P1.33 INVOLVING STUDENTS IN AUTHENTIC RESEARCH THROUGH STUDENT-TEACHER-SCIENTIST PARTNERSHIPS

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1. INTRODUCTION

The National Science Education Standards (National Research Council, 1996) emphasize that students should learn science through inquiry (Science Content Standard A Science as Inquiry) and should understand the concepts and processes that shape our natural world (Science Content Standard D Earth and Space Science). One method of having students learn science through an inquiry approach is to involve them in a student-teacher-scientist partnership that involves students in ongoing research programs (Barstow, D., Tinker, R. F., and Doubler, S., 1996) that require the students to select a research question, understand the data they need to answer that question, analyze the data, draw conclusions, and write a research report.

The Earth System Scientist Network (ESSN) project has worked with scientists to develop research projects for the participation of 8th-12th grade students. This development goes beyond identifying a research question that teachers and students are asked to consider. It also requires: addressing logistical issues surrounding the data; identifying spatial and time requirements unique to each project; identifying, testing and making available the instruments and tools (both hardware and software) that the teachers and students will use; developing the background information and training they will need; identifying additional research questions that provoke the curiosity of the students, and identifying incentives for and methods of recognition of the students and teachers participation. Each project is unique and thus needs to be developed independently of the others; however, each research project needs to address all of these issues.

We have developed a web site (http://essn.terc.edu, See Figure 1) which presents for each project: 1) the information that teachers and students can use to evaluate whether the research project meets their needs and abilities; and 2) the project resources that support the teachers and students participating in the project.

One project that has been developed for the ESSN is *Atmospheric Aerosols: Collecting and Correlating Data* project led by Dr. David Brooks at Drexel University. In this project students will use a sun photometer to take daily measurements of atmospheric aerosols and send the data they collect to Dr. Brooks. They will then work

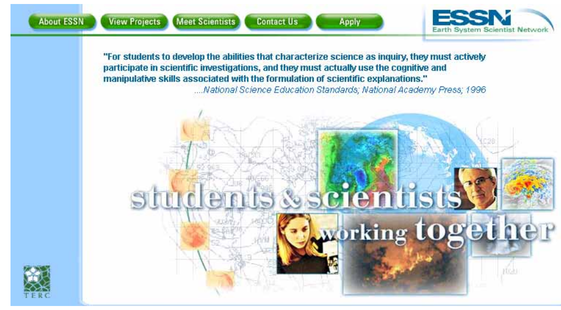

Figure 1 Earth System Scientist Network Homepage

with Dr. Brooks as they conduct their own research, exploring the relationship between aerosols and other local atmospheric variables such as humidity or the air quality index. This project is being implemented during the 2002-2003 school year by three schools: Chatham High School in Chatham, New Jersey; East Lincoln High School in Denver, North Carolina; and Bordentown Regional High School in Bordentown, New Jersey.

2. DEVELOPING THE *ATMOSPHERIC AEROSOLS – COLLECTING AND CORRELATING DATA* PROJECT FOR THE PARTICIPATION OF STUDENTS

The main requirement for a successful student-teacher-scientist partnership is that all involved benefit from the partnership. This means that the scientist needs to be able to see the advantage of having students work on his/her project, and that students and teachers need to see that their efforts will contribute to the project. Teachers also need to understand how participation in the project will help their students develop skills in inquiry as well as content knowledge in the geosciences. Often scientists find that working with younger students and teachers is difficult and time consuming and does not yield sufficient results. Consequently, it is often challenging to get scientists to partner with students and teachers.

In developing projects for the ESSN, we have addressed the concerns of the scientists by reviewing potential projects thoroughly, and by working with the scientists to address the issues necessary to ensure that their student-teacher-scientist partnership is successful. We have identified nine major issues that need to be addressed in developing successful student-teacher-scientist partnerships, and use the ESSN web site to provide corresponding support. Each issue and the way it is addressed for the *Atmospheric Aerosols* project, is discussed below.

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2.1. What is the Scientific Research Question?

Scientific research typically involves a large set of interrelated threads, with a combination of broad questions and very specific activities. Teachers and students cannot be expected to have a comprehensive overview of a research field. However, the specific activities often involve smaller, more approachable pieces. One challenge is to identify those pieces within a larger project that would benefit from the efforts of an extended research team. At the same time, these activities must offer interesting and attainable scientific inquiry experiences that will increase students' inquiry skills and content knowledge in the field.

Dr. David Brooks, the lead scientist on the *Atmospheric Aerosols* project, has been conducting research to learn more about how the concentration of atmospheric aerosols varies in time and space, and how those variations are related to other changes on the Earth. This research addresses global long-term issues, but building a global understanding of aerosols relies heavily on a high density of local data. Therefore, teachers and students can be active research partners by investigating aerosol concentrations in their own geographical area. Locally, aerosol concentrations are closely related to weather patterns and air quality, thereby, increasing the interest and relevance of the project for both students and teachers. We have identified two research questions that are understandable to students, and that can be addressed within the school year. These questions are: 1. How do atmospheric aerosols relate to the published Air Quality Index? 2. How do atmospheric aerosols relate to relative humidity? These questions relate aerosols – probably an unfamiliar concept – to more familiar quantities (See Figure 2).

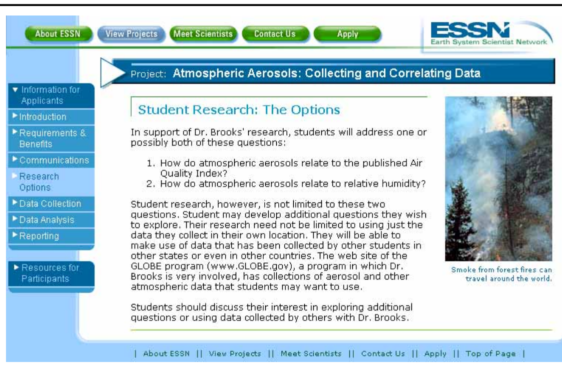

Figure 2 *Atmospheric Aerosols* project: Research Options

2.2 What Data Will the Students Work With?

Once research questions are identified, the scientist and the development team need to identify the data that the students will need, determine in what format it will be, and how students will acquire the data.

In the Atmospheric Aerosol project the students will deal with a combination of data provided by the scientist and their own measurements. This data can be in various forms and obtained in various ways. Most of the data will be collected by the students themselves. However, similar environmental data will be obtained by students in other schools, or by scientists, or by automated instrument networks. Once identified, the data obtained elsewhere will be made accessible to students in a usable format on the ESSN Web site or on CD if necessary.

2.3 Are There Requirements for Participating Schools?

Some research projects require that students be in specific locations, in specific types of environments, or be able to take measurement at specific times. This would limit the schools that can participate. These issues need to be identified early in the development of the research project. In the case of Dr. Brooks' *Atmospheric Aerosols* project, aerosol measurements are desired over as large an area as possible, so the location of the students is not a limitation. However, Dr. Brooks also hopes that students will take aerosol and related measurements every day (weather permitting), even during holidays and vacation periods. Part of facilitating this research project will be working with participating teachers to involve parents and possibly community members to fill in the data gathering gaps when school is not in session (see Figure 3).

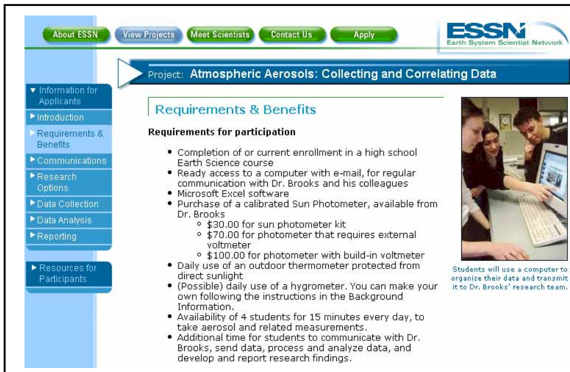

Figure 3 *Atmospheric Aerosols* project: Requirements

2.4 What Research Tools are Needed and What Protocols Will Students and Teachers Follow?

Once the research questions and data have been identified, the tools that the students need to analyze the data, and steps they need to follow in the research, need to be identified. The tools and protocols will vary depending on the research questions and the data being analyzed. For the *Atmospheric Aerosols* project, tools include the GLOBE visualization tools, and spreadsheet software, which can help students manipulate the data mathematically and view it graphically in many ways. Once appropriate tools are available, protocols need to be developed to ensure that students and teachers perform the analysis correctly and the scientists' needs are met (see Figure 4).

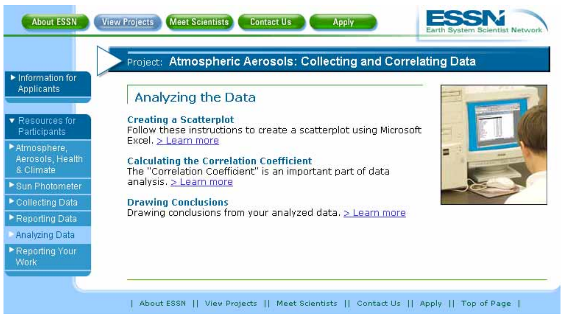

Figure 4. *Atmospheric Aerosols* project: Analyzing Data

2.5 What are the Logistical Issues That Need to be Addressed?

The logistical issues that must be addressed can vary greatly from project to project. A typical issue involves ensuring that students have access to the necessary computers, software and instruments. For most projects, students will need Internet access. Some may require high-speed access if large images need to be transferred, but a dial-up phone line will be sufficient for the *Atmospheric Aerosols* project.

Students and teachers may also need appropriate instruments and be able to take measurements on a continuing basis. This is true of Dr. Brooks' project, where students are requested to take atmospheric optical thickness measurements using a hand held sun photometer (see Figure 5) every day (weather permitting). Part of the development process is to ensure that the instruments and tools needed to participate in the research project are affordable and available to the students and teachers.


Figure 5 Student taking measurements with sun phototmeter

2.6 What Background Information Do Students and Teachers Need?

The scientists and the development team need to work together to determine the background information that students will require in order to understand the scientific importance of the research question, the physical processes being studied, and how they will approach answering the research question. When applicable, students should also understand how the research relates to their own lives. Some of this information will be included within the project web site, or will be available via links from the site. Other background information may be in reference material that students can find in a library. This will give the students and teachers a broader understanding of the project they are working on, and will make it possible for students to formulate and answer their own questions.

In the *Atmospheric Aerosols* project, the web site includes background material on what atmospheric aerosols are and why they are important, and what the aerosol optical thickness, and air quality index are (see Figure 6). Students and teachers understanding of these concepts are crucial for their meaningful participation in the project. As the project evolves additional materials might be identified. These will be added to the web site for the students and teachers to access.

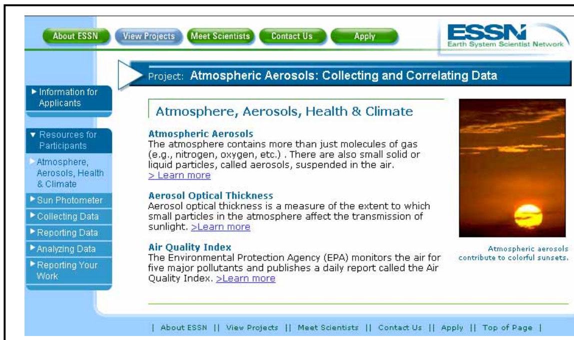

Figure 6 *Atmospheric Aerosols* project: Participant Resources

2.7 What Training is Needed for Teachers and Students?

Again, each project is unique and therefore each demands different training scenarios. The *Atmospheric Aerosols* project requires that the students be able to take accurate measurements with a hand held sun photometer and record the time of the measure to the nearest 15 seconds. In order to facilitate this, Dr.Brooks or a colleague who is also working on the project will try to visit each classroom at the start of the project to discuss with teachers any issues related to collecting or acquiring the data, analyzing the data, and reporting their findings. The scientist then needs to maintain close contact with the teacher and students via e-mail or telephone during the start-up phase of the work to ensure that they are taking the data correctly and that they understand how to do the analysis. Members of the ESSN team are also available to support teachers and students during this time. This training period can last as long as the scientist and teacher feel that the students need the support.

In Dr. Brooks' project students will learn how to use the sun photometer, and will take several sets of trial measurements. Dr. Brooks will evaluate these measurements prior to the time they start collecting data that will be used for their research project.

2.8 What Additional Research Questions Can Students Develop?

One of the goals of the ESSN project is to inspire the students to ask, and try to answer, their own questions based on the data they are using and/or collecting. This may not always occur without some impetus. In order to help spark students' interest, the ESSN project team needs to identify some specific research questions and encourage the students to identify additional ones that may capture their interest. The project team and the scientist need to work closely with the students and teachers to ensure they do not launch research projects that may be beyond their reach.

These research questions can use the same data and tools as the research project. However, as students begin to ask their own questions, they may also consult with the scientist about additional data or information they may need to help them answer their own questions. Students' efforts on these questions could result in a research paper or a science fair project.

2.9 What are the Opportunities for Recognizing the Students and Teachers Contributions?

Scientists receive recognition for their work through the publication of scientific research papers and the presentation of their results at scientific meetings. Students and teachers will also receive recognition through these methods if possible. However, each project should identify other types of recognition that may be more meaningful, which the scientists can give to acknowledge students' and teachers' among their peers, in their school, and in their community.

3. IMPLEMENTATION

For the *Atmospheric Aerosols* project, Dr. Brooks is looking for teachers and schools who can commit themselves to collecting the data for at least several months. Ideally, students will take the measurements during overflights of satellites carrying the MODIS instrument – TERRA and AQUA – and other satellites to be determined. This will help Dr. Brooks interpret the satellite measurements because he will have simultaneous measurements and metadata (descriptive information about conditions) from the ground that will help him determine what the satellite measurements mean at that time and place. Students should report data <u>every</u> day, with just metadata being reported for days when sun photometer measurements cannot be taken because of overcast conditions. This will provide the best dataset for quality control of satellite-based measurements.

The *Atmospheric Aerosols* project will be implemented in three schools during the 2002-2003 school year. These implementations will occur in different ways depending on the needs of the teacher and students and the structure of the existing curriculum.

At East Lincoln High School in Denver, North Carolina the project will begin with five students taking the data and learning the protocols. One class, which meets at the time that the TERRA satellite is overhead, will be responsible for the project. During their work on this project the students will study the relationship between the aerosol optical thickness and the relative humidity at their school.

The two other schools are located in New Jersey, about 70 km apart. The MODIS aerosol optical thickness algorithms process data on a grid about 50km x 50 km. Hence the two schools are in adjacent processing grids. If the schools take measurements simultaneously during the same overflight, it will be possible to compare the results with the MODIS values generated in these two grids. This will provide another important and very interesting comparison of ground- and space-based measurements. Again, complete reporting of both sun photometer measurements (weather permitting) and metadata are required in order to extract useful information from simultaneous measurements

In Bordentown Regional High School in Bordentown, New Jersey, the project will be run in two classes of about eighteen students each, one meeting at the time of the morning passage of the satellite, and one meeting at the time of the afternoon passage of the satellite. This set of two classes will take the measurements until February when two other classes will take over.

Chatham High School, in Chatham, New Jersey has an ongoing research curriculum for students entering the 9^{th} grade (Holzer, M., 2002). Students begin the year with an in-depth analysis of the inquiry process, in which they take observations and interpret those observations. They move onto an extended class investigation in which they take environmental data in their community and analyze the results. The last half of the year the students select research topics to conduct a long-term investigation. It is during this portion of their program that they will participate in the *Atmospheric Aerosol* project.

4. SUMMARY

Through the Earth System Scientist Network project we are working with scientists to facilitate the meaningful participation of students in their research projects. In order for these partnerships to be successful, the development of each research project requires the scientist and development team to address a series of issues. These include identifying the scientific research questions, the data that the students will analyze, the requirements for participating schools, the tools and protocols that the students and teachers will use during their research, logistical issues such as assuring that all the instruments and tools are available to the teachers and students, the background information and training they will need, additional research questions that can help spark the interest of students and encourage them to ask their own questions, and meaningful recognition of students and teachers for their contributions to the research projects.

In the *Atmospheric Aerosols* project, Dr. Brooks can take advantage of having an extended research team to conduct his research, and the students and teachers can contribute to a research project while developing skills in inquiry and expanding content knowledge in Earth system science.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

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