NETWORKING TO ADVANCE THE USE OF SOLAR COOKERS AS EDUCATIONAL TOOLS IN THE CLASSROOM

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Abstract: *There is great potential for Solar Cookers to be utilized as educational tools in the classroom, particularly as the basis for cross curricular and/or project based learning. The theme of solar cooking has application for physics, environmental science, reading, math, geography, history, economics and more. A solar cooker can be an invaluable educational tool.*

A paradigm shift of the most nuanced kind must occur in our thinking for the potential to be realized. In a basic lesson involving solar cookers, students use a pattern to create a solar cooker and then use that cooker to prepare food. While this is a valuable way to introduce solar cooking technology to youth, we advocate taking the solar cooker to another level by identifying it as a teaching tool, a means to an end, the use of which can result in rich, in-depth, multi-disciplinary education.

How do we facilitate this paradigm shift and shape the solar cooker as an indispensable and ubiquitous educational tool?

- *Understand the goals of education in your country. Learn 'Educationese' and utilize the lingo to your advantage.*
- *Identify decision makers within educational institutions.*
- *Begin the process of networking with decision makers both directly and indirectly.*
- *Share proven educational strategies for implementation of your ideas.*
- *Be a presence and be a voice - always. Support is often found in unexpected places.*

We discuss our efforts to advance the use of solar cookers as educational tools and share our successes and failures as we network with school systems, teachers, and universities.

Keywords*: Solar Cooking, Education, STEM, Curriculum, Solar Energy*

1. INTRODUCTION

There is great potential for the Solar Cooker to be utilized as an educational tool to advance understanding of science concepts, human interaction with technology engineering design process, and math application. In addition, the Solar Cooker used thematically for cross curricular units can succesfully bridge a multitude of disciplines including langauge arts and the social studies. Adoption of revised internationally benchmarked science standards; an emphasis on STEM (Science, Technology, Engineering, and Math); and trends toward Inquiry Based Learning and Cross Curricular Teaching Strategies; all present a framework within which Solar Cookers can be effectively utilized.
How can solar cooking enthusiasts, experts, educators, and promoters facilitate the acceptance of the solar cooker as an indispensable educational classroom tool? One must have an understanding of the current status of education reform, particularly in science and STEM, and in the methodologies that produce high levels of student engagement, enthusiasm and understanding. It is essential to network with educators at all levels and with the organizations and institutions that support education, and to be willing to share expertise, provide resources, and link solar cooking activities with the educational goals and standards for which educators are responsible.

2. SCIENCE EDUCATION STANDARDS

In the 1990s, more than 300 scholarly reports were calling for an overhaul of science education in the United States with an emphasis on updated scientific and technologic knowledge along with adoption of more effective teaching strategies. Support for science education reform was considerable. [1]

2.1. National science education standards

In 1996, in response to the calls for reform, the National Academy of Science published the National Science Education Standards (NSES). The NSES were designed to guide educators in achieving the nation’s goal of scientific literacy for its citizens. Individual standards were created that served as learning goals or objectives to be met at particular grade levels. The authors advocated creative problem solving, critical thinking, use of the scientific method, collaboration, cooperative team work, use of technology, and deeper understanding of the natural world. The document included a vision for science education that relied less on lecture and more on investigation and inquiry, less on fragmented lessons and more on long-term plans, less on theory in isolation and more on theory in practice in school settings. [2]

2.2. Next generation science standards

In 2010, Achieve, an independent, bipartisan, non-profit education reform organization in Washington, D.C., released its report titled, *International Science Benchmarking Report - Taking the Lead in Science Education: Forging Next-Generation Science Standards.* The study sought to collect data that would guide a new conceptual framework for science education - one that reflected the expectations and best practices of ten high academically performing nations. The information collected was critical to the formation of the Next Generation Science Standards released in 2013. The new standards, or learning objectives, are internationally benchmarked for Kindergarten through grade 12. Their adoption is voluntary. At this writing, 19 states in the United States have adopted the NGSS, while a total of 40 states have demonstrated an interest in somewhat aligning their individual state standards to NGSS. [3]

3. EMPHASIS ON STEM (SCIENCE, TECHNOLOGY, ENGINEERING, AND MATH)

The United States Congressional STEM Education Caucus was created in 2005 by Representatives Vernon Ehlers of Michigan and Mark Udall of Colorado. The bipartisan caucus seeks to strengthen STEM education both in schools and the workforce by providing a forum for Congress and the science, education, and business communities to discuss problems and solutions related to STEM education. Engineering is included in the current standards with an emphasis on the Engineering Design Process which differs from the Scientific Method. (The Caucus was renamed STEAM in 2013 to include the Arts.) [4]

4. TEACHING METHODS – CROSS CURRICULAR AND INQUIRY BASED LEARNING

Methods of teaching that are conducive to the use of a Solar Cooker include Cross Curricular Instruction and Inquiry Based Learning.
Cross Curricular Instruction is a method of teaching that explicitly helps students understand connections from one discipline to another. It can range from simple to complex.

- Support – Instructor references other disciplines in the context of his/her own instruction.
- Coordinate – Two or more teachers support coordinating lessons.
- Collaborate – Two or more teachers collaborate on a theme based unit that addresses multiple content standards across disciplines.

Inquiry Based Learning can be divided into three categories.

- Structured Inquiry – Students follow precise teacher instructions to complete a hands-on activity.
- Guided Inquiry – Students develop the procedure to investigate a teacher-selected question.
- Student-Initiated Inquiry – Students generate questions about a teacher-selected topic and design their own investigation. [5]

5. SOLAR COOKER AS AN EDUCATIONAL TOOL

From 1996 through 2011 the author conducted solar cooking lessons in her classroom. The cookers became tools for education, a means to an end that included deepened understanding of science concepts, and later expanded to include educational goals in language arts, math and the social studies.

5.1. Science tool

The early Science Education Standards that guided initial lessons included:

- The sun is a major source of energy for the earth, and its energy interacts with matter.
- Electromagnetic radiation is emitted by the sun and travels to earth in waves.
- Light interacts with matter by transmission, including refraction, absorption, and reflection,
- Heat is produced when light is absorbed by matter.

The solar cooker provided an ideal instructional opportunity to fulfill the early goals set forth by the National Academy of Sciences. The lessons included problem solving, critical thinking, experimentation, team work, use of technology, and a deeper understanding of the concepts.
As Science Education Standards in the United States evolved to more closely align with international standards, the solar cooker continued to be a relevant and useful instructional tool. It became evident that one could include many Next Generation Science Standards while teaching a solar cooking themed unit. The following tables include examples of standards taken from the NGSS Middle School

document. Please note that many additional standards at various grade levels and across the science disciplines also correspond to a solar cooking unit. Lessons can be adapted in complexity to be suitable from primary grades to high school level. The following is a small sampling only. [6]

Table 1. Portion of Next Generation Science Standards for Middle School Engineering, Technology, and Applications of Science [6]

NEXT GENERATION SCIENCE STANDARDS FOR MIDDLE SCHOOL ENGINEERING, TECHNOLOGY, AND APPLICATIONS OF SCIENCE
Students who demonstrate understanding can: MS-ETS1-1. • Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. MS-ETS1-2. • Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. MS-ETS1-3 • Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

Table 2. Portion of Next Generation Science Standards for Middle School Earth and Space Science / Human Impacts [6]

NEXT GENERATION SCIENCE STANDARDS FOR MIDDLE SCHOOL EARTH AND SPACE SCIENCE
Students who demonstrate understanding can: MS-ESS3-3. • Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. MS-ESS3-4. • Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

Table 3. Portion of Next Generation Science Standards for Middle School Physical Science / Waves & Electromagnetic Radiation [6]

NEXT GENERATION SCIENCE STANDARDS FOR MIDDLE SCHOOL PHYSICAL SCIENCE
Students who demonstrate an understanding can: MS-PS4-2 • Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.

In Table 4, a solar oven (highlighted by author) is included as an example of a device that can support the following Middle School Physical Science Standard: ***Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.***

Table 4. Portion of Next Generation Science Standards for Middle School Physical Science [6]

MS-PS3.1. Students who demonstrate understanding can: Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. [Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a styrofoam cup] [Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.]		
Performance expectation developed using following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system.	**PS3.A: Definitions of Energy** Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. **PS3.B: Conservation of Energy & Energy Transfer** Energy is spontaneously transferred out of hotter regions or objects and into colder ones. **ETS1.A: Defining Delimiting Engineering Problem** The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions. *(secondary)* **ETS1.B: Developing Possible Solutions** A solution needs to be tested, and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. *(secondary)*	**Energy and Matter** • The transfer of energy can be tracked as energy flows through a designed or natural system.

5.2. Cross curricular tool

Initially, the author's solar cooker lessons were limited to the science classroom; however, it soon became apparent that the topic of solar cooking could easily form the basis for a cross-curricular collaborative unit of instruction. Colleagues teaching the social studies, math, and the language arts demonstrated interest in the solar cooking lessons but understood they had their own required education standards to meet. Examination of the corresponding standards in these three subjects revealed many learning objectives that could be met within a solar oven themed unit of study. Thus, solar cooking expanded beyond the science classroom. The following tables include a small sampling.

Table 5. Ohio Academic Content Standards – Social Studies [2]

ACADEMIC CONTENT STANDARDS FOR MIDDLE SCHOOL SOCIAL STUDIES – ECONOMICS
ECON.68.1a • Identify the short and long term consequences of a personal economic decision. ECON.68.3a • Describe how the wants of people determine what goods and services are produced. ECON.68.5a • Explain why some goods are easier to find than others and how this affects price.

Table 6. Common Core Math Grade 5 [7]

COMMON CORE MATH GRADE 5 - EXPRESSIONS AND EQUATIONS
CCSS.MATH.CONTENT 5.G.A.1 • Use a pair of perpendicular number lines, called axes, to define a coordinate system, with the intersection of the lines (the origin) arranged to coincide with the 0 on each line and a given point in the plane located by using an ordered pair of numbers, called its coordinates.

Table 7. English Language Arts Standards Grades 6 – 8 [7]

ENGLISH LANGUAGE ARTS STANDARDS GRADES 6 – 8 SCIENCE & TECHNICAL SUBJECTS
CCSS.ELA-LITERACY.RST.6-8.7 • Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). CCSS.ELA-LITERACY.RST.6-8.9 • Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

6. NETWORKING TO PROMOTE SOLAR COOKERS

The Solar Sisters, GDS (Jennifer Gasser and Mary Buchenic) network to bring solar cooking to the general population as well as to the education community. What strategies have worked for us?

6.1. Characteristice of networking approach

An assessment of the Solar Sisters Networking approach reveals five important characteristics.

1. Without visibility, there is no networking. Be a presence and a voice. Cook and share food.
2. Approach is positive and enthusiastic, but without presumption or sermonizing.
3. Contacts can be incidental or planned but are always person to person.
4. Communications are rooted in understanding of both educational and social goals.
5. No request for a solar demonstration is turned down - ever.

6.1. Networking results in positive outcomes

The Solar Sisters have facilitated a wide variety of solar cooking programs. Each one, large or small, has extended outreach and the ability to share the value of solar cookers with an ever growing audience. Here is a sampling of four programs which were all the result of a simple person to person conversation held with the individual listed as Contact.

Fellows Riverside Gardens, Youngstown, Ohio, U.S.A.
Contact: Educator at Fellows Riverside Gardens
Program Connection: Garden District Kids
Outcome: One day solar cooking demonstration and tasting event for enrolled children and parents

Youngstown State University, Youngstown, Ohio, U.S.A.
Contact: Dean of Beeghly College of Education
Program Connection: Center for Human Services Development
Outcome: Inclusion of The Solar Sisters' Programming in Center's after school educational classes
Outcome: Family Night – Learn about and make solar cookers for family members in Puerto Rico

Hiram College, Hiram, Ohio, U.S.A.
Contact: Professor of Biology and Director of Learning Streams International
Program Connection: Learning Streams International – U.S. / Pakistan / Dominican Republic
Outcome: Near peer mentor workshop and additional general workshop with makerspace
Outcome: Travel to Pakistan for ecology program at Forman Christian College in Lahore
Outcome: Mentor and two Pakistani teachers using solar cookers as classroom tools for education
Carnegie Science Center, Pittsburgh, Pennsylvania, U.S.A
Contact: Program Manager for Carnegie STEM Girls
Program Connection: Chevron STEM Center at Carnegie Science Center
Outcome: STEM Girls – one day workshop
Outcome: Energy Summit – two day workshop
Outcome: National Engineers Week – three day demonstrations and engagement
Outcome: Sci Tech Days – one day presentation

7. CONCLUSIONS

- The establishment of the solar cooker as an educational classroom tool can be enhanced through networking efforts.
- There is great interest in solar cooking which creates many opportunities for personal contact.
- The novelty of seeing food cooking in the sun works to ones benefit in scheduling events.
- Educators welcome outside opportunities for students to experience hands-on enriching activities.
- Educators understand the potential for solar cookers in the classroom when the rationale is explicitly and clearly conveyed.
- Discussion of educational applications, including alignment to standards, is essential.
- Flexible programming and willingness to adapt are essential.

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