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Program Evaluation • Consultation • Market Research

Year 2 Evaluation of the Connecticut Clean Energy Climate Solutions Project

Submitted to
Clean Air-Cool Planet

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INTRODUCTION

The Connecticut Science Center Collaborative is a partnership among science centers, state agencies, and research institutions that was formed for the purpose of educating the people of Connecticut about the science of climate change, its impacts, and solutions. The Collaborative's members include 30 science centers in Connecticut that, collectively, serve more than three million visitors a year. Also in the collaborative are several prominent research institutions, non-government organizations, and state agencies.

The Clean Energy Climate Solutions Project is a two-year initiative funded by the Connecticut Clean Energy Fund for which ten Connecticut science centers from the Collaborative were chosen to test, evaluate, and develop tools to educate their visitors about clean energy as a solution to climate change.

The primary goals of the project are:

- To develop educational tools and programs for use by a statewide network of science and technology museums, science and nature centers, planetariums and zoos to educate the people of Connecticut about clean energy as a solution to climate change;

- Raise awareness among Connecticut residents about the benefits and availability of clean energy;

- Support initiatives that prepare the next generation of innovators, consumers, and residents to address the challenges of creating a sustainable energy future; and develop a combined, cross-institutional focus on the use of renewable energy in Connecticut.

Goodman Research Group, Inc. (GRG), a research firm specializing in the evaluation of educational programs, materials, and services, has served as external evaluator for the Clean Energy Climate Solutions project and completed the second year of the evaluation study. In the first year, the project focused on the ten science centers identifying and testing off-the-shelf educational products and exhibit components on renewable energy. These products included three educational kits, one for each type of energy: Solar energy, Fuel cell energy, and Wind energy. The evaluation during the first year, accomplished through the use of an online tracking form, focused on the usability and appeal of these kits.

During the second year, the primary focus of the evaluation was the assessment of changes in the knowledge and attitudes of the target audience (middle school students) after their experiences with these kits at the science centers. The science centers also continued to track their use of the kits by means of the tracking form.

METHODS

During the second year of the evaluation study, data were collected using two sources: Student Pre-Post Surveys and Online Tracking Forms.

STUDENT PRE-POST SURVEYS

To assess changes in the knowledge and attitudes of the target audience of middle school students, GRG used a pre-post survey design. Every science center was encouraged to participate in multiple phone conference calls that gave them instructions about data collection. The science centers were given detailed instructions about the sample, their role in data collection, role of GRG in data collection, and the timeline. They were given the following instructions about procedure for data collection:

- Educators at science centers will select the group of students to whom they wished to administer the pre/post surveys. This will be as random as possible, and will depend on the number of clean energy classes that are scheduled over the next few months.
- There will be a pre/post survey for each of the three clean energy kits – wind, solar, and hydrogen fuel cell.
- Surveys can be given to after school students, regular classroom students, spring and summer camp groups, or even at family programs if follow up is possible.
- The pre survey will be given during the first few minutes of the clean energy class or it can be sent to a classroom teacher ahead of time.
- The post survey will be given to a classroom teacher to take back to the school and administer a couple of days after the class was taught at a science center. GRG will provide a pre-paid envelope so that the teacher can mail back the surveys directly to us.
- If a science center is running a week long program, the pre test can be given on Monday and the post test distributed on Friday.

The specific selection criteria for the sample in the study were also communicated to the science centers. This included:

- Target audience was middle school students between the 4th – 6th grades
- Sample size expected from each science center was 25 pre-post surveys

Along with attitudinal and program appeal questions, the pre and post surveys include questions about the clean energy content (See Appendices A and B). The content questions on the surveys were tailored to represent the content in the three different kits. These content questions were developed with collaboration and communication with the Clean Air-Cool Planet staff.

Participants

A total of 136 pre-post surveys were collected by four science centers between May 2008 and September 2008. Table 1 indicates the demographic characteristics of the participants in the pre-post study across the ten science

centers. There were almost equal numbers of males and females, and a high majority of the participants were in the age range of 9-12 years old. The kit used most often at the science centers for the purpose of this study was the wind energy kit.

Table 1
Demographic characteristics of the participants

		Percentages
Kit	Solar	15%
	Fuel Cell	14%
	Wind	71%
Gender	Girls	51%
	Boys	49%
Age	7-8 years	10%
	9 years	30%
	10 years	30%
	11-12 years	30%

TRACKING FORMS

During the first year of the project, GRG had developed a Web-based survey designed to collect information about how the ten science centers involved with the CT Science Center Collaborative used one or more of three kits: Fuel Cell Car, Solar Energy, or Wind Energy. Specifically, the survey collected the following:

- Logistical information about when sessions were held and who attended
- Activities preformed using the kits
- Ease/Difficulty using the kits
- Audience reactions to the kits
- Challenges using the kits and suggestions for improvement

During the second year, modifications were made to the kits based on the recommendations made by GRG in its first year evaluation report. Changes were made to the online surveys to represent these kit modifications and used during the second year (See Appendix C).

Data were collected using the survey between May 2008 and September 2008. Each of the 10 science centers involved in the Collaborative was instructed to complete at least six surveys after using a kit during at least six different sessions. If a science center conducted more than six sessions, they could complete more surveys or select six sessions on which to provide feedback. GRG sent to the science centers periodical reminder emails with a link to the survey.

RESULTS

The results section is divided into two sub-sections. The first section, drawing upon the data from the tracking sheets, provides information on how the kits were implemented at the various science centers. The second section presents findings about outcomes experienced by the students as a result of the program.

PROGRAM IMPLEMENTATION

Session participants

A total of 22 tracking forms were completed by six science centers in the current year. Sessions conducted by these centers lasted anywhere between 45 minutes to six hours, with two hours being the average length of each session. All of the sessions included groups of children, with some also including adults. The various types of groups of children included were school groups, families with children, and children in camps.

Training of the educators

Of the 22 educators who completed tracking sheets at the end of their sessions, 16 had attended formal training for the project, two were trained by a colleague who had attended a training session, and three had not received any particular training for this program. Sixteen educators also indicated that they were *very* or *extremely* comfortable conducting the program activities and the same number felt *very* or *extremely* prepared to conduct them. These date are comparable to the data obtained from the educators in the first year of the project.

Educators indicated that they would have liked more training on the specific topics covered in the program, such as wind energy or global warming. They also suggested getting more information about instructional methods, particularly for teaching the difficult concepts to children, as well as some teaching aids such as work sheets.

Format of the sessions

During any one session, the bulk of the time was spent doing hands-on activities and experimentation. Demonstration of the activity was conducted for a short while at the beginning of the session (See Table 2).

Table 2
Average time spent on different formats during a session

Format of the activity	Average time spent on this format during a session
Demonstration	10 minutes
Hands on activities	30 minutes
Experimentation	20 minutes
Self guided exploration	15 minutes
Other	5 minutes

N=22

Materials and activity guides

Materials used during the activities were quite successful at engaging the audience, according to the educators (See Table 3). The materials also moderately helped the educators to teach the various clean energy concepts addressed during the activities. Most of the educators (15 out of 22) did not modify the materials before using them for the activities. The seven who did modify the materials adapted them to use in conjunction with some other activities. Nine of the 22 educators indicated that the kits were a *little* hard to use and another nine indicated that they were *moderately* or *very* hard to use. Only four educators considered the kits *"not at all"* difficult to use.

Some of the challenges related to the materials indicated by the educators included:

- Inadequate materials – Some educators had to buy extra materials such as multimeters and alligator clips for the solar activity.
- Time – The materials take time to explain, use, and put away.
- Inadequate use – Each kit can engage no more than two students at any given time. The third student, if made to use the same kit, would tend to be bored.
- Additional materials – The kits need to contain more visual materials and teaching aids to help teach younger audiences in particular.

Table 3
Educators' perception about the program materials (Frequencies)

The extent to which the program materials …	Not at all	Only a little	Moderately	Quite a bit	A great deal
Engaged the audience	0	0	4	10	8
Helped the educator teach concept of clean renewable energy	0	0	4	16	1
Helped the educator teach how clean renewable energy relates to their lives	0	3	10	8	1
Helped the educator teach how clean renewable energy is a solution to climate change	0	5	9	7	1

*N = 22
** Missing data

Based on the evaluation data from Year 1, certain modifications were made to the original wind energy kits and the solar kits during the current year. Modifications to the wind energy kit included changes to the blades on the wind turbines and those to the solar kit included adding stickers to the back panels of the solar cells for easier assemblage and providing enough lamps for students to have one light per team. Educators indicated that these modifications increased the ease of conducting the activities for them and the ease of assembling the kit for the audience. However, the audience engagement remained the same as the year before, which was rated similarly positive.

The most frequent uses of the activity guide that accompanied each kit were to gain background information about the project and to learn how to use the three kits. Overall, the educators were satisfied with the quality of the activity guides, and were particularly satisfied with the general background information presented in the guide (See Table 4).

Table 4
Educators' ratings on the activity guide (Frequencies)

	Poor	Fair	Good	Very Good	Excellent
Overall quality of the Guide	0	2	0	8	3
Background information in the Guide	0	2	0	5	6
Format of information presented in the Guide	0	3	8	2	0
User-friendliness of the Guide	0	3	8	2	0

*N = 22
** Missing data

STUDENT IMPACT

The following section includes information about the appeal of the CT Clean Energy program and its impact on participating students' knowledge about, interest in, and attitude toward topics related to clean renewable energy.

Appeal of the CT Clean Energy program

Students enjoyed participating in the clean energy activities. As Table 5 indicates, they gave high ratings on the post survey for how much they liked the activity. Specifically, the fuel cell and solar energy activities got the most favorable ratings. While the ratings for wind energy activities were not as high, they were still positive – between *"sort of liked it"* and *"liked it a lot."*

Table 5
Student ratings on appeal of the activities

Kit	How much did you like the activity?				
	I didn't like the activity at all (1)	I didn't like the activity very much (2)	I sort of liked the activity (3)	I liked the activity a lot (4)	I completely loved the activity (5)
Solar energy (mean = 4.25)	0	0	19%	37%	49%
Fuel Cell energy (mean = 4.33)	0	0	17%	33%	50%
Wind energy (mean = 3.57)	10%	3%	29%	37%	22%

N=136

Further analyses indicated that there were no gender differences in the students' ratings for the appeal of the program; however, there were age differences in those ratings. That is, younger students (ages 7-9 years) gave significantly higher ratings than did older students (age 12 years) on program appeal.

When asked what changes the students would like to see made to the kit, the most common response was that the students liked the activity as it was and did not want any changes made to it. Additional responses about changes to the kit reflected the following suggestions:

- Take home materials: Students were interested in getting some materials to take home after the activity. This would be a good form of reinforcement and could help students, at a later date, review the information they gathered during the session.

- Extra time: Students enjoyed the clean energy activity and were hoping that in future they would be given more time to experiment with the materials.
- Adding videos: A student suggested that it would be helpful to have the information about the kit available on a video that they could follow as they worked on their activity..

Knowledge about clean renewable energy

The changes in students' knowledge about the clean renewable energy were assessed through number of different sets of questions on the pre-post surveys. One question asked the students to rate their own knowledge about various topics related to clean energy on a five-point rating scale in which 1 indicated "*I know nothing*" and 5 indicated "*I know a great deal.*"

Statistical analyses of the mean pre-post ratings showed significant increases in the means from the pre to the post test on all four statements of knowledge about the clean energy (See Table 6). This indicates that the self ratings of the students about their knowledge of clean energy topics increased after their experience with the program kits.

Table 6
Pre-post difference on the clean renewable energy knowledge statements

Student knowledge about …	Mean pre score	Mean post score
Clean renewable energy	2.48	3.42**
Climate Change or Global Warming	3.55	4.38*
How clean renewable energy relates to your life	2.62	3.38**
How clean renewable energy is a solution to climate change	2.74	3.61**

* $p < .05$
** $p < .01$

The second set of questions – about solar, wind, and fuel cell content – was designed to evaluate the content gain in students as a result of the program kit.

Two questions about each of the topic were asked on their respective surveys. In addition there was one question on climate change asked on all the three surveys. As Table 7 indicates, the students' scores showed a significant increase from the pre to the post on most of these questions. The most increase in scores was observed for the wind energy kit.

Table 7
Pre post differences in the students' scores on the content questions

Content area	**Question on the surveys**	**Difference on pre-post score**
Climate change	Which of the following is not a renewable energy?	$p < .05$
Solar energy	In North America, in which direction should a fixed solar panel be facing to produce maximum power at solar noon?	Not significant
	What common naturally occurring element is used to make a solar cell?	$p < .01$
	Total Solar energy content questions score	Not significant
Fuel cell energy	What gases are used by a fuel cell to produce electricity?	
	Look at the answer you checked above, what substance forms as these two gasses are combined in the fuel cell?	$p < .05$
	Total fuel cell energy content questions score	$p < .05$
Wind energy	Wind is generated by the differences of temperature on the planet and in the atmosphere. What source of energy is responsible for these changes?	$p < .01$
	Name one factor that affects the performance of a wind turbine and its energy output.	$p < .01$
	Total wind energy content questions score	$p < .01$

Further analyses indicated that there were statistically significant gender differences in the total pre-post scores on each of the kit. Specifically, for the wind kit total score, significant pre and post differences were found for both boys and girls. However, for the solar kit these differences were found only for girls, whereas for fuel cell kit they were found only for boys.

An open-ended question on the pre-post surveys asked the students to name an action that can help reduce the impact of climate change on our environment. Qualitative analyses of the responses indicated that the number of correct responses to this question rose from 70% to 84% from the pre to the post.

Finally, to assess the content gains, the survey asked the students to list the most interesting thing they learned from the activity. Analyses of the responses indicated that out of the total 136 students who took the surveys, 112 (75%) of the students could mention at least one thing new that they had learned from the activity they performed. While a few of these responses were about clean energy in general, most students (94%) could write specific concepts about solar, fuel cell, or wind energy that they learned. (See Table 8). Some of the concepts learned by the students revolved around the basics of making and using a wind mill to generate wind energy, the technique of using a solar panel to trap solar energy, and the use of water and electricity to operate a car.

Table 8
Things learned by the students from the activities they did.

Type of responses		Number of acceptable responses	Examples
General responses		7	*"That you don't always have to use gas as fuel for energy."* *"What resources are renewable and [how to] make and use them"*
Responses specific to the kit	Solar energy	17	*"The solar power must point North to get maximum power at noon."* *"I learned that solar energy cannot pollute the world."*
	Fuel cells energy	7	*"A car can run by water and electricity."* *"The most interesting thing was that water could make a vehicle move."*
	Wind energy	67	*What angle makes the fan go faster* *That if the blades are facing in different directions they go faster.* *How wind can be turned into energy*

Interest in topics related to clean energy

On both the pre and post surveys, students indicated their interest levels in topics related to clean energy, using a five point rating scale where 1 indicated "*Not at all interested*" and 5 indicated "*Extremely interested.*" On four of the five statements, a significant difference was found in the mean ratings of the students on the pre and post surveys (See Table 9). The ratings given by students to indicate their interest in topics of clean energy after the program experience were higher than those given before the program.

Table 9
Pre-post differences in the students' interest level in clean renewable energy topics

Student interest in…	Mean pre score	Mean post score
Clean renewable energy	2.87	3.23**
Climate Change or Global Warming	3.77	3.98**
How clean renewable energy relates to your life	3.02	3.37**
How clean renewable energy is a solution to climate change	3.42	3.62

* $p < .05$
** $p < .01$

Attitudes toward clean energy topics

Students indicated their attitudes toward topics related to clean energy on the pre and post surveys, using a five point rating scale where 1 indicated "*Disagree a*

lot" and 5 indicated "*Agree a lot.*" Higher ratings indicate more positive attitudes toward clean energy issues.

Statistical analyses indicated no differences in the mean ratings of the students on the attitudinal statements. One possible explanation for this lack of difference is that the students had strong positive attitudes about the clean energy issues even before they took part in the clean energy program experience, as reflected in their pre-survey scores (See Table 10). This phenomenon, called the ceiling effect – there was not much room for improvement – could explain the lack of pre-post differences.

Table 10
Ratings of the students on attitudinal statements on the pre survey

Attitudinal statement	**Disagree a lot (1)**	**Disagree a little (2)**	**Not sure (3)**	**Agree a little (4)**	**Agree a lot (5)**
Learning about the environment and natural resources is worthwhile and necessary (mean = 4.25).	1%	7%	16%	27%	50%
The environment plays an important role in my everyday life (mean = 4.33).	2%	3%	13%	26%	56%
I like learning about the environment and resources (mean = 3.86).	7%	9%	14%	32%	39%
It is important to gather information about clean renewable energy and climate change (mean = 3.92).	4%	8%	21%	24%	41%
I could play a role in helping conserve energy (mean = 4.14).	3%	5%	20%	19%	53%

CONCLUSIONS AND RECOMMENDATIONS

The materials in the kits were engaging and helpful in teaching clean energy concepts. Nonetheless, they were somewhat difficult for educators to use. Therefore, *GRG recommends making certain changes to the materials included in the kits.*

The materials in the clean energy kit were successful at engaging the audience and also served a good teaching aid to the educators. However, they were not very easy to use, as indicated by the educators. Based on the suggestions made by the educators, GRG recommends certain changes to the materials in the kit.

The kits should have adequate quantity of supplies, thereby lessening the burden on educators to procure additional quantities. The teachers would benefit from some visual materials and teaching aids to assist them in presenting the concepts, either prior to or during the hands-on kit activity. The hands-on activity can be supplemented with take-home materials for the participating children.

The clean energy activities had high student appeal. As importantly, the program also was associated with increase in students' *knowledge* about clean energy concepts and increase in their *interest* in clean energy concepts.

The students gave high ratings for how much they liked the activities. Of the three kits, the highest ratings were obtained for the fuel cell kit, then solar energy kit, and then wind energy.

Not only did the students *like* the activities, they *learned* from them. Students' knowledge about clean energy concepts increased significantly after participating in the clean energy activities. The students' own perceptions about how much information they had regarding the clean energy topics increased after the activities and so did their scores on the content questions. The qualitative responses of the students also indicated knowledge gain.

Furthermore, students' own perception of their interest level in clean energy topics showed a significant increase after they had participated in the clean energy activities.

Students' positive attitudes about environment and clean energy concepts were maintained.

Students' attitudes toward environment and clean energy topics were highly positive before they participated in the clean energy activities and these positive attitudes were maintained after the activity experiences.

Given all of these positive outcomes related to the program and kits, *GRG recommends dissemination of the materials to appropriate venues and further* .

Based on the success of the program with the participants of this evaluation, GRG recommends that the Connecticut Clean Energy Fund disseminate the kits and the related materials to appropriate venues such as other science centers and children's museums across the country.

GRG also recommends additions to the current clean energy kits and curriculum to promote *behavioral* changes in the participants. Data from the present study have indicated the gains in *knowledge* and *interest* levels of the participants with regard to clean energy concepts. Additions to the curriculum could focus on suggestions about actions that the participants take in order to promote environmentally friendly behaviors. It would be an attempt to help the participants take the knowledge about clean energy and environment that they gain through the activities and make it personal.