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Creating a Solar-Powered Classroom with Fourth Graders

Scott Morrison and Aaron Sebens

"If these fourth graders can do something about climate change, there's no reason why we all can't."

–White House tweet, June 24, 2013[1]

Aaron Sebens and his fourth grade students received this congratulatory tweet from the White House as a response to the solar-powered classroom that they created in 10 weeks. The process—defining the goals, raising funds, construction, and implementation—involved many subject areas: reading, writing, math, science, and social studies. This article describes how their project came about and what transpired in the classroom.

Aaron is an elementary school teacher and also an ecologically minded teacher.[2] He is not a trained environmental educator, and he is not required to teach about environmental issues, but he brings these concerns into the classroom because he hopes to cultivate an ethic of care in his students.[3] Not only does Aaron believe that students should learn by doing, he also believes that students should learn to be "solutionaries," a term that Zoe Weill, co-founder of the Institute for Humane Education, defines as "conscientious choicemakers and engaged changemakers for a peaceful and healthy world for all."[4] Solutionaries represent the intersection of citizenship and sustainability education.[5]

This project took place at Central Park School for Children in Durham, North Carolina, a public charter, year-round school whose teachers believe that children should have a say in what they learn and that they have the capacity to make a difference in the world. The educational philosophy of the school centers on project-based learning (PBL), a method of teaching in which students gain knowledge and skills by investigating real, relevant, and complex issues. At Central Park School, teachers receive training and ongoing support so that they can effectively utilize PBL in the classroom.

The two central aspects of PBL—project design elements and teaching practices—guide Aaron as he plans for teaching and learning (**Figure A**). His role in the classroom is not so much to be "an expert" as to be a facilitator. In fact, before the project began, he had no experience and minimal background knowledge about solar panels. Thus, he truly modeled for his students what it means to be a lifelong learner. (For those interested in learning more about PBL, there are plenty of helpful resources available.)[6]

Figure A. **Central Aspects of Project Based Design**
(Leading to key knowledge, understanding, & success skills)

Design Elements	Teaching Practices
Challenging problem or question	Design & plan
Sustained inquiry	Align to standards
Authenticity	Build the culture
Student voice & choice	Manage activities
Reflection	Scaffold student learning
Critique & revision	Assess student learning
Public product	Engage & coach

SOURCE: bie.org; see note 6.

There are many similarities between the C3 Framework (**Figure B**, page 6) and PBL. The C3 Framework begins with "Developing Questions and Planning Inquiries," and PBL starts with a "Challenging Problem or Question" and then "Sustained Inquiry." Both end in a similar fashion as well: Dimension 4 of the C3 Framework is "Communicating Conclusions and Taking Informed Action," and the culmination of PBL is a "Public Product." Not only did Aaron integrate these models into this project, he also met numerous content standards, including *Next Generation Science Standards* and *National Curriculum Standards for Social Studies*.[7]

The Inspiration

The seed of this project was sown during a fairly common unit of study. Students were learning about energy: what it is, how it is created, and how it affects their lives. There was a particular emphasis on coal, including the negative effects of using coal-fired power plants. According to the U.S. Energy

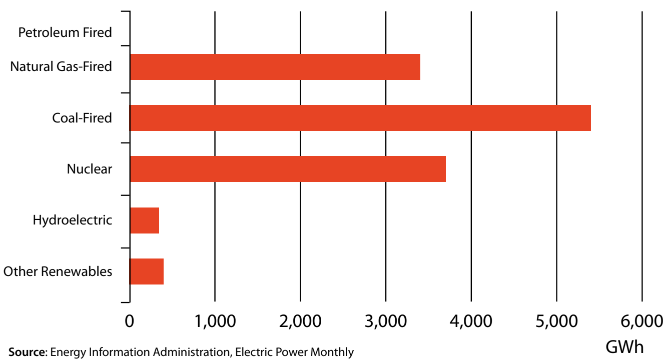
Figure B. **College, Career, and Civic Life (C3) Framework Organization**

Dimension 1: Developing Questions and Planning Inquiries	Dimension 2: Applying Disciplinary Tools and Concepts	Dimension 3: Evaluating Sources and Using Evidence	Dimension 4: Communication Conclusions and Taking Informed Action
Developing Questions and Planning Inquiries	Civics	Gathering and Evaluation Sources	Communicating and Critiquing Conclusions
	Economics		
	Geography	Developing Claims and Using Evidence	Taking Informed Action
	History		

SOURCE: From page 12 of the *College, Career, and Civic Life (C3) Framework for Social Studies State Standards* (Bulletin 113, Silver Spring, MD: NCSS, 2013), **www.socialstudies.org/c3.**

Information Administration, almost 38 percent of the electricity in North Carolina is generated by coal, which is transported from Pennsylvania, West Virginia, and Kentucky.[8] Students examined data in graphs and charts (such as **Figure C**) to understand the predominant role coal played in their everyday lives, and to compare that with other sources of energy.

Figure C. **North Carolina Net Electricity Generation by Source, July 2015**



In order to expand their thinking about other ways that electricity can be produced, students researched alternatives that tend to be cleaner and are renewable: wind, geothermal, hydro, and solar. When they discovered that there were other ways to power the lights and computers in the classroom, some students asked why they did not see alternative energy production very often at home or at school. This is what prompted Aaron to ask his students, "Would you be interested in finding out if we could create a solar-powered classroom?" The answer was immediate: of course they wanted to find out if it was possible!

Allocating "Project Time"

All classroom teachers at Central Park School have designated "Project Time" built into their schedules; it varies from teacher to teacher, but most have approximately three hours each week, and most teachers typically tackle one project per quarter (about nine weeks). Aaron and his students needed more time than usual for this project, so they utilized time scheduled for writer's workshop and math as needed.

Following the design elements of PBL and the C3 Framework, we describe below the solar-panel project by using the most significant questions that guided each phase. Although we organize them in a linear fashion here, several of them were occurring simultaneously at various times during the project.

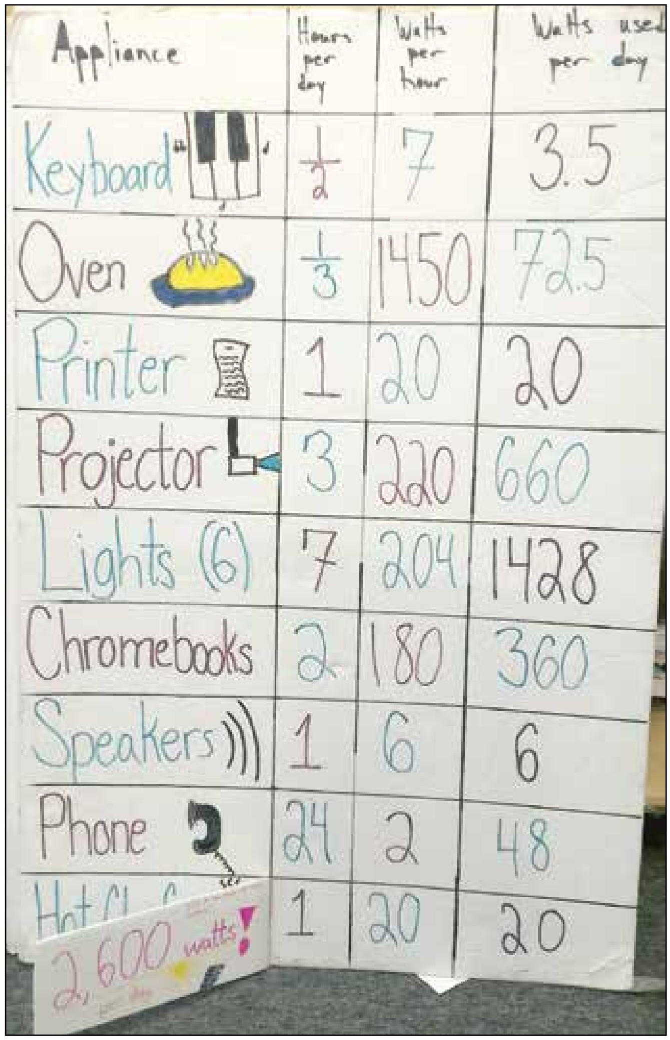
How Do Solar Panels Work?

To begin, Aaron and his students needed to gain some basic background knowledge. Websites like How Stuff Works, Live Science, and Scientific American served as starting points and provided them with information and diagrams.[9] Armed with a classroom set of Google Chromebooks, students bookmarked and shared websites that they found most helpful, took notes on what they were learning; watched video explanations on YouTube, generated lists of new vocabulary words they needed to know, drew diagrams of parts and processes, and jotted down questions. Instruction came in the form of brief lessons centered primarily on research and writing skills, and Aaron used questions to get students thinking and talking: What do good researchers do? How do we know if a website is trustworthy and has good information that we can use? What does it mean to paraphrase? What did we learn yesterday? What kind of information do we still need to find out today?

The ideas students generated in response to such questions were written on the board, synthesized and refined during discussions and in writing, then reinforced by Aaron. Thus, when students were researching and writing, independently or in pairs, they had reminders on the board to guide them. At the end of a class, students came back together to share what they had learned. Again, Aaron wrote findings, thoughts, and new questions on the board so everyone could see, and then he emphasized the common themes and filled in gaps as needed.

How Can a Classroom Become Solar Powered?

Once the students had a general understanding of solar panels and how energy from the sun could be transformed into electricity, they needed to know what kind of hardware could make that happen in their classroom. Thus began another round of research. The students realized, however, that other questions needed to be answered before they could determine what they needed: How much electricity did they use—in their classroom—on a daily, weekly, and monthly basis? How much electricity would the solar panels produce? They knew how to figure this out because of an assignment they had completed a few weeks prior in their study of energy and electricity. Aaron introduced them to a device called an electricity monitor, which costs about $20 and is available at most hardware stores. The electricity monitor tracks the number of kilowatt-hours an appliance uses, and it can even calculate electrical expenses by the day, week, month, and year. One of the students' homework assignments was to take the electricity monitor home and figure out how much electricity was needed to power five different appliances (e.g., televisions, refrigerators, toasters). Students compiled the data in a Google spreadsheet, and they were able to graph the data, calculate averages, and explain what these numbers meant.



How Can We Reduce Consumption?

Because of this experience with the electricity monitor, students were able to assess how much electricity was needed to keep the lights on, charge their laptops, and run the projector. They created a new Google spreadsheet and typed in the data, coming up with a total number of kilowatts they used. With that baseline number, they then had to figure out what kind of solar panel system they needed to provide them with the same amount of electricity. This is when they made an important discovery: the solar panel systems that were most feasible and accessible would not produce nearly enough electricity to meet their needs. In fact, students determined that they would need to reduce their electricity consumption by almost 90 percent if they were to rely entirely on solar energy to power the lights and appliances in the classroom.

This apparent conflict led them to the following question: How can we reduce our electricity consumption? Aaron facilitated a class discussion. Using the data they had collected from the electricity monitor, they had some good ideas. For example, they decided to rely on sunlight and keep the lights turned off during the day as much as possible, to get more efficient light bulbs for when they had to turn the lights on, and to unplug the laptop cart once the computers were charged. With these changes, they were well on their way to reducing consumption.

At this point, Aaron began to divide the work among the students. Those who showed an interest in the scientific and mechanical aspects of solar energy started to research online what equipment might be needed. This group found several different options and kept track of them on a Google spreadsheet, including the name of the company, the technical components of the system, and the cost. A second group focused on a related question, one that would be a key to success.

How Can We Raise Funds for a Good Cause?

There was certainly no money in the school budget to buy a solar panel system, so the students had to find funding on their own; without funding, the project would just be an exercise. Aaron knew that other schools and organizations across the country had used an online fundraising platform called Kickstarter,[10] so he showed students a few examples of how other schools had used it to raised money for innovative projects. Once they saw some examples and agreed that this was what they wanted to do, they had another question to consider: What should we put on our Kickstarter page? The students decided that they wanted to create and post a video explaining what they were doing and why, and they wanted to send a gift to anyone who donated money as a way to thank them.

More group work ensued. A few students volunteered to be the writing team; their job was to write a script for a short, 1-minute video. They embraced the entire writing process: brainstorming, outlining, writing, and revising. Aaron guided them through three drafts before a final version was agreed upon. Two students were responsible for filming and editing. Their collaboration resulted in a 68-second video that would be the centerpiece of the class fundraising effort.

Another group began planning and creating the rewards for donors. They decided that they wanted to make a CD of songs sung by the class, a handwritten thank-you card, and a wall decoration in the shape of a sun and made out of clay. The art teacher was more than happy to help with the clay suns, and Aaron agreed to set aside time for the students to record the different songs they had been singing that year. (Arts integration is another core value at Central Park School. Aaron is a guitar player and singer, so he teaches his students one song per week throughout the year. During the unit on energy and electricity, the students learned the song "Keep Your Dirty Lights On" by Tim O'Brien and Darrell Scott.[11])

How Can We Communicate Our Dream to Others?

The students titled their Kickstarter page "Our Solar Powered Classroom," and they also wrote the following tagline: "We want to make our classroom solar powered so we can conserve resources, have less pollution, learn how it works, and tell the world."[12] The webpage featured the video and a photo of the students. Enthusiasm was growing, and the students wanted to add more information to their webpage. Another group began working on a second video that explained how the solar panels would work. Students were again responsible for writing the script, filming, and editing the video. At the same time, other students were collectively writing more information to display at the Kickstarter page (**Sidebar**).

The Kickstarter page went live two days before the three-week intersession break. Students parted ways hoping to raise about $800, which would be enough to get them started. When they returned to school, they were shocked to find out that people from all over the world had donated more than $5,000! Aaron put a map on the wall, and students placed red dots to show where the donors lived. With the project now well funded and viable, the next step was to let others know what they were doing. In a move that integrated writing and social studies, Aaron guided his students on a letter-writing campaign. In a series of short lessons, the students learned about newspapers in their region, local government officials, and the governor of

From the Kickstarter Webpage

Did you know that every minute enough photons come down to Earth from the sun to power our world for a year? And have you ever wanted to save money, electricity and have less pollution? Well that is our goal. We believe in the sun and would like to fundraise to get enough money to buy solar panels for our classroom so we do not have to use any electricity from the power plant. We have been doing research on how much electricity we use to power our classroom so we know how many solar panels we need, and how much money it will cost. We will figure out how to design and build a solar array, and with help we can take our classroom off the grid. We're really excited about teaching others in our school and community about the power of solar energy.

If we raise more than $1,500 we can even add a wind turbine!

If we get over $2,000 we will tie our panels to the grid and sell clean energy to our community.

How it goes together:

Panel—charge controller—battery—inverter—computer—a bunch of wires

Meaning and Purposes:

Solar panel: it is a silicon panel that collects the rays of the sun.

Charge controller: limits the rate at which electric current is added or drawn from electric batteries. It prevents overcharging and may prevent against overvoltage.

Battery: it stores all of the energy that the solar panel collects.

Power inverter: changes direct current of flowing electrons, changes the speed.

Risks and challenges:

Making enough money; learning how to build a solar array; not using too much electricity when we have the solar array up.

Letter to the Editor

An Invitation to Our Solar Classroom

We are two students from Aaron's 4th grade at Central Park School in Durham, NC.

We are doing a project to make our classroom solar powered so we only use clean energy. We are also getting a wind turbine to help power another class.

One reason we're doing this is to help our city and our earth. Another reason we're getting our classroom solar powered is it's a way of producing energy that does not burn fossil fuels. Best of all it uses something you see every day..... the sun!!!!!

We hope that this project will inspire lots of kids and adults. We also hope that this project goes even further, and that everyone realizes solar electricity is within their reach. And if you are thinking about remodeling your house think about solar and wind energy.

We would like for you to take a tour of our class solar system email us at **208aaron@gmail.com**.

—Cassie W. and Myla S.

the state. Over the course of several days, the students focused on writing letters—to the mayor, the governor, and President Obama. Two students wrote a letter that was published on June 10, 2013, in *The News & Observer*, based in Raleigh (**see sidebar**, page 8). In the weeks that followed, the total amount raised ended up being $5,817, representing support from 201 donors.

How Do We Cooperate to Realize Our Goals?

Aaron purchased the solar panel system, which included a wind turbine, from a company in Pennsylvania, and he drove up there one weekend to pick it up. He had consulted with Carolina Solar a few times during the project to get advice, and they recommended a local company with the right kind of experience. King Brothers Electric agreed to install the panels on the school's roof.

In preparation for the installation, the students opened boxes full of equipment, organized and labeled the parts, and put together different pieces under the supervision of Aaron and some parent volunteers. The students were also busy creating hand-made thank-you cards, making clay suns, and drawing cover art for the CD cases, which would be mailed to all of the donors. This part of the project was very time consuming and stressful, to be sure! It took a lot of effort to make so many cards, CDs, and suns! Here are excerpts from what one student wrote on the Kickstarter page:

Perhaps the biggest job was making the thank you cards. Lots of kids stamped all the cards with our homemade stamps! We had 4 stamps and many people working away. In the art room, there were 3 strings holding the finished cards, all 169 of them! During this week, we will be handwriting separate messages on all of the cards, and Saturday we are planning to send all of them.

There were some focused adults who wrote addresses on envelopes to send cards to the backers! In the addressing room, the moms were working away. It was very interesting for us kids, seeing how people tell where others live in other countries.

Mounted inverter on the wall! A group of people wrestled the inverter onto the wall and will be remounting it soon on a piece of plywood.[12]

Over the course of several Saturdays, the solar panels were installed. This took the collaborative effort of electricians, parents, community members, and students. The last step was to organize, invite, and host as many supports as possible for what they called "Flip the Switch." The students wrote the following on their Kickstarter page (excerpted here):

Hey everyone,
This week we'll be going without electricity and waiting until Friday at 2:00 when we Flip the Switch and send all that clean solar energy to our classroom. … We want to celebrate and thank everyone who has helped make this happen, show you how it works, and celebrate the journey and the outcome. …

We want to give you the opportunity to join us in our celebration. There are two ways you can do that: (1) [S]end us a message and we can send you an invite. (2) If you are going to be joining us on the stream, send us a message and we'll give a little shout out.

Wherever you are in the world we hope you can join us. Thank you for making our big dreams come true!

What Did We Learn?

The fourth grade students in Aaron's class learned quite a few lessons from this project. They worked on their writing and math skills and applied them to a real-world issue. They acquired scientific knowledge related to energy, electricity, and solar power. Perhaps most importantly, they learned that they could make a difference in the world. They flexed what Annie Leonard would call their "citizen muscles." Leonard, who is the Executive Director of Greenpeace USA and author of *The Story of Stuff*, believes that too many of us exercise our consumer muscles a whole lot more than our citizen muscles and, as a result, our citizen muscles are quite flabby.[13] To continue this metaphor, Aaron and his students spent ten weeks working out their citizen muscles. Their classroom, school, and community—and our world—are all the better for it.

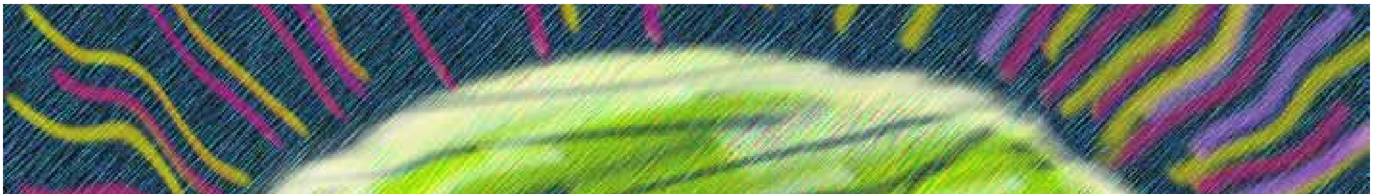
Notes

1. The White House (on Twitter), twitter.com/whitehouse/status/349196565128290304.
2. Christine Moroye, "Complementary Curriculum: The Work of Ecologically Minded Teachers," *Journal of Curriculum Studies* 41, no. 6 (2009): 789-811.
3. Nel Noddings, *The Challenge to Care in Schools*, 2nd ed. (New York: Teachers College Press, 2005).
4. Zoe Weill, "The Solutionaries: Education for a Better World," *Independent School Magazine* (Spring 2012), www.nais.org/Magazines-Newsletters/ISMagazine.
5. Andrew Dobson, "Sustainability Citizenship," *Open Citizenship* 5, no. 1 (2014): 78–86.
6. Johh Larmer, John Mergendoller, and Suzie Boss, *Setting the Standard for Project Based Learning* (Alexandria, VA: ASCD, 2015); Sara Hallerman, John Larmer, and John Mergendoller, *PBL in the Elementary Grades: Step-by-Step Guidance, Tools and Tips for Standards-Focused K-5 Projects* (Novato, CA: Buck Institute for Education, 2011).
7. For a list of standards addressed by this project, please contact the first author at smorrison7@elon.edu.
8. U.S. Energy Information Administration, "North Carolina," www.eia.gov/state/?sid=NC.

9. Jessika Toothman and Scott Aldous, "How Solar Cells Work," *How Stuff Works*, science.howstuffworks.com/environmental/energy/solar-cell.htm; Michael Dhar, "How Do Solar Panels Work?" *Live Science*, www.livescience.com/41995-how-do-solar-panels-work.html; Susannah Locke. "How Does Solar Power Work?" *Scientific American*, www.scientificamerican.com/article/how-does-solar-power-work.
10. Kickstarter, www.kickstarter.com.
11. Tim O'Brien and Darrell Scott, "Keep Your Dirty Lights On" (song, 2013), timanddarrell.com/wp-content/uploads/2013/12/SH460_lyrics_keep_dirty_lights_on.pdf
12. Kickstarter, "Our Solar Powered Classroom," www.kickstarter.com/projects/1474093146/our-solar-powered-classroom/updates.
13. Annie Leonard, *The Story of Stuff: The Impact of Overconsumption on the Planet, Our Communities, and Our Health—And How We Can Make It Better* (New York: Free Press, 2010).

Scott Morrison *is Assistant Professor of Education at Elon University in Elon, North Carolina*

Aaron Sebens *is Director of Media and Technology at Central Park School for Children in Durham, North Carolina*



Life in a Solar-Powered Classroom

—Aaron Sebens

Energy Independence: The lights and electrical outlets in our classroom have received no electricity from the municipal supplier (from "the grid") for two and a half years. As we planned this solar project, we debated off-grid vs. tied-to-the-grid designs. In most instances (in most homes, for example), being tied to the grid is the best option because it eliminates the need for batteries: when your solar panels produce extra electricity, it feeds back into the grid; and when the panels don't produce enough electricity to meet your demand, it's available from the grid. On rainy days, for example, you can still use lots of electricity if you're hooked to the grid. We decided to go off the grid mostly for educational purposes—it's more interactive. Our system requires a lot more monitoring, and we must reduce our consumption of electricity if the supply is low. This is a responsibility that most homeowners don't want, but is extremely important in a classroom setting, where we're trying to understand these things.

There have been several days when we couldn't use our printer because the panels weren't producing any electricity and this use would have lowered the charging capacity of our batteries. But there have also been at least three instances when the school building lost power, but our classroom lights and Chromebooks were humming along like nothing happened.

Solar Panels: Six large solar panels (48 × 30 inches each) made by Sharp and installed by King Brothers Electric sit on our school's metal roof. On a sunny day, they can produce 780 watts per hour.

Energy Storage: There are four Trojan T-105 batteries (same as those on golf carts) in an enclosed box that vents to the outside (so gas from the chemical reaction in the batteries doesn't go into the classroom). Our inverter is capable of being tied to the grid, and I've debated about hooking it into the grid so our extra electricity gets used, but then again it kind of defeats the purpose of the system we have set up.

Wind Turbine: Our wind turbine produces more electricity once leaves have fallen off nearby trees and we receive more forceful wind on top of the building. I estimate that our one turbine provides 5 percent of our electrical needs on a moderately windy day.

HVAC: We are on the school system for heating, ventilation, and air conditioning (HVAC) because those functions use large amounts of energy and, if wholly reliant on solar, would require many more panels and batteries. We use the HVAC probably half the days here in Durham, North Carolina. On other days, we just open a few windows and enjoy the breeze.

Conservation: Our efforts actually began with conservation. We reduced our use of electricity from approximately 20 kilowatts a day to just over 2 kw/day. A big change was going from desktop computers to Chromebooks, which can be recharged when the solar cells are producing a lot of energy. We've also cut the energy devoted to lighting in half by switching from fluorescent to light-emitting diode (LED) lights. We had to reduce our classroom electricity usage by about 90 percent so that we could live within the energy budget of our panels and batteries.