Enhancing scientists' skills for providing standards-based K-8 teacher professional development

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RATIONALE

Current national science teaching standards require teachers to incorporate the discourse and practices of science and engineering into their classroom teaching of core content. These expectations present challenges for teacher professional development providers working with elementary teachers and middle school teachers who were prepared as generalists with only limited coursework or experience with science research.

At the Center for Science and the Schools (CSATS) at Penn State, we have been addressing these challenges through a collaboratively developed teacher professional development program for K-8 teachers called Saturday Science Workshops, a series of 5-7 one-day workshops offered over the course of each academic year.

CHANGING UNDERSTANDING

One goal of this teacher-scientist partnership is to move both teachers and scientists away from a transmission approach to teaching, to reform-oriented practices such as inquiry-based teaching.

Traditional Researcher Workshop	CSATS Supported Researcher Workshop
• Lecture based • Demonstrations • Few hands-on activities if time • Little, if any, reflection time	• Small group learning • Learner centered • Mini lectures to introduce or reinforce concepts • Inquiry-based to replicate the practices of science • Embedded reflection time

CSATS Saturday Science Workshop Agenda Climate Change: What are we learning? Dr. Sukyoung and Cory Baggett	
10:00 am	Welcome, complete paperwork including Act 48 forms and pre-test, breakfast, and introductions.
Overarching Question: As scientists and science educators, how do we learn about our environment and attempt to objectively find answers to the questions that arise?	
10:15 am	**Weather vs. Climate Part I** Guiding Question: What is the difference between weather and climate? • Weather vs Climate Flash Card activity
10:45 am	**Weather vs. Climate Part II** Earth's Systems: Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season. Crosscutting Concepts: Analyze data and progresses to introducing quantitative approaches to collecting data and conducting multiple trails of qualitative observations. • What is the value in constructing a 30 year climatology and what does it tell us?
	Floating Break
12:00 pm	**Weather Stations** Provide opportunities for students to collect, represent, and analyze data. • Setting up and using the weather station.
12:30 pm	Lunch
1:00 pm	**Earth's Complex System** Guiding Question: How do the various components of the Earth's climate system interact? • Activity: Create concept map of "Earth's System" or "How does climate work?"
2:00 pm	**Oceanic Cycles: El Niño & La Niña** Guiding Question: What role do oceanic cycles and natural variability have in Earth's climate in the context of long term trends? • Looking a global temperature patterns, observe the ocean cycles and compare them to global temperature scales and make
3:00 pm	Cory's research and available data sites for teachers to use Applications • Modifications in the classroom
3:20 pm	Wrap-up: Post-test, complete evaluations

TESTIMONIALS

"Thank you SO much for all the information and materials. I must say, I have already started to do lessons with my classes and they are so engaged, interested, and learning so much! They think it is the coolest thing, and actually were surprised they could do experimental science! Again, thank you very much for the materials - I will try to send some photos of the mini "Wind-Fair" student poster presentation session I am planning to create, once the students collect, organize, and analyze their data. I really hope I can make this either a departmental or school-wide event. Again, I cannot thank you enough.

- Ryan B., Hazleton Area High School

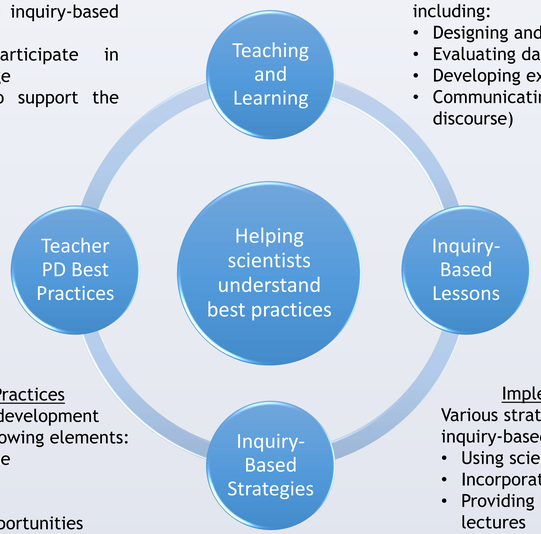
"CSATS offers the best combination of content and pedagogy I've experienced in any science training for teachers. I learn so much and come back to school so jazzed about bringing the new material into the classroom. Thanks!

- Deb H., Lansdowne

"I just wanted to say thank you for another enjoyable learning class. You do a remarkable job putting them together. The instructors have all been fun and extremely knowledgeable about the class topics and made even an art teacher feel good about being there.

- Luke L.

HELPING SCIENTISTS UNDERSTAND BEST PRACTICES IN TEACHER PROFESSIONAL DEVELOPMENT



Teaching and Learning

Teaching and learning theory discussions help researchers understand the importance of:

- Teaching science as practices through inquiry-based activities vs content lectures
- Allowing learners to actively participate in construction of their scientific knowledge
- Providing group learning activities to support the socio-cultural nature of learning

Designing Inquiry-Based Lessons

Together, CSATS and scientists create workshop activities that parallel the scientific practices used by researchers including:

- Designing and implementing investigations
- Evaluating data and looking for patterns
- Developing explanations and solutions
- Communicating and justifying solutions (scientific discourse)

Incorporating Teacher PD Best Practices

Designing effective teacher professional development workshops requires incorporating the following elements:

- Designing a coherent workshop storyline
- Providing active learning opportunities
  - working in teams
  - collaborative problem solving opportunities
- Providing opportunities for learning science content
- Developing a community of learners with multiple workshop offerings
- Providing sufficient reflection time

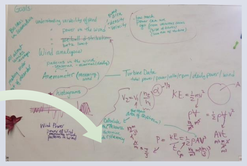
Implementing Inquiry-Based Strategies

Various strategies can be utilized in the design of inquiry-based lessons. They include:

- Using science notebooking
- Incorporating claims, evidence, and reasoning
- Providing background information via mini-lectures
- Collecting, analyzing and presenting data

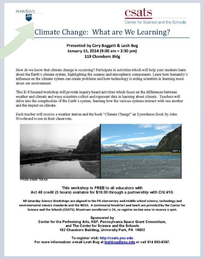
OUR COLLABORATIVE WORKSHOP DESIGN PROCESS WITH SCIENTISTS

Meet with Scientist
- Learn specifics of the scientist's research and how their discipline/field conducts research
- Share NRC Framework and discuss standards
- Set learning goals

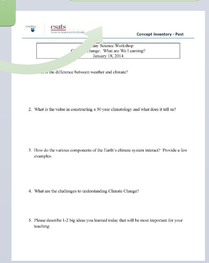


Create Workshop Outline
- Create workshop title and description
- Determine specific NGSS and state standards relevant to workshop
- Develop cohesive storyline

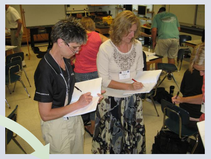
Content meeting with Scientist
- Brainstorm ways for developing inquiry-based activities that accomplish learning goals
- Integrate the scientist's own practices in designing workshop activities



Final Meeting with Scientist
- Discuss and finalize workshop plan
- Finalize pre and post concept inventory
- Order supplies



Teacher PD Workshop
- Co-teaching the workshop, the scientist provides content expertise and CSATS science educator provides pedagogical expertise
- CSATS facilitates workshop logistics



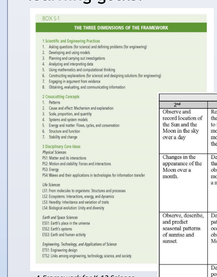
Final Documentation
- Compile evaluations and pre/post concept inventories and share with scientist
- Evaluate achievement of learning goals

Communication

Integrating Next Generation Science Standards

The Framework for K-12 Science Education (NRC, 2012) advocates teaching that actively engages students in science and engineering practices and applies crosscutting concepts to deepen understanding of disciplinary core ideas. As providers of teacher professional development, we include inquiry-based learning activities throughout the workshop enabling teachers to experience how incorporation of those practices and crosscutting concepts can lead to depth of content knowledge.

Utilizing the NRC Framework in conversations with scientists helps familiarize them with reform oriented science education goals. Relevant Next Generation Science Standards (NGSS) and state standards are identified, which inform the workshop design and learning goals.


BOX 3-1
THE THREE DIMENSIONS OF THE FRAMEWORK

1 Scientific and Engineering Practices
1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

2 Crosscutting Concepts
1. Patterns
2. Cause and effect: Mechanism and explanation
3. Scale, proportion, and quantity
4. Systems and system models
5. Energy and matter: Flows, cycles, and conservation
6. Structure and function
7. Stability and change

3 Disciplinary Core Ideas
Physical Sciences
PS1: Matter and its interactions
PS2: Motion and stability: Forces and interactions
PS3: Energy
PS4: Waves and their applications in technologies for information transfer

Life Sciences
LS1: From molecules to organisms: Structures and processes
LS2: Ecosystems: Interactions, energy, and dynamics
LS3: Heredity: Inheritance and variation of traits
LS4: Biological evolution: Unity and diversity

Earth and Space Sciences
ESS1: Earth's place in the universe
ESS2: Earth's systems
ESS3: Earth and human activity

Engineering, Technology, and Applications of Science
ETS1: Engineering design
ETS2: Links among engineering, technology, science, and society

A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. (2012). Washington, D.C.: The National Academies Press.

PA Science Standards K-8

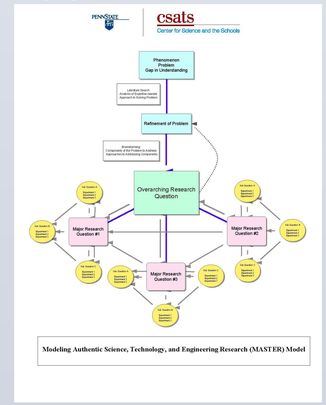
2nd	3rd	4th	5th	6th	7th	8th
Observe and record location of the Sun and the Moon in the sky over a day	Relate the rotation of the earth and day/night, to the apparent movement of the sun, moon, and stars across the sky.	Describe the earth's place in the **solar system** that includes the sun (a star), planets, and many moons.	Make predictions based on patterns in natural systems (e.g., phases of the Moon, time [day, month, and year], weather, seasons)	Use models to demonstrate that earth has different seasons.	Describe repeating patterns in the Sun-Earth-Moon **system** and the positions of stars.	Describe patterns of earth's movements (i.e., rotation and revolution) in relation to the moon and sun (i.e., phases, eclipses, and tides)
Changes in the appearance of the Moon over a month.	Describe the changes that occur in the observable shape of the moon over the course of a month.	Use models to make observations to explain how systems work (e.g., water cycle, Sun-Earth-Moon system).	Describe how models are used to better understand the relationships in natural systems (e.g., Sun-Earth-Moon-Ocean system, ecosystems, observe and draw a diagram to show the effects of flowing water in a watershed).	Use models to demonstrate that the phases of the moon are the result of its orbit around Earth.	Identify and describe instruments that are used to study the universe (e.g., telescope, probes, satellites, space observatories).	Compare and contrast characteristics of celestial bodies found in the solar system (e.g., asteroids, comets, meteors, inner and outer planets).
Observe, describe, and predict seasonal patterns of sunrise and sunset.	Describe the predictable patterns of change that occur over time in the observable shape of the Moon.	Describe Earth's relationship to the Sun and the Moon.	Describe the patterns of Earth's rotation and revolution in relation to the Sun and Moon (i.e., solar eclipse, phases of the Moon, and time).		Describe the patterns of Earth's rotation and revolution in relation to the Sun and Moon (i.e., solar eclipse, lunar eclipse, phases of the Moon, and time).	
	Describe Earth's position and relationship to the Sun and Moon	Describe motions of the Sun - Earth - Moon system.				
		Explain how the motion of the Sun - Earth - Moon system relates to time (e.g., days, months, years)				

NGSS Standards: Space Science

1: Space Systems: Patterns and Cycles	5: Space Systems: Stars and Solar System	Middle School: Space Systems
Use observations of the sun, moon, and stars to describe patterns that can be predicted. (ie. sun and moon appear to rise in one part of the sky, move across the sky, and set; and stars other than our sun are visible at night but not during the day.)	Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the sky.	Develop and use a model of the Earth-sun-moon system to describe the cyclic pattern of lunar phases, eclipses of the sun and moon, and seasons.
Make observations at different times of year to relate the amount of daylight to the time of year.		

COMMUNICATE WITH NON-TECHNICAL AUDIENCES

CSATS developed The Modeling Authentic Science, Technology, and Engineering Research (MASTER) Model, informed by their work with STEM Researchers. The MASTER model provides a scaffold for helping scientists translate the complexities of their own funded research projects to teachers, who can in turn use this scaffold to work with students to design and implement classroom research projects.



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