# Summative Evaluation of

# *FARMING FOR FUELS*

**for**

**The Creative Discovery Museum**

**And**

**The Bioenergy Science Center**

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## EXECUTIVE SUMMARY

### Introduction

*Farming for Fuels* began at The Creative Discovery Museum in the summer of 2008 as a classroom program delivered through the museum's outreach. It next moved out to regional museums the following year in 2009, and finally out to six national sites in 2010. Two of the national sites (NY Hall of Science and The Arizona Science Center) were unable to continue with the project. Overall more than 60,000 students, teachers and parents have been reached by museums in 9 states (TN, GA, NY, AZ, IL, TX, MI, FL, OK). There is a planned expansion for 2013 to five additional museums in the northwestern section of the United States. In addition to direct delivery of the program, *Farming for Fuels* was presented or exhibited at more than a dozen conferences around the country over the last four years, including The Association of Children's Museums, The Association of Science and Technology Centers, The National Science Teachers Association, and The Georgia Educational Technology Conference - reaching hundreds of teachers and museum staff.

### Program Description

Between 2008-2012 a total of 60,564 participants were served through *Farming for Fuels* outreach lessons and family events. Participants included students, teachers and caregivers. Funding began at 100% provided through the Bio Energy Science Center (BESC) led by the Department of Energy's Oak Ridge National Laboratory (DOE/ORNL), and was reduced over a two-year period until the program became self-sustaining in Chattanooga, Tennessee.

The series of activities in the *Farming for Fuels* classroom program, targeted to grades 4-8, was designed to be presented as an inquiry-based lesson introducing the concepts connected with creating biofuels and the need to change to alternative energy sources for transportation. As the program has evolved and been modified by the various sites, the specific format for the presentation has changed according to the needs of the particular museum and school.

In addition to the classroom program, the family event format provided museums with nine potential activity stations, with parallel content to the classroom program. It could be set up and hosted at a school or museum and could reach hundreds of students and their families at one event. As part of the family events a new component was added called "Ask a Scientist." Through this component students, teachers and parents can speak to a real scientist who is on-line via a laptop, Internet connection and Skype software. Scientists from the Bioenergy Science Center interact with individuals in real time, answering their questions and providing information on energy-related topics.

During this last year of the program the content was also delivered via a web based game format: "The Road Trip Challenge." The game was developed to teach wise strategies for energy use. The game is currently being prototyped in a kiosk at the Creative Discovery Museum. It will ultimately be available as an interactive kiosk for

other educational venues and will soon be made available as an iPad "app" through the iTunes store.

## Description of Evaluation Study

The summative evaluation of the *Farming for Fuels* classroom program and family event was conducted over the last two years. Two interim reports were delivered with preliminary results about specific areas of focus. This final report will describe the overall evaluation study methods and results, and make recommendations for potential revisions and improvements to the program.

The evaluator worked with the program team at the Creative Discovery Museum to generate a list of questions to guide the evaluation study. The questions covered each of the major audiences for the program: museum educators, teachers, caregivers and students. Thus respondents for this study were museum staff that delivered the program at the various sites, the teachers and students at the schools who participated in the classroom program, and the parents and students who participated in the family events.

The study utilized mixed methods including observations of Family Events (7) and classroom programs in schools (7), in-person and telephone interviews with museum staff at national (5) and regional sites (3), teacher surveys (45), and a review of program documents. There were two primary ways the evaluator used to strengthen the validity of this study: data triangulation, the use of a variety of data sources and investigator triangulation, the use of multiple researchers (Denzin, 1978). In the analysis phase of the study the evaluator specifically looked at the data from each site as a case study. This type of approach revealed a lot about the processes and outcomes at each of the museum sites, and the ways in which these interrelate.

## Brief Summary of Findings

### *Classroom Program*

Program length and format varied across museum sites. This was often based on the demands or needs of the schools or based on what the museum typically offered in their outreach. Introductions as long as 30 minutes and as short as five minutes were observed. Some sites used more of a large group didactic approach while others spent more time with students rotating through activity stations. Some sites did wrap ups, some did not. The wrap-up at the end of the program seemed like a very important part to keep, in order to help the students make final connections to the meaning of what they had experienced, to check for understanding, and to clear up any remaining scientific misconceptions. Museum sites made personal decisions about what to keep, what to leave out, what to shorten and what to lengthen. This did not necessarily result in an equally positive impact for every participant. Interest in booking the classroom program waned somewhat as funding was reduced, particularly for sites where it was most difficult to connect alternative energy to curriculum standards.

### *Family Event*

Family Events were conducted in a variety of ways. One was held in a museum and stations were spread throughout the space in several rooms and on more than one floor. This was not very effective at tying the ideas and concepts together for visitors. Similarly another museum conducted the Family Event at a school that had two wings; half of the stations were set up in one wing and the other half in the other wing.

One science museum conducted the Family Event at a large private school and included about 20 stations, many more stations than the nine stations that are part of program. Again, families did not make the connection between stations. Rather they saw the event as a sort of large science fair. While this type of approach for delivering science content to families is not a bad one, it did take away from delivering the specific content about the science of biofuels.

The Family Event seemed to work best when held at a school cafeteria/gymnasium where families could move around freely at a relaxed pace and younger siblings had a bit more space as well. Trying to deliver this program in a museum space might work more effectively if there was a large enough space for all of the activity stations. When they are spread around, families may not see how they build on each other to deliver important science content.

Staffing the Family Event was challenging for some sites. Some creative solutions included 1) using students as assistants – who had previously participated in the classroom program, 1) using service clubs such as National Honor Society students, and 3) providing teachers with in-service credit for their time.

### *Main Messages*

Communicating the science effectively and accurately is one of the most important considerations in this program. Across sites there was some variation in how the messages were delivered. Following are some examples based on museum staff interviews. When asked what is the main message you are trying to communicate through this program, educators responded:

> *We have these energy needs and there are different approaches to solving them, some of the approaches are really novel. Maybe you will come up with the next idea.*
>
> *Burning a biofuel is not contributing to the CO2 in the air the same way that burning a fossil fuel is. The (switchgrass) plants are taking the carbon out of the air while they are growing. It's more or less a cycle.*
>
> *What's wrong with using corn for fuel? We have to eat it. What's more important – what we have to eat or what powers our cars?*

*Your children are going to be confronted with these different energy changes. They are our future scientists.*

This group of museums is a kind of network and in order for networks to work most effectively there needs to be a central hub they can all go to. This will be especially critical when additional funding is secured and more museums are added to the network. As the project spreads there are certain essential elements that need to be maintained in the program while still allowing for the museums to stretch and try new things. The core message of the program may be lost if communication in the network is not maintained.

A full list of Recommendations for program improvement begins on page 46.

## INTRODUCTION

*Farming for Fuels* began at The Creative Discovery Museum in the summer of 2008 as a classroom program delivered through the museum's outreach. It next moved out to regional museums the following year in 2009, and finally out to six national sites in 2010. Two of the national sites (NY Hall of Science and The Arizona Science Center) were unable to continue with the project. As this process has evolved, what was a local initiative has had a grand scale up to a national initiative. In addition to the program's activities at the four remaining national sites (DuPage Children's Museum – Naperville IL; Ann Arbor Hands-On Museum; Imaginarium, Ft. Myers FL and The Museum of Nature and Science in Dallas) the program has been presented and discussed across the country at over a dozen regional or national conferences.

The Creative Discovery Museum along with its stakeholders, The Bio Energy Science Center (BESC), Oak Ridge National Laboratory (ORNL) and The Department of Energy (DOE), recognized that the best way to deal with a complex issue such as the science and future of alternative energy is to do it through a kind of strategic alliance. Researchers explain it this way:

"Strategic alliances are intentional inter-organizational collaboratives created to benefit the partners and ultimately the stakeholders." (Austin, 200; Bailey & Koney, 2000).

This final evaluation report will include a description of the program, the program reach, and the analysis of data collected at the national sites and some regional sites in the last two years. At the conclusion of the report, recommendations will be made to consider improving the program as it continues to scale up in the next few years.

### Program Description

The series of activities in the *Farming for Fuels* classroom program, targeted to grades 4-8, was designed to be presented as an inquiry-based lesson introducing the concepts connected with creating biofuels and the need to change to alternative energy sources for transportation. Each activity can be taught individually or as an introduction to the topic. The lesson may be presented as a 15-minute introduction followed by 5 student activity centers through which students rotate. The lesson concludes with a wrap up of the concepts introduced. As the program has evolved and been modified by the various sites, this specific format for the presentation has changed according to the needs of the particular museum and school. This will be discussed in the body of the report.

In addition to the classroom program, the family event format provided museums with 9 potential activity stations, with parallel content to the classroom program. It could be set up and hosted at a school or museum and could reach hundreds of students and their families at one event. As part of the family events a new component was added called "Ask a Scientist." Through this component students, teachers and parents can speak to a real scientist who is on-line via a laptop, Internet connection and Skype software. Scientists from the Bioenergy Science

Center interact with individuals in real time, answering their questions and providing information on energy-related topics.

During this last year of the program the content was also delivered via a web based game format: "The Road Trip Challenge." The game was developed to teach wise strategies for energy use. Students are allowed to design their own cars and select types of fuel to travel to familiar destinations across the country. Through various "legs", each focusing on a specific scientific theme, the game incorporates lessons that explore fuel efficiency, fuel availability as well as the environmental impact of decisions made during the Road Trip Challenge. The game is currently being prototyped in a kiosk at the Creative Discovery Museum. It will ultimately be available as an interactive kiosk for other educational venues and will soon be made available as an iPad "app" through the iTunes store.

## Content Goals

BIG IDEA: Inform the general public about the science of biofuels and the need for it.

1) Science is cool and you can use it to solve problems.
2) There are differences between plant and animal cells.
3) It takes a complex process to convert corn into fuel – grind into cornmeal, use enzymes and microbes to break it down.
4) There are other alternatives to petroleum but there are reasons why they won't work with current (combustion) engines. For example there is no existing infrastructure ad we need to do more research.
5) There are different amounts of sugar in liquid. Some are surprising.


Figure 1: Switchgrass Range in the U.S.

## EVALUATION

The summative evaluation of the *Farming for Fuels* classroom program and family event has been conducted over the last two years. Two interim reports were delivered with preliminary results about specific areas of focus. The first report was delivered in the fall of 2011 and the second in the spring of 2012. This final report will describe the overall evaluation study methods and results, and make recommendations for potential revisions and improvements to the program.

The evaluator worked with the program team at the Creative Discovery Museum to generate a list of questions to guide the evaluation study. The questions covered each of the major audiences for the program: museum educators, teachers, caregivers and students. The list of questions is included in Appendix A.

### Data Collection Methods

This evaluation study utilized mixed methods including observations of Family Events and student outreach program in schools, in-person and telephone interviews with museum staff at national and regional sites, teacher surveys, and a review of program documents. All methods were considered appropriate for answering the evaluation questions. The teacher surveys utilized both closed ended and open-ended questions. The interviews used primarily open-ended questions. Open-ended questions served an important purpose in this type of study. Fink (2003) describes their value in the following way:

"Qualitative surveys collect information on the meanings that people attach to their experiences and on the ways they express themselves. They are useful when you cannot rely on your own previous experience and the literature to guide you in designing closed ended questions or when you want detailed information in the respondent's own words. Qualitative surveys are particularly suited to examining feelings, opinions and values of individuals or groups. They are also useful when you have access to only small samples."

Open-ended questions allowed respondents to give answers in their own words. These questions were useful in identifying unanticipated impacts or in learning about the program as the participants really see it. Often this resulted in quotable material. Respondents' own words are indicated throughout the text through italicized lettering and indented paragraphs.

Site visits were conducted to 4 museums. A total of 7 family events and 7 classroom programs were observed. Appendix B contains a detailed summary of all data sources.

There were two primary ways the evaluator used to strengthen the validity of this study (Denzin, 1978).

- Data triangulation is the use of a variety of data sources. These are detailed in Appendix B.

- Investigator triangulation is the use of several different researchers or evaluators. This is particularly important when observation is a main method of data collection. In this study four individuals conducted program observations. Observation notes were always compared between researchers to assure strong inter-observer reliability.

## Data Analysis

Observation and interview data were analyzed using *inductive constant comparison*, whereby new units of data are compared to all previous units of data. This type of data interpretation results in a rich and descriptive narrative, often including the respondents' own words. In analyzing and reporting observation and interview results, the *range* of participant experiences is considered. During the study, data collectors regularly shared and discussed their findings so that a continual analysis took place and emerging themes and ideas were recognized and further explored in a broader context.

The on-line surveys were analyzed using *content analysis*. Content analysis looked for recurring themes and words in the survey responses.

### *Case Studies*

The evaluator specifically looked at the data from each site as a case study. This type of approach revealed a lot about the processes and outcomes at each of the museum sites, and the ways in which these interrelate. The approach is particularly useful when an established program such as *Farming for Fuels* is implemented in a new setting (Balbach, 1999), as it was first at the regional level and ultimately the national level. The rich detail of a case study can provide information about the design of the program and the context in which it was delivered, potentially allowing others who may come in contact with the project to determine whether it might be appropriate for their site. One of the many strengths of a case study approach to this evaluation is that it was not based on the assumption that program implementation necessarily followed a predictable and consistent path.

## Respondents

Respondents for this study were museum staff that delivered the program at the various sites, the teachers and students at the schools who participated in the classroom program, and the parents and students who participated in the family events. All respondents were guaranteed confidentiality so while data may be connected to a specific site, no names of any individuals will appear in this report.

## RESULTS

### Overall Program Reach

Between 2008-2012 a total of 60,564 participants were served through the *Farming for Fuels* outreach lessons and family events. Participants included: students, teachers and caregivers. Funding began at 100% provided through the Bio Energy Science Center (BESC) led by the Department of Energy's Oak Ridge National Laboratory (DOE/ORNL), was reduced over a two-year period until the program became self-sustaining.

- Participants served at 100% cost of funding to ORNL/DOE = 32,422
- Participants served at 50% cost of funding to ORNL/DOE = 21,250
- Participants served at $0 cost to ORNL/DOE = 6,892

The following is a breakdown of participants served through the program, by year and funding-level:

2008-2009

Total Participants served: 3,447 (All lessons fully-funded through BESC)

2009-2010

Total Participants served: 8,935

- Participants served: Full-funding through BESC=7,769
- Participants served: 50%-funding through BESC=1,166
- Participants served: 0%-funding through BESC=0

2010-2011

Total Participants served: 25,824

- Participants served: Full-funding through BESC=18,733
- Participants served: 50%-funding through BESC=7,091
- Participants served: 0%-funding through BESC=0

2011-2012

Total Participants served: 22,358

- Participants served: Full-funding through BESC=2,473
- Participants served: 50%-funding through BESC=12,993
- Participants served: 0%-funding through BESC=6,892

Since 2008, the Creative Discovery Museum alone has reached 11,552 students, teachers and caregivers through their *Farming for Fuels* educational outreach effort.

Overall more than 60,000 students, teachers and parents have been reached by museums in 9 states (TN, GA, NY, AZ, IL, TX, MI, FL, OK). There is a planned expansion for 2013 to five additional museums in the northwestern section of the united States.

In addition to direct delivery of the program, *Farming for Fuels* was presented or exhibited at more than a dozen of conferences around the country over the last four years, including The Association of Children's Museums, The Association of Science and Technology Centers, The National Science Teachers Association and The Georgia Educational Technology Conference - reaching hundreds of teachers and museum staff. A complete listing of conference presentations is included in Appendix C.

## Professional Development

Each time the program scaled up to a new area (regional and national) The Creative Discovery Museum provided a summer workshop to orient the new participants to first the classroom program and later the family event. The evaluator observed the summer workshop (July 2011) that provided training for delivering the family events. It was attended by both regional and national participating museums. The regionals had already been delivering the family events at that point and thus were able to provide some mentoring to the national sites. The workshop coincided with the 5th annual BESC Science Retreat, held in Chattanooga. Museum staff attended the workshop from:

- Creative Discovery Museum, Chattanooga, TN
- Imaginarium, Ft. Myers FL
- DuPage Children's Museum, Naperville IL
- Museum of Nature and Science, Dallas TX
- Ann Arbor Hands On Museum, Michigan
- Adventure Science Center, Nashville, TN
- Tellus, Cartersville GA
- East Tennessee Discovery Center, Knoxville TN

This was an important opportunity for all of the sites to be together around the table(s) so they would have an opportunity to share how the classroom program had worked in the previous year, as they would be continuing that format in the coming year in addition to adding the family event format.

Staff from The Creative Discovery Museum provided the group with a comprehensive overview of how they (CDM) currently delivered *Farming for Fuels* Family Science Nights. They discussed key aspects such as the need for volunteers, the importance of school coordination and cooperation. They added that they sometimes discounted the price of the Family Night as an incentive if the school could provide sufficient number of volunteers.

Throughout the day museums shared tips about the content and materials for the program. This was a very well received part of the workshop. All of the staff that the evaluator interviewed on site mentioned how important these opportunities for coming together and sharing were. Many of them said they kept in touch after the 2010 summer workshop via e-mail but eventually got busy and did not keep up.

Two BESC scientists visited the workshop and gave a presentation to museum educators about the science content and the progress of their research. In the evening, scientists and post docs who were attending the BESC retreat traveled to The Creative Discovery Museum where they had the opportunity to experience the *Farming for Fuels* activity stations. Staff from the various museums attending the workshop earlier that day served as facilitators at the stations. This gave them an opportunity to work with the materials and practice the interpretation. As a result of this experience more than one educator got a new idea about how to work with the materials, or decided on an alternative material that might work better in their museum.

Overall the workshop was well received by all participants. They indicated that they appreciated having the opportunity to hear how others delivered the program at their site and comparing alternative ways of interpreting some of the biofuels content, especially when the content was perceived as too difficult or challenging. They were also grateful for the opportunity to work with materials that would be used for their Family Science Nights. Lastly they appreciated meeting and hearing from the actual scientists who were conducting the important biofuels research.

## Museum Case Studies

The following section will discuss the delivery of the program at four national sites. Each case will describe findings based on observations of the classroom program, the family event and additional findings from staff interviews conducted either on site or over the telephone. There is a broader description of the national sites as the evaluator was able to visit all of these programs. However visiting the regional sites was not included in the scope of this evaluation. Instead Dr. Beaumont conducted interviews over the telephone with key staff at the regional sites. Alternatively she sent them an on line survey with the same questions.

### *DuPage Children's Museum – Naperville IL*

### Classroom Program

DuPage Children's Museum (DCM) has conducted school outreach for many years. It has been a part of their regular operations. They have served Pre-K-5$^{th}$ grades primarily but have been particularly interested lately in reaching older groups of students – into middle school.

Their typical school program is scheduled for 90 minutes and includes an introduction, activity stations and a wrap up. Thus, the *Farming for Fuels* classroom program structure fit well into their system. DCM was one of the few participating

museums that had to extend the curriculum to fit into their longer schedule. They increased each of the stations to 10-11 minutes and added more depth in the introduction and wrap up discussions. They not only have a wrap up at the end of the overall program, but also conduct brief wrap-ups at each activity station before having students move on to the next one. The following description of the program is based on data collected by the evaluator during site visits to several schools.

At the beginning of the program the museum educator discussed the carbon cycle by physically having students come up in front and act as a prop/part of the carbon cycle (plant, sun, etc.) Each child who participated in this activity got to hold a small object symbolizing their part in the carbon cycle, including a monster truck to symbolize automobiles. In the introduction there was an intentional focus on renewable vs. non-renewable energy. DCM staff created an energy poster that they used in both the introduction and wrap up. An image of it is included at the end of the report in Appendix D.

Volunteers for the program were sometimes classroom teachers, but often parents as well. They received just a few minutes of training before students arrived in the room. The content covered by *Farming for Fuels* can be somewhat challenging to take on for someone unfamiliar with this subject. Thus, DCM provided each volunteer at an activity station with a handout explaining step by step what he or she would do and the science behind it. If given enough time volunteers could familiarize themselves with the content before students arrived.

The evaluator had an additional opportunity to observe the classroom program in a new format, as it was adapted for a whole school "Science in the Community" event in Chicago. The program was set up in one classroom and five rotations of fourth grade students moved through the program during the day. Each session lasted 45 minutes, which was half the time of the typical *Farming for Fuels* classroom program DCM delivers. Each activity station lasted seven minutes and included introduction, activity and wrap up. There was also a brief overall introduction at the beginning and wrap up at the end. According to the DCM educators this was much too fast to adequately teach the content. They provided the students with opportunities at four activity stations: 1) Dynoscopes, 2) Processing station, 3) Create an air-powered car and 4) Explore gravity, wind and solar energy. All stations were facilitated by DCM staff with the exception of the fourth. The third station was based on an activity that was part of an existing school outreach program DCM delivers called Kids Design Engineering. The program was well received by teachers and parents who participated. Regarding the non-facilitated station: exploring gravity, wind and solar energy, a teacher commented,

> *They're doing it with no direction, using all the energy words. They listened and heard what she said. Now they're observing.*

**Family Event**

Before the *Farming for Fuels* program was offered, DuPage Children's Museum had been conducting Science Nights and Math Nights at the museum. They hoped that

delivering the family events to the schools would bring back families that had not been able to attend them at the museum due to cost. As it turned out most of the family events became incorporated into the existing structure for museum wide Science Nights.

The activities were facilitated by LAB R.A.T.S., who also deliver the classroom program. Events took place in both daytime (weekends) and evenings (weekdays). Visitors had access to the entire museum. The *Farming for Fuels* activities were scattered around the museum in several of the classroom labs on the lower level as well as on the main floor. Visitors were given "maps" to locate the activities. There did not seem to be a logical flow. One data collector described the following in her field notes:

> *Visitors wandered through them and seemed to see them as isolated experiments instead of a program with a message.*

She went on to recommend the following:

> *If they were all in one room or there were footprints on the floor directing traffic from one activity to another, visitors would be able to see the activities as having a sequential order and synthesize how they related to one another. (Field notes 4/14/12)*

Until the evaluator began conducting site visits DCM had not used the reflection tool/data sheet that Dallas and Ft. Myers used. Even after establishing this practice, visitors were confused about the purpose of the reflection tool, so very few were ever submitted.

Most of the children who participated during the DCM family events were under the age of 7. Museum staff felt the program goals were "over their heads." They stated that the program would be better suited for older children, but that they don't often get older children during this time frame (Saturday morning). Even though DCM staff felt the content was hard to grasp they saw value in having younger children exposed to this type of science, even if just to spark curiosity and interest.

The observational data collected during the family events indicated that the activities seemed disconnected and the overall message of alternative energy was somewhat diluted. Nevertheless the activities were engaging and visitors spent quite a bit of time at each, in particular the "CO2 bubbles" and "Alternative Energy Cars". The LAB R.A.T.S. staff facilitated most of the activities and in doing so, clearly communicated the content. The biggest concern with the structure of the family event was that visitors were experiencing these stations along with the rest of a very large and engaging children's museum. So it is likely they may have missed some of the connections between activities.

**Museum Educator/Staff Interview Summary**

According to one of the museum staff that delivered the *Farming for Fuels* program to classrooms, teachers were very pleased with the program. He described a time when he was leaving a classroom and the teacher stopped him to say,

*I've never seen my class so engaged.*

For another teacher the hands-on nature of the program was a bit uncomfortable as students were active and noisy. This teacher was overheard as the students were lining up saying,

*See, this is why we can't do science.*

The museum educator who was interviewed indicated that the content seemed appropriate for 4th and 5th graders to whom the program has been presented. He checks for student understanding throughout the program by noticing students' questions during the introduction, at the stations, and during the wrap up. When DCM educators, called LAB R.A.T.S. are trained to deliver this program they are shown how each of the stations connects so that as students move through they can better see the connections and grasp the full content.

This educator did not find the science content to be too challenging, although he did state that he had a pretty broad base of science knowledge. He had initial concerns that the content might have hints of a political agenda as sometimes happens with new environmental discoveries/science, but was pleased that wasn't the case.

The DCM school program staff is currently exploring the possibility of creating a new school program using their original Energy school program and adding portions of the *Farming for Fuels* curriculum in order to keep the content current and cutting edge. A group of teachers are advising the staff on the program development. They hope to begin offering the program in 2013.

***Imaginarium Ft. Myers FL***

**Classroom Program**

The evaluator observed three programs at Edison Park School in Ft. Myers. All three were conducted in one classroom with the 5th grade students rotating through. Rotations were 8:15-9; 9:15-10 and 10:15-11. Things were tightly packed but the museum educator did a very effective job of starting and ending on time and keeping her energy level up for all three classes, not an easy task for any educator especially when repeating the same class three times.

She began with a brief introduction to the whole class, and provided a written program outline for the teacher to follow along. There were four stations as this educator combined the gas engine model with the alternative cars station. The introduction included some of the following:

"What is fuel?" " What do we use fuel for?" "What does the word bio mean?" " What other words can you think of that begin with bio?"

An important term that was brought up in each class by the students was "renewable and non-renewable." This even surprised the educator and she worked it nicely into her introduction. She explained the carbon cycle, how plants take in carbon dioxide and can't keep up, so much of it goes into the air and creates pollution "like a blanket that keeps you warm (connection to global warming)."

She talked about how much we use corn in our diets, corn syrup – and how corn is being used to create ethanol but how it would be more effective if we could create fuel from something we don't eat. This led to an explanation about switchgrass.

She broke the students into groups by counting off 1-4. At each station there was a data sheet students had to complete as part of their exploration. Students spent approximately 10 minutes at each station. Teachers or parents who facilitated the stations checked for student understanding by asking questions as students explored and having them fill in their data sheets.

The educator's overall conclusion that she emphasized at the end of each round was the following:

"Scientists are actually working on solar cars right now. We need cars that don't depend on gas. What is a short- term solution? Ethanol is already being added to our gas. But we need more. In the future maybe switchgrass will be a solution."

**Family Event**

The evaluator observed one Family Event hosted by the Imaginarium in Ft. Myers FL. It was held at a public middle school in a nearby town. The museum educator allowed the adult volunteers to look over the nine activity stations and choose one that they thought they could facilitate. She trained each volunteer and then asked, "Are you comfortable?" Throughout the evening she walked between the stations to support the volunteers. One of the volunteers was a teacher who is doing research on photocells in his graduate program. He was very interested to facilitate the solar energy car station. He stated that his school tends to "teach to the test" and students do not get enough science as a result. He would like to see this Family Event held during the day in the gym at their school, allowing every grade level to cycle through – thus exposing the entire school to this important content.

The volunteer at the Perennial vs. Annual station was overheard explaining to a parent the community was building a plant locally to harvest seaweed and algae to make ethanol.

Unfortunately there were only a few families who attended this event. Most were the volunteers and their children. The educator from the Imaginarium stated that this was one of the least attended family events they have done this year. However,

one 4th grade boy made the observation all worthwhile. After he worked his way through every station, meticulously completing the reflection tool/ data sheet, he was overheard helping the volunteers. He said to a parent, "If all the plants die we all die and if we all die the plants would die." In his explanation of the mutual relationship between plants and humans might he have been giving his naïve interpretation of the carbon cycle?

**Museum Educator/Staff Interview Summary**

According to museum staff they have made only minor changes to the program. They revised the data sheets students fill out at each station and created a new diagram of the internal combustion engine. They also combined the internal combustion engine with the alternative energy cars station (this has been done by several of the sites). They typically plan for the Dynoscopes and Processing Stations to be unfacilitated if there aren't enough volunteers.

One of the challenges of booking and delivering the classroom program is that it is a topic that is rarely covered in the Ft. Myers area elementary schools. Nevertheless, over the two years they have been delivering the program there have been a handful of teachers who have booked a second time (during one of the site visits the evaluator overheard a student saying "oh, I remember – we did this last year"). The educator indicated that they tend to have a lot of repeat customers in all of their school outreach programs, "they love us and they want us back."

Another challenge is that some of the schools are more focused on reading or math rather than science, so they are unlikely to book a science outreach program. One advantage both of the museum educators who were interviewed mentioned was that Florida Gulf Coast University is an environmentally focused school and many teachers are graduating from there. This could lead to increased interest in the area for the topic of alternative fuels – specifically biofuels. Teacher turnover is very frequent so they anticipate many new teachers coming into the system in the next few years.

***Museum of Nature and Science – Dallas TX***

**Classroom Program**

Observations were conducted of three 4th grade classrooms at Lamplighter School (See Appendix E for a detailed example of field notes collected during this site visit.) Lamplighter is an independent "progressive" day school in the Dallas area for students in pre-kindergarten through fourth grade that emphasizes experiential and cooperative learning.

The science teacher who helped facilitate the *Farming for Fuels* classroom program was also the Science Curriculum Coordinator at the school. Four activity stations

were offered: (a) processing of food materials for biofuels, (b) examining cells with a digital microscope, (c) alternative energy sources (solar- and wind-powered cars) and (d) internal combustion engine.

According to museum staff the classroom program is typically 55 minutes in length: 30 minute whole group introduction, five minute exploration at each of four stations, five minute wrap up. The three classes of fourth graders that were observed each experienced a similar format of the program: approximately 20 minutes of whole group introduction, 20 minutes of interacting with the stations and a five minute wrap up. The classes were closely scheduled with no real break in between.

The introduction was particularly effective and engaged the students. The museum educator made use of the whiteboard to record students' responses to his questions and had several other *Farming for Fuels* visuals available (e.g. switchgrass poster). See Appendix D.

Some items at the stations functioned simply as distractions for the students. If students didn't know how an item was meant to be used in a meaningful way at a station, they invented something to do with it; e.g., load the truck with ground up beans, play toss or stack the foam blocks, pretend to drink from a plastic bottle at the processing station. It should be noted that other than the museum educator there was no other facilitation of the stations. The science teacher engaged somewhat, but was often observed away from the program.

At the processing, internal combustion, and plant cell stations, the message of the activity that directly related to the logic of "Farming for Fuels" was not available to the students without an adult to verbally explain it.

It was difficult to determine if students were gaining anything from the alternative energy station. They worked with solar and wind cars, but the museum educator mentioned in the program introduction that solar cars are not a good alternative energy solution as they are currently too expensive. Thus students may have wondered why solar cars were highlighted as one to try.

The evaluator spoke briefly with the science teacher who stated that he was considering adding alternative energy to his curriculum in the future. This year there was only a slight connection to energy in the curriculum.

**Family Event**

The evaluators observed a *Farming for Fuels* Family Event at Our Lady of Perpetual Help Catholic School in Dallas. The school is a private, K-12 English immersion school that strives to use current technology in instruction. The school principal described the school body as small and family-like. The *Farming for Fuels* family event was incorporated into the school's "Family Science Night," which included student-led science activities and displays of student science projects throughout the school. Parents and students who attended the Family Science Night may not have realized the specific biofuels theme. The *Farming for Fuels* stations were not

distinctly set apart and there was no signage that would have alerted participants and given them an initial orientation.

Set up and training for this family event were particularly challenging. Adults and students were continuously entering the gym during the set-up time. The lead museum educator commented that it was difficult for her to know which adults were there to volunteer for the stations. Twenty minutes before the program was scheduled to begin the museum educator started informally describing the sugar testing station and pointed out other stations to two adult volunteers asking them to "check it out." One of the volunteers asked, "We'll be running the stations, right?" and the museum educator answered, "Right."

As volunteers were ultimately identified, the museum educator described stations to them one at a time and asked them to staff them during the evening. The adult volunteers then looked over station materials and tried to acquaint themselves better with the content and their tasks. At times, volunteers switched stations with each other during the set-up period. In one case, a volunteer at the Cell Wall Model station said, "I'm switching" after she saw the solar cars move in the Alternative Energy Station, perhaps she was thinking that looked like more fun. In another example a middle school student who was shown the Carbon Cycle station, but looked uncomfortable while she was getting instructions, moved to the Sugar Testing Station. The switching around required the museum educator to repeat training at particular stations multiple times. Most of the instructions given to the volunteers were about the logistics of using the station materials, and less focus on the content.

Families began entering the gym as early as 5:30 even though the family event was scheduled for 6 p.m. About 5 minutes before the official start, there was an influx of participants. Once the event was in progress, the noise level in the gym was very high. It was difficult to hear what was being said at the stations.

A stack of *Farming for Fuels* activity station data/reflection sheets were on a table by the entrance to the gym. During part of the evening the museum educator would stand by the entrance and pass out the data sheets to families as they entered, however this was inconsistent. Volunteers tried to ask families if they had their data sheet with them when they approached an activity. However, this too was inconsistent, only happened at three of the stations.

Most of the family night participants appeared to be Latino; they were overheard speaking both English and Spanish. Participants appeared to range in age from preschoolers to older adults and included multi-generational family groups. Overall, participants engaged in *Farming for Fuels* activity stations in the following ways:

- Looking at materials briefly while passing by

- Engaging in constructing a product with station materials, either independently or by watching what another person was doing at the station.
- Engaging in constructing a product with station materials, guided by the station volunteer
- Parents often joined their child who was engaged in an activity at a station.
- It appeared in several cases that children were explaining what they were doing to their parent – often in Spanish, as the parent was not an English speaker.
- Older students at times informally took on the role of station volunteer, assisting the assigned adult.

To help volunteers effectively staff a station, it might be helpful to have a handout with a series of simple guiding questions that the person staffing the table can ask station visitors.

Overall, despite the seeming chaos, this event was very well received by teachers and school administrators. Especially notable to the faculty were the multi generational groups working together on science.

**Museum Educator/Staff Interview Summary**

The evaluator conducted an interview with the museum educator who typically delivered the *Farming for Fuels* classroom program. He had only been on staff for one year at the time of the interview. He stated that he was trained by another educator simply by shadowing her in the classroom program, assisting and eventually participating. They originally would send out two educators to deliver the classroom program but during the 2011-12 school year things "dropped off" so that only one educator was sent out to do the program. He felt it was manageable especially "with the assistance of the teachers." He does not ask for volunteers in advance or let the teachers know of his needs:

> *I look at it as I'm going on my own. I generally prefer that. I don't want to inconvenience other people when it can be done successfully without having to pull those other people in…*

He had to cut the program down to four stations so that it could be managed by only one educator. He chose to eliminate Sugar Testing as he felt that it did not fit as well with the other stations in terms of connections. He said " the other stations can kind of build on each other" but sugar testing was somewhat outside of that. He thought it could serve as a good wrap up activity.

In terms of the classroom program format he typically tries to do 20-minute "lecture", and 20 minutes of stations with five minutes of flex time at the beginning and end to allow for student questions. This site stood out as having the longest whole group presentation, he referred to as "lecture." It worked very well and in this particular school students were asking great questions. It is likely that the type of open classroom with whole group activities being the norm helped. He described one of the benefits of the whole group lecture this way:

> *I try and ask questions to bring out the stuff that they know and to get them to go 'oh that's why that thing has been talked about before'.*

The classroom program has been presented to 3rd-6th grades. The educator noted that 3rd graders have had less experience with the topic of energy than 6th graders, so they need more support.

The evaluator also conducted an interview with two educators who deliver the family event as well as the classroom program. Neither of them had been with the museum more than about a year, so they had not participated in any of The Creative Discovery Museum's summer workshops. Their training had been through key person in the museum, as well as through the written materials developed and adapted by the museum. One of them stated that she wished they could send two educators out instead of only one. She suggested that expanding the program length might help:

> *Sometimes I feel like it's so much information that is hard to fit in an hour. It would be nice to have an hour and a half.*

As a result of the shorter time and only one educator they have had to compress and or eliminate some of the content.

> *I don't emphasize the cell wall. There is lignin in the cell wall and it's hard to break down. With everything else that we're talking about, I don't get to that. I feel it takes kids who are older and a bit more familiar with the cell structure to get that.*

***Ann Arbor Hands-On Museum – Ann Arbor MI***

**Classroom Program**

During the site visit the evaluator was unable to observe a classroom program. According to museum staff bookings there had only been about six classroom programs scheduled during the 2011-12 calendar year. Most of the museum's time and focus had been on delivering Family Events.

**Family Event**

The evaluator observed two family events held on consecutive nights at two different schools. After the first event there was quite a bit of concern. The family event included about 20 stations and only about five of them were part of the *Farming for Fuels* program offerings. The atmosphere in the large school gym was much like a large science fair or circus. There were plenty of families in attendance (approximately 250 individuals), however the theme of alternative energy was not the focus of the evening. The museum educator altered several of the stations to the point where they lost their intended meaning. For example at the sugar testing station, several drink choices (Coke, Diet Coke, Capri Sun) were offered for testing – the focus seemed to be more on nutrition and avoiding sugary drinks. There was even some discussion about Aspartame.

Other examples include at the CO2 Bubbles station, when the museum educator explained:

> *We call it Bubbles Over Ice. Participants experiment with blowing table bubbles. This allows exploration of volume, circumference, area, radius and diameter… general measurements as well as properties of water. We will also use dry ice to explore physical properties of carbon dioxide.*

At the "Titration Station" the educator told family participants:

> *A slight change to the PH of oceans can be a catastrophic to the environment.*

Finally, a discussion at the "Seed Need" activity turned awkwardly from rye grass seed to climate change, global warming and burning fossil fuels. When asked how the educator made that connection for the adult he stated, "segue." At best it was an unnatural one.

This museum educator was one of the first to point out what he considered a lack of conceptual linkages between stations. After some discussion with CDM program staff he revised the family event some to reflect what he saw as the necessary progression between stations, in order to improve the conceptual flow of ideas. He described his goal as "weaving a narrative." He sees the event as needing to be very linear. The original full data sheet is included in Appendix F along with those of other museum sites. Stations are numbered to reflect the preferred order or flow. An example is below:

| | | |
|---|---|---|
| **1) Seed Need**<br>What is the difference<br>Between an annual and a perennial? | **2) Up Close and Personal**<br>What do you notice about<br>the plant and animal slides? | **3) Mechanical Separation**<br>How tough is it to break down? |
| **8) Titration Station**<br>What does CO2 do to the PH<br>Of water? | **9) A Few Alternatives**<br>What are some other<br>sources of power and energy? | **4) Chemical Separation**<br>How can we break it down<br>Further? |
| **7) CO2 Bubbles**<br>Which is denser:<br>Regular air or CO2? | **6) A Whole Lotta Power**<br>Where is energy stored? | **5) Sounds Sweet to Me**<br>Which liquid had the most<br>Sugar? |

**Museum Educator/Staff Interview Summary**

According to the lead educator who delivers the *Farming for Fuels* programming, their goal in delivering a family event is to bring in a wide variety of activities that correlate with state curriculum standards and are appropriate for grades K-5. The event explores many topics in science including chemistry, physics, ecology, biology and math.

Alternative energy is not a curriculum standard for the state. Teachers are looking for energy or environmental themed programs but not specifically alternative energy. Unless a program meets their standards, teachers are unlikely to want it. However, in the family event format, interest in the topic can be raised. It is "current and cool" for the museum to advertise

### *New York Hall of Science – Queens NY*

This site discontinued the program after the first year. Unfortunately the evaluator was unable to gather any data regarding their experience in the program. There was no response to requests for a phone interview or survey.

### *Arizona Science Center*

This site also discontinued the program after the first year. A phone interview was conducted with museum staff, who delivered the classroom program.

Much of their outreach happens to Title 1 schools but for reasons the museum educator couldn't explain, it was decided that *Farming for Fuels* would not be offered to Title 1 schools. That limited the pool of available schools with whom to do outreach. The other schools were not as interested in the program because it did not fit in with their curriculum. Even though the program was free, the Science Center was unable to find interested schools. Their outreach program, especially to Title 1 schools, was very busy and left them little time to pursue other possibilities for schools that might be a good fit for *Farming for Fuels*.

> *Some of our other programs align so well with the standards that if a school had to choose between programs they're going to choose the one that is about the digestive system and the human body as opposed to this one. (AZ)*

After the initial workshop in Chattanooga they realized the scripts and outlines suggested a much longer program than their typical outreach and they were not sure how to cut it down to make it fit their timing. However another area of education within the museum found it to be a very good fit. They conducted a 6-week long camp, one class per week, as part of their STEM programs. Students who participated were in 4th-6th grades. The Science Center added a few additional activities to stretch the program for the camp format. Each program lasted 45-90 minutes and was presented in a classroom at a school, so still outreach. The STEM program has the advantage of returning six times to the same students, thus enabling the educators to build the lesson up over time and add layers. Unfortunately the "alternative energy" camp was only presented in one 6-week session and never repeated. The staff member who presented the camp was no longer at the Science Center so could not be contacted for follow up.

The *Farming for Fuels* classroom program is still listed in their outreach offerings but has only been booked twice in the last two years.

The Science Center found the materials provided by the Creative Discovery Museum to be less than durable:

> *… that was a problem we ran into a lot, they broke easily and when we're taking things out to the schools all the time and there are so many different hands they really need to be more durable than they were. (AZ)*

Overall the Science Center staff found that the stations were not interactive enough:

> *It seemed like they were going from station to station and being told what to do. But there was really no way for them to understand the purpose of it. (AZ)*

For example, the combustion engine was particularly challenging:

> *The students were given a handout and they were supposed to write in the parts of the motor. But they weren't given anything ahead of time so they would know what those parts were. (AZ)*

The complexity of the content was somewhat overwhelming.

> *There should have been a lot more instructions for us – there could have been more background information, because it was very complex. It should have been simplified. The specialist on my team was able to understand it with a little bit of background. But I don't have a background in science at all – so it was very difficult for me to understand. (AZ)*

The topic of switch grass and corn was unfamiliar to students in Arizona.

> *I think that's probably something that was difficult for students to even really think about, because they don't really see that out here. (AZ)*

## Regional Sites

### *East Tennessee Discovery Center - Knoxville TN*

Findings described below are based on a telephone interview with two members of the museum staff at East Tennessee Discovery Center (ETDC). This site began participating in 2009-10 school year. They were part of the regional program roll out. *Farming for Fuels* fits their museum mission, "to inspire a love of learning… and science." This is not considered a standard program to them; it was a little more complex and new information for many schools. Museum staff explained that the state of Tennessee projects a huge number of STEM careers in the next 5-10 years. As far as they are concerned, this type of content is more important than ever.

This site is currently short staffed so there is only one educator who is trained in delivering *Farming for Fuels*. That limits the number of classroom programs that can be booked as the staff member works part time.

### Classroom Program

According to one of the museum staff that was interviewed, the first thing they did when they received the *Farming for Fuels* curriculum lesson plan was "rewrote it outright." They had to make it fit into a 50-55 minute time slot and felt that not everything would work in the classroom setting. In order to make the best use of the one museum educator's time, this site has found it easiest to fill a day at the school. For example they often present to a whole grade level in one day. They set up in the school gym and all the 4th or 5th grades rotated to the gym. They were able to run 3-4 classes a day through the program.

Staff stated that they were very "impressed" with the quality of the materials provided by the grant. She went on to say,

> *This is the thing that they need to know because the world is going to change and we need abilities in those areas, so they need to be aware of it.*

While they consider *Farming for Fuels* as enrichment for the schools, they were able to identify at least three of the state standards that the program fulfilled. One example was he study of animal and plant cells.

The classroom program begins with a 30-minute introduction to the carbon cycle, introducing the difference between renewable and non-renewable resources. She incorporates many of the materials that don't seem to work in the activity stations, in the lesson introduction. For example she demonstrates the internal combustion engine and models the grinding station. Students then rotate to three stations: the dynoscope, alternative energy cars and the sugar testing.

**Family Event**

Data from this museum's interviews suggested that the Family Event was a preferred format as it has a broader reach, educating and involving parents, "everybody comes." It makes families aware of something they might not have thought of before. Typically classroom teachers facilitate the activity stations. They receive in-service credit for their time. Museum staff provides them with 30-45 minutes of raining before the event and they also help with set up. The Family Event has been requested.

They explained that they offer six stations at the Family Event. However they set up two tables with duplicates of each activity, so 12 stations overall. One of the stations this site eliminated from the Family Event was the CO2 bubbles. Instead they do strawberry DNA testing. Building the cell model seemed to them too challenging for the younger children who were attending the Family Event so they eliminated that one as well.

The museum educator who delivers most of the *Farming for Fuels* programming indicated that she believes the classroom program is a better format for the content. She stated that it would be more effective if there could be an introduction to the program as there is in the classroom format, to orient all of the families to the content before they participate.

***Adventure Science Center – Nashville TN***

Findings described below are based on a telephone interview with museum staff at Adventure Science Center (ASC). This site began participating in 2008-09 school year. They were part of the regional program roll out. As with other sites they began delivering the classroom program first and later followed with the family events. They have been able to sustain the program by using it in different formats and adapting some of the stations to better fit their needs and those of the teachers in the area.

**Classroom Program**

Staff at this site stated that one benefit of the classroom format versus the family event was that it was smaller and very transportable. Thus it made it easy to get bookings for the program – it came right to the teachers' classrooms. When the program was free this was especially easy. However when the funding was reduced it became more difficult:

> *I believe [it was more difficult to book the program] partly because of expenses but partly just how well it matched up, or didn't with the teachers' needs.*

Classroom programs were facilitated by a combination of teachers and volunteers. In some cases too many parents volunteered and sometimes there were not enough so the museum staff had to ask the teacher to facilitate more than one activity. There were usually three adults to staff the five stations.

Staff indicated that some of the stations were challenging to set up and facilitate and that sometimes the content was a bit overwhelming to be able to cover in the course of a classroom program:

> *I think the ideas were good. I guess for the amount of time the school had and how deeply you should go into any of the stations, sometimes it felt like we were trying to cover too many things.*

One example was the identification of the engine. They came up with an innovative solution to make the station more engaging and meaningful:

> *One of our volunteers took a lawnmower engine and did a cut away, so you could pull the cord and see how it worked inside… but that became too difficult so we switched to weed whacker engines. We found some four-cycle weed whacker engines that were smaller and made arrangements with a vocational school. The students did research, CAD drawings, first did virtual cuts and then went in and made the cuts on the engines themselves. Now they're building plexi cases for those. Now the students we serve can actually do something with the engine and see something happen. They can walk through the four cycles and look at where the parts are and how they move, so it becomes very clear where the exhaust cycle is. So it was easier to tie into the goals of the program.*

Another challenging station was the processing one where students grind corn, soybeans etc. Staff at ASC found it both difficult to set up and to manage. Part of the issue was the mess created by the ground products.

Many of the small revisions they made to the program came from overhearing what teachers were doing at the stations. For example, during one classroom program a museum educator overheard the teacher comparing the processing of these materials to the digestive system.

> *There was one teacher who had just finished a unit on the human digestive system. So she started comparing the station to using teeth to grind. It seemed logical [to me] to do a comparison between how the digestive system works to how the 'refinery' does. It's like a digestive system.*

They also took the smaller mortar and pestle sets that came as part of the family event and used them in the classroom program. This seemed to be more manageable. They used one mortar and pestle for each item: corn, soybeans and grass. They asked students to do a comparison after grinding each one separately.

**Family Event**

Adventure Science Center was able to deliver the family event in several creative formats. For example, they were approached by a charter school that was just about

to open in the fall. The school was interested in offering a special fifth grade event during the summer to introduce the new school. They thought this would serve as a great orientation event. As a result of this partnership forming, the family event became a good match for other charter schools. This created a new audience for ASC to serve. Teachers who moved between schools introduced *Farming for Fuels* to their new school, which helped the program spread.

To prepare adult volunteers to facilitate the stations ASC staff did the following:

> *I took the sheets that [CDM] developed and streamlined them a bit and rewrote some so they were more directed to the role of the volunteer. I tried to get those out [to the volunteers] ahead of time so that they could look at them and decide who wanted to do what. I don't consider [the sheets] to be finished being revised, or the training process. It's just too massive and I keep tweaking as I go.*

If there are not enough volunteers to staff all the stations ASC staff do not set up all of them. Sometimes it has also worked to "cluster" stations in a way that they can be monitored by fewer volunteers and still be successful and meaningful to participants.

> *For example I used the internal combustion engine with the engineering of the cars and then with the solar and wind powered cars. And then the Dynoscopes and "Make a Cell" work well together.*

One of the challenging stations at the family event was "Make a Cell", specifically cleaning it up afterwards. Their solution after several trials was to use vanilla yogurt as the base and different colored cereal, pretzels and candy as the cell parts – so edible cells. This was much more popular however children were choosing the foods they wanted to eat to make their cell rather than paying attention to the actual meaning/function of the cell parts. So ASC staff created a worksheet based on the one provided by CDM. They also ask the children to use the scientific language rather than food name. For example they ask for hydrogens or oxygens rather than marshmallows or gumdrops. That helped add more meaning and purpose to the activity.

***Tellus Science Museum – Cartersville GA***

Two staff members from Tellus Science Museum, who were unable to participate in a telephone interview, responded instead to an online survey regarding their experience with the program. The summary follows:

**Reach of school program**

| School Year | # of students served |
|---|---|
| **2009-10** | 828 |
| **2010-11** | 1461 |
| **2011-12** | 1722 |

**How easy were the Farming for Fuels lessons for you to use? (N=2)**

| Answer Options | Response Percent | Response Count |
|---|---|---|
| **Very Easy** | 50.0% | 1 |
| **Somewhat Easy** | 50.0% | 1 |
| **Somewhat Difficult** | 0.0% | 0 |
| **Very Difficult** | 0.0% | 0 |

Comments:

> *We have made significant modifications to better meet Georgia Science Standards for the grade levels we are presenting this to.*

**How confident were you about your understanding of the science content contained in the Farming for Fuels lessons? (N=2)**

| Answer Options | Response Percent | Response Count |
|---|---|---|
| **Very Confident** | 100.0% | 2 |
| **Somewhat Confident** | 0.0% | 0 |
| **Somewhat Unsure** | 0.0% | 0 |
| **Very Unsure** | 0.0% | 0 |

Comments:

> *I felt the sessions were appropriately planned and executed. Being on site for the schools science night was very helpful.*

**To what extent is the Farming for Fuels program a good fit for your museum's mission? (N=2)**

*It has been a wonderful program to scaffold our alternative energy program around.*

*We have a gallery devoted to transportation.*

**Have you been able to sustain the program in the schools even after the funding ran out? If so, please explain. (N=2)**

*Yes, actually our numbers have continued to grow each year.*

*Yes, as a normal school program charging $9 per student.*

**Have you hosted a Farming for Fuels Family Event at your museum? If so, please describe how that worked and how successful it was. (N=2)**

*Several times. It went very well with 600 -800 in attendance each evening.*

*Not since the grant ran out. It worked well the first few times. After that visitors tired over the repeating subject matter.*

**Please describe how well you think the Farming for Fuels curriculum worked for the age of your museum's school programs' audience. (N=2)**

*As mentioned before we have made modifications so that Farming for Fuels is now offered for high school and middle school and multi-generational families.*

*Good fit for middle school.*

**How well did the equipment and supplies provided by the Creative Discovery Museum work for the program? (N=2)**

*Not all of the equipment and supplies have been used. The dynoscopes and laptops have been the most seminal equipment that we received.*

*For the most part just fine.*

**What did you think about the sequencing of the lesson, the stations, etc.? (N=2)**

*We did not use the car making station as we felt that the nails and hammers were inappropriate/not safe for our environment. We also did not use the gumdrops for the water molecules, as we do not allow food in the museum.*

*This was poorly thought out and needed a lot of revision.*

**Did the Farming for Fuels lessons seem to relate to what you understood about the main goals of the program? (N=2)**

| Answer Options | Response Percent | Response Count |
|---|---|---|
| **Yes** | 100.0% | 2 |
| **No** | 0.0% | 0 |

## Findings from Teachers Across Sites

The findings summarized below are based on 45 respondents who completed an on-line survey distributed in June 2012. The population of respondents included all teachers or school personnel who booked either a school outreach lesson or family event. Ninety-five invitations were sent to complete the survey, 45 responded – a 47% response rate which is above the average of 30% for an on-line survey (Sue & Ritter, 2007))

**1) When your school booked a Farming for Fuels event, how important was each of the following considerations? (N=45)**

| Answer Options | Not important | Somewhat important | Important | Very Important |
|---|---|---|---|---|
| **Science content** | 1 | 2 | 10 | 32 |
| **Alternative energy content** | 2 | 7 | 17 | 19 |
| **Hands-on learning** | 0 | 0 | 5 | 40 |
| **Availability of a family event** | 14 | 9 | 4 | 18 |
| **School Partnership with museum** | 1 | 12 | 19 | 13 |

**2) Did your school host a Farming for Fuels family event? (N=45)**

| Answer Options | Response Percent | Response Count |
|---|---|---|
| **Yes** | 44.4% | 20 |
| **No** | 55.6% | 25 |

**3) Did your school host a Farming for Fuels classroom program? (N=45)**

| Answer Options | Response Percent | Response Count |
|---|---|---|
| **Yes** | 60.0% | 27 |
| **No** | 40.0% | 18 |

**4) Please explain what considerations affected your school's choice between a family event and a classroom program, if applicable. (N=33)**

Twenty-two respondents specifically commented regarding their choice of a family event. Common themes were:

- It provided a way to bring the whole family together for a learning experience.

*This provided opportunities for everyone to enjoy and learn.*

*We were able to provide this wonderful opportunity to all of our students, families and community members.*

*We want to encourage family activities and allow all boys and girls to have the opportunity to interact with their families.*

- It was something the schools already did so *Farming for Fuels* was a good fit.

*We always host a Family Science Night for all family members of our school.*

*We have monthly academic/family nights and this was a perfect fit with our schedule.*

- The schools are required to do some family outreach.

*We wanted to bridge the gap between parents and school.*

*We like to provide family learning events as part of our Title 1 programs.*

*Our school improvement plan needs to have outreach to our families in an academic setting.*

There were a small number of respondents who stated that they were not aware that a Family Event was an option.

Nine respondents explained their reasons for selecting a classroom program. Common themes included the following:

- Programs targeted at students (rather than families) were important.

*We felt that the students were the priority in the learning. What they were able to learn could be carried back to home.*

*Using a classroom program ensures that all students are exposed to the program rather than just the students whose parents are able to bring them back to school in the evening.*

- It fit well into their grade level/curriculum.

*We wanted all our 7th graders to participate in content relating to GLCEs (grade level content expectations).*

*This worked well with our 4th grade curricular goals.*

*This program fit into our 5th grade energy curriculum.*

- It helped them prepare for standardized testing.

*Science STAAR (State of Texas Assessments of Academic Readiness)*

**5) Did you attend a Farming for Fuels event at your school? (N=45)**

| Answer Options | Response Percent | Response Count |
|---|---|---|
| **Yes** | 88.9% | 40 |
| **No** | 11.1% | 5 |

**6) Which of the Farming for Fuels stations was most memorable for you? Please briefly describe the station and why you chose it. (N=26)**

Specifically mentioned were the following:

- Sugar Testing: 8
- Testing new energy sources for cars: 7
- Processing station: 6
- Carbon: 2
- Microscopes: 2

*I enjoyed seeing the student engagement. I also enjoyed the connection students could make with what they were learning in social studies.*

*I liked how there was a process that showed how alternative fuels could be harvested and then processed.*

*They were all appropriate and kept students engaged, but I was very interested in the station that measured the amount of sugars in liquids because it also addressed health and nutrition.*

*It was great for them to see how even a seemingly small change can make a big impact on the environment.*

**7) From what you saw, how effective were the hands-on activities at the stations? (N=39)**

| Answer Options | Not Effective | Somewhat Effective | Effective | Very Effective |
|---|---|---|---|---|
| **Engaging students** | 0 | 2 | 4 | 33 |
| **Teaching science content or process** | 0 | 1 | 7 | 30 |

**8) Overall, do you feel the program effectively taught students the following concepts? (N=39)**

| Answer Options | Not Effective | Somewhat Effective | Effective | Very Effective | N/A |
|---|---|---|---|---|---|
| **Knowledge about alternative energy sources** | 0 | 2 | 11 | 25 | 1 |
| **Understanding why using alternative energy sources is important** | 0 | 1 | 18 | 20 | 0 |
| **Social impact of using a food source like corn as an energy source** | 1 | 5 | 17 | 16 | 0 |
| **Why the structure of the switchgrass cell makes using its energy difficult** | 3 | 5 | 15 | 10 | 6 |

**9) What feedback did you receive from teachers and administrators after the classroom program or family event? (N=37)**

Overall 100% indicated that they received positive feedback. A representative group of comments for each program are listed below.

Classroom program

> *I was the science teacher who booked the program. My students were talking about the presentation for weeks afterwards and I mentioned it again later in the year when we got to renewable and non-renewable resources. The students had a better understanding after participating in the program.*
>
> *This was a classroom program for three 5th grade classes. All the students were interested and engaged and very excited to participate in the stations and learn more about alternative energy sources.*

Family Event

> *Everyone was very happy and excited about the outcome. It was the first time our school did an event like this and had 208 people attend. They would love to have it again. Parents wanted to know when the next one would happen.*
>
> *My students were able to come back afterwards and make connections to the content learned in class.*

There were a few concerns raised regarding the training of adult/parent volunteers at the Family Events.

> *For some stations there was not enough information or direction for uninformed adult volunteers to direct the station objective.*
>
> *Some parents weren't equipped with [enough] knowledge to handle certain stations.*

## CONCLUSIONS

### Big Concepts

In the following section the evaluator discusses how the "big concepts" about biofuels seemed to be getting across in the classroom program. The conclusions and discussion are based on multiple program observations. Each section begins with italicized text taken from a document provided by The Creative Discovery Museum and is followed by the evaluator's comments and recommendations based multiple observations of classroom programs and family events. As a disclaimer, the evaluator is not an expert in this science. There may be errors in some of the science explanations. Ideas and comments made here are based on what was presented by the various educators, a kind of synthesizing of best ideas.

*Big Concepts we want parents and kids to understand:*

1. ***What are alternative energy sources?***

*An alternative energy source is any source of energy that can be reproduced in a short period of time without the burning of materials that contain carbon. Examples are solar energy, wind energy (turbines), hydrogen energy. All energy comes from the sun and is captured by plants and animals to be passed along. This process in a plant is call photosynthesis and occurs when the plant takes sunlight and water and converts these to sugar, which is the energy source.*

**Evaluator Comments**

Why aren't biofuels included in this list of alternative energy sources? Perhaps there should be an image added at the alternative energy "cars" activity station that indicates biofuels/switchgrass as a potential alternative energy source for the future, since it is featured in the group's introduction.

Recommended flow of ideas:

- All energy comes from the sun and is captured by plants and animals to be passed along.
- An alternative energy source is any source of energy that can be reproduced in a short period of time without the burning of materials that contain carbon.
- Examples of this include solar energy, wind energy, hydrogen energy and biofuels.
- In a plant the process of capturing energy is called photosynthesis and occurs when a plant takes sunlight and water and converts them to sugar, which is the energy source.

2. ***Why is using alternative energy sources for fuel important for the environment?***

*The natural carbon cycle is out of balance when extra carbon dioxide escapes into the air from the burning of fossil fuels. The trees and ocean take in carbon dioxide and give off oxygen. When humans interfere with that cycle, too much carbon blocks the night heat loss and contributes greatly to the warming of the earth.*

The word "extra" in the first statement is unclear. The idea that something can block the night heat loss is confusing. Is there another way to word these?

Recommended flow of ideas:

- The natural carbon cycle is out of balance when more carbon dioxide escapes into the air than is absorbed by plants, trees, and the ocean.
- When humans burn a lot of fossil fuel, too much heavy carbon locks the night heat loss and contributes greatly to the warming of the earth.
- Gasoline for our cars is now mixed with ethanol, an alternative energy source that is made out of corn, which is a "biofuel".

The following is a suggestion for the next big concept that was not included in the CDM document. This seems to link #2 and #4 more readily:

3. ***Not all alternative energy sources are equally good.***

Recommended flow of ideas:

- Some alternative energy sources are too expensive currently to reproduce.
- Ethanol, when made from corn, produces pollution as well as reducing it.
- Corn is also a major food source in the world.

4. ***Why is finding non-food source items with which to create alternative energy important?***

*When we use a food source to create energy, we put some carbon in the air by growing the corn. Although it helps by using less fossil fuel, the corn creates a problem with nitrogen run-off into the rivers. Also, multiple uses of corn, such as making plastic with it, create higher prices for food.*

Recommended flow of ideas:

- Using a food source such as corn for energy makes food more expensive and adds to food insecurity for poor people.

- Corn is also not a good choice because processing it uses a lot of energy and creates the problem of nitrogen run-off into rivers.

5. ***Why are non-food source alternative energy sources hard for scientists to develop?***

   *We need to change the cellular structure of switchgrass for a short-term solution that uses current engine technology. The cell wall has lignin, which cannot be broken down by enzymes or microorganisms like corn or soybeans can. Switchgrass cannot be used as a food because the lignin cannot be digested even by a cow that can digest other grasses because it has a four-part stomach.*

**Evaluator Comments**

This big concept is really about how challenging it is for scientists to develop non-food biofuels. Consider adding an opening statement defining switchgrass: "Switchgrass is a non-food alternative energy source. It is a type of biofuel."

Overall it would be helpful if the term "biofuel" was introduced and used more often throughout these concepts. It is used in the presentation of both the classroom program and family event but is not included in these descriptions of the main concepts.

## Classroom Program

Program length and format varied across museum sites. This was often based on the demands or needs of the schools or based on what the museum typically offered in their outreach. Introductions as long as 20 minutes and as short as five minutes were observed. Some sites did wrap ups, some did not. This seemed like a very important part to keep in the program to help the students make final connections to the meaning of what they had done. One site did the wrap up very simply as students lined up to leave the room. Museum sites made personal decisions about what to keep, what to leave out, what to shorten and what to lengthen. This did not necessarily result in an equally positive impact for every participant.

Across sites a few activity stations seemed to be a bit problematic for educators and students.

### *Dynoscopes – Look at a Plant Cell*

The descriptive words on the cell slides were very small. Without facilitation students did not know what they are looking at or for. Students spent a lot of time moving slides around to see something or looking at out of focus material because without being told, they didn't know how to focus the slide.

Left unattended this station often degenerated into silliness looking at body parts etc. However with facilitation even this part of the activity can be a learning

experience. This station needs facilitation because if the students cannot figure out how to focus the microscopes the meaning of the activity is lost.

### *Internal Combustion Engine*

Without the Educator at the internal combustion station, students pulled on the crank to make it move or watched other students pull on the crank. Several sites eliminated this component altogether from the classroom program. One of the regional sites completely modified the engine using a four-cycle weed whacker. They partnered with a local vocational school to modify and build the exhibit to be used in the classroom program.

### *Alternative Energy Cars*

It is important how the educator sets up the purpose of solar cars. In at least one school the educator stressed that solar cars are not a solution because they are too expensive to develop, however they are there for students to explore as an option. This may confuse students.

## Family Event

Family Events were conducted in a variety of ways. One was held in a museum and stations were spread throughout the space in several rooms and on more than one floor. This was not very effective at tying the ideas and concepts together for visitors. In fact many of them did not realize they were part of the same special science topic: biofuels. In a children's museums setting for whom 3-5 year old are the most frequent child visitors, the content was perceived to be too difficult. While it was a way to bring in older children, the children's museum was not successful at attracting enough to make the *Farming for Fuels* Family Event a success. Similarly another museum conducted the Family Event at a school that had two wings and half of the stations were set up in one wing and the other half in the other wing.

One science museum conducted the Family Event at a large private school and included many more stations than the nine (approx.) stations which are part of program. Again, families did not make the connection between stations. Rather they saw the event as a sort of large science fair. While this type of approach for delivering science content to families is not a bad one, it did take away from delivering the specific content about the science of biofuels.

The Family Event seems to work best when held at a school cafeteria/gymnasium where families can move around freely at a relaxed pace and younger siblings have a bit more space as well. Trying to deliver this program in a museum space might work more effectively of there was a large enough space for all of the activity stations. When they are spread around, as at DuPage, families may not see how they build on each other to deliver important science content.

While staffing the stations (nine of them) with enough volunteers was sometimes challenging the data revealed a few interesting and creative solutions.

- High School Service Club
- High School Honor Society
- Teachers select students who already participated in the classroom program to assist the parent volunteers

There were also differences in the way volunteers were trained. Some sites trained volunteers on every station and then let them choose which one they wanted to facilitate. Other sites trained individual volunteers on individual stations that they went on to facilitate. Based on the observations, the latter method seemed to result in the volunteer taking more ownership of the station and therefore doing a more effective job facilitating.

When asked what the difference was between delivering the program to the classroom versus to a group of families the consensus seemed to be that the Family Event is able to reach a wider and more diverse group of people. In addition as one educator put it, " it starts the dialogue that they may not have had otherwise." The classroom program allows for a more focused teaching experience.

**Activities**

Below is a summary of findings across the data regarding many of the nine commonly used stations in Family Events. The names are taken from CDM's Family Event worksheet. Other museum sites revised the station names (see Appendix G).

***Make a Cell***

This station was messy and several museums changed the objects they used to create the cell. One of the most popular ideas was to create an edible cell – made of food. This wasn't possible at every site because of restrictions and children's food allergies. However for those where it could work it seemed to add more purpose to the activity and certainly added enjoyment.

***Sugar Testing***

At several sites the purpose and meaning of this station seemed to get lost. While the goal of the activity seemed to be finding out which liquid/food had the most sugar, the connection to the sugar in corn was often missed. It also made a difference how the station was facilitated. At one Family Event the evaluator observed a teen facilitating and ignoring the participants. He would demonstrate how to use the refractometer and then say which has the most sugar, and then sit down. Without more explanation children and adults missed the point. One of the regional sites had an interesting modification that seemed to help. They found most participants would not stay long enough to complete the graph. However one they were participants were asked to make a prediction before each test they spent more time and seemed more engaged.

### *Look at Cells*

This station was discussed in the Classroom Program section. While the microscopes were technologically very interesting, without facilitation families had difficulty figuring out 1) how to operate them and 2) what they should be looking at – what the connection was to alternative energy. Nevertheless as one museum educator stated, "it's nice to be able to show them this equipment." Without facilitation children often used the dynoscopes to look at their hair, skin, nails, etc. While this was interesting, it did not serve the science content.

### *Perennial vs. Annual Plants*

This station provided families with a take home activity – an opportunity to watch a seed grow. The connection to alternative energy needed to be explained by a facilitator or museum educator.

### *Process Food Yourself*

This was another station where there was a high mess factor. Some sites chose to eliminate it from the family event for that reason. When it was facilitated, there was an opportunity for good conversation.

### *New Energy Sources*

This was one of the most popular stations across sites. Adults often chose to facilitate this station, and many children participated.

### *Where and What is Carbon (CO2 Bubbles)*

This station was always facilitated and attracted a lot of attention. It was one of the best opportunities for conversation about the carbon cycle. There was a lot of interest in the temperature of the dry ice and why gloves needed to be worn.

### *Make a Molecule*

Younger children had difficulty understanding the science behind this activity. It was a step-by-step craft activity for many. When facilitated, there was opportunity for introducing important science vocabulary (oxygen, hydrogen, etc.)

### *Be a Scientist*

This activity was especially enjoyable for adults, fathers in particular.

## Communicating the Science

A question the evaluator posed to each of the museum educators during the site visits was: what is the main message you are hoping students and families will take away from this experience. Below is a range of responses across sites:

> *We have these energy needs and there are different approaches to solving them, some of the approaches are really novel. Maybe you will come up with the next idea.*
>
> *Burning a biofuel is not contributing to the CO2 in the air the same way that burning a fossil fuel is. The (switchgrass) plants are taking the carbon out of the air while they are growing. It's more or less a cycle.*
>
> *What's wrong with using corn for fuel? We have to eat it. What's more important – what we have to eat or what powers our cars?*
>
> *Wouldn't it be nice to pull up to a water station instead of a gas station? Parents this is your children's future. Your children are going to be confronted with these different energy changes. They are our future scientists.*

At the summer meeting held in Chattanooga in July 2011, museum educators requested that a "Frequently asked questions" document be developed for museums so that they could give accurate science responses to families who engage them in conversations about alternative energy and the current research. That document was not present at any of the sites. On more than one occasion, the evaluator overheard and observed conversations between adults and museum staff that led to conclusions that might not have been accurate. For example, at one museum a woman asked the museum educator what the difference was between annual and perennial, which one was heartier. The educator was not clear with his answer and then diverted the conversation into one about greenhouse gases, CO2 emissions and global warming. It seemed like a leap at best. When the evaluator inquired about the woman's end of the conversation that led from grass to global warming he said, "it was just a segue." If the scientific connection is not clear about subject content and facts, this can come off as purely trying to communicate an environmental agenda.

In the staff interviews the evaluator asked what they thought the program's main messages were.

> *Alternative fuels and the impact on the environment, looking at the importance both in terms of the energy and the environment as well as the methods you need to look at to produce biofuels.*

## Communicating as a project team

As discussed earlier, museum educators who came together for the summer workshops really appreciated the ability to share information, challenges and

solutions. However, once they returned to their museums, this type of exchange was not as easy to maintain. It has been recommended previously that the Creative Discovery Outreach staff develop an on-line network through a resource such as Google, Yahoo or Basecamp, where educators can post their ideas, suggestions for materials, their challenges, their successes, great stories or quotes form the outreach lesson as well as Family Nights. This may have prevented some of the challenges that arose during the year, such as how to book a school outreach lesson if a district didn't see the benefit of this topic, or how to best organize a themed Family Event that included biofuels and did not divert too far from it.

This group of museums is a kind of network and in order for networks to work most effectively there needs to be a central hub they can all go to. In the summer of 2010 and 2011 that hub was a physical location, but moving forward it could be virtual. This will be especially critical if additional funding is secured and more museums are added to the network. As the project spreads there are certain essential elements that need to be maintained in the program while still allowing for the museums to stretch and try new things. The core message of the program may be lost if communication in the network is not maintained.

## RECOMMENDATIONS

The following list of recommendations is based on the findings in the data. Recommendations are grouped by program component.

### General

- Communicating the science and the message of alternative energies effectively and accurately is one of the most important considerations of this program. Be creative but organized as you develop a plan to maximize the effectiveness of both the classroom program and Family Event. Keep in mind the Big Idea and Program's Content Goals:

    - Big Idea: Inform the general public about the science of biofuels and the need for it.

    - Content Goals

    1. Science is cool and you can use it to solve problems.
    2. There are differences between plant and animal cells.
    3. It takes a complex process to convert corn into fuel – grind into cornmeal, and use enzymes and microbes to break it down.
    4. There are other alternatives to petroleum but there are reasons why they won't work with current combustion engines. For example there is no existing infrastructure and we need to do more research.
    5. There are different amounts of sugar in liquid. Some are surprising.

- Consider reviewing all curriculum (printed) from the national sites to see what might be missing, changed or added to the content. Confirm that the science clear.
- Periodically have teachers in the key grade levels review the *Farming for Fuels* curriculum and written materials to be sure the content is clear to them.
- Museum educators need to be adequately trained in the program's content before presenting it. While this may seem obvious, this step is sometimes overlooked, and when it is the negative consequences can be great.
- The *Farming for Fuels* program is designed for upper elementary though middle school students. Keep this target audience in mind when planning and presenting the classroom program or Family Event. If the audience is younger than fourth grade, the goals of the program will likely not be accomplished. The students will not have enough prior knowledge to understand or retain the content.
- Continue to connect the alternative energy curriculum and activities to current state and national standards.

- Select durable materials for classroom programs and Family Events, as all activities are hands-on and materials will be used over and over again by many students.
- Communication between museum partners is critical to the continued success of the *Farming for Fuels* program. A mechanism that enables regular, sustained communication between partners should be established and continually monitored for effectiveness.
- Identify a mechanism for allowing regular contact with BESC scientists. Contact with scientists/researchers allows educators the opportunity to learn more about current research and get their questions answered. They may be asked questions in their classroom program or Family Event that they cannot answer adequately. This interaction will also allow the scientists to learn about how their work is being translated and shared with students, teachers and families.
- Consider alternative ways to expand the reach of *Farming for Fuel*s program experiences by incorporating the activities into after-school programs, clubs, summer school or day camps, science nights, or 'Ask a Scientist' sessions.

**Classroom Program**

- Be careful when planning the classroom program content so that you don't attempt to cover too much material in a relatively short period. With sufficient time allowed for an introduction and a wrap-up, two to four activity stations might be enough for a 55-minute session.
- Remind school administrators, teachers and support staff or volunteers that *Farming for Fuels* is based on hands-on activities. Educational research indicates that hands-on learning in the area of science is most effective. Because the program is activity driven, at times the learning environment may become noisy. As long as there is good organization, experiential learning is occurring and noise is not necessarily a detriment. Rather it often indicates that students are actively engaged in the learning process.
- At the beginning of a classroom program provide the classroom teacher with a written summary of your lesson so that they can follow along and use the document for follow-up and enrichment after the program.
- Include a wrap-up at the end of the classroom program in order to help students make final connections to the meaning of what they experienced, to check for understanding, and to clear up any scientific misconceptions.

**Family Event**

- A sufficient number of museum educators should be on-site at Family Events to help provide volunteer training, set up activity stations, answer questions and address other needs as they arise.
- Proximity of stations and sequencing of activities was key to the family event's success. Try to have stations close to each other, with a designated path from "Big Picture-Introductory" conceptual learning to "Big Picture-

Conclusion" concrete learning stations. This will enable learners to construct topic-specific knowledge along their journey, ending the event with a "Big Picture" of some of the challenges and many possible solutions to our current transportation-related energy needs.

- Location of the activity stations and flexibility of movement among them are important to consider. Large rooms like school cafeterias, gymnasiums or museum foyers were good choices for Family Events. Placing laminated footprints on the floor or providing maps that define the name and location of each activity station might improve the likelihood of sequential, constructivist learning.
- Encourage caregivers, siblings, relatives and friends to participate and be actively engaged with their children in the Family Event activities.
- At Family Events, sufficient staffing of learning stations is key. Consider your resources such as student assistants who have previously participated in a *Farming for Fuels* classroom program, members of service clubs or National Honor Society or teachers who have a special interest in the program and/or the topic of alternative energies.
- The content covered by the *Farming for Fuels* curriculum can be challenging for someone unfamiliar with the subject of alternative energies. Consider providing each volunteer at an activity station with a handout explaining step-by-step what he or she should do and the science behind it. Allow enough time for volunteers to familiarize themselves with the content and ask any questions they may have, before families arrive.
- Provide a list of simple guiding questions the volunteer can ask children and caregivers to add to their understanding of the activity.
- Provide adequate uninterrupted time for volunteer training prior to the beginning of the event. A list of volunteers should be provided to the museum educator when they arrive on site. Volunteers need adequate time to become familiar with the activity station they will be responsible for. They should be made aware of the goals of the Family Event. If fewer volunteers are available, museums should consider setting up fewer activities or clustering stations.
- Several museums that participated in the *Farming for Fuels* program over the last few years have found success by using a monetary discount as an incentive for schools to book a program, while also enhancing the probability of an effective on-site experience. Thus discounting the price of a Family Event should be considered, particularly if a school can provide a sufficient number of high quality, highly motivated volunteers.
- Consider providing students and their caregivers with a reflection tool/data record sheet that could be completed as they work their way through each activity station.
- One or more volunteers should be assigned the task of providing the data sheets to each station. The volunteers should be instructed to refer to the data sheets often, ad check what students are recording for accuracy.
- Provide some opportunity for wrap up at each activity station (as in the classroom program). This will help ensure that the goal of the activity station

has been met and it will allow students and their caregivers to construct the "Big Picture" as they move through the activities.

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**APPENDICES**

## APPENDIX A: Evaluation Questions

*Museum educators*

1) To what extent do museum educators believe the lessons are user-friendly?
2) To what extent are museum educators confident about their understanding of the science contained in the lesson?
3) To what extent is this project a fit for each institution's mission?
4) Do museum educators perceive that they have the support they need readily available for the presentation of the lessons?
5) To what extent are the lessons sustainable - will schools continue to pay for them after funding runs out?
6) To what extent and in what ways are family events adaptable to a museum setting?
7) Does the program delivery equipment, supplied by the Creative Discovery Museum, work as expected?
8) To what extent is the content in the lessons age-appropriate for the audience of each museum?
9) To what extent does the sequencing of the lesson make sense and seem to relate to the main goals of the *Farming for Fuels* curriculum?

*Teachers*

1) In what way does the information presented in the lessons connect with what teachers are doing in the classroom/their curriculum?
2) To what extent and in what ways was the content in the lesson presented in a way in which students could understand and retain?
3) To what extent did teachers feel prepared to facilitate the activity stations during the lesson?
4) To what extent did teachers feel their students were prepared for the lesson?
5) To what extent do the teachers perceive that the lessons included student assessment?
6) To what extent does the lesson support the educational standards for each participating school system?
7) To what extent does the sequence of the lesson and activities make sense and seem to relate to the main goals of the program?

*Caregivers*

1) What did caregivers perceive their child learned about biofuels?
2) To what extent do caregivers feel their children understand about alternative energy for transportation??
3) To what extent do caregivers feel the information presented in the program will help their child be successful in school?
4) To what extent has attending the program increased caregivers' interest and understanding about the need for alternative energy?
5) To what extent do caregivers believe this is an important issue for their child to be familiar with?

*Students/Children*

1) To what extent do students/children recognize that alternative energy is important?
2) To what extent do students/children recognize that biofuels are an alternative energy source for transportation?
3) To what extent and in what ways were the program activities enjoyable?
4) Which activities seemed to stand out to students/children?
5) Which activities did students and children engage in during the lesson or Family Event?

## APPENDIX B: Data Sources

Site visits (Program observations and Staff Interviews)

1. Saturday December 10, 2011- DuPage Children's Museum: Family Science Saturday
2. Wednesday February 8, 2012 – Imaginarium Ft. Myers: 3 School Outreach Lessons
3. Thursday February 9, 2012 – Imaginarium Ft. Myers: Family Science Night
4. Friday March 16, 2012 – DuPage Children's Museum Family Science Night
5. Wednesday March 28 – Ann Arbor Hands On Museum: Family Science Night
6. Thursday March 29 – Ann Arbor Hands On Museum: Family Science Night
7. Saturday April 14 – DuPage Children's Museum: Family Science Saturday
8. Tuesday April 17 – Museum of Nature and Science Dallas: 3 School Outreach Lessons
9. Tuesday April 17 – Museum of Nature and Science Dallas: Family Science Night
10. Thursday May 3 – DuPage Children's Museums: School Outreach Lessons (Science and Society Day)

End of school year 2011-12 On-line Teacher Survey: 45 Respondents

Administered on-line in June 2012 to teachers who had booked a *Farming for Fuels* program during the 2011-12 school year. 95 invitations were sent to complete the survey, 45 responded – a 47% response rate which is above the average of 30% for an on-line survey (Sue & Ritter, 2007))

Regional/National Phone Interviews or On-line Surveys

1. Arizona Science Center (Phone Interview)
2. East Tennessee Discovery Center (2 Phone Interviews)
3. Tellus Science Museum – GA (2 Surveys)
4. Adventure Science Center TN (Phone Interview)

## APPENDIX C: Conference Presentations

2012
National Science Teachers Association (NSTA) - Atlanta, GA (Regional)
Association of Science and Technology Centers (ASTC) - Columbus, OH (National)
Association of Children's Museums (ACM) - Portland, OR (National)
The Georgia Educational Technology Conference

2011
NSTA - San Francisco, CA (National)
NSTA -Hartford, CT (Regional)
Georgia Educational Technology Association (GETA) - Atlanta, GA (State)
ASTC - Baltimore, MD (Regional)
NSTA - New Orleans, LA (Regional)
NSTA - Seattle, WA (Regional)
ACM - Houston, TX (National)

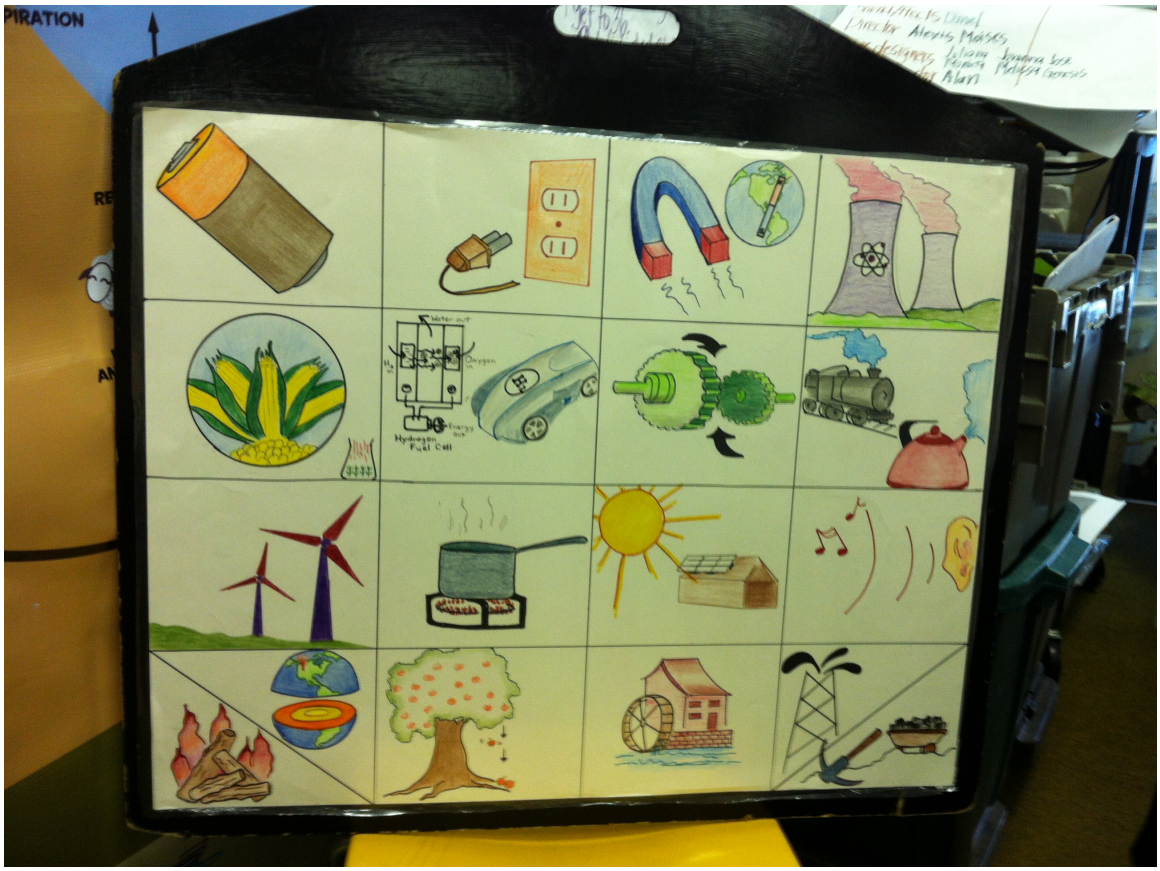
2010
NSTA - Baltimore, MD (Regional)
NSTA- Nashville TN (Regional)
NSTA - Philadelphia, PA (National)

2009
Tennessee Science Teachers Association Conference (TSTA) - Franklin, TN (State).
NSTA - Ft. Lauderdale, FL (Regional)
NSTA - Phoenix, AZ (Regional)

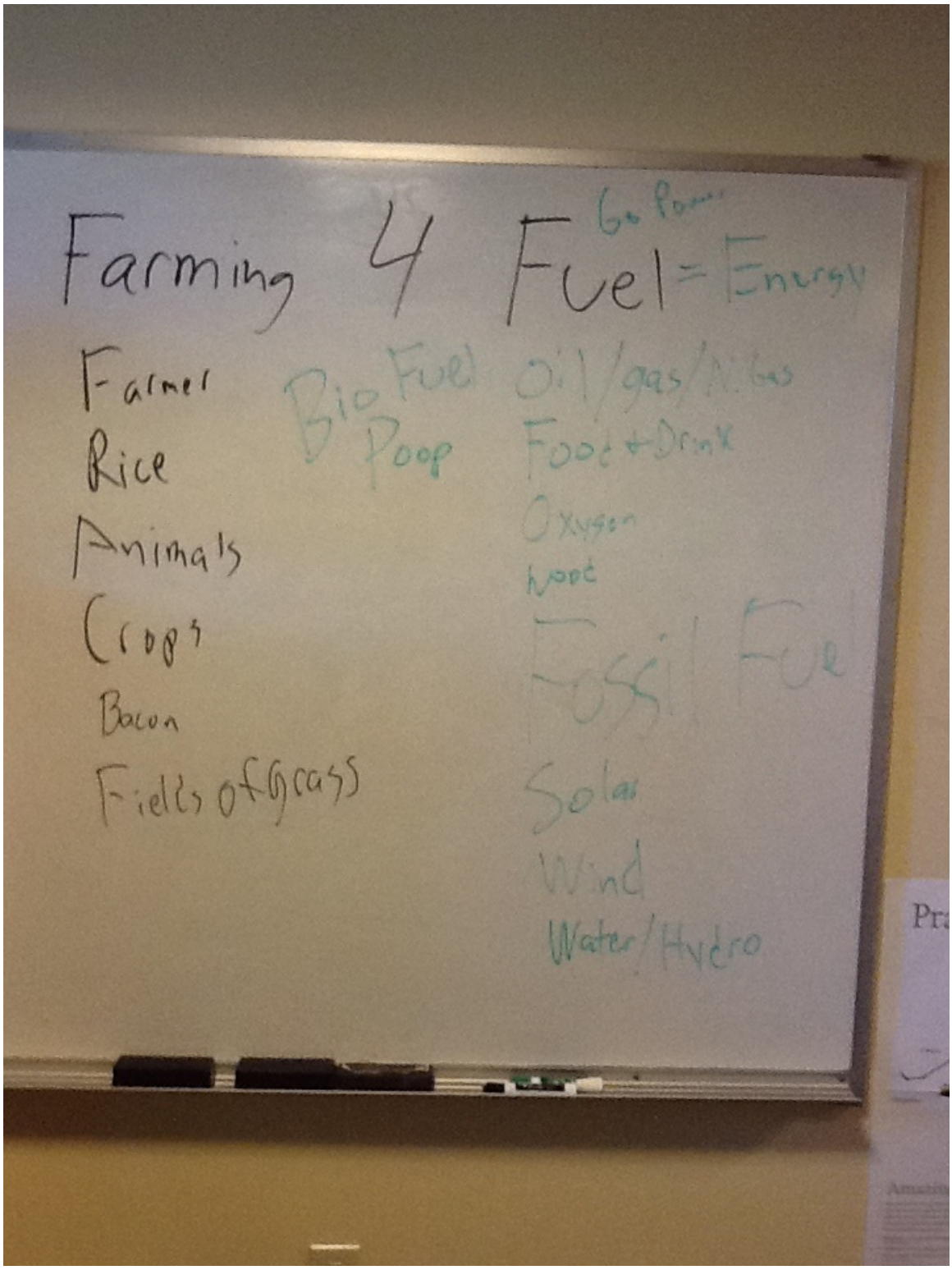
## APPENDIX D: Images from *Farming for Fuels*


**DuPage Children's Museum: Use of multiple visuals during classroom program**


**DuPage Children's Museum: Production of Biofuel**




**DuPage Children's Museum: Sources of Energy**




**Dallas Classroom Program Introduction – Student discussion**

## APPENDIX E: Sample of Classroom Program Field Notes

Introduction to 4th graders - approximately 20 minutes

Museum educator ["educator"] asks students "What is fuel?"

[Multiple students raise their hands and give responses such as the following.]

- Stuff that runs something,
- Gives life, energy
- Some kind of oily stuff

[The Educator lists student responses under the heading "Fuel." The Educator continues to ask questions and write student responses under the "Fuel" heading on the whiteboard.]

Educator: Do you put fuel in you?

Student: Yes

Student: Fuel gives us energy

Educator: Fuel equals energy. Food is fuel for us. [He elaborates on this.]

Educator: What are types of energy?

Student: Batteries

Educator: Batteries are a chemical energy.

Student: 5 –hour energy

Student: Gas

Educator: Gas, or gasoline

[Students continue with responses such as electricity, food, oil.] As students respond the Educator at times elaborates on a student response and at times probes to draw out more information, such as asking "what is a bigger way to say it?" to lead students from "oil" to "fossil fuels."]

Educator: What are bad things about fossil fuels?

Student: They're going to run out.

Educator: Renewable resources, what does that mean?

Student: We can get them again.

[The Educator explains where fossil fuels come from and that we are using them up. He asks students about the periodic table, says that carbon is an element, and holds up the carbon cycle banner.]

Educator: Have you heard of the carbon cycle?

Student: [a student response, not captured]

The Educator explains the carbon cycle and that carbon is a heavy gas,

Student: The Greenhouse Effect

Educator: Heat and energy in the sun is getting trapped. There is too much carbon in the sky for plants to use, a misbalance.

[The Educator points to the left hand side of the whiteboard where the word "Farming" is written.]

Educator: On the other side, what do you think about farming?

[Students respond with words and phrases such as plants, animals, wind farming, barn, eggs, The Educator writes each student response on the left-hand side of the whiteboard. Next to the word "plants," he writes "crops."]

Educator: We want to farm energy. Grow plants to turn into fuel. Have you heard of ethanol?

No student responses.

Educator: Corn, corn syrup, corn turned into food, syrup, fuel. Is it a good idea to turn food into fuel?

Student: A very good idea

Educator: Is it a good idea…. [a lengthier explanation of the implications of using corn for fuel]

Students, unanimously, say "No"

Educator: All plants make their own sugar. We want to get sugar from plants to turn into fuel. Educator shows switch grass banner.

Educator: With corn, you have to plant a new seed every time. This grass grows 12 feet every time, several times a year. Grass as it grows takes carbon out of the air. [Educator refers to the grass at students' homes and how when they cut it, it just grows back up.]

Educator: The ways we can learn more is to go to the stations. If we continue as we are we will run out of fossil fuels.

End of introduction

<u>Small Groups at Stations</u>

[Note: Data from all three classes are combined for the observations of small groups at the stations.]

The Educator moves from station to station answering student questions, demonstrating what to do at each station, and, at the processing station, calling students' attention to the materials to read.

- Processing station

***Educator and teacher talk at processing station***

Educator: "The aim is to get it to a powder and then it goes through this process."

[The Educator shows student the diagram of the process.]

Educator: "As small as you break it down, you're not getting to the cellular level."

Educator: “Tell me what you’re doing.”

Student: “We’re grinding.”

Educator: “Why?”

Student: “To make powder to make fuel.”

Educator: “These are the steps.” [The Educator uses the diagram and explains briefly each step in the process.]

Educator sees student with the truck underneath the grinder, he says, “The truck is for the start and the end of the process.”

Teacher to students using the mortars and pestles with the switch grass, “Do any of you cook at home with something like this? It’s kind of hard.”

Teacher: “Do you remember what he said about how to use that” [Referring to grinder.]?

Student: “It’s hard to grind that.”

A second student, “Exactly.”

Educator: “These are the steps in the process of being made. You’re supposed to be reading and learning. That’s why I went over what the process is.”

***Student talk and behavior at processing station***

At the grinding station, Students used the grinder, vigorously. Students used the mortar and pestle with the coarse grained material - soybeans. Later students were observed using the mortar and pestle with the grass. Students experimented with differing containers (or no container) underneath the grinder; e.g., one of the two small dump trucks on the table).

Almost no students who visited it read text at the station. There were a few exceptions. Also, a student in the first group to visit the station asked, “What’s number 1?” out loud, but there was no adult there to respond.

Student is using the mortar and pestle with the beans and another student is watching.

A student picks up a bottle, looks at it, and puts it back. Picks up another bottle and pretends to drink from it.

A student puts the dump truck toy under the grinder and loads it with corn.

- Internal combustion engine station

***Educator and Teacher talk at internal combustion engine***

Educator: "Do you all understand how the engine works?"

Student: Yes

Educator: How?

[no response]

Educator: "How does the engine work?" [Then he explains.]

***Adult-student interactions at the internal combustion***

Evaluator to a student who was pulling the engine crank: "What's giving the engine power?"

Student response "It's my energy. I'm making it move."

Educator to a student: How does the engine work?"" The student didn't respond and the Educator described the primer, pulling up the gas, spark, etc.

---

Student, handling the second engine model, asks the Educator, "What's this?" The Educator responds, " This is a mechanical version of that" looking at the larger engine in the case.

**Student talk and behavior at the internal combustion station**

I want to see the motor.

Are you trying to start it?

A student held and looked the second engine model.

---

Two students:

What is this?

"Pull, pull, pull"

Student: Harder

Educator: How's an engine work?

**Other notes about the internal-combustion station**

Without the Educator at the internal combustion station, students pulled on the crank to make it move or watched other students pull on the crank. There was also another engine model that only a couple of students were observed with.

**Plant cells station**

**Educator talk and behavior at the plant cells station**

[Regarding the dynoscope] educator tells the students, "Use the black knob to change the focus"

**Adult-student interactions at the plant cell station:**

Student was looking at her hand with the digital microscope but it was out of focus and student was moving slide around to try to see something.

The Teacher came over and showed the student how to focus the microscope.

The student said, "Look at my hand, it's really weird."

---

A student is pointing the lens at her cheek.

The Educator moves to the table and says, "You can use the microscope for your hands, but not your face."

The student moves the lens to her hand and says, "That's weird."

---

The Educator says to students, "Start with the plant slides." Students still are not able to focus the microscope.

---

Teacher: "Did you guys look at the slides? Kind of need to focus it.

Student put the lens on a slide and the teacher focuses it and moves the slide.

**Student talk and behavior at the cell station**

Student is looking at magnified image of own finger and exclaims to another student: "I had no idea."

"I like this."

2 students are looking at a cell under the microscope

"It looks like a coconut."

"It looks like a sand dollar"

---

A student is observed reading the labels on the cell slides.

---

Two students take turns putting the lens to their eyeballs.

Two other students toss the cell foam blocks to each other.

---

Students use microscope on their leg, a bracelet, and their hair.

---

A student is stacking the foam blocks.

---

A student uses microscope lens on the foam block.

**Evaluator comments on the cell station:**

The descriptive words on the cell slides are very small. It's not set up so the students would know what they are looking at. Students spent a lot of time moving slides around to see something or looking at out of focus material because without being told, they didn't know how to focus the slide and also didn't show any signs of knowing that what they were looking at was out of focus and that the microscope needed to be focused.

No students were observed looking at foam blocks while looking at slides or referring to the information on the foam blocks.

**Alternative energy stations**

The Teacher spent time at the alternative energy station demonstrating and troubleshooting moving the cars with the light and fan. The teacher brought out a wooden track that he had on hand and moved the cars over to it, which helped the cars to move.

**Adult-student interactions at the alternative energy station**

The teacher spends considerable time at this station, especially during the first class. He brings over a wooden track and sets the cars up on it. As students visit the station, he assists them in getting the solar cars to move.

---

When a student comments to the Educator that one of the lights is not working, the Educator explains that it has been used too much and is now too weak, but it still works, just not very well.

**Student talk and behavior at the alternative energy station**

Two students are using the two lights to move the solar cars. One comments to the other that one of the lights does not work.

---

Look, it still gets sunlight. [while using a solar car]. If you have it afar, it goes slow. If you have it close, it goes fast.

---

Two students with wind car and fan, using the fan to blow the car one way while a student uses his breathe to blow it the opposite way.

**Educator summary at the end of the class**

[For **Class 1**, this didn't happen.]

**Class 2**:

Do you have questions? Do you understand farming for fuel? We need to not use fossil fuels. It's better to use pants, but we need to get the sugar out and change it into alcohol. With plants, it's hard to get the sugar out. The goal is to figure out the best way possible. this is new science. Any idea can be a good idea. Except poop…

Student: Poop from animals.

Student: I can put my head on the table and feel the vibration.

Student question: What's that thing called?

Educator: Digital microscope.

**Class 3**:

Has everyone been to every station? Any questions? The thing to remember is that we are able to grow something that we can turn into a fuel to get us off fossil fuels.

Student questions: You said manure can't be used?

Educator: It's not very efficient.

**APPENDIX F: Family Event Data Sheets Developed by individual museum sites**

1) **Dallas: English**
2) **Dallas: Spanish**
3) **DuPage**
4) **Ft. Myers**
5) **Ann Arbor**

Museum of Nature & Science

*Fuel Up!: Biofuels Family Science Night Passport*

School name: _____ Date:_____

Children's Names/Grades: _____

**Your challenge:** Answer a question at EACH station and have the educator at your station initial the provided box.

| | | |
|---|---|---|
| **MAKE A PLANT CELL**<br>Q: Why is it hard to get energy from grass instead of food (like corn)? ☐ | **GUESS HOW MUCH SUGAR?**<br>Q: What do we get from a plant that gives us energy? Where do we store that energy? ☐ | **MICROSCOPIC MARVELS**<br>Q: Are plant and animal cells the same? ☐ |
| **PERENNIAL vs ANNUAL PLANTS**<br>Q: What is the main difference between grass plants and fruit and vegetables? ☐ | **FOOD PROCESSING POWER**<br>Q: In order to make liquid fuel, we have to turn the sugar from plants in to what type of liquid? ☐ | **NEW ENERGY SOURCES**<br>Q: We use fossil fuels to power our cars, planes, and other vehicles. What are some examples alternative energy? ☐ |
| **WHAT IS CARBON?**<br>Q: What does carbon have to do with the air we breathe? ☐ | **MAKE A MOLECULE**<br>Q: What is a molecule and what elements are in an ETHANOL molecule? ☐ | **INNOVATION STATION**<br>Q: Can you invent a car that moves without your help? ☐ |

***Your feedback helps us improve this program.***
*Please return this completed form to the TREASURE CHEST table.*

1. Circle the ages of all children attending the event: (5 6 7 8 9 10 11 12 12+)

2. Attending this event was important to helping my child(ren) succeed in school.
   a. Strongly agree b. Agree c. Disagree d. Strongly disagree

3. I would attend another *Fuel Up! Family Science Night* with my child(ren).
   a. Strongly agree b. Agree c. Disagree d. Strongly disagree

4. My favorite activity was: _____

5. My child(ren)'s favorite activity was (if listing for more than one child, please include the child's age): _____

   _____

6. What could make this event better: _____

Museum of Nature & Science

*Fuel Up!: Pasaporte - Biocumbustibles Noche de la Ciencia en Familia*

Escuela: _____ Fecha:_____

Nombre / Grado: _____

**Tu desafio:** Responde una pregunta de CADA estacion y asegurate que el maestro ponga las iniciales en el cuadro.

| | | |
|---|---|---|
| **CREA UNA CELULA VEGETAL**<br>P: Por que es dificil obtener energia de la hierba en lugar de energia de la comida(como el maiz)? ☐ | **ADIVINA CUANTA AZUCAR?**<br>P: Que obtenemos de una planta que nos da energia? Donde almacenamos esa energia? ☐ | **MARAVILLAS MICROSCOPICAS**<br>Q: Son las celulas de animales y de plantas lo mismo? ☐ |
| **PLANTAS ETERNAS vs ANUALES**<br>P: Cual es la diferencia principal entre las plantas de hierba y las frutas y vegetales? ☐ | **PODER DE PROCESAMIENTO DE LA COMIDA**<br>P: Para poder hacer un combustible liquido, tenemos que convertir el azucar de las plantas, en que tipo de liquido? ☐ | **NUEVAS FUENTES DE ENERGIA**<br>P: Usamos combustibles fosiles para hacer funcionar autos, aviones, y otros vehiculos. Cuales son algunos ejemplos de energia alternativa? ☐ |
| **QUE ES CARBON?**<br>P: Que tiene que ver el carbon con el aire que respiramos? ☐ | **HAZ UNA MOLECULA**<br>P: Que es una molecula y que elementos estan en una molecula de ETHANOL? ☐ | **ESTACION DE INNOVACION**<br>P: Puedes inventar un auto que se mueva sin tu ayuda? ☐ |

***Tu opinion nos ayuda a mejorar este programa***
*Por favor devuelva esta forma al encargado de la mesa.*

1. Circule todas las edades de los ninos que atendieron el evento: (5 6 7 8 9 10 11 12 12+)

2. El venir a este evento fue importante para ayudar a mis hijos a progresar en la escuela.
   a. Totalmente de acuerdo b. De acuerdo c. Desacuerdo d. Totalmente en desacuerdo

3. Yo volveria a otro *Fuel Up! Noche de la Ciencia enFamilia* con mis hijos.
   a. Totalmente de acuerdo b. De acuerdo c. Desacuerdo d. Totalmente en desacuerdo

4. Mi actividad favorita fue:_____

5. La actividad favorita de mis hijos fue (si tiene mas de un hijo(a) incluya las edades). _____
   _____

6. Que se puede hacer para mejorar este evento?: _____

## "Farming for Fuels" Reflection

Have an adult initial each activity or station you explored today

| | | |
|---|---|---|
| **Energy Cars**<br><br>What are some ways you can power a car? | **Sugar Testing**<br><br>What liquid had the most sugar? | **Seed Planting**<br><br>What is the difference between an annual and a perennial? |
| **Build Your Own Energy Car**<br><br>Can you make a car that moves without your help? | **CO2 Bubbles**<br><br>What does carbon have to do with air? | **Extracting the "Fuel"**<br><br>How do we get biofuels from switchgrass? |
| **Dynoscopes**<br><br>Are animal cells the same as plant cells? | **Design a Plant Cell**<br><br>What makes it hard to get sugar from grass? | **Molecule Models**<br><br>How do you make an oxygen molecule? |

1. Please circle ages of children who participated in this event with you:

1-3 4-6 7-10 11 and older

2. Attending this event was important for helping my child(ren) succeed in school.

Strongly agree Agree Disagree Strongly disagree

3. I would attend another Alternative Energy Family Event with my child(ren)

Strongly agree Agree Disagree Strongly disagree

4. I believe the content covered in Farming for Fuels is important for my child to be familiar with.

Strongly agree Agree Disagree Strongly disagree

5. I believe the content covered in Farming for Fuels was at an appropriate level for my child to understand.

Strongly agree Agree Disagree Strongly disagree

6. Here is something new that I learned today _____.

7. How could we make this event better?

# Alternative Energy Family Night

Children's Names:_____/_____

## ANSWER A QUESTION AT EACH STATION

| | | |
|---|---|---|
| Make A Cell:<br>What makes it hard to get sugar from grass?<br>_____<br>_____ | Sugar Testing:<br>What liquid had the most sugar?<br>_____<br>_____ | Look at Cells:<br>Are animal cells the same as plant cells?<br>_____<br>_____ |
| Perennial vs. Annual Plants:<br>What is the difference between a perennial and an annual?<br>_____<br>_____ | Process Food Yourself:<br>How do we get Biofuel from Switch Grass?<br>_____<br>_____ | New Energy Sources:<br>What are some ways you could power a car?<br>_____<br>_____ |
| Where and What Is Carbon?:<br>What does Carbon Dioxide have to do with the air?<br>_____<br>_____ | Make a Molecule:<br>What elements are in ethanol molecules?<br>_____<br>_____ | Be a Scientist:<br>Can you make a car that moves without your help?<br>_____<br>_____ |

***Fill out and turn in at the treasure chest table to get a prize!***

Please circle ages of children attending the event. [5 6 7 8 9 10 11 12]

1. Attending this event was important to helping my child(ren) succeed in school.
   Strongly Agree  Agree  Disagree  Strongly Disagree
2. I would attend another Alternative Energy Family Night with my child(ren).
   Strongly Agree  Agree  Disagree  Strongly Disagree
3. My favorite activity was_____
4. My child(ren)'s favorite activity was (If listing for more than one child, please include the child's age)
   _____
   _____
5. Please tell us what new science facts your family explored tonight
   _____
   _____
6. What could make this event better?
   _____
   _____

conceptual flow

Ann Arbor Hands-On Museum

rye seeds

**"Farming for Fuels" Reflection**

Have the volunteer initial each station as you explore

mortar pestle scissors how difficult it is

| | | |
|---|---|---|
| **Seed Need** | **Up Close and Personal** (dynoscope) | **Mechanical Separation** |
| What is the difference between an annual and a perennial? | What do you notice about the plant and animal slides? (added slides sketching) | How tough is it to break down? (destroy) |
| **Titration Station** | **A Few Alternatives** | **Chemical Separation** |
| What does CO2 do to the pH of the water? | What are some other sources of power/energy? (solar small cars-new toy) | How can we break it down further? |
| **CO2 Bubbles** | **A Whole Lotta Power** | **Sounds Sweet to Me** |
| Which is denser: Regular air or CO2? | Where is energy "stored"? | Which liquid had the most sugar? (diet + regular soda testing sugar) |

DNA wheat germ soap salt rubbing alcohol

**1. Please circle ages of children who participated in this event with you:**

*1-3* *4-6* *7-10* *11+*

**2. Attending this event was important for helping my child(ren) succeed in school.**

*Strongly agree* *Agree* *Disagree* *Strongly disagree*

**3. I would attend another Alternative Energy Family Event with my child(ren)**

*Strongly agree* *Agree* *Disagree* *Strongly disagree*

**4. I believe the content covered in Farming for Fuels is important for my child to be familiar with.**

*Strongly agree* *Agree* *Disagree* *Strongly disagree*

**5. I believe the content covered in Farming for Fuels was at an appropriate level for my child to understand.**

*Strongly agree* *Agree* *Disagree* *Strongly disagree*

**6. Here is something new that I learned today:**

**7. How could we make this event better?** *(please continue on back if needed)*

---

**Every adult who completes this survey and includes their name and mailing address will be entered into a drawing for a $50 Target gift card. Please turn in your survey to the front desk. Thank you!**

**Please print name and mailing address:**

If you have any questions regarding this study or how we will use the data please e-mail Dr. Lorrie Beaumont: lbeaumont@evergreeneresearch.com

## APPENDIX G: Family Event Station Names by Site

| | | |
|---|---|---|
| Seed Need (Ann Arbor)<br>Perennial vs. Annual Plants (Ft. Myers)<br>Seed Planting (DuPage)<br>Perennial vs. Annual Plants (Dallas) | Up Close and Personal (Ann Arbor)<br>Look at Cells (Ft. Myers)<br>Dynoscopes (DuPage)<br>Microscopic Marvels (Dallas) | Mechanical Separation (Ann Arbor)<br>Process Food Yourself (Ft. Myers)<br>Extracting the Fuel (DuPage)<br>From Grass to Gas (Dallas) |
| Be a Scientist (Ft. Myers)<br>Build Your Own Energy Car (DuPage)<br>Innovation Station (Dallas) | A Few Alternatives (Ann Arbor)<br>New Energy Sources (Ft. Myers)<br>New Energy Sources (Dallas) | Make a Cell (Ft. Myers)<br>Design a plant cell (DuPage)<br>Construct a Plant Cell (Dallas) |
| CO2 Bubbles (Ann Arbor)<br>Where and What is Carbon (Ft. Myers)<br>What is Carbon? (Dallas) | Make a Molecule (Ft. Myers)<br>Molecule Models (DuPage)<br>Make a Molecule (Dallas) | Sounds Sweet to Me (Ann Arbor)<br>Sugar Testing (Ft. Myers) (DuPage)<br>Guess How Much Sugar? (Dallas) |

<u>Additional Stations Added</u>

1) Titration Station

Ann Arbor only – How greenhouse gases are changing the Ph of our oceans

2) Chemical Separation (Ann Arbor only)

How to extract DNA from wheat germ by adding various liquids

3) A Whole Lotta Power

Ann Arbor only

Demonstrating stored energy by exploding plastic film canisters