Full text of O L O W Science As Inquiry conference

Reception | Meeting Room | Resources | Oceanside

|Unifying Concepts and Processes | Science As Inquiry NEW | Physical Science NEW | Life Science NEW |
| Earth & Space | Science & Technology | Personal & Social Perspectives NEW | History & Nature of Science NEW | Other topics |

Science as Inquiry

Please add ocean content under the appropriate standard

http://books.nap.edu/html/nses/

Developing Students Abilities and Understanding

Item 1 **Peter Tuddenham** *Oct 22, 2004 20:12*

Developing Student Abilities and Understanding

K-4

http://books.nap.edu/html/nses/6c.html#si

From the earliest grades, students should experience science in a form that engages them in the active construction of ideas and explanations that enhance their opportunities to develop the abilities of doing science. Teaching science as inquiry provides teachers with the opportunity to develop student abilities and to enrich student understanding of science. Students should do science in ways that are within their developmental capabilities. This standard sets forth some abilities of scientific inquiry appropriate for students in grades K-4.

In the early years of school, students can investigate earth materials, organisms, and properties of common objects. Although children develop concepts and vocabulary from such experiences, they also should develop inquiry skills. As students focus on the processes of doing investigations, they develop the ability to ask scientific questions, investigate aspects of the world around them, and use their observations to construct reasonable explanations for the questions posed. Guided by teachers, students continually develop their science knowledge. Students should also learn through the inquiry process how to communicate about their own and their peers' investigations and explanations.

There is logic behind the abilities outlined in the inquiry standard, but a step-by-step sequence or scientific method is not implied. In practice, student questions might arise from previous investigations, planned classroom activities, or questions students ask each other. For instance, if children ask each other how animals are similar and different, an investigation might arise into characteristics of organisms they can observe.

Full inquiry involves asking a simple question, completing an investigation, answering the question, and presenting the results to others. In elementary grades, students begin to develop the physical and intellectual abilities of scientific inquiry. They can design investigations to try things to see what happens--they tend to focus on concrete results of tests and will entertain the idea of a "fair" test (a test in which only one variable at a time is changed). However, children in K-4 have difficulty with experimentation as a process of testing ideas and the logic of using evidence to formulate explanations

5-8

http://books.nap.edu/html/nses/6d.html#si

Students in grades 5-8 should be provided opportunities to engage in full and in partial inquiries. In a full inquiry students begin with a question, design an investigation, gather evidence, formulate an answer to the original question, and communicate the investigative process and results. In partial inquiries, they develop abilities and understanding of selected aspects of the inquiry process. Students might, for instance, describe how they would design an investigation, develop explanations based on scientific information and evidence provided through a classroom activity, or recognize and analyze several alternative explanations for a natural phenomenon presented in a teacher-led demonstration.

Students in grades 5-8 can begin to recognize the relationship between explanation and evidence. They can understand that background knowledge and theories guide the design of investigations, the types of observations made, and the interpretations of data. In turn, the experiments and investigations students conduct become experiences that shape and modify their background knowledge.

With an appropriate curriculum and adequate instruction, middle-school students can develop the skills of investigation and the understanding that scientific inquiry is guided by knowledge, observations, ideas, and questions. Middle-school students might have trouble identifying variables and controlling more than one variable in an experiment. Students also might have difficulties understanding the influence of different variables in an experiment--for example, variables that have no effect, marginal effect, or opposite effects on an outcome.

Teachers of science for middle-school students should note that students tend to center on evidence that confirms their current beliefs and concepts (i.e., personal explanations), and ignore or fail to perceive evidence that does not agree with their current concepts. It is important for teachers of science to challenge current beliefs and concepts and provide scientific explanations as alternatives.

Several factors of this standard should be highlighted. The instructional activities of a scientific inquiry should engage students in identifying and shaping an understanding of the question under inquiry. Students should know what the question is asking, what background knowledge is being used to frame the question, and what they will have to do to answer the question. The students' questions should be relevant and meaningful for them. To help focus investigations, students should frame questions, such as "What do we want to find out about . . .?", "How can we make the most accurate observations?", "Is this the best way to answer our questions?" and "If we do this, then what do we expect will happen?"

Students in grades 5-8 can begin to recognize the relationship between explanation and evidence.

The instructional activities of a scientific inquiry should involve students in establishing and refining the methods, materials, and data they will collect. As students conduct investigations and make observations, they should consider questions such as "What data will answer the question?" and "What are the best observations or measurements to make?" Students should be encouraged to repeat data-collection procedures and to share data among groups.

In middle schools, students produce oral or written reports that present the results of their inquiries. Such reports and discussions should be a frequent occurrence in science programs. Students' discussions should center on questions, such as "How should we organize the data to present the clearest answer to our question?" or "How should we organize the evidence to present the strongest explanation?" Out of the discussions about the range of ideas, the background knowledge claims, and the data, the opportunity arises for learners to shape their experiences about the practice of science and the rules of scientific thinking and knowing.

The language and practices evident in the classroom are an important element of doing inquiries. Students need opportunities to present their abilities and understanding and to use the knowledge and language of science to communicate scientific explanations and ideas. Writing, labeling drawings, completing concept maps, developing spreadsheets, and designing computer graphics should be a part of the science education. These should be presented in a way that allows students to receive constructive feedback on the quality of thought and expression and the accuracy of scientific explanations.

This standard should not be interpreted as advocating a "scientific method." The conceptual and procedural abilities suggest a logical progression, but they do not imply a rigid approach to scientific inquiry. On the contrary, they imply codevelopment of the skills of students in acquiring science knowledge, in using high-level reasoning, in applying their existing understanding of scientific ideas, and in communicating scientific information. This standard cannot be met by having the students memorize the abilities and understandings. It can be met only when students frequently engage in active inquiries.

9-12

http://books.nap.edu/html/nses/6e.html#si

For students to develop the abilities that characterize science as inquiry, they must actively participate in scientific investigations, and they must actually use the cognitive and manipulative skills associated with the formulation of scientific explanations. This standard describes the fundamental abilities and understandings of inquiry, as well as a larger framework for conducting scientific investigations of natural phenomena.

In grades 9-12, students should develop sophistication in their abilities and understanding of scientific inquiry. Students can understand that experiments are guided by concepts and are performed to test ideas. Some students still have trouble with variables and controlled experiments. Further, students often have trouble dealing with data that seem anomalous and in proposing explanations based on evidence and logic rather than on their prior beliefs about the natural world.

One challenge to teachers of science and to curriculum developers is making science investigations meaningful. Investigations should derive from questions and issues that have meaning for students. Scientific topics that have been highlighted by current events provide one source, whereas actual science- and technology-related problems provide another source of meaningful investigations. Finally, teachers of science should remember that some experiences begin with little meaning for students but develop meaning through active involvement, continued exposure, and growing skill and understanding.

A critical component of successful scientific inquiry in grades 9-12 includes having students reflect on the concepts that guide the inquiry. Also important is the prior establishment of an adequate knowledge base to support the investigation and help develop scientific explanations. The concepts of the world that students bring to school will shape the way they engage in science investigations, and serve as filters for their explanations of scientific phenomena. Left unexamined, the limited nature of students' beliefs will interfere with their ability to develop a deep understanding of science. Thus, in a full inquiry, instructional strategies such as small-group discussions, labeled drawings, writings, and concept mapping should be used by the teacher of science to gain information about students' current explanations. Those student explanations then become a baseline for instruction as teachers help students construct explanations aligned with scientific knowledge; teachers also help students evaluate their own explanations and those made by scientists.

Students also need to learn how to analyze evidence and data. The evidence they analyze may be from their investigations, other students' investigations, or databases. Data manipulation and analysis strategies need to be modeled by teachers of science and practiced by students. Determining the range of the data, the mean and mode values of the data, plotting the data, developing mathematical functions from the data, and looking for anomalous data are all examples of analyses students can perform. Teachers of science can ask questions, such as "What explanation did you expect to develop from the data?" "Were there any surprises in the data?" "How confident do you feel about the accuracy of the data?" Students should answer questions such as these during full and partial inquiries.

Public discussions of the explanations proposed by students is a form of peer review of investigations, and peer review is an important aspect of science. Talking with peers about science experiences helps students develop meaning and understanding. Their conversations clarify the concepts and processes of science, helping students make sense of the content of science. Teachers of science should engage students in conversations that focus on questions, such as "How do we know?" "How certain are you of those results?" "Is there a better way to do the investigation?" "If you had to explain this to someone who knew nothing about the project, how would you do it?" "Is there an alternative scientific explanation for the one we proposed?" "Should we do the investigation over?" "Do we need more evidence?" "What are our sources of experimental error?" "How do you account for an explanation that is different from ours?"

Questions like these make it possible for students to analyze data, develop a richer knowledge base, reason using science concepts, make connections between evidence and explanations, and recognize alternative explanations. Ideas should be examined and discussed in class so that other students can benefit from the feedback. Teachers of science can use the ideas of students in their class, ideas from other classes, and ideas from texts, databases, or other sources--but scientific ideas and methods should be discussed in the fashion just described.

Response 1:1 **Margaret Tower** *Oct 30, 2004 22:07*

Science can be FUN! A learner can get so involved in investigating a question in one's mind that lunch is forgotten! What do you mean scientists learn a lot from failure? Asking lots of questions is really OK? Hooray! I WOULD LIKE TO BE A SCIENTIST"

9-12 Abilities necessary to do scientific inquiry

Item 2 **Peter Tuddenham** *Oct 22, 2004 20:17*

9-12 Abilities necessary to do scientific inquiry

Response 2:1 **Margaret Tower** *Oct 30, 2004 22:12*

CURIOSITY! I am always asking WHY? So what if I fail! If it is fun, I'll try it. There must be another way to solve my question.

5-9 Abilities necessary to do scientific inquiry

Item 3 **Peter Tuddenham** *Oct 22, 2004 20:17*

5-9 Abilities necessary to do scientific inquiry

Response 3:1 **Susan Snyder** *Oct 27, 2004 21:08*

Content topic: As new information is collected, using observations, inferences, and experimentation, knowledge about the ocean increases. Although people have learned a lot about the ocean, only about 1% of the ocean has been explored; there is a lot left to be discovered.

Response 3:2 **Margaret Tower** *Oct 30, 2004 22:24*

Why, why, why is that happening? What is that thing? You mean you don't know all the answers? I can experiment with my hunches? What is already known about that question? Is it right? Would I get the same result? Where do I go from here?

K-4 Abilities necessary to do scientific inquiry

Item 4 **Peter Tuddenham** *Oct 22, 2004 20:17*

K-4 Abilities necessary to do scientific inquiry

Response 4:1 **Margaret Tower** *Oct 30, 2004 22:27*

I want to do fun things! What is that? You mean you do not know? How can I find out? Does anyone else know the answer? I'll find out!

9-12 Understandings about scientific inquiry

Item 5 **Peter Tuddenham** *Oct 22, 2004 20:18*

9-12 Understandings about scientific inquiry

Response 5:1 **Margaret Tower** *Oct 30, 2004 22:18*

Is there a question on my mind? What does the literature say? Can someone else get the same results with my procedure? Do I have a control? Were my predictions correct? What did I learn from this experience? What other questions do I need to answer?

5-8 Understandings about scientific inquiry

Item 6 **Peter Tuddenham** *Oct 22, 2004 20:18*

5-8 Understandings about scientific inquiry

Response 6:1 **Margaret Tower** *Oct 30, 2004 22:32*

I want to be a scientist! I want to experiment! What is going on? Why is that happening? Does anyone know? I have a hunch. I'll try it out. How will I know what really caused that reaction? I better have a sample on the side that I do not do anything to. It's FUN!

K-4 Understandings about scientific inquiry

Item 7 **Peter Tuddenham** *Oct 22, 2004 20:18*

K-4 Understandings about scientific inquiry

Response 7:1 **Bob Stewart** *Oct 30, 2004 14:26*

How do we know about the ocean?

How did we collect evidence, did we really use hypotheses to learn key concepts (Deep sea vents, theory of currents, etc were discovered without hypothesis), so discovery in the ocean is different than discovery in chemistry.

How can we test ideas if we cannot do experiments on the ocean? Oceanography and earth science differ from sciences such as chemistry where we can do experiments.

K-12 Other topics

Item 8 **Peter Tuddenham** *Oct 22, 2004 20:19*

K-12 Other topics

Response 8:1 **Margaret Tower** *Oct 30, 2004 22:37*

In the interests of Homeland Security, we must grow our own scientists! Currently, onlyl 8% of our college students are majoring in science. It is very difficult for foreign born to enter this country now. Our country will not be able to keep its high position in science in the world, if the pre-kindergarden through high school learners are not turned on to the FUN OF SCIENCE!
