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Evaluation of an energy conservation program for 9th grade students

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The Energy Challenge is an environmental education program that is administered to ninth grade students in the public schools of a small Midwestern city in the United States. The program is sponsored and administered by the two local electric utilities, and it has been going on for seven years. To determine the effectiveness of the program, a pretest-posttest mail survey of students and parents was performed. The results suggest that the Energy Challenge has a positive effect on improving knowledge, motivation, and behavior of students concerning home energy usage and conservation.

Key Words: environmental education, energy conservation, junior high school

Introduction

Energy has become one of the most important commodities in the world, and unlike some other resources, our current energy resources truly are nonrenewable (for a primer on the issue, see Chiras, 2010). The coal, oil, natural gas, and uranium that fuel our lifestyle will not be regenerated in our lifetimes, or 100 lifetimes for that matter. Thus, energy conservation should be a very highly ranking social priority.

To meet this need, an educational intervention was developed to teach children about how their homes use energy and how they can conserve energy. This program is called the Energy Challenge, and it is a joint effort between two local utility companies and the public schools that is now seven years old. This report describes an evaluation of the Energy Challenge program.

Overview of Environmental Education Studies

The main purpose of environmental education is to help create a citizenry that adopts responsible environmental behaviors (many authors have noted this point, it is perhaps first attributable to Stapp, et al., 1969, and it is also an important component of the Belgrade charter, 1975), and we are currently in the middle of the United Nation's Decade of Education for Sustainable Development, which runs from 2005 to 2014. There have been many attempts to develop educational interventions with the purpose of promoting responsible environmental behavior (for reviews, see Boerschig & De Young, 1993; Leeming, Dwyer, Porter, & Cobern, 1993; Zelezny, 1999). In general, these educational programs are reasonably effective. In quantitative terms, for 13 classroom interventions, Zelezny found effect sizes ranging from r = .15 to .88 for reported behavior, with .63 being the median. These reviews have combined a wide variety of

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environmental education programs on many different topics (e.g., ecology and nature, recycling and waste, pollution, water conservation), but none of them have focused on energy conservation specifically.

In fact, surprisingly few reports of educational programs that focus on energy conservation have appeared in the literature in the last 10 years. We know of only one study that evaluated energy conservation programs (Zografakis, Menegaki, & Tsagarakis, 2008). These researchers used a pre-post design, and they asked children and parents to self-report on their environmental behaviors. These data showed that the programs were effective at producing behavior changes. However, the researchers did not evaluate one single program; rather, they looked at changes in self-reported behavior across one year for students in primary, junior high, and senior high schools who had been exposed to some kind of energy conservation information during the school year.

Some environmental education programs are designed to specifically capitalize on the ripple effect wherein children learn the lessons in school and then carry the message home to their parents and other family members (as described below, this is one of the goals of the Energy Challenge program, too). Duvall and Zint (2007) reviewed ten environmental education programs that focused specifically on using children as the agents to influence adults. These programs were diverse in terms of age of the children (K-12), length of the program (1.5 hours to 1 year), and topic of the program (e.g., water pollution, endangered species, water and land use, local environmental issues). Of these ten studies, six used a pretest-posttest design (as we have done), and nine of the ten conducted the posttest at the completion of the program (the only exception being Vaughn, Gack, Solorazano, & Ray, 2003, who administered a follow up survey 8 months after the program concluded). Duvall and Zint concluded that for intergenerational learning to occur the programs had to actively involve the parents and focus on local environmental issues. Similarly, Larsson, Andersson, and Osbeck (2010) discussed three theoretical perspectives on how children can influence their family's consumption.

The current report is unique in three aspects. First, it presents a unique educational program focusing on energy conservation that can easily be added to a science curriculum, and it formally evaluates the program for its effects on attitudes, motivation, knowledge, and behaviors. Second, in addition to assessing the learning that happens at the student level, this report assesses if the students are making an influence on their parents. Third, the effects of the program were measured four weeks after the program was over. Few evaluations of environmental education programs perform a follow-up this long after the program was completed.

Description of the Energy Challenge Program

The Energy Challenge program is administered in the ninth grade and is designed to fit in with the junior high school science curriculum. The regular science curriculum has a component on energy, and after the students have completed this component of the curriculum, the Energy Challenge happens in five steps. First, students take home permission slips to be signed by the parents that allow the utility companies to use current data on energy consumption from the students' homes.

Second, volunteers from the utilities visit the classrooms for a one class period intervention that has four parts: 1) an overview of energy in terms of where it comes from and how much it costs, 2) an analysis of how energy is used in the home, including a discussion of which appliances use large amounts of energy, 3) a hands-on demonstration of a home furnace that focuses on how to make the furnace operate efficiently, and 4) a demonstration of an infrared camera that shows how a home loses heat through conduction and infiltration.

The third step of the Energy Challenge is for the students to take home and complete a home energy audit. In doing this audit, the students determine many aspects of their house that influence energy use: the number of windows and doors, the area of the house, the temperature of the water heater, the flow rate of the showers, the types of fuel used by the house, etc. The students enter this data into a computer program that is pre-programmed with their actual energy consumption data, and a report is generated that breaks down their energy use into major sectors (heating, cooling, water heating, and appliances) and compares their usage to other homes.

Fourth, the volunteers return to the classrooms about two weeks later for a follow-up session. This session features an interactive game where the students work in small groups to correctly answer questions about information that was presented in the first session. The context of the game is that the students are moving out on their own and they need to find an apartment that will have affordable energy bills. Each group of students is given $850 at the start of the game, and then they have to "pay the bill" after each question, with correct answers costing them less than incorrect answers. At the end of the game, the students receive small prizes proportional to how much money they saved.

The fifth step is for the students to take home the report of the energy audit, discuss it with their parents, and bring back a note signed by the parents. Students receive a small gift for bringing the signed forms back to the teacher.

This program was run in a small Midwestern city's junior high school classes. This community has just under 100,000 residents (81% white, 11% African-American, and 26% of the households had at least one child under the age of 18), a national cost of living 92% of the US national average, and a median family income of $52,000. The school district has three junior high schools that serve about 2500 students in total. The program was administered in the ninth grade science classes; each of the junior high schools had 6-10 science classes, and the science classes have 20-30 students enrolled in them.

Although the school district was very supportive of the Energy Challenge program, they did not allow the researchers to collect the data in class using class time. However, the administrators did feel that an evaluation was appropriate and important, so they permitted a mail survey to be done. While a mail survey has several drawbacks (the most notable is that there is no way to ensure a representative sample of people return the survey), we felt that a mail survey was sufficiently effective for assessing if the program was meeting its goals.

Evaluation of the Energy Challenge

At an intuitive level, every effort has been made to ensure that the Energy Challenge is a well-designed educational intervention. As such, the Energy Challenge should be an effective method for promoting conservation behavior. Indeed, this is what the teachers and students report anecdotally.

We endeavored to undertake a formal evaluation of the Energy Challenge. Specifically, our hypotheses were that students' knowledge of home energy use, attitudes towards conserving energy, motivation to engage in conservation behaviors, and actual performance of conservation behaviors should all increase as a result of participating in the Energy Challenge program. Further, the study design afforded the opportunity to collect data about parents' attitudes, intentions, motivation, and behavior. However, since parents are less involved in the Energy Challenge, we formed no a priori hypotheses about the effects of the Energy Challenge on these variables. Naturally, we hoped that we would see positive changes in these variables.

Previous research has indicated that both knowledge and attitudes are likely to be important factors in changing environmental behavior (for reviews, see Bamberg & Moser, 2007; Hines,

Hungerford, & Tomera, 1987; Kazdin, 2009; Steg & Vlek, 2009). However, another important factor that has not received much attention in the environmental education literature is motivation. The Belgrade Charter (1975), considered the defining document of environmental education, specifically mentions "motivations" as one the key concepts that environmental education should target. Self-determination theory (Deci & Ryan, 2000, 2002, 2009; Reeve, Ryan, Deci, & Hyungshim, 2008) provides a useful theoretical starting point.

Briefly, self-determination theory proposes that there are four kinds of motivation that fall along a continuum ranging from completely controlled by other people to completely determined by the self. Two kinds of motivation are more or less controlled by other people, namely *external* (the motivation to engage in the behavior is to receive external contingencies) and *introjected* (the motivation is to avoid feelings of guilt or shame). In contrast, two kinds of motivation are determined by the self, namely *identified* (the motivation is to act in accordance with personal values and beliefs), and *intrinsic* (the motivation is to do something that is challenging or pleasant). The theory posits that behaviors that are perceived to be determined by the self are more likely to be freely initiated and maintained (Osbaldiston & Sheldon, 2003; Seguin, Pelletier, & Hunsley, 1999). Conversely, those behaviors that feel controlled or determined by other people are not likely to be freely engaged in. Thus, fostering a sense of self-determined motivation (either identified or intrinsic motivation) is likely to be an important component of the goal of creating a citizenry that adopts responsible environmental behaviors.

Method

In order to test the effectiveness of the Energy Challenge program, we used three methods. First, feedback was sought from parents and students. Second, a mail survey incorporating a pretest-posttest design was administered to students and parents. Third, we also compared actual household electricity records, but this is discussed below in the Discussion section.

Feedback from Participants

Feedback about the program was sought from both students and parents who participated in the Energy Challenge program. Because providing feedback was optional, it was not possible to draw a random sample of these participants, so a convenience sample was used.

Researchers approached the participants and asked for feedback on the program. Because most participants freely offered information, a structured interview would have been inappropriate, but the information that was collected centered around three questions: did the students seem to enjoy the Energy Challenge, did students seem to learn anything from the Energy Challenge, and did the students seem to change their behaviors as a result of the Energy Challenge?

Mail Survey of Students and Parents

Sample. One of the three junior high schools was selected to be sampled. The pretest was mailed in March to a random sample of 400 homes of ninth grade students and their parents, and 170 sets of surveys were returned. In early April, the Energy Challenge program was delivered at the schools. The program only took two class periods, but those two periods were separated by two weeks. The posttest was mailed in May (four weeks after the program ended) to all homes that returned the pretest after the program had been completed, 65 sets of surveys were returned plus 3 additional student surveys were returned without parent surveys. In order to maximize the

return rate, all surveys were kept to one page in length. A coupon for free food (either french fries or ice cream) at local merchants was included as token of appreciation.

Student survey. For the students on both the pretest and posttest, the attitude measure was formed by averaging two questions, "How much do you care about saving energy?" and "How important to you is conserving energy?", to which students responded on a 7-pont scale ranging from *not at all* to *very much*. Knowledge was measured using four items that asked if students knew what kind of fuel their water heater uses, what kind of fuel their furnace uses, why an air filter should be replaced, and what the optimal setting for an air conditioner is. For each item, an incorrect answer (or "don't know") was given a score of 0 and an appropriate answer was given a score of 1; the four items were then summed to form a knowledge score. Motivation was measured using a variation of the perceived locus of causality scale (Ryan & Connell, 1989) that asked students to rate four reasons for why they engage in conservation behaviors. These four reasons were "Because I'm expected to, or my parents might disapprove if I didn't" (external), "Because I make myself; I'd feel guilty if I didn't" (introjected), "Because I feel it is important or valuable to do these things" (identified), and "Because I enjoy the challenge of doing these things" (intrinsic), and they were rated on a 5-point scale ranging from *not at all* to *very much*. Finally, behavior was assessed by asking two questions about how much effort students made to either turn off lights or take short showers. Students responded using a 7-point scale ranging from *not at all* to *very much*.

In addition to the above items, the posttest asked students what they thought of the Energy Challenge by using 7-point Likert scales with the anchors *liked it*, *good*, and *helpful*, all of which were associated with low numbers. The posttest also asked the students how much effort they put into the Energy Challenge with a 7-point Likert scale anchored by *a great deal* at the high end.

Parent survey. For the parents, attitudes were measured by asking how important conserving energy is to them, intentions were measured by asking how likely they are to make changes to their home or lifestyle that will save energy, and motivation was measured with questions similar in wording to those used for the students. Attitudes were measured on a 7-point scale ranging from *not at all* to *very much*, and motivation and intentions were measured on a 5-point scale.

Behavior was measured in three ways. A general, *global* measure of conservation was assessed by asking how actively parents try to conserve energy at home. Two items asked about *specific* efforts to turn off lights and take short showers. An item in the posttest survey asked if they had followed through on any of the Energy Challenge *recommendations*. Both the general and specific items were measured on a 7-point scale, and the recommendations item was a categorical yes/no question. The posttest also asked parents what they thought of the Energy Challenge by using 7-point scales anchored at the low end by *good*, *helpful*, *effective*, *useful for students*, and *useful for parents*.

Results

Feedback from Participants

The parents and students were asked for feedback about the program, and the responses to the program were very positive. Students reported enjoying their participation in the program. The class sessions were lively and active, and students were highly engaged in the learning process. Especially during the game, students whispered excitedly among themselves with the answers to the questions and were joyful when they got the answers correct.

In terms of learning about energy conservation, the feedback was also positive. Students reported that the home energy audit, where they examined their home for all sorts of features,

made them realize how electricity was used in the house. Comments from students included "When you think about electricity, you think about lights and the TV, you don't think about the furnace and the water heater," "I didn't know where electricity came from. I thought it was just in the house and we always had it," and "I didn't know we had to pay for electricity." Clearly, the program helped students gain a greater understanding of what happens in their houses.

One of the goals of the program was to educate people about the importance of cleaning the filter in the furnace and central air conditioner so that it operates efficiently. Many parents reported learning about this from their children. Several parents reported increased awareness of the need to do this, including comments like "I thought you only needed to do that once a year," "I didn't know you could buy replacement filters at the grocery store," and "I really don't know when the last time—if ever—we changed those filters."

In terms of engaging in conservation behavior, the feedback was positive. When we asked students if they were going to start doing the conservation behaviors, they all reported that they would. One parent said, "My daughter is always getting on me to turn off the lights," and another said, "We're all much more aware of our consumption because of this program."

There were some negative comments. One parent said, "You're always pushing energy conservation, but when we do all these things, it doesn't change our bill." Another said, "All these recommendations are just the same things I always hear, there is no new information here." Finally, one parent objected to the fact that we provided coupons for what she perceived to be junk food as incentives for participating in the survey.

Mail survey: Students' and parents' attitudes toward the program

Recall that a survey was mailed to both parents and students both before and after the program. The posttest asked students about their attitudes toward the Energy Challenge. For the *liked it*, *good*, and *helpful* items, the means (and standard deviations) were 3.7 (1.7), 3.1 (1.4), and 3.1 (1.8), respectively. These means were all less than the mid-point of 4 and lower values indicated more positive feelings. Students also reported putting in a good amount of effort, the mean (and standard deviation) was 4.5 (1.5), where *a great deal* was the anchor at the high end of the 7-point scale.

While the students seemed to enjoy the program, the parents had even better things to say about it. For the *good*, *helpful*, *effective*, *useful for students*, and *useful for parents* items, the means (and standard deviations) were 2.6 (1.4), 2.8 (1.6), 3.1 (1.5), 2.6 (1.7), and 2.7 (1.7). These means were all toward the positive end of the scale and suggested that parents think the program has merit.

Pretest-posttest comparisons

This quantitative aspect of this research was a pre-post design. We entered the data from all the returned surveys into SPSS, and we used a correlated groups t-test to infer if there were changes in the students' knowledge, motivation, and behaviors as a result of participating in the Energy Challenge.

The Energy Challenge had positive effects on students' knowledge, motivation, and behaviors. These results are summarized in Table 1. Specifically, knowledge, identified motivation, and behavior all show statistically significant increases in the posttest survey based on the correlated groups t-test, $SE = .14$, $t(67) = 3.64$, $p < .001$, $SE = .15$, $t(67) = 2.79$, $p = .007$, $SE = .17$, $t(67) = 3.31$, $p = .001$, respectively. Table 1 also presents the effect size r and these values can be compared directly to those reported by Zelezny (1999).

Table 1. Comparisons of Means for Students at Time 1 and Time 2

Items	T1[a]	T1[b]	T2[b]	*r*
Attitudes[c]	4.69	4.70	4.91	0.16
Knowledge[d]	2.16	2.32	2.80*	0.41
Motivation				
External[d]	2.61	2.79	2.76	0.03
Introjected[d]	2.56	2.53	2.71	0.15
Identified[d]	3.15	3.07	3.47*	0.34
Intrinsic[d]	1.72	1.91	2.05	0.14
Behavior[c]	3.75	3.49	4.05*	0.37

[a]This column reports the means for all participants returning the time 1 survey, n = 170.
[b]These columns report the means only for students returning both the time 1 and time 2 surveys, n = 68.
[c]These items are measured on a 7-point scale.
[d]These items are measured on a 5-point scale.
*p<.01. To test differences between time1 and time 2, a correlated groups t(67) was computed.

Discussion

Effectiveness of the Energy Challenge

Overall, the Energy Challenge program has a positive effect. The feedback indicates that both students and parents enjoy the program and find it useful. It produces significant increases in knowledge, motivation, and energy conservation behavior in students. Unfortunately, there are no evaluations of similar programs with which the Energy Challenge can be directly compared. The major factor of the program that makes it non-comparable is the fact that it only uses two hours of in-class instruction time plus a small amount of outside of class time. No other interventions this brief are reported in the literature.

However, in keeping with the general pattern of research on the effectiveness of environmental education, the Energy Challenge produces comparable results to programs that have longer durations. Zelezny (1999) reported typical effect sizes in the range of r = .15 to .88, with .63 being the median, and Culen and Volk (2000) reported effect sizes of r = .24. The Energy Challenge had an effect size of r = .37 for the students' behavior. This result is particularly noteworthy since Zelezny found no other studies that had durations of less than 10 hours. Similarly, Culen and Volk reported on programs that lasted between 4 and 14 weeks and had effect sizes of r = .24.

Long Term Effects of the Energy Challenge

The indirect effects of the Energy Challenge may be even greater than the measured differences between the pretest and posttest. Both the students and parents reported feeling favorably to the program. Students who enjoyed the program as ninth graders will hopefully continue to enjoy learning about how energy can be conserved such that as they become adults they will carry forward some of these good habits. The significant increase in identified motivation suggests that

this is likely to happen. Recall that identified motivation, measured by the item "it's important or valuable to do (conservation behaviors)," showed an increase from the pretest to the posttest. The vast majority of research on self-determination theory convincingly shows a positive relationship between identified motivation and engaging in behaviors (Deci & Ryan, 2000, 2002, 2009; Reeve, Ryan, Deci, & Hyungshim, 2008), and two studies have documented this effect specifically for environmental behaviors (Osbaldiston & Sheldon, 2003; Seguin, Pelletier, & Hunsley, 1999). From this body of research, we can infer that if students continue to carry these internalized values with them as they become adults, then the effects of the Energy Challenge will be even greater than those quantified here.

The time period between the end of the Energy Challenge and the post-survey was about four weeks. We felt this length of time was sufficient to allow immediate effects of the Energy Challenge to subside, but was recent enough for students and parents to still remember the program and be able to comment meaningfully on it. Of course, how long the effects truly last is an important question. We believe that because we waited four weeks after the end of the Energy Challenge program, our results suggest that the effect of the program is relatively strong. Most programs are typically evaluated at the conclusion of the program. Specifically, Leeming et al. (1993) reviewed 17 environmental educational programs, and 14 of them conducted the evaluation immediately at the end of the program. Similarly, Duvall and Zint (2007) reviewed 10 studies, and 9 of them conducted the evaluation immediately at the end of the program. The fact that we waited four weeks is a strength of this research

An attempt was made to evaluate the Energy Challenge in terms of actual energy conserved over a period of one year. Electricity records were obtained from the electricity utilities for the year prior to and the year following the Energy Challenge for participants of the program. The results revealed no differences across time at the household level. There are several factors that could influence this result. First, the data were only available on the household level, and while each household included a child who had been through the Energy Challenge, there was no way to monitor the electricity consumption for that child. Although the Energy Challenge was designed to utilize the ripple effect, this ripple effect may not be strong enough to influence the conservation behaviors of everyone in the household. Second, conservation behaviors seem to be very difficult to promote in long-term, large scale ways, and most educational efforts only serve to act as a "drop in the bucket." While no drop has a measurable effect, eventually the bucket will be filled.

General Discussion

We began this article by noting that most of our current energy resources are not renewable. We acknowledge that alternative sources of energy (like hydrogen or wind) offer us hope, but we are not likely to replace large quantities of fossil fuels with energy from alternative sources in the next decade. What are our choices if we hope to avoid having the lights go out?

Conservation of the resources that we have is the cheapest and most effective strategy to extend our supply of fossil fuels. Environmental education through the school system is a key component of this strategy. Although the general idea of environmental education is nearly four decades old, using environmental education to promote energy conservation seems to be a relatively unexplored direction. Some research was done in past decades, but that stream has practically dried up in the 2000's, despite efforts to push the agenda like the United Nation's Decade of Education for Sustainable Development (UNESCO, 2011). Is the task of keeping the lights on too big for the educational system to tackle?

We think not. Programs similar to the Energy Challenge can be combined with or blended into existing lesson plans. These additions do not have to be time intensive; the Energy Challenge

uses only two class periods. Further, there are many examples of creative and interesting classroom activities that could be used (e.g., Lazaros, Spotts, & Verdon, 2010; Roman, 2008; Schnittka, Bell, & Richards, 2010; Toolin & Watson, 2010). Interested teachers could incorporate a program or combine pieces from different programs into their lesson plans with relatively little effort or investment. Some research has been done on training teachers how to teach about energy conservation (e.g., Farnsworth & Gardner, 1978; Summers, Kruger, Mant, & Childs, 1998).

In spite of this small investment, a simple program like the Energy Challenge can have a meaningful change on attitudes, motives, and behaviors. Of course, it is only a drop in the bucket—any attempt to address our staggering consumption of fossil fuels can only begin as a drop in the bucket—but we have documented how this drop in the bucket does have a ripple effect and is effective.

Limitations

The major limitation of this research is in the administration of the survey. Mail surveys are inherently limited by self-selection bias in that people who choose to reply to the survey are possibly those people who are more interested in the issues. Thus, there is every possibility that only those people who were influenced by the program chose to return the survey. This problem is particularly acute for the parents in the study. As with all intergenerational studies, parents are only volunteers and there is no way to be sure that a representative sample has been captured.

Another limitation of the mail survey was the number of respondents. Research of this type typically uses sample sizes of less than 80; of the 10 studies reviewed by Duvall and Zint (2007), only 2 studies used sample sizes that were greater than 80, and 4 studies used sample sizes smaller than 50. Although efforts were made to help ensure a high response rate (easy to complete form, a token of appreciation, self-addressed stamped envelope included, use of official letter head, use of reminder phone calls), the pretest response rate was 42% and the posttest rate was 40%. The small number of respondents is responsible for the study having low statistical power. For a dependent t-test with 68 participants and a difference between means of 0.3 and a standard deviation of 1.3, a one-sided test only has a power of .57. Thus, it is possible that some of the non-statistical results are due to Type II error rather than the Energy Challenge having no effect.

Energy conservation is a pressing need in our society. We have already seen wars being fought over energy resources, and future conflict seems likely as developed countries continue their unbridled use of non-renewable resources and less developed countries continue to strive for increases in standards of living. The amount of fossil fuels on earth is finite, and one of the easiest ways to ensure that there will be enough for everyone is to develop conservation behaviors. Programs like the Energy Challenge are the first steps in this direction.

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Dokuzuncu sınıflar için bir enerji koruma programının değerlendirilmesi

Bir çevre eğitim programı olan enerji mücadelesi Amerika Birleşik Devletleri'ndeki orta batıdaki küçük bir şehirde bir okuldaki dokuzuncu sınıf öğrencilerine uygulandı. Program iki yerel elektrik kuruluşu tarafından desteklendi ve uygulandı ve yedi yıldır süreç devam ediyordu. Programının etkiliğini belirlemek amacıyla öğrencilerin ve ebeveynlerin katıldığı bir öntest-sontest posta araştırması gerçekleştirildi. Sonuçlar enerji mücadelesinin öğrencilerin ev enerji kullanımı ve korunumu ile ilgili olarak davranışlarında, motivasyonlarında ve bilgilerinin geliştirilmesinde olumlu etki yaptığını ortaya koydu.

Anahtar kelimeler: çevre eğitimi, enerji korunumu, dokuzuncu sınıf öğrencileri