NEW STANDARDS CALL FOR NEW PRACTICES

CLASSROOM OBSERVATION PROTOCOL HELPS SCIENCE TEACHERS ADAPT TO NEW CONTENT

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Since 2013, a majority of states have been working to implement new standards for K-12 science education that are based on the National Research Council's framework for science education and the Next Generation Science Standards (Achieve & Lead States, 2013; NORC, 2017; National Research Council, 2012).

The new science standards emphasize deeper understanding of content in relation to practices and a three-dimensional approach to

OBSERVATION PROTOCOL CATEGORIES

Gather: Ask questions, plan and carry out investigations, use models to organize information and data, use mathematical thinking.	**Reason:** Analyze and use data, construct explanations, use models, reason about relationships, engage in argument from evidence.	**Communicate Reasoning:** Communicate information, present arguments supported by evidence, use models to communicate reasoning.	**Learning Environment:** Teacher organized, prepared materials, lesson pacing, students engaged, clear expectations, learning assessed.

Source: Moulding, 2015.

science instruction. They provide an opportunity for educators to improve teaching and learning. How can we ensure that opportunity will be realized?

Professional learning models are a key lever for changing instructional practices to be consistent with the learning expectations established by new standards (e.g. Daehler, Folsom, & Shinohara, 2011; Council of State Science Supervisors, 2017; Student Achievement Partners, 2017). But these models must be designed with intentionality and evaluated for effectiveness.

The Partnership for Effective Science Teaching and Learning (PESTL), a three-year program designed to align with the National Research Council framework, meets these needs (Moulding, 2015). A Mathematics and Science Partnership grant from the U.S. Department of Education supported development of the program along with a test of the model with Utah schools and teachers (Blank & Moulding, 2017).

One of the key challenges — and opportunities — for developing professional learning for the new context is that the standards call not only for shifts in science content, but also change in the instructional practices to be used in classrooms.

An important goal of professional learning now is increasing teacher understanding of three-dimensional science instruction — core disciplinary ideas, science and engineering practices, and crosscutting concepts (National Research Council, 2012). Each of the new science standards is written with the three dimensions.

Core disciplinary ideas focus K-12 science curriculum, instruction, and assessments on the most important aspects of science. They are grouped in four domains: life science, physical science, earth and space science, and engineering, technology and applications of science.

Science and engineering practices describe behaviors that scientists engage in as they investigate and build models and theories about the natural world and the key set of engineering practices that engineers use as they design and build models and systems.

Crosscutting concepts have application across all domains of science. As such, they are a way of linking the different domains of science.

Now the approach to professional learning for new standards must move beyond the previous understanding of two dimensions of content: topics

WHERE TO GET THE PROTOCOL

The PESTL Observation Protocol for Science is available by request. Contact Rolf K. Blank (Rolfb444@gmail.com) or Brett Moulding (mouldingb@ogdensd.org).

and cognitive complexity or cognitive demand (Porter, 2002; Resnick, Rothman, Slattery, & Vranek, 2004). With the three-dimensional science standards, schools and districts need new models for professional learning and evaluation of learning outcomes (Council of State Science Supervisors, 2017).

In their educator's guide, *A Vision and Plan for Science Teaching and Learning,* Moulding, Bybee, and Paulson (2015) emphasize the importance of science professional learning that includes modeling classroom instruction and "engaging teachers in science performances as learners of science" (p. 119).

UTAH PARTNERSHIP

The Partnership for Effective Science Teaching and Learning, a science professional learning initiative serving six school districts in Utah, addressed these needs. The initiative supported the districts in advancing standards-based instruction in elementary classrooms and enabled teachers to use their content knowledge to focus on effective instructional strategies.

The program objectives were:

- Increase teachers' pedagogical content knowledge in science specific to disciplinary core ideas, crosscutting concepts, and science and engineering practices;
- Develop teachers' use of effective instructional strategies in science;
- Develop teachers' deep understanding of science standards and the nature of science to increase their effectiveness in science teaching;
- Refine alignment of instructional resources and formative assessment tasks to the science and engineering practices, crosscutting concepts, and disciplinary core ideas;
- Increase teachers' interest in and enjoyment of science learning.

The partnership model includes a five-day summer seminar on science content, after-school instructional alignment sessions, two after-school book studies, and a science content course specific to teacher grade-level (via Saturday sessions).

The components are linked through structured science professional learning communities (PLCs) led by a trained facilitator. The program design was strongly influenced by three National Research Council science publications (2007, 2008, 2012) and early drafts of the Council of State Science Supervisors Science Professional Learning Standards (Council of State Science Supervisors, 2017).

Funding for the initiative came from a state grant under ESEA Title IIB. While the state approved a three-year design for science professional learning for grades 3-6 teachers (Moulding, 2015), funding constraints limited the program to two years.

Facilitators briefed all teachers in the target grades of participating districts on the program, and teachers volunteered to participate. During 2015-17, a total of 99 teachers from six districts engaged in 100 hours of science professional learning per year.

MEASUREMENT TOOL

From the beginning, program leaders built in ongoing evaluation to provide periodic feedback reports to administrators and teachers and track change in teaching practices and teacher knowledge over the course of the program's two years. To do this, a new measurement tool was needed.

An important development in professional learning research over the past decade has been the use of new classroom observation instruments and methods to compare changes in teacher practice before and after professional learning. But the new instruments are not specific to or differentiated by subject area or content standards. This was a significant limitation for the program, given our focus on changing specific instructional practices in classrooms.

To carry out our research objectives, we needed:

1. The data collection instrument to incorporate key elements of the content standards;
2. Measures of instructional practices that exemplify the content standards incorporated in an observation protocol instrument; and
3. A systematic, consistent classroom observation methodology to collect data on standards-based practices teachers are using.

We developed the PESTL Observation Protocol for Science to provide quantified ratings of instructional practices observed in classrooms. The protocol provides a summary rating of how well teachers are using their science knowledge and instructional skills in shaping classroom instruction to meet specific science learning expectations for their grade. It is both a research tool and a key element of the professional learning because the initial data from classroom observation of teaching practices are shared and discussed with each teacher.

We field-tested and revised the protocol through an initial application and tryout with teachers and schools. The final version includes 18 categories of science classroom practices that directly link to the National Research Council's framework for K-12 science education (National Research Council, 2012) and Utah state standards for science education.

The observation categories are

PESTL OBSERVATION PROTOCOL FOR THREE-DIMENSIONAL TEACHING AND LEARNING		
Science teaching and learning performances: Gathering indicators		
GATHERING	**1-5 scale:** 1=low 5=high	**Notes**
Instructions to raters: Award up to 2 score points to rate teacher performance; award up to 3 points for student response.		
Teacher uses phenomenon to engage students in asking questions and/or obtaining information and extends student thinking about science phenomena in ways that lead to: **Students asking questions and obtaining** data, information, and/or clarifying ideas.		
Teacher uses crosscutting concepts to frame student expectations. **Students use** crosscutting concepts to ask questions, structure response to others' questions, obtain information, and/or clarify or extend others' questions.		
Teacher creates opportunities for students to connect experiences, previous learning, and core ideas from similar phenomena to the phenomenon being investigated. **Teacher uses** accurate language to conceptualize core ideas in discussions and actively extends students' thinking of science ideas during discussion. **Students accurately obtain information and connect** core ideas and conceptual models from similar phenomena to the phenomenon being investigated and discussed.		

grouped for analysis and reporting in four scales that summarize the model for effective standards-focused science instruction: Gather, Reason, Communicate Reasoning, and Learning Environment (see box on p. 51).

In the PESTL model, trained observers with expertise and experience in science education carry out class observations and ratings based on 45-minute teaching and learning science episodes. The observers rate instructional practices for quality of implementation from 1 (low) to 5 (high).

The level of observation rating incorporates what students are doing in class, how teachers interact with students, how activities reflect state standards, and use of three-dimensional instruction. The observation protocol uses couplets of teacher and student behaviors to give a full picture of the learning and teaching occurring in the science classroom. (See table above for an example of one observational category.)

The ratings are summarized for each teacher and average ratings are computed by category and scale for each district.

CHANGE IN PESTL SCIENCE PRACTICES OBSERVATION RATINGS, YEAR 1 TO YEAR 2

Table shows average ratings (1 to 5) on 18 observation categories for science practices in the PESTL Observation Protocol for Science.

	Average observation ratings	
Ratings of PESTL teachers (n=99)	**Year 1**	**Year 2**
Gather	3.4	4.0*
Reason	3.2	3.6*
Communicate Reasoning	2.9	3.8*
Learning Environment	4.4	4.4

* Statistical significance: $p<.01$

SHIFTS IN SCIENCE INSTRUCTION

The program's evaluation study included analysis of change in observed science teaching and learning from inception in year one to end of year two. Observations occurred in winter and spring of year one and year two. Trained science educators observed and rated the 99 teachers from six school districts participating in the professional learning program as well as a control group of teachers from one district not participating in the program.

Analysis of the observation ratings data between 2015-16 (year one) and 2016-17 (year two) shows significant increase in standards-based instruction in science after two years of participation in the professional learning program.

At the beginning of year one, teacher instructional practices ratings on three reporting scales averaged

3.4 (Gather), 3.1 (Reason), and 3.0 (Communicate Reasoning), on a scale of 1 (low) to 5 (high). The averages at these levels indicated that some teachers were using standards-focused practices but about the same proportion were not. For example, the Gather scale includes the practices "ask questions" and "carry out investigations." An average rating of 3 for a district's participating teachers meant these practices were observed in half of the science classes.

By the end of the second year, average classroom observation ratings for teachers who participated in the professional learning were significantly higher (see the table on p. 53) on three of the ratings scales at the $p < .01$ level of statistical significance. Instructional practices on the Gather scale were an average of 4.0, scores on the Reason scale were 3.6, and scores on the Communicate Reasoning scale were 3.8. This represented average improvement in standards-focused science instruction of .5 to 1.3 scale points (on scale of 1 to 5) for teachers in the professional learning program.

Teachers participating in the program rated higher than control group teachers. Program teachers averaged from 2.5 to 3 rating points higher on the Gather, Reason, and Communicate Reasoning ratings categories. Control teachers' observational ratings averaged 1.3 for Gather, Reason, and Communicate Reasoning categories, i.e. substantially lower than program teachers' ratings.

However, the observational ratings of the Learning Environment categories for program and control teachers were similar (4.4 vs. 3.9). This finding indicates that the conditions for science teaching and learning, including materials, texts, classroom management, and student behavior, did not differ significantly between the program and control teacher classrooms.

VALUABLE TOOLS FOR NEW SCIENCE STANDARDS

The PESTL model continues to be used in professional learning with Utah teachers and is now part of a new two-year program for teachers in the state of Hawaii. Since this model for professional learning and the classroom observation protocol are based on the National Research Council's framework for science education, the findings from this research project are relevant for many states and districts implementing new science standards.

The protocol can be used for both formative evaluation of the implementation of science professional learning and summative evaluation of change in participants' standards-based instructional practices. It can be a valuable tool as professional learning continues to evolve and adapt to learning standards and the needs of educators and students.

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