EVALUATION OF THE WISCONSIN ENERGY CYCLE EDUCATION PROGRAM

Susan E. Stein, Midwest Renewable Energy Association, Amherst, WI
Scott Pigg, Energy Center of Wisconsin, Madison, WI
Tehri Parker, Midwest Renewable Energy Association, Amherst, WI

Introduction

In order to become responsible, decision-making citizens, students need to become better informed on energy issues including an understanding of the complexities involved. They need, for example, to learn about resource availability and the role of consumer demand, as well as the extent of related environmental impact. In this way they may begin to understand why there are disagreements between experts concerning current oil and natural gas supplies and that the predictions of experts are not always correct (Treiney 1990 as stated by Marker 1991). During the next decade, decisions will need to be made as society shifts to new sources of energy. It will be imperative that students also understand the amount of time and energy that will be required to change the major energy sources used in this country (Marker 1991).

In response to this increased attention to energy issues, the demand for new energy education materials and programs has increased, especially for those with an environmental focus. To fill this need, energy education materials have been developed be environmental organizations, public utility companies, business groups, and educational publishers (Leon 1992). Governmental agencies such as the National Energy Information Center, the National Appropriate Technology Assistance Service, and the Conservation and Renewable Energy Inquiry and Referral Service have all produced general information, curricula, and visual material on energy. Educational and promotional materials in energy have also been provided by industry trade associations such as the American Nuclear Society, the American Coal Foundation, the Renewable Fuels Association, and the Solar Energy Industries Association, to name a few. The Climate Protection Institute, National Energy Foundation, Worldwatch Institute, Union of Concerned Scientists, and World Resources Institute are just a few of the private and non-profit organizations who have also focused activities, educational programs, curricula, resources, and other publications on the subject of energy (Sherman 1992). The Department of Energy was a sponsor of the 1993 North American Association of Environmental Education conference in Big Sky, Montana.

Recently developed energy education materials focus on a broad range of topics including historical perspectives of energy use, current energy issues, cultural values, uses of energy sources, and personal consumption. These topics span many of the disciplines including art, language arts, math, science, social studies, spelling, music, drama, chemistry, earth science, physical science, and geology (Rohwedder 1992, Wellnitz 1992).

A 1990 NEED energy poll found that students are not adequately informed to make decisions on energy use and policy. Only 30% of junior and high school students could identify the major use of coal, and 70% did not know that energy is given off when uranium atoms are split. More than 1/2 of students in the poll did not know that heating and cooling homes requires more energy than supplying them with hot water or lighting (Frantz 1992). Even with the abundance of energy education programs, a 1991 NEED project survey discovered that only 9% of middle and high school students were aware of the average price of electricity, and more than 60% did not know the difference between renewable and nonrenewable energy (Frantz 1992). Somehow, major concepts of energy, such as renewable vs. nonrenewable energy, efficiency, and current major sources of energy consumed in the United States, were not being grasped by students.

Some educators have pointed to the abstract and theoretical nature of energy education materials as one reason for low student knowledge and interest in this topic. They point to the need for materials that encourage hands-on experience (Rohwedder 1992). Results from various surveys and studies show that more hands-on, action-oriented curricula ranks among the top five needs reported by educators (Sivek 1987, Glass 1984). The most effective approach to educating students about energy is to start with their own lives and their own use of energy (Wellnitz 1992). Many of the energy education programs that exist do not provide hands-on experience. Even with the resurgence of energy education within the school curricula and the surge of energy education activities and materials provided by various organizations, there is a critical need for educational activities that involve, intrigue, and motivate students to learn about energy and to act as responsible consumers of the earth's resources.

Wisconsin Energy Cycle Education Program

The Wisconsin Energy Cycle Education Program (WECEP) represents an innovative approach to energy education. As an interactive educational tool, the goal of the Energy Cycle is to stimulate curiosity and the desire to learn more about electricity, energy production, supply and demand, and related environmental issues.

The Energy Cycle Education Program (ECEP) was brought to Wisconsin by Wisconsin Demand-Side Demonstrations (WDSD), a non-profit corporation created by the Public Service Commission of Wisconsin in November 1990. The ECEP was originally developed by the North Carolina Alternative Energy Corporation (NCAEC) in conjunction with SEASUN power systems to promote energy awareness and conservation.

The Energy Cycle is a "legs-on" learning device that utilizes a bicycle to generate electricity which, in turn, is used to power an educational display board consisting of meters, light bulbs and other small appliances. As students pedal the Energy Cycle they can see and "feel" their own energy being converted to electricity to power the display board elements. As instructors switch, for example, the flow of electricity from efficient compact fluorescent bulbs to the inefficient incandescent light bulbs, participants have a hard time pedaling the bike and clearly discover the meaning of "energy efficiency". The assumption is that the interactive component of Energy Cycle lesson will make students want to learn more about energy, electricity and its use. As the lesson progresses, the instructor guides the learner through a series of activities intended to help them better understand the basic concepts of energy education such as energy sources and available supplies, electrical power generation and distribution, energy conversion and storage, peak demands, and the environmental impacts of energy development, production, and use. The Energy Cycle lesson is designed to help students learn about the efficiency levels of various household appliances and ways they can help conserve energy and thereby reduce impacts they have on environmental quality.

In June of 1993 WDSD funded the purchase of five Energy Cycle units to be placed in environmental learning centers around the state and contracted with the Central Wisconsin Environmental Station (CWES) to coordinate the program. The decision to place the units in environmental learning centers was made based on cost-effectiveness, program-effectiveness, and context-effectiveness. Students already come to EE centers for a range of environmental lessons, thus reducing transport costs associated with taking the EC units to the schools. Instructors at environmental learning centers are likely to be motivated by and committed to the program and style of presentation, making it program-effective. The program is context-effective in the sense that it fits in with the curriculum needs of public schools and environmental centers.

A resource guide accompanies the Energy Cycle, and consists of a manual, a poster, and a video tape. The NCAEC produced the manual, which is comprised of Energy cycle assembly and transport instructions, as well as eight activities which involve students in learning the concepts of energy conversion, efficiency, peak shaving, energy storage, the value of electricity, and transportation. A color poster also illustrates the cycle of energy, linking the sun to plants, fossil fuels, hydro power and eventually to the electrical bulbs that light up on the display panel. Demonstrations of the activities and components of the Energy Cycle are included in the videotape.

Project Objective

The overall goal of the project described in this paper was to evaluate the effectiveness of the Energy Cycle Education Program lesson plan in promoting participants' awareness, positive attitudes, and behavioral intentions regarding energy resources and conservation practices. The hypothesis was that students would demonstrate increased knowledge of energy issues, more positive attitudes, and stronger behavioral intentions toward energy conservation. The study incorporated the perspectives of grade school students, their teachers, and the Energy Cycle Program instructors. Recommendations, based on the study's results, will be developed to guide program improvements at CWES and to assist other EE centers in utilizing the Energy Cycle Program. An evaluation process was developed to assess the effectiveness of the Energy Cycle education activities relative to fifth and sixth grade students who participate in the Energy Cycle education activities at CWES, classroom teachers who accompany participants during Energy Cycle programs, and Energy Cycle instructors at participating EE centers.

The evaluation process included the following steps:

1. formation of an Evaluation Advisory Committee
2. research design selection
3. study sample selection
4. description of treatment (Energy Cycle lesson activities)
5. Energy Cycle instructor training
6. student test and questionnaire development
7. description of test administration process
8. Teacher questionnaire development
9. Energy Cycle instructor questionnaire development

This paper will focus on steps number 1-6. This paper will not address student, teacher, or Energy Cycle instructor questionnaire development or results.

Methods

Evaluation Advisory Committee Formation An Evaluation Advisory Committee was formed to guide and develop the evaluation process. They assisted in preparing the evaluation plan and the research design, by reviewing test and questionnaire content and administration procedures for student tests and teacher questionnaires, and by overseeing the analysis of results. This committee was made up of UW-SP faculty, directors of environmental education centers, and WDSD staff.

Research Design Selection The Solomon Four-Group experimental design was used in this project. It was chosen because of its strength in controlling both external and internal variables, including its ability to measure the effect of the Energy Cycle education activity treatment while controlling for pretest influence. In the Solomon 4-Group design, subjects to be tested are randomly assigned to one of four groups, as shown in Figure 1. Two of the groups receive treatment (the Energy Cycle lesson), and two serve as control groups. In addition, two groups (one treatment and one control) receive pre- and post-tests, while the other two groups receive only post-tests. This design allows for an analysis of the influence of pretesting in addition to measuring the main impact of treatment.

	Pretest	Treatment*	Posttest
Group 1	o	x	o
Group 2	o		o
Group 3		x	o
Group 4			o

*Treatment = participation in the Energy Cycle lesson

Figure 1. Solomon 4-Group Design

In the WECEP groups 1 and 2 were scheduled to take the pretest 10-14 days before their visit to CWES and take the posttest 10-14 days after their visit. Groups 3 and 4 took the posttest 10-14 days after their visit. Two of the schools in group 2 had longer posttest gaps. Test results indicate that the increased posttest gap did not effect performance.

Study Sample Selection. A list of potential groups to include in the study was developed by considering all school groups scheduled for environmental education activities at the Central Wisconsin Environmental Station during the study period of September 1994 through May 1995. Selection of schools was stratified to include certain grade levels and group sizes. Only school groups that were scheduled to attend CWES for a regular program were selected. An attempt was made to choose groups from a variety of locations including urban and rural settings. Classroom teachers of participant groups were contacted by phone. The details of the study were explained and teachers were asked if they would participate in the study.

Participating school groups were assigned to research groups. Where possible, assignment to groups was random. Reasons for non-random assignment to groups included time constraints and a teacher's desire to keep to their pre-arranged lessons at CWES. Non-random assignment was only an issue in 3 out of 14 cases. Grade levels were not balanced among the different groups as much as desired due to time constraints. Participant selection began too late in the semester to change some of the groups' course selections. This resulted in a greater percentage of 5th grade students in the control groups and a greater percentage of 6th grade students in the treatment groups. This process resulted in 818 total participants from 14 different schools participating in the study (see Table 1).

Table 1. Student Participants in WECEP

	Grade	Number of Participants
Group 1 (3 schools)	5	0
(experimental)	6	258
	Total	258
Group 2 (4 schools)	5	0
(control)	6	145
	Total	145
Group 3 (5 schools)	5	57
(experimental)	5/6	24
	6	176
	Total	257
Group 4 (3 schools)	5	52
(control)	6	108
	Total	160

Treatment (Energy Cycle lesson activities) Description. The Experimental Treatment consisted of having students participate in the Energy Cycle lesson plan activities at CWES. Learning groups consisted of 10-15 students. As is typical of school programs at CWES, groups of students rotated through the Energy Cycle lesson along with their other scheduled lessons. Total exposure time of the Energy Cycle lesson varied from 1 hour to 1 1/2 hours depending on school schedule. Energy Cycle instructors filled out data sheets for each student group to track exposure time, number of student participants, student demographics and the energy education concepts taught during each lesson.

Energy Cycle Instructor Training. A training program was developed to educate instructors at CWES on how to use the Energy Cycle and teach the lesson. The training program was very important to assure consistency in the way instructors taught the lesson (i.e. treatment consistency). Training goals for Energy Cycle instructors were to have knowledge of how the Energy Cycle unit works in order to operate the units and trouble shoot potential mechanical problems, to have a clear understanding of the learning activities that have been developed for use with the Energy Cycle, to gain a solid background and understand the energy concepts involved in the Energy Cycle lesson, and to understand their role in the evaluation process.

CWES Instructors were trained in how to teach the Energy Cycle lesson at the beginning of each semester. Training included a 1 hour lesson in working with the Energy Cycle units during staff training weekend, observing the Energy Cycle lesson being taught to school groups by an experienced Energy Cycle instructor, teaching the Energy Cycle lesson while being observed by an experienced Energy Cycle instructor, finally, teaching the lesson on their own. The instructors were given the CWES Energy Cycle lesson plan and data sheet along with other handouts on operation of the Energy Cycle, concepts to teach during the lesson, and general background information on energy to enhance their lesson.

Student Test and Questionnaire Development. A primary focus of this project was to assess the effectiveness of the Energy Cycle lesson plan activities by measuring the lesson's impact on students. To accomplish this goal, a test was developed to measure changes in students' knowledge, attitudes and behavioral intention. Questionnaires for students, teachers, and Energy Cycle instructors were also developed to determine such things as how much students liked the lesson and if their teachers felt it was valuable. To assure that the tests were valid and reliable, the test development process required several steps and involved input from the Evaluation Advisory Committee. These steps included:

1. create a test development plan
2. select energy concepts to be included on the tests
3. form a conceptual matrix to ensure representation of all selected concepts and domains on the Energy Cycle test
4. develop test questions
5. address the issues of validity and reliability
6. evaluate the test
7. develop testing procedures

Energy Cycle Test. The Energy Cycle test was designed to measure students' changes in knowledge, attitudes, and behavioral intention. A "test development plan" was created to guide the process of creating tests which would measure student knowledge, attitude, and behavioral intention related to energy. The plan covered several issues such as selection of content to be tested, number and style of test items, and validity and reliability.

Key lesson concepts to be included in the test were identified by the WECEP coordinators by reviewing the lesson plan check sheet and an associated list of concepts previously put together by the WECEP Advisory Committee. The eleven concepts chosen to be included in the tests are listed in Figure 2.

A conceptual matrix (Figure 2) was formed to ensure that all eleven concepts were adequately covered by the test items. In the knowledge subtest, there were 1-2 items for each concept. The attitude subtest, however, focused only on the four concepts most directly related to attitudes. The behavioral intention subtest focused exclusively on the concept of "good energy habits".

Energy Cycle Concept	Number of test items in each Domain		
	Knowledge	Attitude	Behavioral Intention
Value of electricity	3		
Electricity production	2		
Renewable/non-renewable	2	2	
Environmental impact of energy production	2		
Energy conservation lessens negative environmental impacts	1	4	
Efficiency levels of lighting	1	4	
Appliances that produce heat use large amounts of electricity	3		
Energy conversion	1		
Energy is lost during conversion	2		
Demand-side management	1		
Good energy habits	2	5	9

Figure 2. Conceptual Matrix of Energy Cycle lesson plan concepts and test items

Initially a large pool of test items was created to cover all concepts and the three domains. From this pool, thirty-eight test questions were selected by the committee, using a blank matrix as a guide. A variety of test question types were utilized. The number of items to be included in the test was determined, in part, by the amount of student time available for taking the test, student attention span (5th and 6th grade level), and teacher imposed time limits. The test was designed to last 20 minutes, not including instructions.

The validity and reliability of the test items were examined using a procedure suggested by Roggenbuck and Passineau (1986) This procedure was mostly concerned with content validity, which referred to the degree to which the Energy Cycle test actually measured the content and concepts of the Energy Cycle lesson. Roggenbuck and Passineau (1986) in their evaluation of an Environmental Education program at the Indiana Dunes National Lakeshore list 4 steps for the development of a measurement instrument to insure content validity:

1. Specify, through instrument definitions and detailed lesson plans, the domains to be assessed.
2. Develop test items which represent or sample these domains.
3. Rationally analyze the correspondence between the items and the specified content domains.

4. Utilize the judgment of a "panel of subject area experts" to review the adequacy with which steps 1 to 3 have been accomplished.

The test development methods, items, and full tests were evaluated by the Evaluation Advisory Committee. Committee members were asked to rate the validity of each test item and the test as a whole. The results of their evaluation were reviewed and the test was modified. The committee was also asked to review the items and tests as a whole to determine age level appropriateness and general clarity of the questions. Based on the recommendations of the evaluation advisory committee, a final version of the test was developed.

A preliminary pilot test was administered in two 5th grade and two 6th grade classrooms in May 1994. All four classroom groups attended CWES programs during the spring 1994 semester. One of the 5th grade and one of the 6th grade classes participated in the Energy Cycle lesson. The other two did not.

The test was revised based on the results of the pilot test and suggestions from the Committee. The final test had 39 total questions, 16 for knowledge, 14 for attitude, and 9 for behavioral intention. Eleven of the questions were semantic differential, 7 were likert-type, 12 were multiple choice, 3 were true-false, 4 were forced choice, one was open-ended, and one was matching. This test was designed to be administered to both treatment and control group study participants as a pre-and post-test.

Administration of Formal Tests. Test administration procedures and clear instructions were developed to control for variance in test administration and testing conditions. The test was administered to participating school groups between September 1994 and March 1995. Pretest materials were sent to classroom teachers included in Groups 1 and 2 of the Solomon design. Posttest materials were given to classroom teachers in all groups of the Solomon design during their visit to CWES. Specific instructions regarding test administration were mailed to teachers along with the tests. To standardize administration procedures teachers were instructed to read a specific test instructions sheet to the students twice and to not answer any questions or give further instructions.

Evaluation Findings

The evaluation of the study's findings began with the examination of the overall indicators of attitude, knowledge, and behavioral intention, and the aggregate responses to all questions for each indicator. All questions were scored on a scale of zero to five, with higher scores representing a more desirable (or correct) response.

A comparison of simple mean pre- and post-test scores by school for the three factors (attitude, knowledge, and behavioral intention) suggests that the energy cycle unit had a significant impact on attitudes and knowledge, but not on behavioral intention. The post-test scores for attitude and knowledge were generally higher for schools in the treatment group compared to the control group. For the schools with pre- and post-tests (Groups 1 and 3), all of the eight treatment schools showed a significant increase in attitude and knowledge, while none of the seven control schools showed a significant change. None of the schools, treatment or control, showed significant changes in scores for behavioral intention, however.

In addition, taking the pre-test did not appear to have any noteworthy impact on posttest scores. Note that Group 3, which received the energy cycle unit but did not receive a pretest had elevated posttest scores for attitude and knowledge just like Group 1, which received a pretest. And posttest scores for the two control groups (Groups 2 and 4) were comparable.

More detailed analysis tended to confirm these "first blush" findings. Specifically, the analysis included a model of posttest scores as a function of treatment, as well as possible sensitization and practice effects that might arise from pretesting. The model had the form

$$S_{post} = ß_1 D_t + ß_2 D_{pre} + ß_3 D_t D_{pre} + ß_4 + e$$

where: S_{post} is the posttest score;
D_t is a dummy variable for participation in the energy cycle unit (1=yes, 0=no);
D_{pre} is a dummy variable for whether a pretest was administered (yes=1, no=0);
C is a constant; and,
e represents random error.

In this formulation, the items of interest are represented by coefficients that represent departures from the overall average posttest score (that is itself captured in $ß_4$). The coefficient $ß_1$ represents the main effect that participation in the energy cycle unit has on the posttest score; in other words the change in posttest score that is correlated with having received the energy cycle unit. The coefficients $ß_2$ and $ß_3$ represent possible effects from pretesting. The first, $ß_2$, represents a "practice" effect; i.e, students do better on the post test just by virtue of having taken the pretest. The second, $ß_3$, represents a "sensitization" effect, in which students are more aware of (or sensitized to) the lesson in the energy cycle by virtue of having been exposed to the pretest before the unit.

The results of running this model for the three indicators are shown in Table 3, along with measures of statistical significance.

Table 3. Results of Evaluation Posttest Model

Coefficient (and t-statistic)	Attitude	Knowledge	Behavioral Intention
B_1 (energy cycle effect)	+0.37 (7.0)*	+0.52 (7.6)*	+0.09 (1.1)
B_2 (pretest practice effect)	-0.05 (0.8)	+0.09 (1.2)	+0.25 (2.6)*
B_3 (pretest sensitization effect)	+0.17 (2.2)*	+0.13 (1.3)	-0.41 (3.3)*
B_4 (constant)	+3.55 (84.5)*	+2.52 (46.7)*	+3.09 (45.0)*
Additional model statistics:			
n	822	809	817
adjusted r^2	0.15	0.16	0.01

* = statistically significant at p<95%

The most striking results in the table are the large, positive coefficients on the energy cycle variable ($ß_1$) for attitude and knowledge, along with highly significant ($p<0.01$) t statistics. The pretest effects are much smaller in magnitude, and are mostly not statistically significant, suggesting that the influence of pretesting on the results is negligible.

The above model is predicated on the assumption that the groups did not differ significantly in their pre-test scores (one would expect higher pretest scores to be associated with higher posttest scores). When the two groups who received pretests are compared, however, (Groups 1 and 2) it is shown that they are not equivalent (Table 4). Constraints of the study did not allow for the comparison of individual student pre and posttest scores. Researchers were therefore unable to use Analysis of Covariance to control for the effect of pretest differences.

Table 4. Comparison of pretests scores between groups

Mean pretest score, with 95% conf. Interval	**Attitude**	**Knowledge**	**Behavioral Intention**
Group 1 (treatment)	3.66	2.80	2.97
Group 2 (control)	3.47	2.57	3.27
t-test for difference	3.66	3.47	3.59

Group 1 has significantly higher pre-test scores for the attitude and knowledge indices than Group 2, and a significantly lower score for behavioral intention. Investigating further, we found that grade level was not evenly distributed among the groups, as Table 5 below shows.

Table 5. Grade level of participants by group

	Fifth Grade	**Fifth/Sixth Grade Mixed**	**Sixth Grade**
Group 1 (n=260)	0%	0%	100%
Group 2 (n=147)	71%	29%	0%
Group 3 (n=257)	22%	9%	69%
Group 4 (n=160)	32%	0%	68%

In particular, Group 1 is entirely composed of sixth graders, while Group 2 is dominated by fifth graders. It could be this simple difference in grade composition that explains much of the differences in pre-test scores.

Unfortunately, the data are structured such that there is no way to completely disaggregate separate effects of grade, pre-test score, whether or not the student was pre-tested, and the effect of the energy cycle unit itself. The major limiting factor is that one cannot simultaneously correct for pretest scores and also test the effect of having a pretest. However, the results are also limited by the inability to link pretest and posttest results for individual students.

If the possible effect of taking a pretest is neglected, analysis of the mean change in score for Groups 1 and 2 can be conducted. The results, shown in Table 6, suggest that despite differences in the pre-test scores, there was a substantial and statistically significant increase in attitude and knowledge for students in the treatment group that did not occur in the control group. Also, there was no significant change in the behavioral intention score for either group.

Table 6. Analysis of pre and posttest scores

	Group	Pretest Score	Posttest Score	Change
Attitude	1	3.66	4.04	0.38
	2	3.47	3.50	0.03
Knowledge	1	2.80	3.27	0.47
	2	2.57	2.62	0.05
Behavioral Intention	1	2.97	3.03	0.06
	2	3.27	3.34	0.08

Overall, the results indicate that the energy cycle unit did result in an increase in attitude and knowledge, but not behavioral intention. The confounding influence of grade and the structure of the data make it difficult to quantify the degree of this impact, however.

An analysis of the results for individual questions reveals that nearly all of the aggregate effect on attitude and knowledge came from questions that had to do with incandescent versus compact fluorescent lighting. Presumably, the hands-on demonstration of the difference in energy use between the two types of bulbs made a more lasting impression than did more general lesson items that were not directly connected to the energy cycle demonstration.

The behavioral intention section contained several questions that were aimed at the energy implications of student's lifestyle at home:

- I let the water run until it gets hot before I wash my face and hands.
- I turn off lights in the house when they are not needed.
- I use an electric blow dryer to dry my hair.
- I leave the refrigerator door open while I decide what to eat.

Students circled one of the following answers that best described their actions in these situations: always, almost always, sometimes, almost never, and never.

There were no differences in scores between students in the treatment and control groups for any of these items. Apparently, the energy cycle lesson did not lead to short term changes in behavior in these areas.

There was one behavioral intention question that did exhibit a significant change. This was also a question dealing with lighting:

You go to the store with your parents to buy light bulbs. You find incandescent light bulbs that cost $1 and compact fluorescent light bulbs that cost $10. Would you encourage your parents to buy:

all compact fluorescents
all incandescent bulbs
some of each

For this question the proportion of students who chose (a) increased from 32% to 47% among students in the treatment group, but remained at about 22% for students in the control group.

Summary and Conclusion

In summary, the data from the evaluation indicate that the Energy Cycle lesson treatment was successful in increasing students' knowledge about energy concepts. Additionally, students who participated in the treatment groups had increased positive attitudes toward energy conservation. These changes were specifically linked to the Energy Cycle activities that revolved around the efficiency levels of different types of light bulbs. This finding can be explained by several factors, including how the Energy Cycle lesson was taught, the content of the Energy Cycle lesson, and the interactive nature of the light bulb activities.

First, the light bulb activities using the Energy Cycle were consistently taught across all lessons and by all Energy Cycle instructors. The instructors tended to focus their lesson on the concepts related to lighting over the other information taught by the lesson. Instructors noted that they had more background understanding of this material, and felt more comfortable teaching about the efficiency of different light bulbs than some of the more complicated energy concepts (such as energy conversions, and production). The instructors also felt that the students were more responsive to the light bulb activities than the other portions of the lesson.

Second, the Energy Cycle lesson contained several activities that involved the use of the light bulbs on the display board. This replication tended to reinforce the concepts relating to the efficiency of different lighting options. By contrast many of the other concepts were taught only once by a single Energy Cycle activity.

Finally, the light bulb activities taught by the Energy Cycle lesson were one of the most engaging and hands-on portions of the lesson. Students were involved in many areas including riding the Energy Cycle, feeling the heat of different light bulbs, and competing to see who could light the most bulbs. Other portions of the lesson tended to involve fewer students, and less activity.

The data from this study also shows that there were no significant differences in the behavioral intentions of the experimental and control groups following their participation in the Energy Cycle project. This finding is consistent with other research studies in the field of environmental education which indicate that the behavioral intentions of students are difficult to measure, and often do not seem to follow gains in knowledge and attitudes (Carlson 1995, Simmons 1991). Further research needs to be conducted in this area to identify the barriers to changing student behavior.

In conclusion, the Wisconsin Energy Cycle Education project provided a good first step toward educating elementary students about energy concepts and energy conservation. It addressed the need identified by the literature for more hands-on engaging activities to teach about this topic. It also supported the findings of prior research which suggested that hands-on learning could be effective for teaching complex concepts. The project is currently being incorporated into a larger K-12 grade energy education curriculum that will be implemented in Wisconsin over the next two years. As a part of this project the Energy Cycle equipment and lesson will be updated to address some of the limitations that were identified by this study. Additional research on the Energy Cycle should address such issues as: can the study be replicated in other settings with similar results, are there long-term effects of the Energy Cycle program on student knowledge and attitudes, how can the lesson be modified to improve students' behavioral intentions toward energy conservation, and how can the evaluation of the program be improved to better capture the changes that occur among students.

References

1. Barrow, Lloyd H. and Constance C. Holden. "Validation of the test of energy concepts and values for high school." *Journal of Research in Science Teaching* 21(2):187-196. 1984
2. Bennett, Dean B. "Evaluating environmental education programs". *Environmental Education*, eds. William B. Stapp and James A. Swan. New York: Sage Publications. 133-164. 1974
3. Campbell, Donald T. and Julian C. Stanley.. "Experimental and Quasi-Experimental Designs for Research" Chicago:Rand Mc Nally & Co. 1963
4. Frantz, Ron.. "Lessons from the NEED project". *Social Education* 56(1):30-32. 1992
5. Glass, Lynn W. "Wanted: more student involvement activities in energy education". *School Science and Mathematics* 84(8):644-648. 1984
6. Lenssen, Nicolas. "Empowering Development: The New Energy Equation", *Worldwatch Paper 111* Washington D. C.: Worldwatch Institute. 1992
7. Leon, Warren. "The return of energy education". *Social Education* 56(1):20 1992
8. Marker, Gerald W. "Has the time come to revive energy education?" *The Social Studies* 82 (n5):183-187. 1991
9. Roggenbuck, Joseph W. and Joseph F. Passineau. "An Evaluation of the Effectiveness of the Bailly/Chellberg Interpretive Program" Indiana Dunes National Lakeshore, National Park Service. 1986
10. Rohwedder, W. J. and Leeann Tourtillott eds. "Environmental Education Compendium for Energy Resources" California: California Energy Extension Service in the Governor's Office of Planning and Research. 1992
11. Sherman, Robin and Kim Stone. "Resources for teaching about energy in the social studies classroom". *Social Education* 56(1): 27-30. 1992
12. Sivek, Daniel J. "An Analysis of Selected Predictions of Environmental Behavior of Three Conservation Organizations" Southern Illinois University - Carbondale. 1987
13. Wellnitz, Thomas R."An energy activity sampler." *Social Education* 56(1):24-26. 1992