Science Instructional Practices Survey (SIPS):
A New Tool for Identifying Progress in Teaching the NGSS[1]

Introducing the Science Instructional Practices Survey (SIPS)

The Science Instructional Practices Survey (SIPS) is a new, short **survey tool designed to document shifts in 3rd-10th grade teacher instructional practice** towards practices aligned with the Next Generation Science Standards (NGSS). Such assessment is important to document progress and guide future decisions regarding the efforts involved in shifting to new standards. The SIPS improves on existing survey instruments by identifying a broad range of instructional practices that support student inquiry in science, as well as communication and critical thinking skills. This survey instrument highlights key shifts in teaching and learning that are central to the design of the NGSS and similar new science standards being adopted by states and throughout the country.

The Need to Measure Shifts in Instructional Practice

Ambitious efforts are taking place to implement a new vision for science education in the United States, in both NGSS adopted states and those states creating other standards. Teacher educators across the United States are involved in supporting teacher shifts in practice toward the new standards. With these efforts, it will be important to document shifts in science instruction towards the goals of NGSS and broader science education reform. Survey instruments are often used to capture instructional practices, but a survey that captured NGSS science instructional practices did not previously exist. To address this need, we developed and validated the SIPS survey instrument.

Collection of survey data will help policy makers and teacher educators understand teachers' progress in implementing NGSS Science and Engineering Practices (NGSS SE Practices), including the following exemplar questions.

- How are teachers providing opportunities for students to engage in science and engineering practices in their classrooms?
- What are the shifts teachers are making to provide science instruction that makes science accessible for all students?
- To what extent does participation in professional development activities support teachers in shifting their practices?

[1] This report is based on Hayes, K.N. Lee, C. S., DiStefano, R., O'Connor, D., & Seitz, J. (2016). Measuring science instructional practice: A survey tool for the age of NGSS. *Journal of Science Teacher Education*. *27*, 137-164

A Tool for Tracking Trends, Not Evaluating Teachers

The survey questions ask teachers to rate their efforts to engage their students in using the NGSS SE Practices as part of their comprehensive classroom instruction. The **SIPS is NOT intended to evaluate individual teacher practice, but rather to report average results** across a group of teachers. When administered before and after professional development activities, district administrators, professional development providers and policymakers can use the SIPS as a way to shed light on the impact of professional learning experiences on teacher practice. The SIPS can also be used more generally to highlight how instruction is changing over time.

NGSS Science and Engineering Practices (SE Practices)

The NGSS are designed to shift science learning away from memorizing facts and following procedures **towards more student-centered instruction**, where teachers serve as facilitators, encouraging students to ask their own questions, conduct investigations, and analyze information and solve problems. Student knowledge and prior conceptualizations are treated as assets in the classroom. The standards identify core scientific concepts to be learned at each grade level, as well as the eight NGSS SE Practices that students should apply throughout their learning:

1. Asking questions and defining problems
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 and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information[2]

The Science Partnership

This educator brief is one of a series published by the Science Partnership, an 8-year project to develop, implement, and study a comprehensive K-12 professional development model for science education. The Science Partnership is a collaborative led by the California State University East Bay and the Alameda County Office of Education**,** with partners including the California Science Project, school districts and teacher leaders. Its work supports science teachers in shifting their instructional practices by developing teacher knowledge, teacher leadership and organizational capacity. The Science Partnership focuses on schools that serve predominately low-income, underrepresented students in the East Bay region of the San Francisco Bay Area. The SIPS Survey was developed by Kathryn Hayes, Christine Lee Bae, Rachelle DiStefano, Dawn O'Connor, and Jeff Seitz.

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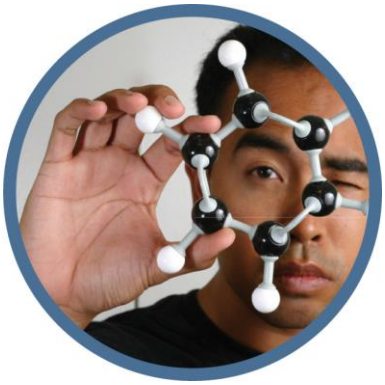

[2] SIPS Items relating to this NGSS SE Practice did not factor out properly and were not included in the final survey.

Documenting NGSS SE Practices in Support of Implementation

The SIPS fills a gap in survey research tools to investigate this type of more student-centered instruction. In addition to asking direct questions about engaging students in the NGSS Practices, the SIPS also includes items to measure traditional instruction (such as lecture), and engaging student prior knowledge, areas not typically included in other science education survey instruments. The survey tool consists of 24 questions covering the following six areas of instructional practice, with four of these areas linking to the NGSS Practices as indicated below:

1. Instigating an Investigation (NGSS Practices 1 and 3)
2. Data Collection and Analysis (NGSS Practices 3-5)
3. Critique, Explanation and Argumentation (NGSS Practices 6-7)
4. Modeling (NGSS Practice 2)
5. Traditional Instruction
6. Prior Knowledge

It will take several years for teachers and school leaders to learn and become fully adept at teaching based on the Next Generation Science Standards**.** As states move forward to adopt and implement these new and challenging standards, patience and persistence will be required to help teachers, school leaders, students and parents progress through the transition. **Data from SIPS can help education leaders understand the long-term movement of teaching practices** towards the NGSS vision, and assist them in targeting and allocating resources to support teachers in their professional learning[3].

How to Administer the SIPS

The SIPS can be completed in approximately 10-20 minutes. Teachers who have little exposure to NGSS, as well as those experienced with the standards may take the survey. We recommend collecting data for at least 10 teachers to obtain a valid average, and administering it both before and after professional development. That said, we recommend administering the survey no more than two times per year.

Interpreting Results

Scoring the SIPS is done by calculating the average Likert rating (1 = Never, 2 = Rarely/a few times a year, 3 = Sometimes/once or twice a month, 4 = Often, 5 = Daily or almost daily) for each respondent for each of the six aspects of instructional practice (see the SIPS Scoring Guide), then averaging across all respondents. **Reminder: the SIPS is NOT intended for evaluation or comparison of individual teacher practice. All analysis should be done using average scores drawn from at least 10 surveys.** With that data in hand, school and district leaders can examine trends and compare progress in each area.

[3] The SIPS should be used cautiously with elementary teachers as the survey questions were designed for use primarily with teachers who specialize in science instruction. Thus, for example, elementary teacher responses on the frequency of their science instruction may not be comparable for data aggregation.

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SIPS Survey

	Never	Rarely (a few times a year)	Sometimes (once or twice a month)	Often (once or twice a week)	Daily or almost daily
How often do your students do each of the following in your science classes:					
1. Generate questions or predictions to explore	1	2	3	4	5
2. Identify questions from observations of phenomena	1	2	3	4	5
3. Choose variables to investigate (such as in a lab setting)	1	2	3	4	5
4. Design or implement their OWN investigations	1	2	3	4	5
5. Make and record observations	1	2	3	4	5
6. Gather quantitative or qualitative data	1	2	3	4	5
7. Organize data into charts or graphs	1	2	3	4	5
8. Analyze relationships using charts or graphs	1	2	3	4	5
9. Analyze results using basic calculations	1	2	3	4	5
10. Explain the reasoning behind an idea	1	2	3	4	5
11. Respectfully critique each others' reasoning	1	2	3	4	5
12. Supply evidence to support a claim or explanation	1	2	3	4	5
13. Consider alternative explanations	1	2	3	4	5
14. Make an argument that supports or refutes a claim	1	2	3	4	5
15. Create a physical model of a scientific phenomenon (like creating a representation of the solar system)	1	2	3	4	5
16. Develop a conceptual model based on data or observations (model is not provided by textbook or teacher)	1	2	3	4	5
17. Use models to predict outcomes	1	2	3	4	5
How often do you do each of the following in your science instruction:					
18. Provide direct instruction to explain science concepts	1	2	3	4	5
19. Demonstrate an experiment and have students watch	1	2	3	4	5
20. Use activity sheets to reinforce skills or content	1	2	3	4	5
21. Go over science vocabulary	1	2	3	4	5
22. Apply science concepts to explain natural events or real-world situations.	1	2	3	4	5
23. Talk with your students about things they do at home that are similar to what is done in science class (e.g., measuring, boiling water).	1	2	3	4	5
24. Discuss students' prior knowledge or experience related to the science topic or concept.	1	2	3	4	5

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SIPS Survey Scoring Guide

To score the SIPs survey, a unique score should be calculated by averaging the ratings of items within that factor. For example, for the factor "Instigating an Investigation", the score will be the average ratings from items 1 to 4.

Factor	NGSS SE Practice	Survey Item	Score
1. Instigating an Investigation	1) Questioning 3) Planning and Carrying Out an Investigation	1. Generate questions or predictions to explore	Average of items 1 to 4: _____
		2. Identify questions from observations of phenomena	
		3. Choose variables to investigate (such as in a lab setting)	
		4. Design or implement their OWN investigations	
2. Data Collection and Analyses	3) Planning and Carrying Out an Investigation 4) Analyzing and Interpreting Data 5) Using Mathematical and Computational Thinking	5. Make and record observations	Average of items 5 to 9: _____
		6. Gather quantitative or qualitative data	
		7. Organize data into charts or graphs	
		8. Analyze relationships using charts or graphs	
		9. Analyze results using basic calculations	
3. Critique, Argumentation, and Explanation	6) Constructing Explanations 7) Engaging in Argument from Evidence	10. Explain the reasoning behind an idea	Average of items 10 to 15: _____
		11. Respectfully critique each others' reasoning	
		12. Supply evidence to support a claim or explanation	
		13. Consider alternative explanations	
		14. Make an argument that supports or refutes a claim	
4. Modeling	2) Developing and Using Models	15. Create a physical model of a scientific phenomenon (like creating a representation of the solar system)	Average of items 16 to 18: _____
		16. Develop a conceptual model based on data or observations	
		17. Use models to predict outcomes	
5. Traditional Instruction		18. Provide direct instruction to explain science concepts	Average of items 19 to 22: _____
		19. Demonstrate an experiment and have students watch	
		20. Use activity sheets to reinforce skills or content	
		21. Go over science vocabulary	
6. Prior Knowledge		22. Apply science concepts to explain natural events or real-world situations.	Average of items 22 to 24: _____
		23. Talk with your students about things they do at home that are similar to what is done in science class (e.g., measuring, boiling water).	
		24. Discuss students' prior knowledge or experience related to the science topic or concept.	

SIPS Instrument Design and Validation

Instrument development and testing proceeded in seven phases:

- In Phase 1, project researchers conducted an extensive review of the literature (Fig. 2.1) from which they documented areas of instructional practice.

- Phase 2 focused on creating survey items, including review and modification of items from existing instruments as well as development of new items. Particular attention was given to writing items that differentiate levels of student involvement and cognitive demand. For example, "Identify questions from observations of phenomena" supports activity at a higher student cognitive level than simply "generate questions or predictions to explore."

Sources of science instructional practices response items.

Main source instruments	Citation
Horizon Survey of Science and Mathematics Education	Banilower, et., 2013
Science teaching practices	Lee, et al., 2009
Scientific inquiry scale	Llewellyn, 2013
PSOP (observation tool)	Forbes, et al., 2013
EQUIP (observation tool)	Marshall, et al., 2009
NGSS practices	NRC, 2012

- Phases 3 and 4 involved validation through expert review and teacher cognitive interviews (i.e., listening to teachers verbalize their thought process as they answer the questionnaire). The 31-item survey was then tested with 397 science teachers in third through tenth grades.

- In Phase 5, construct validity was assessed through Exploratory Factor Analysis (EFA). The emergent factors were then tested for validity through confirmatory factor analysis (CFA) with an independent sample. The six factor model met all Goodness of Fit indices.

- Phase 6 consisted of establishing reliability through internal consistency (Cronbach's alpha =.80-.88).

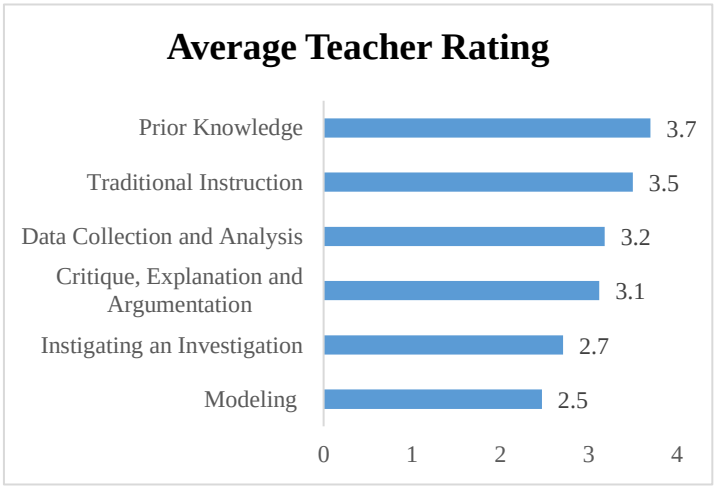
- In Phase 7, external validity was evaluated through examining the correlations between the survey scores and hours of professional development, as well as school demographics.

Cautionary Recommendations

As a self-report survey, the SIPS is inherently vulnerable to participant bias. In particular, teachers who are newer to the NGSS and lack a deep understanding of the instructional shifts may give less accurate ratings. That said, self-report surveys are commonly used in educational research, to understand the types of practices in active use in the classroom, and to provide a relatively simple and inexpensive mechanism to determine general trends across a large sample of teachers. Potential bias can be ameliorated by conducting retrospective surveys (i.e., asking teachers to rate themselves looking back to a previous moment in time, perhaps prior to participating in selected professional development activities) or by triangulating survey results with classroom observations.

Example of the SIPS instrument in Use

Example 1: Comparing Average Teacher Practices



In this example, 155 teachers indicated the amount of time they engaged in each area of instructional practice. First, teachers reported engaging in Modeling (Factor 4) the least, closely followed by Instigating an Investigation (Factor 1) and Critique, Explanation and Argumentation (Factor 3). The relatively low average ratings for Factors 3 and 4 correspond to scholarship that suggests modeling, explanation, and argumentation are the least familiar to teachers and the least often implemented (Capps & Crawford, 2013; Forbes, et al. 2014). As expected, Traditional Instruction averaged relatively high, although not the highest, which was Prior Knowledge.

Example 2: Changes in Instructional Practice Following PD

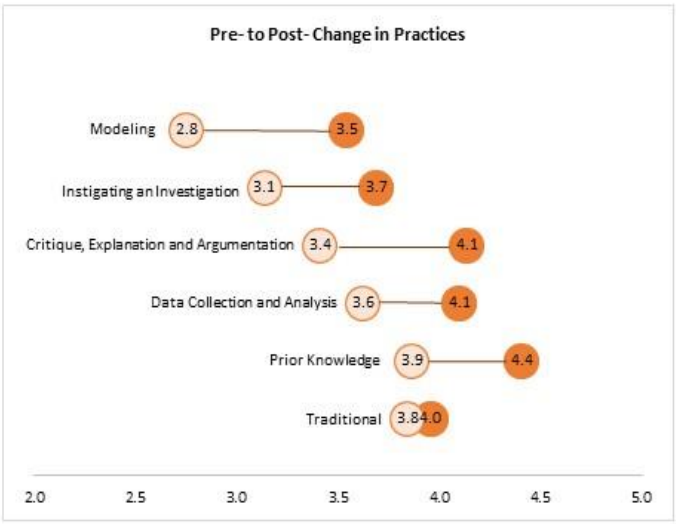


Figure 2 demonstrates teacher practices before and after a 4-month Professional Development. These 28 teachers rated low on several constructs having to do with modeling, investigations, and critique. However, they demonstrated substantive and significant (in all but Traditional) pre- to post-increases after the PD. Whether these increases remain in place could be tested by asking the teachers to take the survey again the following year.

Example 3: Statistical Analysis of the Relationship with PD

We used the SIPS instrument to analyze whether teachers' number of science professional development hours had a significant relationship with their rating on each subscale. Regression analysis demonstrated that the number of hours significantly but weakly predicted the amount of time they spent on 1) Instigating an Investigation, 3) Critique, Explanation and Argumentation, and 4) Modeling, in each case explaining 3-4% of the variance with $p < .05$. In addition, PD hours had a negative relationship with 5) Traditional Instruction, explaining 4% of the variance ($p < .5$).