"Overview Showing How Student Science Research Projects Provide Support for Meeting PA State Science Standards and Assessment Anchors"

Richard Close
Director of Outreach
Delaware Valley Science Fairs

There has been much discussion and debate regarding the value of students doing student science research projects. In doing science research projects students follow what is known as the "Inquiry Cycle" (similar to but significantly different from the old "scientific method"). The Inquiry Cycle has 8 parts:

1) the student identified question to be solved,
2) background research,
3) experimental design(procedure) to follow,
4) data taking through completion of the procedure,
5) analysis of data,
6) conclusions based on empirical evidence from the experiment,
7) dissemination of the findings to peer group/ professional scientists and
8) new question(s) raised from dissemination.

This sets the stage for another research question as new questions are raised from others and the process repeats itself.

From this it can be seen that logical problem solving is practiced by the student if they follow these steps. But how does this help the students meet the Pennsylvania Science and Technology Standards? How are they prepared for the PSSA Assessments that will be starting in Spring, 2007? To see, let's look at the State Science Standards and the newly released "Assessment Anchors" and "Eligible Content" that will drive the PSSA Science Assessment. There are 8 major areas that the standards are divided into. These standards comprise what the students of Pennsylvania are expected to know and be able to do in the areas of Science, Technology and Environmental Education.(These are found at the PDE website.)
The areas identified are:

1) Unifying Themes of Science
2) Inquiry and Design
3) Biological Sciences
4) Physical Science, Chemistry and Physics
5) Earth Sciences
6) Technological Education
7) Technological Devices
8) Science, Technology and Human Endeavor

Standards 1, 2, 6, 7 and 8 bring in new areas of thinking for the students. They will be highlighted to demonstrate that by **having students doing student science research, they will have opportunities to learn, practice and "hone" their skills and knowledge in these areas.**

Standards 3, 4 and 5 -- Biological Sciences, Physical Science, Chemistry and Physics, and Earth Sciences are the content-driven standards. These areas key on facts and concepts of science disciplines. Portions of the content of the various science disciplines, as identified in standards 3, 4 and 5, would be addressed in science research project as the students 1) do the background research for the problem or area under consideration and 2) perform the experimentation—"doing the science" that reveals the content identified in the content standards. A student researcher must know and understand the underlying, foundational concepts—the knowledge--- identified in these standards so that they can understand and extend the learning from the research project. As can be seen standards 3, 4 and 5 are compatible with rather than in opposition to the inquiry and process standards 1, 2 6, 7 and 8.("**Knowledge** -- facts, principles, theories and laws verifiable through scientific inquiry by the world community of scientists; includes physics, chemistry, earth science and biological sciences.")[1]

In **Standard 1---Unifying Themes of Science**--- students are challenged to be able **to identify the concepts of systems, model design, patterns, scale and change** in the natural world. This is a key area that student researchers develop as they complete their experimental design(through systems and "scale usage") and make their observations through quantitative data measurement. Then by analysis and interpretation the researcher develops their skills in seeing patterns, change and model design to answer their initial research question. **The research project gives the students a real life opportunity to see how these unifying themes in science can be observed through their own experimentation and inquiry.**

In **standard 2**, **Inquiry and Design**, students are challenged to "develop appropriate scientific experiments: raising questions, formulating hypotheses, testing, controlled experiments, recognizing variables, manipulating variables, interpreting data, and producing solutions."[1]

In addition they are to "apply the elements of scientific inquiry to solve problems by:

- Generating questions about objects, organisms and/or events that can be answered through scientific investigations.
- Evaluating the appropriateness of questions.
- Designing an investigation with adequate control and limited variables to investigate a question.
- Conducting a multiple step experiment.
- Organizing experimental information using a variety of analytic methods.
- Judging the significance of experimental information in answering the question.
- Suggesting additional steps that might be done experimentally."[1]

Where will students have the opportunity to have these rich, scientific experiences on an ongoing basis--not a once a week, "guided inquiry", cookbook lab that most science texts provide**? Students and teachers will find that through the completion of a long-term student science research project they will be continually experiencing these scientific process skills while still dealing with the content and knowledge demanded by the state and national science standards.**

[1] **Academic Standards for Science and Technology,** Pennsylvania Department of Education, 2002.

Standard 6 and 7 deals with **Technology Education** and **Technological Devices**. Depending on the project selected the student will have a greater or lesser amount of learning about technology, technological tools and technological problem solving. However, since almost all projects use computers and measurement devices, there is a portion of the standards that science research projects work with. Such standard indicators as "select and safely apply appropriate tools, materials and processes necessary to solve complex problems" and "apply advanced tool and equipment manipulation techniques to solve problems"[1] point to the student use and understanding of measurement and to the use of technology to solve problems, which is done during student science research projects. In addition, the standards statement "apply basic computer operations and concepts" challenges students to use computers in their problem solutions, **something that is done as they complete their student science research project.**

Standard 8 encompasses **Science, Technology and Human Endeavors**. This area requires the student to be able to analyze and apply solutions of science to real world conditions. Standard statements such as:

1) Analyze the relationship between societal demands and scientific and technological enterprises,

2)Analyze how human ingenuity and technological resources satisfy specific human needs and improve the quality of life and

3) Evaluate possibilities consequences and impacts of scientific and technological solutions require students to be able to apply their science learning to real world situations and conditions. This aspect too is part of student-driven science research. The student scientist is required to apply their investigation and project to a real world application. For many students, this is a first time experience of taking something they have "discovered" and think through how to apply this learning to a practical situation or condition. Rarely will students be asked to apply learning like this. Often textbook learning requests an application but seldom do teachers have students think about how their investigative discovery could apply to a real life situation. **Once again, the student science research project provides the means for standards-driven learning.**

The new PA Science Assessment Anchors provide teachers and students "eligible content" that the PSSA Science Assessment could incorporate in the assessment, starting in 2007. A few of the following are areas of "eligible content" that are strongly dealt with through the performance of student science research projects:

- Evaluate the appropriateness of research questions (e.g., testable vs. not-testable).
- Explain how specific scientific knowledge or technological design concepts solve practical problems
- Analyze or compare the use of both direct and indirect observation as means to study the world
- Use appropriate quantitative data to describe or interpret change in systems
- Critique the elements of an experimental design (e.g., raising questions, formulating hypotheses, developing procedures, identifying variables, manipulating variables, interpreting data, and drawing conclusions) applicable to a specific experimental design.

[1] **Academic Standards for Science and Technology,** Pennsylvania Department of Education, 2002.

- Critique the elements of the design process (e.g. identify the problem, understand criteria, create solutions, select solution, test/evaluate and communicate results) applicable to a specific technological design.
- Use data to make inferences and predictions, or to draw conclusions, demonstrating understanding of experimental limits.
- Critique the results and conclusions of scientific inquiry for consistency and logic.
- Communicate results of investigations using multiple representations.
- Evaluate appropriate methods, instruments, and scale for precise quantitative and qualitative observations
- Analyze and predict the effect of making a change in one part of a system on the system as a whole.
- Use appropriate quantitative data to describe or interpret a system
- Compare the accuracy of predictions represented in a model to actual observations and behavior.
- Describe or interpret recurring patterns
- Analyze stationary patterns and physical patterns of motion to make predictions or draw conclusion

(taken from **Assessment Anchors for Science and Technology,** Pennsylvania Department of Education, 2004.)

These along with any of the content pieces that the student science research project deals with demonstrates once again the great value of having students meet the standards as well as preparing for the state science assessment **by using the science research project platform.**

In Closing

Knowledge of what science is incorporates carefully developed and integrated components:

- **Nature of Science**
- **Unifying themes of science**
- **Inquiry**
- **Process skills**
- **Problem solving**
- **Scientific thinking**

As you can see from the above summarization from the Pennsylvania Science & Technology Standards, students must learn science by doing. Inquiry is the key component for understanding science. How do students experience this? **By doing science as real scientists!** Where do they get the experiences like this? **By doing science research!** What platform allows this to happen on an ongoing, long-term basis?

Student science research projects!