



Energy from the Sun—in Space and on Earth

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Progress Report, FY13

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Introduction

This Progress Report provides an overview of the activities conducted during FY13 on the *Energy from the Sun—In Space and on Earth* (ESSE) project. ESSE was awarded a no-cost extension in October 2013 with a new project completion date of February 13, 2015. A final project report will be submitted in accordance with this new completion date. This progress report contains activities conducted between December 2012 and December 2013. Our project objectives continue to be to:

- 1) Train teachers in California using existing, high quality, standards-aligned heliophysics E/PO materials
- 2) Increase student interest in STEM careers through contact with science undergraduates and scientists
- 3) Partner with utilities to integrate heliophysics content into utility-sponsored trainings
- 4) Leverage solar school networks to bring NASA materials and programs to a new audience of educators.



Teachers working together to trace Earth's magnetic field lines

Our key deliverable for ESS is a model of teacher professional development that integrates solar energy with heliophysics content. The workshop is designed to show the inter-connectedness of a wide range of topics that are often presented as separate ideas. In this third year of the project we have found authentic ways to integrate the two topics. And we have developed a new activity using a globe and solar cells that helps teachers to connect the topics for their students. We see a fair amount of evidence that teachers are taking this integrated perspective into the classroom.

After the workshops, teachers noted opportunities to present solar topics in theme units, project-based units, or into different parts of the curriculum. One teacher said, “The main idea that I plan to use in my classroom is the many ways that solar topics can be woven through the school year and subjects, in a hands-on and meaningful way.” In addition to presenting the ideas as integrated units, teachers saw that they could integrate solar science and energy with other content areas. One teacher said that the universal importance of the Sun makes it particularly useful for teaching about multicultural topics.

We know that we have a winning combination of topics. All of our teacher workshops were pre-registered at capacity and with waiting lists. During the past year we conducted four teacher workshops. In early February we held our Follow-on Workshop in Sacramento with our partners from WeCare Solar and the Sacramento Municipal Utility District. The following month we held our second Follow-on Workshop for teachers in the greater Bay Area at UC Berkeley with science presenters from the Space Sciences Laboratory. This past summer was focused on conducting our multi-day workshops. The first was held June 24-27 in Pasadena at the NASA Jet Propulsion Laboratory with our National Energy Education Division (NEED) project partners, and the second was held August 1-3 in Berkeley at the UC Space Sciences Lab with our partners from WeCare Solar and the Sacramento Municipal Utilities District.



Documenting activities for use at school sites

The interest in our professional development workshops for 2013 was quite high again; we received over 100 applications alone for the workshop at JPL. This we believe was due to the fact that we were able to leverage a new-to-us network of teachers: the California Partnership program (a partnership between the CA Energy Commission and the CA Department of Education). As a result, we reached a large group of educators who are working with students in Green Academies and are very interested in the topics we address. Unfortunately, we only had funding for thirty educators, but we able to re-route many applicants to other NASA summer workshops at JPL and the Los Angeles area.

The Bay Area workshop had thirty-five educators pre-registered and a final number of twenty-five in attendance. At this time we are in communication with our summer participants regarding the follow-on workshops scheduled for early 2014—and again, we are being met with enthusiasm for Part II of our professional development effort.

We continue to receive very positive comments from our educators at the conclusion of our workshops with nearly all participants indicating a high degree of interest in implementing the materials they used during the workshop. The following findings regard our workshop held this summer in Berkeley, but we



Increased teacher confidence with new topics and activities

saw similar changes among teachers at our southern California workshop. Before the workshop, 15 percent of teachers had implemented the workshop topics in their classroom. By the end of the workshop, all teachers intended to implement the materials in the classroom.

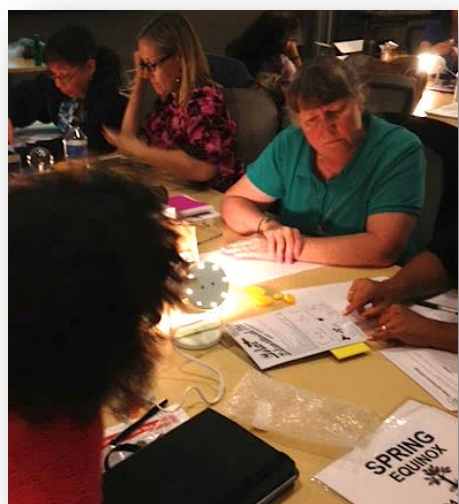
In recent email correspondence, one of our teachers commented, “I am using the solar lessons as an elective for the 2nd - 6th graders...I am using a variety of the lessons, especially the energy from the Sun unit. I get to present it six times through the school year. So, thank you for the training and I am loving the units.”



Solar cells used to power a small motor

Another educator took what he had learned, shared it with his San Francisco Bayview-Hunters Point area colleagues and used the resources as part of a back-to-school community event called “Back Pack Giveaway.” He wrote to me to say, “Yes! You saw students, parents and SFUSD staff at the Science Booth using solar cells... I was teaching the importance of solar energy! The booth was called ‘Hands-on Solar Energy Investigation and Science Guides for Parents. Great success!’”

Based on what teachers report to us, we find that they leave the workshop experience with a better understanding of all content provided, including the electromagnetic spectrum, solar circuitry, seasons, and the science of the Sun among others. They also reported learning about



Working with NEED's energy activities

common misconceptions students have about the seasons and the Sun-Earth connection. They appreciated being exposed to a variety of resources and activities, and they reported their intention to implement the new learning and materials in the classroom. Many teachers remarked that having the materials (teacher guides, kits and supplies) from the workshop at hand is key to their using the resources. The main barriers they anticipated were overcoming students' misconceptions and their own lack of deep knowledge of the material. Many teachers also anticipated difficulty finding the time in the course of the year to offer the material to students.

One of the goals of the follow-on workshops is to share strategies for implementing the materials. We have found that, in spite of the time challenge teachers report, *they are using the materials*. Hearing from colleagues *how* they implement and *when* they implement the solar topics can be very instructive to teachers who are still trying to find opportunities to get the activities and resources into their classrooms.



Safe viewing of the Sun's features

including an overview of solar energy and its applications, the science of energy and energy transformations. We also introduce solar ovens and use them to discuss a number of topics, including the Sun's angle, Earth's rotation, energy transformations, and engineering.

We have maintained a similar structure for both multi-day workshops. We begin with the energy game developed by the Astronomical Society of the Pacific with NASA funding—it is a wonderful way for teachers to get to know one another and to immediately start working with energy transformations and the notion that the Sun is the ultimate source of most of the energy forms on Earth. We then introduce the ESSE team, teachers, workshop goals, and key concepts that will be covered during the workshop.

The first science plenary session focuses on exploring magnetism, electromagnetism, and the electromagnetic spectrum. With these foundational topics in place, we shift to a variety of solar energy topics,

The second science plenary session is focused on the reasons for Earth's seasons, a topic that teachers note, has many ways to connect the science of the Sun with solar energy. We have several teacher leaders on this project; they are educators who have taken the ESSE materials and integrated them into their practice with great skill. As such, they make excellent role models for teachers attending the workshop and also wonderful presenters, as they showcase outstanding implementations of ESSE resources and activities in their own classrooms. Other solar topics that we cover during the workshop are electricity, photovoltaics, circuitry and powering loads with solar sources. By the time we are on day three of our workshops we offer breakout sessions, one of them using the *Living with a Star GEMS Guide* for middle and high school students and the other session using NASA's *Eye on the Sky* for elementary students. Passive solar design and Sun angle exploration are two more topics we cover—both are excellent at integrating our two topics. At the end of the workshop we return the focus of professional

development back to heliophysics with an overview of NASA's cutting edge science and its many heliophysics missions.



Customized JPL Tour for ESSE teachers

Laboratory. Good weather also allowed us the chance to get hands-on with telescopes and do solar viewing over several days, use solar ovens, and test our UV beads.

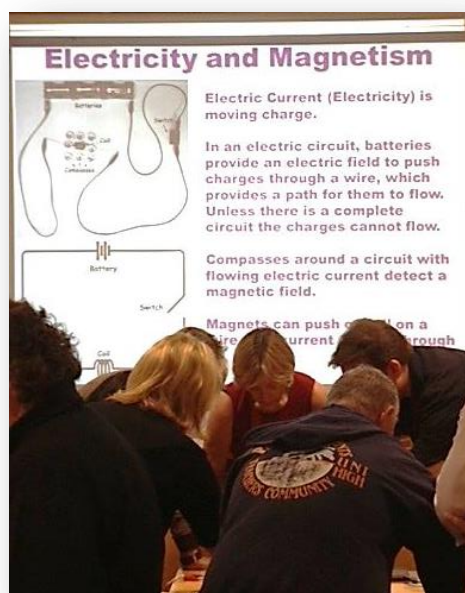
The workshops also each include field trip/tours. This summer we were fortunate to have a tour of JPL conducted by Ota Lutz and her staff. We also had a great introduction to the range of teacher professional development opportunities at JPL and teacher resources available to local teachers. In Berkeley, teachers participated in a tour of the Laboratory's Mission Operations Center where they got a behind-the-scenes look at the operations of many NASA heliophysics missions housed at the Space Sciences

The follow-on workshops are structured to allow time for teachers to: 1) share how they have used ESSE resources in their classroom practice and 2) plan for implementation using the educator and scientist expertise at the workshop. The follow-on is also another opportunity to deepen understanding of the workshop topics, including solar circuitry, photovoltaics and the safe use of materials.

Overview of the 2013 JPL/Pasadena ESSE Workshop

What Teachers Learned

Science Content: Just as we have seen in the other workshops that we conducted over the past three years, most teachers began the 2013 southern California workshop with limited understanding of the topics presented. While teachers have interest in heliophysics and solar energy, not all have a solid understanding of either topic—this is particularly true of elementary school teachers. These findings are based on evidence from both the workshop survey and the pre- and post-test self-assessment. On the survey, few teachers felt that prior to the workshop they had “quite a bit of knowledge about the topics presented.” The average score across all items was 2.44 before the first session, but, by the end of the workshop sessions, the average score had increased to 4.29 (out of a total of 5 points). All teachers but one felt that they “clearly understand the information/topics presented in the workshop.” In the comments, teachers reported gaining new knowledge and information. The presentations were described as “very eye-opening and interesting”, “clear”, “understandable”, “helpful”, “wonderful”, and “informative”.



Understanding magnetism and electricity through hands-on exploration

seasons on earth”—had the highest post-test scores. Teachers’ knowledge of the “Features and events of the Sun” as well as “Understanding the connections between seasons and solar energy” showed some of the greatest increases on the pre/post self-assessment. Of the topics presented, “Understanding of solar circuitry,” while demonstrating gains on the pre/post self-assessment, received the lowest average post-test score. We have found that this topic is new to most teachers—in particular, those in the elementary grades—and requires more time to understand fully. In past follow-on workshops we have revisited the topic and will do so again in our future follow-on workshops.

Logistics for presenting materials in the classroom: In addition to content, teachers gained experience with the materials, which they felt would help them implement the topics in the classroom. For example, one teacher said, “The season activity was powerful! I can never quite work out the logistics. It’s brilliant that everyone forms a circle, walks around, and has a class discussion.” In addition to learning logistics, teachers felt that they gained practice in implementing topics and materials in the classroom. The two items on the pre/post self-assessment that showed the greatest gains were both ideas for using solar data and for teaching how solar activity can affect events on earth.

Confidence: Teachers describe feeling more confident in their knowledge of the topics and more confident in their ability to present them to students. By the end of the workshop, all but two teachers agreed with the statement, “I feel that I know enough about the topics to confidently present them to my students.” That said, several were concerned about their ability to remember

the details of the topics or to use the equipment and materials safely, especially with younger aged students.

How Teachers Intend to Implement Strategies

As integrated or connected concepts: We have worked to show the interconnectedness of a wide range of topics that are often taught separately. Teachers said that the connections between the ideas “helped clarify” many aspects of the topics. Many teachers saw the opportunity to present the topics in theme units, project-based units, or into different parts of the curriculum. One teacher said the content “ties in very nicely with [our] school-wide Environmental Science” focus. Teachers also appreciated the layers of activities, which could be used to make projects as simple or complex as they required.

Through integration with other content areas: In addition to presenting the ideas as integrated units, teachers saw that they could integrate ESSE topics with other content areas, particularly Language Arts. They appreciated the “great ideas for integrating science across the curriculum” and saw the activities lending themselves to “powerful learning, discussion, and writing.” Although more elementary than middle/high school teachers seemed to think about integrating with writing, teachers from all levels identified opportunities to bring deeper mathematics into the activities.



Experimentation at one of the electromagnetism stations

Sharing with other teachers: Two-thirds of the teachers said that they intended to use the topics to train other teachers and half felt confident that they could share the materials in a workshop-like setting. All felt that they would talk to colleagues about the workshop experience, and all felt that they would recommend the workshop to fellow teachers. Since the workshops, we have received several requests for additional workshop resources for trainings teachers are conducting at their schools; several have asked for 10-20 copies. Following is correspondence with of a school librarian who was sharing the resources with teachers and planned to implement the ESSE activities school wide: “In June I attended the “Energy from the Sun” workshop at JPL. Last week, our leadership

team got together to plan out a “solar-focused” year of school wide activities. The materials from the workshop have been great! The teachers are willing to try this new approach but having

action photos of the ideas/lessons, materials, worksheets, and extensions all ready to go was a huge selling point.”

As both basic and supplemental curriculum: Before the workshop, only one quarter of teachers had implemented the workshop topics in their classroom; by the end of the workshop, all teachers intended to implement the materials in the classroom, and almost half of teachers felt that the materials would work as both integral and supplemental to their basic curriculum. This was true of both elementary and high school teachers. Of the remaining 17 teachers, 8 were more likely to use the materials as supplemental while 9 were more likely to use the materials as integral to basic curriculum. Although one teacher stated, “The major challenge in teaching the content is having the time to do so when there are so many other 2nd grade science concepts to cover,” conversely, another 2nd grade teacher said, “I want to incorporate it to prepare [my students] for 3rd grade and to have this important knowledge.” Other teachers mentioned that this addresses most earth science standards, and that the knowledge they gained will benefit them in the classroom.

By using materials and resources provided: Teachers were appreciative of the materials received and felt that both the kits and the resources on the flash drive would enable them to implement the topics in the classroom. As one teacher said, “This workshop was all that I expected and more, in that it provided ideas and materials and resources that will help me and my students understand the role of the sun in our lives.”

Potential Challenges

Student prior beliefs, level of preparation, and grasp of academic language: Many teachers felt that overcoming their students’ misconceptions would be the biggest barrier, but, as one teacher said, “The hands-on activities should help a lot.” Similarly, teachers also noted that

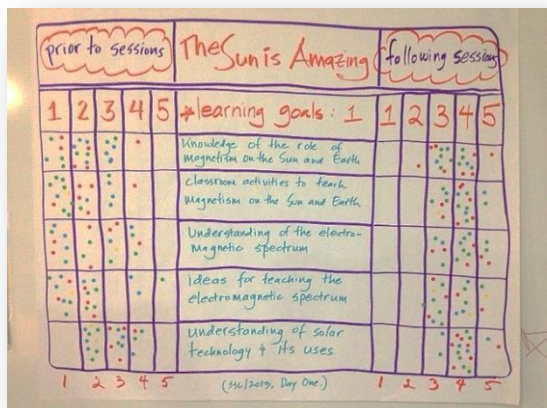
students have limited background knowledge about the topics when they enter the classroom. Students also often lack the “vocabulary and thinking skills” to grasp the materials.



Using a model to explain the changing angle of the sun over the course of a year

Time and resources: The lack of time or limited resources is an ongoing challenge for teachers when it comes to presenting new topics. While few teachers anticipated that barriers would make it difficult, finding time and limited resources were frequently-mentioned challenges. Specific challenges ranged from large class sizes, limited

funding for materials, and issues with scheduling and weather. Many teachers included plans for overcoming the barriers in their comments, such as approaching the PTA for funding, and moving the activities to the end of the school year when weather is sunnier.



Teachers self-report learning at the end of each day of the workshop

average score across all items was 2.25 before the first session; but, by the end of the sessions, the average score had increased to 3.85. Further, all teachers felt that they “clearly understand the information and topics presented in the workshop.” In the comments, teachers reported new knowledge and information. As one teacher said, “I learned a great deal of new information. I will absolutely include sun content in my lessons because my students will love some of the great lessons and activities we learned here.” As in Pasadena, the activities associated with exploring magnetism and with the reasons for the seasons, were often mentioned as particularly helpful; they are excellent resources to introduce the basic science of the Sun along with activities that are classroom-ready. Teachers remarked that the reasons for the seasons activity provided a “better way to describe seasons” and that they intend to “use the stark light bulb and polystyrene spheres to have my class model the reasons for the seasons and day and night.”

At the end of the workshop, on the self-assessment, “Classroom activities to teach magnetism on the Sun and Earth” showed the second-highest overall gain between pre and post assessments. Teacher comments include the following: “I found great resources to describe electricity and magnetism;” “I plan to implement the magnetism and electricity component. I found all the analogies used very relevant and realistic;” and finally, “I will use the activities that covered magnetism and electricity. I am planning to complement a project using solar cells to build portable lights.” One additional comment is, “I learned a great way to teach about the electromagnetic spectrum and also how to draw to visually show magnetic fields—both are great because they are hands-on ways [to teach] with fantastic visuals to help students see what they can’t see.”

Overview of the 2013 Bay Area ESSE Workshop:

What Teachers Learned

Science Content: This group of Bay Area teachers also began the workshop with limited under-standing of the topics presented. On the survey, few teachers felt that prior to the workshop, they had “quite a bit of knowledge about the topics presented.” On the self-assessment (on a scale of 1 to 5 where 1=limited knowledge and 5=extensive knowledge), the

Of the topics presented, “Understanding of solar circuitry” demonstrated the largest gains on the pre/post self-assessment, and had a relatively high post-test score of 4.0. “Familiarity with how photovoltaic (PV) cells work” received the lowest post-test score and had the smallest change between pre and post assessment. This may be due to the fact that teachers had opportunities to work hands-on with solar cells and creating various circuits to power loads, but the details of how photovoltaics work may need more time to be fully explained and understood. This topic continues to be challenging for teachers and we have returned to it in follow-on workshops and will do the same in future follow-on trainings.

Learning techniques for presenting materials in the classroom: In addition to deepening their content knowledge, teachers felt that they picked up tips and strategies for offering the materials in their classrooms. Two teachers intend to borrow workshop analogies, such as different waterfalls to explain amperage and voltage, and a straw in a drink to explain sunspot structure and color. In conversations with the evaluator, several teachers mentioned that they appreciated the analogies, saying that they thought the way vocabulary was introduced would make it easier for their students to acquire the academic language. Two other teachers felt that emphasizing the practical applications of the science would be particularly appealing to their students.

Confidence: Teachers described feeling more confident in their knowledge of the topics and more confident in their ability to present them to students. By the end of the workshop, only one of the teachers disagreed with the statement, “I feel that I know enough about the topics to confidently present them to my students.” But several were concerned about their ability to remember the details of the topics. In response to this need, the follow-on workshops serve as a sort of “refresher course” to help solidify learning.

How Teachers Intend to Implement Strategies

Through integration with other content areas: Teachers reported seeing the value of teaching solar science and energy together: “Understanding solar energy definitely deepens my capacity to teach the sun;” “I teach green energy and now have more relevant info to share with students;” and lastly, “I think knowledge of solar energy will help me to teach applications of science of the sun.” This next comment indicates the range of topics that can be linked to the Sun: “I will definitely include more content about the sun in my classroom. It connects so well with other areas of scientific inquiry, such as magnetism/electricity, weather, chemistry, water cycle, food chains and webs, photosynthesis, etc. It also will lend itself well to nonfiction writing.”

Sharing with other teachers: Half of teachers noted they intend to use the topics to train other teachers, and they feel confident that they could share the materials in a workshop-like setting. All but one felt that they would talk to colleagues about the workshop experience, and all felt that

they would recommend the workshop to fellow teachers. Although teachers did not mention in the surveys that the workshop was a good networking opportunity, this opinion did come up at various times during the course of the workshop.

As both basic and supplemental curriculum: Before the workshop, 15 percent of teachers had implemented the topics in their classroom. By the end of the workshop, all teachers indicated that they intended to implement the materials in the classroom. Seventy-five percent felt that the materials would work both as a basic curriculum or integral to existing curricula. All but one felt that they would use materials as a supplement to their basic curriculum. Below are some comments regarding how the activity/lessons will be used: “I would like to use solar energy lessons to do practical, hands-on, student engaging, relevant lessons and not just textbook solar physics. I would like to plant the seed of appreciation of renewable energy capability.” Another teacher writes, “the sun is so important in all cultures, this gave me ideas on how to focus a whole unit that encompasses all subjects all revolving around the sun! (study of cultures, math, science, writing, love it!)”. And another notion for supplementing existing classwork, “I can use this especially in my Digital Electronics class. I’m thinking how to edit units to do solar-based instead.”

Potential Challenges

Student prior beliefs, level of preparation, and grasp of academic language: Teachers felt that overcoming their students’ misconceptions would be the biggest barrier—this challenge seems to hold consistent over most teacher groups. Similarly, teachers also noted that students have limited background knowledge about the materials when they enter the classroom. Students also often lack the scientific vocabulary. Given the levels of student science literacy reported by teachers at both workshops, the need for ongoing workshops to address this is clear.

Time and resources: The lack of time or limited resources is an ongoing challenge for teachers when it comes to presenting new topics. While few teachers anticipated that barriers would prevent them from using the ESSE resources, finding time and limited resources were mentioned as challenges by a quarter of teachers. The need for resources has come up in all of our work with teachers and we budgeted a generously for teacher supplies and equipment, knowing that *having* the supplies would more likely lead to use of the activities. Along these lines, one teacher said, “there is not a lot of extra money floating around at public schools, and although there are grants available, they take a long time to complete. Therefore, it is difficult to get materials quickly. This workshop has, however, provided us with a number of valuable materials that I will use.” And another reported, “The vast amounts of resources that we are receiving are really helpful—not only do I have the knowledge to teach about solar generated electricity, but I have the materials too!”

Finding the time to actually add new topics to the classroom day is another challenge—many teachers identified time as a leading constraint to implementation. While we cannot add more hours to the day, we can identify strategies that our teacher leaders have used for getting solar into their curriculum, such as integrating into existing curriculum, scheduling these activities during “dead days” and holiday time, starting solar clubs and creating after-school programming. We have found that this topic of when to teach these topics generates very rich discussion among teachers.

A few more comments on the workshops from teacher participants in the summer workshops—

- “Great variety of speakers/presenters. And they are all SO GOOD!”
- “Awesome to see what great teachers are doing”
- “The hands-on activities are especially valuable and fun.”
- “I value the opportunity to chat with fellow teachers.”
- “I really enjoyed the workshop, the speakers and the generosity of the program. These programs are what keep me excited to go back to school and do what I do. It refreshes me and keeps me updated.”
- “Thank you! I gained much material that is useful to me and for teaching physics concepts to students.”
- “This has been the very best workshop I have ever attended. Amazing presenters, good mix of sitting/content and hands-on, great positive approach-spoke on my level. I could understand explanations!”
- “This workshop surpassed my expectations, and I thoroughly enjoyed it. The presentations were great and the presenters top-rated.”
- “With these resources, my students can explore careers in space science.”
- “This was amazing! This was the absolute best conference I’ve ever attended.”

Cal Day Career Panel

Cal Day is UC Berkeley’s campus-wide Open House. The Center for Science Education has participated in Cal Day for many years, coordinating presentations by scientists, tours of the Mission Operations Center, clean rooms, and other areas of interest. As part of ESSE, we coordinated our third “Cool Careers in Space Science” panel discussion. It was well attended by the general public, parents, teens and children, and several teachers. The panel included a recent UC Berkeley graduate in physics who works at SSL, a space physicist (a young woman!), an engineer working on several solar missions and a member of our Mission Operations Center. With our new completion date in 2015, we plan to be part of Cal Day this April as well.

2013 Solar Week

Solar Week, supported by this grant, is held twice a year, in the spring and again in the fall. Spring Solar Week was held March 18-22, 2013. We added a new scientist, Lindsay Glesener, to the group of heliophysicists who contributed to interactive bulletin board. The totals for bulletin board plus curriculum pages for the spring were:

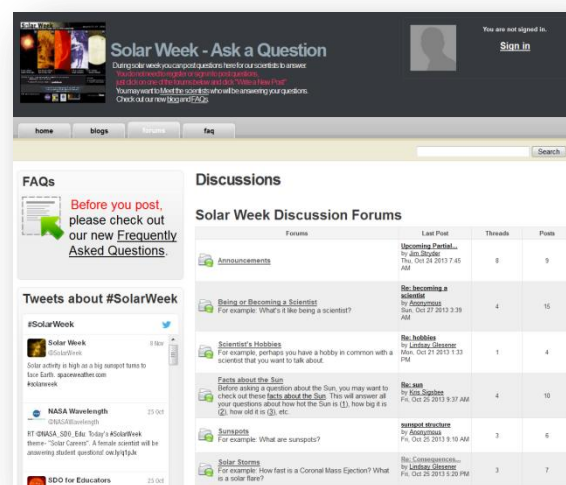
- Individual page requests (hits): 47,582
- Distinct IP addresses: 10,480 (the number of unique, unduplicated computers that visited the site at least once).
- 113 posts (questions from classrooms and answers from scientists) appeared on the interactive bulletin board.
- 90.9% of 20 students said “Yes, Solar Week makes me want to learn more about science.” (from anonymous Survey Monkey student questionnaire).
- “I think [Solar Week] is now wanting to make me a scientist...I love this website.” -- student, grade 8

Fall Solar Week ran from October 21-25, 2013.

Unfortunately, time to publicize the fall event coincided with the federal government shutdown. As a result, some scientists weren't sure or weren't able to participate. The bulletin board was less lively, but the pages still got a lot of hits.

Totals for bulletin board plus curriculum pages:

- Individual page requests (hits): 180,323
- Distinct IP addresses: 32,851 (the number of unique, unduplicated computers that visited the site at least once).
- 79 posts (questions from classrooms and answers from scientists) appeared on the interactive bulletin board.
- Student comments (from anonymous Survey Monkey student questionnaire), “Yes, Solar Week makes me want to learn more about science.” and “It's really great to have such a good website for students. I really appreciate it.” – 8th grade student. We also heard from middle school teachers who remarked that their “students were inspired” by the fact that all the solar scientists are female.



Fall 2013 bulletin board

This past year has been productive for ESSE. Our workshops have generated a great deal of teacher interest, we see our materials being implemented broadly, at multiple grade levels and in diverse communities, and we hear from teachers that there continues to be a great need for workshops of the caliber we present. With our approved extension of the project we will be conducting our follow-on workshops for this past year's teacher cohort in the spring—a time of year that our teachers have noted to be preferred. We are also planning another workshop to be conducted this summer.