

Engaging Students in Solar Thermal Technology Experimentation

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The Florida Solar Energy Center (FSEC), a research institute of the University of Central Florida (UCF) has been involved in solar and alternative energy research since 1975. FSEC's mission is to research and develop renewable energy, energy-efficiency and alternative energy technologies that enhance Florida's and the nation's economy and environment.¹ Current research areas include solar thermal, photovoltaics, hydrogen fuel cells, electric vehicles and energy efficiency in buildings. As Florida's leading energy research center, FSEC also is tasked with educating the public about its research. This is accomplished in numerous ways including training and professional development for business, industry and education providers. Informal education and outreach to the public, particularly to students and teachers is also an important component of FSEC's mission. Teaching teachers has been an effective way for FSEC to increase awareness and knowledge about its research and subsequent renewable energy technologies that can enhance and improve quality of life on Earth.

Purpose: In order to engage diverse populations of students in solar thermal technology experimentation, a cross cultural Science, Technology, Engineering, Arts and Mathematics (STEAM) education project plan is underway. Currently, this program is being identified as *Solar for Underserved Populations* or *Solar UP*. It addresses a real world global problem – access to safe drinking water. The goal of this project is to engage students in solar thermal experimentation to find real-world solutions to this problem.

In many parts of the world, having safe water to drink cannot be taken for granted. Haiti, for example, is experiencing a massive crisis after Hurricane Matthew, which hit the Caribbean nation in early October of 2016. Nearly 1,000 people died and entire communities were wiped off the map. In an Al Jazeera article published October 11, 2016 it was stated, “Matthew, the most powerful Atlantic storm since 2007, last week levelled homes, fouled water sources and killed livestock, leaving victims pleading for help to arrive quickly.”² It was estimated that approximately 1.4 million people required aid. A solar cooker designed to more rapidly pasteurize water would be a life-saving device in such situations.

Methodology: The cross cultural *Solar UP* education project plan includes professional development for teachers, R & D solar thermal experimentation, hands-on experiences for students resulting in working solar thermal devices, and a showcase where students share their solar thermal projects with the public. This project is designed to integrate and reinforce STEAM skills and promote awareness of global energy and social issues.

The R & D portion of the education plan involves using Fresnel lenses to enhance existing solar thermal designs, causing temperatures within the solar devices to increase more rapidly thus reducing the time needed to pasteurize water. It is intended that the initial experiments will be carried out by teachers as part of a professional development experience held at the Florida Solar Energy Center in late January 2017. This experience will help teachers to confidently implement solar thermal design projects with their own students and to carry out experiments and testing of their students' solar devices. This professional development experience takes the format of a full day, hands-on solar cooker workshop, which covers an array of information, including basic solar concepts, introduction to four solar cooker designs, review of equipment and materials and the fundamentals of building. The workshop also includes time for teachers to research cooker designs and identify those that would work best under varying environmental conditions, as well as those that would work best for their instructional objectives. Teachers are given FSEC's *Solar Matters* curriculum, and access to free and low cost materials. Technical assistance is offered to

ensure that projects can be successfully implemented in the classroom or in the afterschool setting. At the solar cooker workshop, teachers will adapt their cooker designs using Fresnel lenses with the goal of more rapidly increasing cooker temperatures in order to heat food or pasteurize water in less time. Teachers will identify one or more geographic areas that would benefit from the use of their solar device to include as background information for their students when designing or testing the solar devices. **Figure 1**, shows teachers at one of FSEC's solar cooker workshops using a discarded umbrella to build a parabolic cooker.



Figure 1

One or more of the teacher designed solar devices will be tested at schools using the protocols developed by the teachers at the workshop. Students will implement the testing procedures and collect data that will minimally include insolation and H₂O temperatures over time, which details the performance of their particular enhanced solar thermal design. The students will prepare an analysis of the data to be reviewed by FSEC researchers. Ideally, this design would not only be tested in the U.S. but also in a foreign partner school where the need is great, such as in India or Haiti.

The solar thermal apparatus and the results of the students' research will be shared during FSEC's annual outreach event for students and teachers known as EnergyWhiz, which is described in the paragraphs below. The solar thermal devices from Solar UP will undergo further evaluation by researchers and engineers who are also tasked with judging solar cookers at EnergyWhiz. Research logs and design journals will be reviewed, and each solar device will be inspected for safety and its performance assessed. Those designs that show the most promise will be shared on the FSEC website.

EnergyWhiz provides a time and place for students to share their unique, energy-related projects with industry, technical experts, researchers and the public. Over 1,000 students participate annually in EnergyWhiz. Students work in teams on their projects throughout the school year, using STEAM knowledge and abilities. They develop and practice critical thinking, problem-solving and workforce skills. EnergyWhiz also allows students the freedom to learn from one another and to see different solar and renewable energy applications used in a variety of ways. **Figure 2**, shows students gathering for EnergyWhiz at the Florida Solar Energy Center in Cocoa, Florida - May 14, 2016.



Figure 2

EnergyWhiz events for 2017 include Junior Solar Sprint (JSS), Energy Innovations (EI), Electrathon, Critter Comfort Cottage (C3) and the Solar Energy Cook-off. A brief description of each competition follows.

The **Junior Solar Sprint (JSS)** as shown in **Figure 3**, challenges students to design and build model-sized, photovoltaic-powered cars, and to also test their vehicles' performance in head-to-head, double elimination races. Energy Innovations requires students to work together to design and market a full-scale photovoltaic solar-electric powered device that has real-world applicability. An example of an **Energy Innovations (EI)** design project is shown in **Figure 4**. This student is setting up his photovoltaic-powered, water purifier. The **Electrathon**, as shown



Figure 3



Figure 4



Figure 5



Figure 6

in **Figure 5**, is a competition involving custom, participant-designed and built, electric vehicles that must be expertly driven to maximize distance traveled within a given time limit, and without draining the vehicles battery. **Critter Comfort Cottage (C3)** as shown in **Figure 6**, is a real-world engineering and communications challenge that requires students to use green building design and construction techniques to create cost-effective, comfortable “homes” for critters of their choosing.

The **Solar Energy Cook-off** is one of the most popular events at EnergyWhiz. It is a two-part competition that combines knowledge and abilities used in engineering and construction, as well as culinary arts. It is in this last activity that the Solar UP projects and research will be showcased.

In the Solar Energy Cook-off, teams design and build solar thermal devices that are then used to cook culinary creations. Each team is judged on both the solar cooker design and the dish that was cooked using solar energy. The culinary aspect of the competition is judged by chefs for visual appeal and taste as shown in **Figures 7 & 8**.



Figure 7



Figure 8

Another important aspect of the Solar Energy Cook-off is the evaluation of each of the team's cooker design, its construction and performance. This is accomplished by researchers, industry experts, solar professionals and scientists. This review (**Figure 9**) provides students with face-to-face feedback, allowing students the opportunity to ask questions of the experts and gain critical information. It also offers students a venue to show their creativity as they include artwork, costumes, stories, music, videos and more to convey the bigger picture and impact of their solar cooker project. The creativity of students is apparent as they often create themes for

their projects which extend to their dress, staging of food, display of cookers and the very culinary dishes they cook.



Figure 9

In **figure 10 & 11**, this team of creative female students used a construction theme to convey their message of “Girls Doing Work”, complete with hardhats and safety vests.



Figure 10



Figure 11

A separate competition category within the Solar Energy Cook-off will be created for the Solar UP program. These designs will be judged on cost, availability of materials used for the geographic region selected, ease of use and its effectiveness in pasteurizing water. Student teams, whose designs receive the highest overall score, will be awarded with trophies and

ribbons. Photos of the winning designs and teams will be posted to the FSEC EnergyWhiz webpage. Educational activities and experiments that are a by-product of the Solar UP program will be adapted and included in FSEC's *Solar Matters* curriculum, which is free to educators and available through the FSEC website.

Results: By designing, building and using a variety of solar cookers, students not only understand basic energy concepts, they see how these devices can be used to improve the quality of life for those in other countries. It acts as a tool to introduce social, global and environmental issues that are often far removed from the average student's life in the United States. Most Americans do not appreciate the ease with which we turn a spigot and out pours safe drinking water or press a button on a microwave and cook a meal. This project asks students to step into the shoes of those billions of people without those conveniences.

Conclusion: This cross cultural R & D project which reduces the time required to pasteurize water using a solar thermal device using a lightweight Fresnel lens can be used as a teaching tool to integrate STEAM areas and further educate students about solar technology using the scientific process. Using the established EnergyWhiz event as a mechanism to showcase the results of the Solar UP program expands its reach and opportunities for implementation at other schools. Programs such as Solar UP or the Solar Energy Cook-off could be similarly implemented in other parts of the world connecting us through the common need for safe drinking water.

References

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