to investigate the differential effect of using environmentally oriented instructional materials on performance on high and low cognitive level test items.

Consequently, the purpose of this study was to investigate the effects of teaching an environmentally oriented science unit related to water on students' achievement in science and on their attitude toward the environment. Specifically, the study addressed the following questions:

1. Do students taught using an environmentally oriented science unit achieve higher in science than students taught using a commonly used science unit?
2. Do students taught using an environmentally oriented science unit achieve higher on higher cognitive level test items than students taught using a commonly used science unit?
3. Do students taught using an environmentally oriented science unit have a more positive attitude toward the environment than students taught using a commonly used science unit?

Methodology

Subjects

The subjects in the present study were 63 students enrolled in two sections of a Grade 7 class at a private school in Beirut, where English is the language of instruction. The same teacher taught the two sections. Students were heterogeneous in terms of achievement and socio-economic status. The first section consisted of 33 students (15 males, 18 females), while the second section consisted of 30 students (17 males, 13 females). The average age of the students was twelve years, with ages ranging from 11 to 13.

Design

The design of the study was a pretest-treatment-posttest two-group design with intact groups. Assignment to control or experimental group was random. Since the study used intact groups, students' grades in math and science, as well as scores on the achievement test before the treatment were used as covariates to adjust for possible differences between the control and experimental groups in science and mathematics achievement. Using performance in math as a covariate is important, because math is correlated with achievement in general (Fraser, 1987; Hafner, 1991; Khouj, 1982). In addition, an attitude questionnaire was administered before the treatment, and its scores were used as covariates to adjust for possible differences in the attitudes of students before the treatment. Dependent variables in this study were achievement in science, as measured by a multiple-choice test, and attitude toward the environment, as measured by an attitude questionnaire. The independent variable was the instructional approach with its two levels: Environmental and commonly used.

Instructional Materials

The two researchers prepared two units on water, one experimental and one control. These units were reviewed and revised by the head of the science department and the science teacher in the school in which the study was conducted. The two units covered the same topics (See Appendix A) and contained the same laboratory experiments. What differed was the instructional approach used in each of these units.

The environmental approach was adapted from ChemCom (Chemistry in the Community, 1989), a curriculum that uses an issues-oriented approach presenting science from an environmental perspective. This approach is analogous to Problem Based Learning (PBL) or the case method of teaching. PBL is "... a pedagogical strategy for posing significant, contextualized, real world situations, and providing resources, guidance, and instruction to learners as they develop content knowledge and problem solving skills" (Mayo, Donnelly, Nash, Schwartz, 1993). One of the unique characteristics of PBL is teaching content by using real-world problems familiar to the learners and, in most instances, based on local problems. This approach reverses traditional science teaching practices in which teachers present content through lectures or other methods followed by applications in real world situations. In this respect, PBL can be considered constructivist, since students construct their knowledge based on experiences they encounter in the classroom[1].

The problems in PBL are typically in the form of cases, which are descriptions of real world problems preferably acquired from the students' local environment and akin to their experiences. According to Herried (1994) using cases entails learning by doing, which has the potential to help students develop analytical and decision-making skills, internalize learning, learn how to address genuine real-life problems, among other skills. Moreover, using cases in the classroom has a strong appeal to students, leading them to develop positive attitudes toward science and achieving higher science. When using cases appropriately, there is less emphasis on knowledge objectives than on comprehension, application, analysis, synthesis, and evaluation.

The environmentally oriented unit aimed to change students' attitude toward the environment by integrating science and environmental issues. The integration and the issues-oriented approach attempted to persuade students about the importance of environmental issues following Hovland's model of attitude change. The teacher (the "who") used the issues-oriented and integrated instructional unit (the "what") to convince the students (the "whom") of the utility and importance of science in solving environmental problems. Moreover, using activity-oriented and student-centered instructional activities and showing students the current state of the environment (the "how") was assumed to change their attitude toward becoming more environmentally aware (with what effect).

The environmentally oriented unit started with a written statement to set the stage for the lessons and activities that followed, as it is presented in Table 1. Then each

1. Adapted from http://www.cositoledo.org/isci/teacher_isci_pbl.htm and http://www.pbl.uci.edu/whatispbl.html).

Table 1
The Statement Used at the Beginning of the Environmental Unit

Pollution in the Rouaiss River

In the mountains of North-Central Lebanon there exists a river called the Rouaiss river. This river runs above a tree-line for its first two kilometers near a town called Aqura. The road is difficult to walk or to drive on. The water is famous for its taste and health effects.

When the river reaches the "apple country" downward it loses its nice taste. One can even detect an unpleasant saltiness, especially in springtime. This is due to fertilizers, which reach the river by water run-off. Large amounts of fertilizers cause an increase in algae and water weeds. The river becomes ugly and ill-smelling.

In summer, the smell of pesticides can be detected in the water. This is due to large amounts of toxic chemicals found in pesticides used in the "apple country."

When the river passes through villages, the water gets even worse. It contains garbage, such as tin, paper, plastic bags, and remains of food. Cases of typhoid fever and other intestinal diseases have been reported. Household water has to be treated before use.

A gas filling station started service there few years ago. Two summers ago, a gasoline truck, on its way up, went off the road at the river bank. The gas truck reservoir was punctured as it hit a rock. All its content spilled over into the river. For several weeks, there was a campaign to clean up the river. But, lack of knowledge, primitive equipment, and the nature of the land didn't help. So, the river was only partially cleaned. Gasoline remained even the following Summer. Trout once found in large quantities is nearly extinct. The municipality has tried hard to bring trout back into the river, but has not succeeded. The ecological balance was so affected, that trout can no longer capture its food in nature.

What nature takes centuries to make beautiful, man can destroy in a short time for the sake of "civilization" and "progress."

lesson in the unit started with a written statement, presented in Table 2, in the form of a newspaper article presenting an issue related to water, its solution, or both. A discussion of the problems and solutions presented in the statement followed, and students suggested alternative solutions or evaluated the implemented solutions. Subject matter was covered accordingly, and always by referring to the statement and student proposed solutions. At the end of each activity, or set of activities, students participated in discussions aimed at reflecting upon the proposed solutions in relation to the subject matter covered. Thus, instruction in the experimental group included the following elements: a) focus on everyday rather than academic problems, b) student-centered decision-making activities, c) reflective activities, and, d) closure. Moreover, to help students change their beliefs, they were encouraged to take their own decisions regarding the issues presented in the written statements, discuss these decisions in class, and evaluate whether or not the solutions were feasible and socially acceptable.

The written statements were prepared by the two researchers, and reviewed by a science educator and the teacher at the school where the research took place. The statements were also piloted with students randomly selected from another section of the same class level. The students participating in the pilot test read the statements and commented on them. Most of the students read each of the statements in less than ten minutes with no major difficulties. Technical and difficult words were explained by footnotes.

The teaching approach used with the control group followed the method

Table2
An example of the statements used at the beginning of each lesson.

Water Treatment at the Water Treatment Plant

As Aqura grew, more wastes were dumped into the Rouaiss River. Dirt came out with the water from taps. Water became ill-smelling and lost its clarity.

The people were alarmed especially that cases of typhoid fever and other intestinal diseases were reported. Water reaching the houses was no more usable. The water cycle was not able to clean the water anymore. Something had to be done.

The Municipality called for a meeting to discuss the subject. The decision to build a water treatment plant was taken. A couple of months later, a water treatment plant was installed. Water coming out of the water treatment plant and reaching the houses through pipes was clean and safe for use. It contained no more dirt, and was disease-free. People could use tap water with no fear once more.

Questions:

1. How is the water treatment plant similar to the water cycle?
2. What are some of the procedures used to purify in the water treatment plant?
3. What are the advantages and disadvantages of building a water treatment plant?
4. You heard a number of people in Aqura saying: "Since the municipality built a water treatment plant, we can now throw everything in the Rouaiss River". What are the problems with this argument, if any? Justify your answers.

presented in the science textbook used in the school. The approach presented science as a body of knowledge and a way of investigation, and did not address science from an environmental standpoint. Lessons in the control unit compensated for the statements used in the environmental unit by asking the students to read the lesson. The experimental and control units covered identical content which came from the Physical Science National Science Textbook (1993 edition).

Instruments

Two instruments were used in this study: An achievement test and an attitude questionnaire.

Achievement Test. Assessing the cognitive outcomes of integrating environmental issues in science can be accomplished in a variety of ways, such as using case studies or multiple-choice tests, among other formats. In effect, since using PBL is expected to increase students' achievement in higher cognitive skills, then assessment should address these skills. While assessing higher cognitive skills and learning outcomes is preferably done by using case studies to gauge students' abilities to make decisions in context (Dori & Herscovitz, 1999; Dori & Tal, 2000), it was decided to use a multiple choice test in this study for two reasons. First, since the study was conducted in an educational system that valued traditional performance outcomes, it was essential to use a familiar and credible test format in an attempt to reduce the participating students', teachers', and school administrators' stress levels, which may have resulted from using unfamiliar and novel test formats. Second, it was necessary to use a test that contained items at all cognitive levels to demonstrate that using an environmentally oriented science unit did not result in lower performance on these outcomes.

The achievement test was a multiple-choice test consisting of 30 items with four options each. The cognitive levels of the items ranged from knowledge to synthesis according to Bloom's taxonomy. Some items were adapted from already existing tests, while others were constructed by the researchers (see Appendix B for examples of the test items). The test was prepared by the two researchers and reviewed by a math educator, who has done extensive work on assessment. The total possible score on the achievement test was 30 points distributed as follows 7 points for the knowledge items, 4 points for the comprehension items, 9 points for the application items, and 10 points for the analysis and synthesis items. Each correct answer received a score of one, irrespective of its cognitive level. The thirty items of the achievement test were classified according to their cognitive level by the researchers and a math educator. Agreement between reviewers was 83.3% (25 out of 30 questions). The five items that were categorized differently were all beyond the knowledge level. These five items were modified until total agreement was reached. The content validity of the test was assured by aligning the test items with the objectives of the unit using a table of specifications. The internal consistency reliability of the test was calculated using the Kuder-Richardson formula and was found to be 0.60.

Children' Attitudes Toward the Environment Scale (CATES). The attitude questionnaire used in this study was the Children' Attitudes Toward the Environment Scale (CATES) designed by Musser and Malkus (1994) to measure environmental attitudes of school children. According to Musser and Malkus (1994) and Malkus and Musser (1993), CATES was designed to be developmentally appropriate for children between the ages of 8 and 12 years. However, a version appropriate for pre-school children was developed recently (Musser & Diamond, 1999). The test consists of three types of statements representing belief (I think...), behavior (I do...), and affect (I like...), as it is shown in Table 3. These three types of statements are based on the view that attitude has three components: Beliefs, behavioral intentions, and affect (Fishbein, 1967; Fishbein & Ajzen, 1975). The final version of the scale contains eight belief statements, nine affective statements, and eight behavior statements. Each item of CATES consists of two statements each describing a group of children (Table 3). The two statements of the same item are separated by the word "but." When the scale is administered, children are asked to choose to which of the two groups of children they belong (the group described on the left side of the word "but" or the group on the right side). Under each statement, there are two boxes, one big and one small. After choosing the group to which they belong, children are instructed to put a check in the big box if they are a lot like the described children or a check mark in the small box if they are only a little like the children described in the statement. Each item is scored from 1 to 4, with one representing the least pro-environmental attitude, and four the most pro-environmental. Scores from each item are added to produce a total environmental attitude score, which could range from 25 to 100. In studies of the psychometric properties of CATES, the internal consistency reliability ranged from 0.70 to 0.85 and the test-retest reliability was 0.68 (Malkus & Musser, 1993; Musser & Malkus, 1994). Moreover, CATES correlated with other measures of environmental attitudes and was related to children's choices of pro-environmental activities (Malkus & Musser, 1993).

Table 3
Examples of the Items used in the Attitude Questionnaire

1. Some kids like to leave water running, when they brush their teeth	*But*	Other kids always turn the water off, while brushing their teeth
☐ ☐		☐ ☐
2. Some kids use both sides of the paper, when they draw or write.	*But*	Other kids use only one side of the paper, when they draw or write.
☐ ☐		☐ ☐
3. Some kids think we should throw away things when we're done with them.	*But*	other kids think we should recycle things
☐ ☐		☐ ☐
4. Some kids think dams on rivers are bad, because they hurt plants and animals.	*But*	Other kids think dams on rivers are good, because they prevent floods.
☐ ☐		☐ ☐

Twenty-one, out of a total of 25 items of CATES, were used in this study without jeopardizing the balance between the belief, affect, and behavior components, resulting in 8 affect statements, 6 belief statements and 7 behavioral statements. The discarded items referred to issues unrelated to the background of Lebanese students. Before the study, the questionnaire was piloted with a group of students in a different school belonging to the same grade level. The questionnaire was adjusted based on students' comments regarding the wording of the questions. Following the guidelines provided by to Musser and Malkus (1994) and Malkus and Musser (1993), each item was scored from 1 to 4, with 1 representing the least pro-environmental attitude, and 4 the most pro-environmental. Scores from each item were added to produce a total environmental attitude score, which could range from 21 to 84. The calculated split-half reliability of the questionnaire in this study was 0.62.

Procedures

Before beginning the treatment, the teacher, who was certified to teach science at the middle school level and who taught both the experimental and the control groups, was trained to teach the units. One of the researchers met five times with the teacher to discuss the content of the lessons and the teaching approaches. All experiments were prepared beforehand. The teacher presented a mini-lesson using both approaches in the presence of one of the researchers who gave her corrective feedback. One of the researchers attended all lessons in both experimental and control classes for the duration of the study that lasted for 15 teaching periods.

Scores of prior achievement in science and in mathematics were collected from the respective teachers. These scores corresponded to the students' grades from the beginning of the school year and up to the time of implementation of this study that started in February.

Data Analysis

First, all scores were converted into percentages to facilitate comparisons between the control and experimental groups. Then descriptive statistics (means and standard deviations) were calculated for each of the following: Achievement test scores before treatment (Pre-achieve), achievement test scores after treatment (Post-achieve), science scores before treatment (Pre-science), math scores before treatment (Pre-math), scores on the comprehension and above items (Post-comp), attitude scores prior to treatment (Pre-attitude), and attitude scores after treatment (Post-attitude).

In order to address the questions in the study, we performed two Analyses of Covariance (ANCOVA) procedures with the Post-achieve and Post-comp scores of the control and experimental groups as dependent variables and Pre-math, Pre-science, and Pre-achieve as covariates. In addition, we carried another ANCOVA procedure using the Post-attitude scores as a dependent variable and the Pre-attitude scores as a covariate. The assumptions of ANCOVA were checked and found to be satisfied (see Stevens, 1990).

Results

The means and standard deviations for the experimental and the control groups on Post-achieve and Post-comp, Pre-achieve, Pre-science, and Pre-math are presented in Table 4. In addition, the means and standard deviations on the attitude questionnaire before and after the treatment are presented in Table 5.

Table 4
Descriptive Statistics for Achievement Scores and Covariates

	Experimental Group (n=33)		Control Group (n=30)	
	Mean	SD	Mean	SD
Post-achieve	68.50	10.75	63.23	12.22
Post-comp	72.11	12.11	66.34	13.66
Pre-achieve	47.93	9.61	45.56	10.60
Pre-science	65.27	13.87	66.09	12.30
Pre-math	65.97	12.86	60.36	14.97

Table 5
Means and Standard Deviations of the Attitude Questionnaire Scores Before and After the Treatment.

	Experimental Group (n=33)		Control Group (n=30)	
	Mean	SD	Mean	SD
Post-attitude	81.98	7.22	75.65	10.59
Pre-attitude	75.31	9.48	75.35	9.91

Table 6 presents the results of the ANCOVA procedure used to compare the achievement of the control and experimental groups. A significant effect for the experimental group was found with $F = 4.14$ ($p < .05$). Since the mean score for the experimental group was 68.50% and that of the control was 63.23%, the experimental group achieved significantly higher than the control group.

Table 6
Analysis of Covariance of Achievement Test Scores

Source of Variation	Sum of Squares	df	Mean Square	F	Significance of F
Covariates	270.82	3	90.27	12.46	0.000
Pre-science	85.03	1	85.03	11.73	0.001
Pre-math	1.16	1	1.16	0.16	0.691
Pre-achieve	0.88	1	0.88	0.12	0.729
Main Effects					
Group	29.98	1	29.98	4.14	0.047
Explained	317.55	4	79.39	10.95	0.000
Residual	319.40	54	7.25		
Total	708.95	58	12.22		

The results regarding the question of whether students taught using an environmentally oriented science unit achieved higher on higher cognitive level test items than students taught using the commonly used teaching unit (Question 2) are shown in Table 7. The results show a significant effect for the experimental group with $F = 3.90$ ($p < 0.06$). Since the mean score for the experimental group was 72.11, and that of the control group was 66.34, the experimental group achieved significantly higher than the control group.

Finally, the results of the ANCOVA procedure used to compare the attitudes of the control and experimental groups are shown in Table 8. The results show a significant effect for the experimental group with $F = 11.06$ ($p < .01$). Since the mean score of the experimental group was 81.98% on the post-treatment questionnaire, it is significantly higher than the control group whose mean score was 75.65%.

Discussion and Conclusions

Students in the experimental group who were taught the environmentally-oriented unit achieved significantly higher on the achievement test and on the higher

Table 7
Analysis of Covariance for Scores on Comprehension and Above Cognitive Level Questions

Source of Variation	Sum of Squares	df	Mean Square	F	Significance of F
Covariates	140.30	3	46.77	7.71	0.000
Pre-science	38.20	1	38.20	6.29	0.015
Pre-math	0.84	1	0.84	0.14	0.711
Pre-achieve	2.40	1	2.40	0.40	0.532
Main Effects					
Group	23.64	1	23.64	3.90	0.054
Explained	176.26	4	44.07	7.26	0.000
Residual	327.74	54	6.07		
Total	504.00	58	8.69		

Table 8
Analysis of Covariance for Attitude Scores

Source of Variation	Sum of Squares	df	Mean Square	F	Significance of F
Covariates	1693.04	1	1693.04	55.09	0.000
Pre-attitude	1693.04	1	1693.04	55.09	0.000
Main Effects					
Group	339.97	1	339.97	11.06	0.002
Explained	2029.67	2	1014.84	33.02	0.000
Residual	1444.51	47	30.73		
Total	3474.18	49	70.90		

cognitive level questions than students in the control group who were taught the commonly used unit. Moreover, students in the experimental group showed significantly more positive attitudes toward the environment than students in the control group. Hassard and Weisburg (1992), Simon (1992), and Williams and Reynolds (1993) have found similar results regarding achievement, while Showers and Shrigley (1995), Defina (1991, 1995), and Armstrong and Impara (1991) found similar results regarding attitude.

Why is it that students studying an environmentally oriented science unit achieved higher and developed more positive attitudes than students studying a commonly used unit? It seems that the relevance of the problems and solutions addressed in the unit helped students realize the usefulness of learning science in their daily lives (Knamiller, 1983, 1984a, 1984b; Newton, 1988), especially that the lessons used local examples that made things seem real. Science was no more irrelevant formulae or information that could not be used outside the classroom. It became a vehicle to grasp and solve real problems. Newton (1988) suggests that students are both motivated and educated by material that is relevant to their everyday life, and that "relevant science education has the potential to do more that render palatable dry and unmotivating science" (p. 828). Thus, relevance may have contributed to the development of more positive attitude and higher achievement in higher cognitive level items. Moreover, it is possible that the relevance of the topics and student involvement in the lessons made learning more meaningful resulting in more positive attitudes and higher achievement (BouJaoude, 1992; BouJaoude & Giuliano, 1994; Cavallo, 1996; Liberatore-Cavallo & Schafer, 1994).

Another contributing factor to the success of the unit could be the novelty of the approach that helped foster a positive learning environment in the classroom. The unit may have motivated students and made them feel that science is fun. The environmental unit succeeded in capturing students' attention and interest. The classroom observations conducted by one of the researchers demonstrated that students were eager to participate in class discussions and activities. Of particular importance to them were the laboratory experiments and demonstrations in the context of solving an everyday problem. Furthermore, the fact that the unit presented information in the context of a problem may have encouraged students to think beyond the level of facts and concepts and may have driven them into a problem-solving situation where the relationships between facts and concepts became important and where deep processing of information was necessary. This may have resulted in significantly higher grades on the higher cognitive level items. In comparison, the commonly used unit did not leave room for such levels of thinking and problem solving.

Finally, the nature of the environmental unit seems to have fostered pro-environmental attitudes since issues related to the environment constituted the core of the lessons, and all discussions concentrated on finding acceptable solutions to environmental problems. During class sessions, students exhibited concern for the environment, be it in the lesson topics or other topics. Students felt personally involved in environmental problems, were eager to find solutions, and many times proposed very interesting devices to clean up waste and contaminated water as well as to get rid of garbage.

The findings suggest that integrating environmental issues in the science curriculum assures success in traditional examinations, along with improving attitudes. This situation should help convince teachers, curriculum developers, and school administrators that this integration is not a threat to the acquisition of content knowledge. Rather, integration can act as a catalyst for higher and more meaningful achievement and more positive attitudes. Consequently integrating environmental issues in science may help both science and the environment by improving attitude, which is a precursor for behavior, without jeopardizing mastery of content matter knowledge. Thus, if a country aims to prepare scientifically literate citizens, who are capable of decision-making regarding everyday science-related concerns without neglecting to provide them with options in higher education, then a curriculum that integrates science and environmental issues may serve the purpose. This curriculum may help transform scientific literacy from a myth (Shamos, 1995) into a reality.

More research, however, is need to investigate the school and out-of-school factors that may make integration successful, how different students benefit from integration, the developmental appropriateness of integrated curricula, and the nature of teacher preparation for successful integration among other issues. In addition, the development and sustainability of positive attitudes are complex issues that need educators' very close attention. For example, measuring attitudes right at the conclusion of a study may not provide enough evidence that the positive attitudes are sustainable. It may be necessary to find out, in future longitudinal research, whether or not the positive attitudes are sustained for long periods of time, and whether or not these attitudes are translated into useful and environmentally friendly behavior.

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Appendix A

Science concepts covered in the instructional units included:

1. Solute, solvent, solution, colloids, and suspensions, solubility, insoluble, saturated, unsaturated, supersaturated.
2. States of water, density of water, elements that make water, heat conduction in water
3. Molecular structure of water
4. Physical properties of water and their significance to life on earth
5. Hydrological cycle
6. Water purification techniques (such as filtration, decantation, and distillation, chlorinating, aeration)
7. Water pollutants
8. Water conservation
9. Solutions to water pollution
10. Water treatment and water treatment plants
11. Artificial and natural water purification systems

Appendix B

Knowledge

In the water treatment plant, water is aerated in order to:

1. Eliminate harmful bacteria
2. Make it lighter in color
3. Remove unpleasant odors and tastes
4. Remove solid materials form it

Comprehension

Which of the following is involved in cloud formation

1. Evaporation
2. Distillation
3. Filtration
4. Separation

Application

What may cause a glass soft drink bottle to explode when placed in a freezer overnight?

1. The water in the soft drink contracts when it freezes
2. The glass soft drink bottle contracts when it freezes
3. The water in the soft drink expands when it freezes
4. The glass soft drink bottle expands when it freezes

Analysis

The factory in which your father works releases polluting gases. People in the area are complaining. What do you think should be done to the factory

1. Nothing should be done since my father works in the factory
2. The factory should be closed since it is causing problems
3. A filter which controls poisonous gases should be installed
4. People living in the area around the factory should relocate.

Synthesis

Given four solutions:

- Solution A: 500 mL of olive oil
- Solution B: 500 mL of fresh water
- Solution C: a red solution containing 90 g of sugar in 500 mL of water
- Solution D: a blue solution containing 20 g of sugar in 500 mL of water

If these solutions are poured carefully on the side of a graduated cylinder, which of them will occupy the bottom of the cylinder?

1. Solution A
2. Solution B
3. Solution C
4. Solution D