

TOSHIBA AMERICA FOUNDATION

Grants Program for 7-12 Science and Math Education

School: Community High School District 94
326 Joliet Street
West Chicago IL 60185

Project Title: Determining the Feasibility of Solar Power to Relieve Community High School's Dependence on Fossil Fuel

Grant Amount: \$2,090

Project Manager: Annette Rubino, Science teacher

Project Summary: Community High School will install a pyranometer to gather data on solar radiation to evaluate the possibility of pursuing a cost-effective alternative energy source. The goal of this research project is to have students participate as scientists and consumers as they build a case for acquisition of appropriate solar equipment. The two most important learning objectives are: 1) Increase problem-solving ability, and 2) Increase ability to interpret tabular/graphical data for decision making.

Grades Affected: 9 through 11

Number of Students to Benefit: 495

Subject: Science

July 7, 2003

Toshiba Foundation

Re: Grant Proposal for Pyranometer

It is with great hope and anticipation that I write this letter of support relative to our science department's proposal for the purchase of a pyranometer. This instrument will make it possible for our students to measure solar energy. In addition to other applications, students will collect and analyze the long-term data from the pyranometer to make a recommendation to the School Board and administration regarding the cost effectiveness of installing solar panels to decrease the high school's dependence on fossil fuels.

I believe the incorporation of the pyranometer into our curriculum will increase student achievement in Science and Math. The system promotes a type of learning experience that requires students to analyze and interpret information in the context of the problems or questions they have identified. The application of information to a real-life situation will make their learning more meaningful.

Dr. Eric Mieland of Fermi National Accelerator Laboratory has agreed to serve as a partner with us. He will assist with installation of the equipment, train our teachers and students in the use of the pyranometer and provide guidance as the use of this equipment is integrated into our curriculum.

Our science department is committed to "self-initiated learning environments," in which students gather their own data and use a variety of sources to practice effective research techniques. The addition of this equipment would be a valuable tool for our teachers' continuing pursuit of learning environments that intrigue and engage our students.

The administration is committed to dedicating resources for installation of the equipment and for teacher training and curriculum writing to incorporate its use into our curriculum.

Sincerely,

John Highland
Principal

Objectives/Planned Outcomes

Learning Objectives of this project include:

- 1) Improve curriculum coherence over grade levels and across subjects.
- 2) Understand and apply the methods of scientific inquiry to investigate and solve real world problems.
- 3) Strengthen the interaction of science, math and technology disciplines.
- 4) Increase excitement and pleasure in learning.

Planned Outcomes include:

- 1) Optimize student learning by placing information within a larger setting so that the connections among subjects and every day life are evident.
- 2) Students will do science, not merely study science. The basis for students to learn concepts is through active involvement and investigations.
- 3) Students will discover that science is not isolated but is connected to other academic areas.
- 4) Students will use science to understand weather issues like the ozone layer and alternative energy sources.

5) Students will become lifelong learners with a passion for problem solving.

Measurement:

- 1) Pre- and post-test questions designed to elicit student views of information presented in classroom setting.
- 2) Pre- and post-test questions designed to measure student involvement in this research project.
- 3) Pre- and post-test questions designed to measure student perception of applicability of research to other academic disciplines.
- 4) Pre- and post-test questions designed to measure baseline knowledge on ozone layer and alternative energy sources.
- 5) Post-test questions designed to measure student problem-solving ability using the local science assessment test. This will be administered to 11th grade science students two years after the beginning of the project.

Methods/Strategies

At the beginning of 2004, approximately 500 students will be pre-tested on solar radiation for both problem solving ability and interpretation of tabular/graphical data. Once installation of the pyranometer has been completed, students in Physical, Integrated, and Science I classes will be responsible for

keeping a daily journal of solar radiation data and correlated climatic conditions. Classroom monitors will show weather and solar radiation data as well as the school website. Students can access this site from remote locations if Internet is available.

- Daily: students retrieve latest 24 hour solar data and weather
- Weekly, students manually plot the solar radiation data points
- Monthly, students will interpret the data and compare to data taken from the Fermilab site (extra copy for school leaders)
- Quarterly, student journals will be collected and reviewed by science instructors and graded using a rubric.

School leaders identified earlier in the year will receive copies of monthly individual interpretations for consideration in the report to be made to the School Board. The presentation will establish baseline data for five months and allow for interpretation. It is hoped that the School Board will encourage school leaders to continue with analysis of data and begin research on solar equipment (Phase 3).

INVESTIGATION OF SOLAR ENERGY

Question to investigate: Solar Energy / Global Warming / Measuring Solar Radiation

Objectives:

- Collect information on the sun and the use of solar energy as natural resource
- Describe the manner in which the sun produces energy
- Discuss methods of collecting and storing solar energy
- Explore current uses of solar energy as an alternative energy resource
- Collect information on the heating process that occurs in the lower atmosphere
- Compile a list of human activities that enhance the global warming process
- Discuss the techniques that are used to measure global warming
- Explore the arguments that are made in the scientific community in the debate about global warming
- Build a device to measure solar radiation
- Collect data on solar radiation in your locale with your device
- Discover the effect that certain variables have on solar radiation
- Compare data on solar radiation with that collected at a distant site

Materials:

1. E-mail and other telecommunications applications such as WWW and telnet (optional)
2. Resources on solar energy obtained from a library or another source
3. Two plastic soda bottles
4. Black and white paint
5. Playdoh
6. Two Thermometers
7. Computer with graphing program (optional)
8. Directions for building the solar radiation device / obtained electronically (optional)

Activities:

1. Research materials that are available to you (either through the library or telecommunications resources).
2. Describe what solar energy is. (You might find it helpful to use a lamp with an ordinary light bulb to demonstrate the effects of radiated light and heat.)
3. Describe how the sun produces its energy
4. Describe the methods that are used to collect this energy for use by humans to satisfy the need for sources of energy.
5. Discuss active and passive methods of collecting solar energy. Discuss the use of photovoltaic cells (solar cells) that are used to provide voltage to electrical systems.
6. Access NASA Spacelink by telnet or gopher at or via WWW to find resources on the sun, solar energy, and the use of solar energy as a natural resource. (optional)
7. Take the two soda bottles that you collected for this activity, paint one black and the other white.
8. Make a cork for each bottle from the playdoh. Insert a thermometer in
9. Take a reading from each thermometer. Record the readings at time = 0 minutes.
10. Put the bottles in a sunny area and take readings from the thermometers every twenty minutes. Record the readings in a data table.
11. Graph the data from your table by hand or by using a computer equipped with a graphing program.
12. Analyze the graphs for each of the bottles. Did the time vs. temperature ratio look the same for both of the bottles? Why or why not?
13. Have students write a conclusion that summarizes the results of the experiment. How could this information be used in the design of a solar collector?
14. Use the knowledge about solar energy that you have acquired to build a simple solar collection device that will heat a volume of water when exposed to the sun.

15. Access the Eco Gopher at the University of Virginia and CIESIN- NASA -EOS Global Change and Information Network Gopher to obtain information on global warming. (optional)
16. Make a list of the human activities that contribute to the process of global warming. Discuss the Greenhouse Effect and describe the effect that the activities that you listed previously have on the environment.
17. Organize the class in teams. Use the research that you have collected about the process of global warming and the Greenhouse effect to prepare to for a "data - based" debate. Teams take sides on the issues involved and use the data to defend their positions. Make a rule that arguments must be made or defended based on the data collected and research that is available. Of course research data is subject to scrutiny, but only as far as scientific arguments can be made to challenge it. Remind students that personal attacks are not appropriate, and cause the attackers to lose face in the eyes of those who are making sound, well thought out arguments.
18. Make an e-mail connection using Academy One or the KidSphere listserv with at least two other classes and hold a world conference via e-mail discussing what should be done about global warming. Each class should be divided into groups representing different countries. (optional)
19. You may wish to publish a report on the results of your world conference.
20. Locate two or more classes using the telnet or WWW addresses from number eighteen. These classes should be at different latitudes. Ask them to participate with you in a collaborative project on solar radiation. The addresses above are for Academy One and KidSphere. You can also find classes through other networks or discussion groups that serve teachers.
21. Access the Antarctic Telecommunications Program journal entry that discusses solar radiation, greenhouse gas, and global warming studies that are being conducted at the South Pole.
22. Access NASA Spacelink by telnet or gopher at or via WWW and get the directions for building a simple device for measuring solar radiation. Build and calibrate your device according to the instructions that you find. Classes should "standardize" by using identical materials.
23. On a sunny day measure solar radiation at 9am, 10am, 11am, 12 noon, 1PM, 2PM, and 3PM at each of the locations. If you encounter cloudy days, wait a day or so until the weather clears before collecting data. Exchange data with the other sites that are participating.
24. Collect data from each site, enter it on a spreadsheet and graph the results.
25. Discuss how latitude and time of day effect the amount of solar radiation encountered.
26. Write a conclusion on the data that you have and the implications that the data has on the use of solar energy as a renewable resource, the process of global warming, and the effects of solar radiation on the planet and it's inhabitants.

Discussion of Alternatives

The five core faculty leaders for this project had explored optional quantitative and qualitative evaluations to measure science students' growth once the solar radiation data were available. They rejected any methods that did not involve qualitative or quantitative data collection.

Both the Illinois State Board of Education learning standards and the No Child Left Behind Act require measurable activities and thus the need for pre- and post-test development is critical. This National Blue Ribbon suburban school of 2,200 students has a rich curricular and extracurricular program, advanced technology systems and a commitment to excellence for its culturally diverse student body. In order to qualify for this title again, the bar has been raised and requires baseline data on desired outcomes followed by demonstration of increasing growth year by year.

PROJECT MANAGEMENT

Equipment purchase:

On the recommendation of Dr. Eric Mieland of Fermi National Accelerator Laboratory's weather station, Community High School

contacted Campbell Scientific, Inc. regarding purchase of a silicon pyranometer to measure sun and sky radiation. Site visits to Fermilab and consultation with Dr. Mieland provided a demonstration of the equipment and data retrieval. Site selection was discussed, and Dr. Mieland offered suggestions for location of this equipment. The district's business office will oversee purchase of equipment (see Appendix A) and installation costs the district will incur.

Site Selection:

The roof atop the science wing of the school is flat and offers the best location for the pyranometer. Careful studies will be conducted to ensure that the location is free from vegetation overhang or artificial lights. This process will involve school engineers, business office, project manager, Horticulture club and designated student leaders involved in the project. The school's engineers will provide architectural drawings to facilitate the service entrance of the cable to the datalogger equipment in the weather display case.

Equipment Installation:

School engineers will provide the installation of the pyranometer, mounting arm, base and leveling fixture, penetrate

the roof and bring cable to the internal components. The Information Technology department will complete the internal installation and train staff on support software. Business office will monitor labor costs and incidentals associated with the installation.

Curriculum Development:

Five faculty members (See Appendix B for resumés) have been identified as the core group to develop the pre- and post-tests to measure problem-solving abilities and interpretation of solar radiation data. Dr. Eric Mieland will provide data from Fermilab's pyranometer for test development. Future cross-curricular activities will be identified after the entire science staff has been trained on the instrument and data extraction.

Public Relations:

The public relations department will work closely with the science staff, student leaders, and administration to announce to the public the project and update the community on milestones reached.

Project Timetable

Site selection for the pyranometer is critical before installation. The second story over the science classrooms has a flat roof. The external silicon photovoltaic detector will need to be positioned so that it is not used under vegetation or artificial lights, according to the manufacturer. Provisions must be made to predict future growth of the mature trees surrounding the campus when selecting this location. This process will involve the Horticulture club.

Once the site is determined, the purchase base will be leveled, approximately 100 feet of wire will be required to reach inside to the datalogger and finally to the support software, which allows for storage of one million data points. Numerical and graphical data will provide printed reports.

Solar radiation data will be analyzed, as the next program expansion could include acquisition of solar panels to reduce current energy dependence for gas and electricity.

PROPOSED CALENDAR *

START DATE	END DATE	ACTIVITY
08/01/03	11/01/03	Grant submitted and approved Phase 1
09/02/03	09/16/03	Student leaders identified pre-tests administered
09/02/03	10/01/03	Site Selection
11/10/03	11/11/03	Purchase Equipment
12/01/03	12/31/03	Installation of equipment
01/02/04	01/16/04	Kickoff and training session Phase 2
05/01/04	05/11/04	Analysis of solar radiation data
05/11/04	05/11/04	Student leaders present 5 months of data and interpretation to school board
09/01/04	06/01/05	Data collection continues during 2 nd year
06/08/05	09/01/05	Program expansion Phase 3
09/01/05	10/01/05	Bid for solar panels accepted

* subject to change

PROPOSED BUDGET

EQUIPMENT: (Campbell Scientific, Inc. - reflects discount)

Pyranometer LI200X-L silicon pyranometer	264.00
LI2003S LiCor Base and leveling fixture	52.80
CR510 Basic Datalogger w/ 128K memory	720.00
100 ft wire @ .27 ft	26.00
SRM=5A RAD 20 Short Haul Modem x2	172.80
SC932 9 pin to RS-232 DCE interface	158.40
015 ARM pyranometer mounting arm	72.00
PC 208W datalogger support software	290.60
Shipping and Handling	75.00
Total Equipment Costs	\$ 1,831.60

Installation Supervision Honorarium **250.00**

(Dr. Eric Mieland of Fermi Lab)

Total Requested from Toshiba Foundation: **\$ 2,082.00**

Contribution by School District: **\$ 1,194.00**

Curriculum Writing/Pre- and Post-Test Development by Science

Faculty - 5 teachers @ 8 hrs ea. X \$23 per hour = \$920

Installation Costs re: Maintenance Department and Technology Department Staff: 8 hours X

\$20 = \$160

Substitute Teachers for Teacher Training Sessions with Eric Mieland of Fermi Lab - 3 X 2

hours X \$19 ea. = \$114

(Dr. Mieland will donate his time for training and mentoring teachers and students.)

EVALUATION

Pre- and post-tests on weather units will be developed to measure students' command of the material. The goal of the science department is to show a 10% growth in interpretation of graphical solar radiation data and problem-solving abilities the first year and 20% for the second year.

Student leaders (ideally 9th graders of the class of 2007) will be identified who will focus on a year's worth of solar radiation data. They will work with Community High School faculty and Dr. Eric Mieland of Fermi National Accelerator Laboratory to analyze and present the data to the administration and school board. The student leaders will develop a feasibility study that could prove the cost effectiveness of investing in solar power in the near future. By the time this group completes their education, they will have participated in the project for four years and groomed three underclasses to continue the project if needed.

The feasibility study will entail searching for vendors that have good standing with customers such as the City of Chicago, where currently nine rooftops of public buildings have functioning solar panels. Reports suggest that costs have been reduced and in some instances that pay back period has been shortened. The cost savings vs. initial outlay will assist the board and administration with decisions for the future dependence on traditional energy sources vs. alternative sources.