

Secondary Science Core Teaching Practices Delphi Study Round 1 Summary

Section 1: Ratings Summary

The following ten practices were rated by all survey participants (n=24). Based on the 5-pt. Likert scale (1=Strongly Disagree...5=Strongly Agree) for the importance of each practice, practices shaded in blue had a mean rating ≥ 3.50 or had a mode ≥ 4.00 . The eight practices shaded blue are included in Round 2 rating and feedback.

Science Teaching Practice Short Title	Mean	Mode	S.D.	Mean Difference From Top	Mean Diff. Next Practice
Constructing Models	4.71	5	0.55	0	0
Scientific Phenomena	4.67	5	0.87	-0.04	-0.04
Employ Scientific Evidence	4.58	5	0.58	-0.13	-0.09
Facilitating Discourse	4.54	5	0.83	-0.17	-0.04
Addressing Alt. Conceptions	4.29	5	1.04	-0.42	-0.25
Planning Investigations	4.08	5	0.93	-0.63	-0.21
Managing Materials	4.00	5	1.22	-0.71	-0.08
Focus on Core Concepts	3.96	5	1.08	-0.75	-0.04
Using Science Textbooks	3.13	3	0.80	-1.58	-0.83
Test Preparation	2.21	2	0.98	-2.50	-0.92

Section 2 Additions from Participants

Participants suggested 51 additional science teaching core practices that were coded into 17 new themes. Inter-rater agreement on these codes was 90%. Practices suggested by more than one individual are included in Round 2 (shaded in blue).

Practice Title	Frequency
Eliciting Student Ideas about Science	9
Establishing Relevant Connections to Science	5
Introducing and Modeling Strategies for Scientific Thinking and Practice	5
Differentiating Science Instruction	4
Building a Classroom Culture	3
Providing Feedback	2
Integrating the Sciences	2
Adapting Instruction	2
Scaffolding Academic Language	2
Explaining Scientific Concepts and Practices	2
Utilizing Technology Tools	1
Alternate Science Texts	1
Teaching with Enthusiasm	1
Student Reflection	1
Assigning Meaningful Homework	1
Providing Opportunities for Discovery Learning	1
Collaborate with Other Teachers	1
Uses a Wide Variety of Learning Resources	1

Section 1: Participant Feedback (Highest => Lowest Mean)

<p>Practice Title: Constructing Models</p> <p>Existing Description: The teacher uses, refines, and provides opportunities for students to construct mathematical, physical, or conceptual models of scientific phenomena.</p>
<p>Summary of Feedback: Ranked #1: This practice was rated highly by nearly all participants. Many comments addressed the practice of model/theory creation in actual science research and the importance for students to generate, refine, and use models of scientific phenomena. Some comments focused on improving this practice by more clearly specifying what constitutes a model and what teachers are doing to make models central to science learning.</p> <p><i>Note: The title and description of this practice was revised in light of the feedback for Round 2.</i></p> <p>Illustrative Feedback</p> <ul style="list-style-type: none">(a) It is vitally important that students evaluate the model for flaws because no constructed conceptual model completely or perfectly illustrates a concept.(b) Using models, including mathematical, physical and conceptual models, to analyze data or to make predictions of phenomena is a key dimension of science practice and a powerful means for teachers to help students gain deep conceptual understanding of concepts.(c) This is an important practice as far as reform-based science teaching goes, especially when we consider how many researchers (Windschitl, Schauble, Lehrer, Reiser, etc.) are conceiving of science instruction and inquiry-base teaching as constructing, refining, and defending models.
<p>Suggested Revisions</p> <ul style="list-style-type: none">(d) I suggest alternate wording: Teachers support students to make their conceptual model for a system or phenomenon explicit via words, diagrams, graphs and/or mathematics. Teachers encourage students to confront their model with evidence, develop explanations of phenomena based on their model, and to revise and extend their model based on evidence and argument.(e) Using and interpreting models is also very important. The title, Constructing models, does not reflect that.(g) The teacher also should be supporting the student in actively using and constructing models...I am not an expert about modeling...but it seems that you need to refine and be more explicit about what you mean as a model.

Practice Title: Using Scientific Phenomena

Existing Description: The teacher connects abstract scientific concepts to phenomena of the material world. This includes the use of phenomena in demonstrations, hands-on activities, and laboratory investigations.

Summary of Feedback: Rated #2: Participants in favor of this practice noted that creating opportunities for students to connect the abstract with the material world is at the heart of science teaching and often the basis for generating scientific explanations. Those who disagreed with this practice accepted the premise, but believed that the description needed greater clarification. Others believed that the practice should be expanded beyond phenomena to relevant issues (STS).

Note: Given this feedback, separate practices related to scientific phenomena (revised based on comments) and incorporating relevant science issues appear in the Round 2 survey.

Illustrative Feedback

- (a) Connecting abstract scientific concepts learned in lecture or reading to visual and kinesthetic stimulation (demonstrations, activities, and labs) could very well be the most important core practice for science teachers.
- (b) There is research suggesting the importance of connecting science concepts to authentic contexts. For example, Ann Rivet and Joe Krajcik investigated the importance of contextualizing science concepts in real world experiences (Rivet & Krajcik, 2008 - JRST). The work of Calabrese Barton and her colleagues (e.g. JLS 2010) suggest the importance of actively engaging students in science that is connected to the students' communities and worlds.
- (c) This seems like a broad approach rather than a practice...it seems open to interpretation maybe leading to problematic notions of discovery learning or confirmatory approaches.

Suggested Revisions

- (d) Consider re-wording the practice to indicate that instruction begins with students exploring the phenomenon...Follow-up instruction and discussion focuses on developing a scientific understanding of the phenomenon. I think the current wording above is inadequate --- to me, it simply infers that teachers need to make learning relevant to everyday life.
- (e) Too limiting, unless by concepts what is also meant are processes. Also, I think that the focus should not be on the phenomena but on what teachers do to facilitate observations that can be made by students and to see patterns in these observations.
- (f) "Using scientific phenomena" may better be phrased as "Connecting to scientific phenomena".

Practice Title: Employing Scientific Evidence

Existing Description: The teacher models the use of evidence in the justification of scientific claims and provides opportunities for students to use evidence to justify their own claims.

Summary of Feedback: Ranked Tied #3: Participants noted the high importance of using evidence in explanations and arguments. Despite the importance of evidence in science, many participants noted that employing scientific evidence should not be distinct from the constructing of models or arguments. Other participants felt that the practice should actually be focused on teachers modeling different scientific practices, like the use of evidence in generating arguments and explanations.

Note: In Round 2, employing scientific evidence is more explicitly included in the Construction of Models practice. Furthermore, this practice has been revised to focus on the practice of teachers modeling scientific practices that include employing the use of evidence.

Illustrative Feedback

- (a) Science is all about the use of evidence to develop explanations, so this is clearly a core practice.
- (b) I'd like it if it were combined with modeling and not separate. This is an example also of how managing classroom discourse cannot be separated out from these other candidate practices.
- (c) Modeling evaluation of evidence for the justification of scientific claims and providing opportunities for students to use their own evidence to verify their own claims is an integral part of science teachers should emphasize in their classes.

Suggested Revisions

- (d) This is, to my mind, really part of Practice 2 (perhaps, depending upon the circumstances, in reverse). Models and theories, which are claims about the way the world "works", depend upon evidence and the ability of students to bring models to bear on patterns in data is this process.
- (e) I agree that this is important. However, I wonder in terms of rating teacher practice what counts as high quality. Teachers can turn this scientific practice of supporting claims with evidence into an algorithm where it is no longer an authentic practice and does not support student learning (McNeill, 2009). I wonder if there needs to be greater clarification.

Practice Title: Facilitating Classroom Discourse

Existing Description: The teacher creates opportunities for students to engage in extended science-related talk with the teacher or among peers. Furthermore, this practice focuses on the teacher's ability to take up student ideas or have other students take up, clarify, and specify ideas.

Summary of Feedback: Ranked Tied #4: Although this practice ranks third, participants' comments were most emphatic about the importance of engaging students in dialogue around scientific issues, evidence, and phenomena. Many participants cited the facilitation of discourse and opportunities for student discourse as the most important job of a science teacher. Participants raising concerns indicated that discourse opportunities had to extend beyond ineffective IRE strategies.

Note: This practice was revised for Round 2 to reflect the level of discourse that counts as "meaningful".

Illustrative Feedback

- (a) We know from research that students need to engage in dialogue as a way of making sense of what they are exploring/learning. This is a difficult core practice for beginning teachers.
- (b) I take Lemke's view on this - the one single action that could do more than anything else to improve students learning of science is to provide more opportunity to use the language of science. Most discourse in most science classrooms rarely transcends IRE format. In part this is a product of what is seen as a body of unequivocal and unquestioned body of knowledge. However, it should be possible to generate better quality dialogue.
- (c) This is Duschl's 'social' dimension of inquiry or reform-based science teaching. Also discussed at great length in Ready, Set, Science!

Suggested Revisions

- (d) I agree that this is very important. However, I am not sure if it fully captures dialogic interactions between students. I am concerned that a discussion that is more traditional in terms of an IRE structure would still receive a high rating. There is research that suggests even when curriculum is designed to foster student-centered discussions, teacher approaches continue to be predominately authoritative (Alozie et al., 2010; McNeill & Pimentel, 2010; Puntambekar et al. (2007).
- (e) Change the first "or" to an "and", so that two way talk with the teacher only does not satisfy as the practice being evoked here.

Practice Title: Addressing Alternate Conceptions

Existing Description: The teacher addresses existing student alternate conceptions of the material world through various instructional strategies such as discrepant events, questioning, or activities.

Summary of Feedback: Ranked #5: Participants diverged in their perspectives on addressing alternate conceptions. Some participants cited the above description as an ineffective 'fix it' model in which teachers might unsuccessfully try to replace existing conceptions. Other participants believed that some scientific knowledge is so established, that alternate conceptions should be addressed explicitly in this manner. In several instances, participants cited the importance of eliciting student ideas as key to any practice surrounding scientific concepts.

Note: This practice has been reshaped in light of participants' feedback into a practice focused on "Eliciting Student Thinking". Aspects of addressing alternate conceptions are also present in the new practice "Adapting Science Instruction".

Illustrative Feedback

- (a) Science is a discipline in which students do develop their own conceptions (often alternative) for phenomena they see every day. Therefore, it's critical that teachers are familiar with common alternative conceptions, and ways to challenge these conceptions.
- (b) This is a 'fix it' model for dealing with alternative conception where the ideas are seen as wrong. An alternative for dealing with alternative conceptions is to examine the intuitions and productive components/part of the alternative conception.
- (c) Identifying students' misconceptions and addressing them at the start of any new unit will assist the students in their understanding in the Big Picture. The use of discrepant events not only provides the experience in a cost effective as well as safe presentation is a great way to pull from the student's natural sense of curiosity and wonder.

Suggested Revisions

- (d) The term "addresses" does not tell us what actual practice might be involved--the way it is currently described it seems like a situation rather than a practice. I would expand what it is that teachers are paying attention to in the first place, so I might re-phrase something like "The goal is to elicit students' understandings of a science event that is related to an important scientific idea and then to analyze students' ways of engaging with that puzzle in order to adapt upcoming instruction..."
- (e) Perhaps this practice could be expanded upon or placed under a larger umbrella of attending to student ideas. I think addressing existing student alternative conceptions important. But first the teacher must solicit student ideas -- must get students to talk about their ideas. And then he or she must build lessons around what students already know...

Practice Title: Planning and Facilitating Investigations

Existing Description: The teacher plans opportunities for and facilitates investigations of the material world. This practice focuses on the quality of the inquiry experience that is created for students and the extent to which the teacher facilitates the investigation that allows students to engage in the task.

Summary of Feedback: Ranked #6: Participants identified the execution of investigations as a practice that differentiates science from other disciplines. While many participants found investigations to be an essential part of the science classroom, questions were raised about the nature of what students would be required to do and the vague nature of the teacher practice. Specifically, many comments talked about the variety of investigation types and how students might be asked to raise questions or define procedures in one context, but not in another.

Note: This practice title includes on Planning Investigations in Round 2. The description has also been revised in light of feedback.

Illustrative Feedback

- (a) Again, I think this core practice is one that distinguishes science teaching from other disciplines. Investigations are a core practice of scientists. To engage students in the practices of scientists, they must be able to facilitate investigations.
- (b) Investigations are the pivotal point around which science revolves making this a core teaching practice. Not only does it enable students to experience, understand and question concepts to a much greater degree, they are typically exciting for students, which facilitates receptiveness to learning on their part.
- (c) I am not quite sure what this practice is referring to. Does this mean the teacher scaffolds investigations, or does it mean the teacher supports students' creating and conducting their own investigations? I do not believe all investigations need to be created by the student, so as to allow focused time on, for example, constructing explanations that draw on evidence from the investigation rather than using all the available time for investigation creation...

Suggested Revisions

- (d) Rework: "The teacher plans opportunities for and facilitates investigations of the material world. This practice focuses on the quality of the inquiry experience that is cultivated for students and the extent to which the teacher differentiates the investigation that allows students to engage in the task.
- (e) I would tease apart the planning from the facilitating of the investigations. One dynamic is facilitating students' planning of investigations.
- (f) Rephrase: "The teacher engages students in investigations of the material world, including but not limited to investigations planned by the students. Investigations planned by the teacher are designed to facilitate understanding a concept, or confronting an alternate conception, and to leave space for student questions and student initiated variations in procedure".

Practice Title: Managing Materials and Safety

Existing Description: The teacher manages classroom materials, especially lab equipment, and student behavior in a way that facilitates academic work and a safe environment. While the ideal classroom is not quiet, the teacher limits disruptive behavior and in the classroom and laboratory and ensures a safe environment.

Summary of Feedback: #7: Most participants identified classroom safety as imperative for science classrooms. However, many participants noted that the management of materials and the management of behavior should be split into two separate practices. Others noted that the management of materials is unique to science teaching, but that maintaining a safe environment and managing classroom behavior is required in classrooms of all disciplines and thus, should not be included as a core science teaching practice.

Note: This practice has been broken into two parts: (1) Managing Materials and Lab Equipment and a new practice (2) Creating a Classroom Culture that includes managing student behavior.

Illustrative Feedback

- (a) The practice has two parts that may need to be pulled apart. Management of materials and management of behaviors. To the latter, behavioral problems (boredom, confusion, apathy) will typically arise when teachers do not attend to managing ideas and information and making the learning relevant. Safety with respect to equipment and with respect to participation in class are both important. Pull this practice apart.
- (b) Safety has to be #1. All labs conducted in the science classroom should be performed using eye protection, gloves or whatever the materials to be manipulated suggest. Having enough materials so that students are not up and moving about the room sharing equipment also seems essential when planning materials management.
- (c) Managing materials and safety is vital for the safety of students, but being successful at it (lets hope we all are) does not make the students learn better. So I do not rate it as a core teaching practice.

Suggested Revisions

- (d) The title, Managing materials and safety, seems too restrictive. How about "Managing classrooms and labs?"
- (e) I didn't check 'strongly agree' here because I think that there are two things blended in this practice - preparing materials, and management of the students.

Practice Title: Focus on Core Concepts

Existing Description: The teacher plans lessons and units that focus instruction on core science concepts and theories as outlined by the K-12 Framework for Science Education and other appropriate standards.

Summary of Feedback: Ranked #8: Participants responded with a range of commitments to teaching science based on core concepts. Many in favor of designing curriculum around core concepts suggested that the concepts could not be disconnected from the scientific practices and crosscutting concepts also defined in the new Frameworks for Science Education. Other participants vouched for more teacher autonomy to determine what concepts were relevant to their students and contexts that might not be defined by the Frameworks.

Note: This practice has been slightly revised for Round 2.

Illustrative Feedback

- (a) I think this core skill distinguishes purposeful, goal-directed teaching from simply filling the class period with activities to keep students busy.
- (b) The core concepts need to be linked with the practices and processes of doing and using knowledge. The Framework strongly recommends that practices be done within conceptual domains.
- (c) Instruction needs to focus on the lessons and units outlined by the state standards but there has to be room for additional lessons that are the glue that holds the standards together. The standards do not stand alone and need to be supplemented by experiences and lessons that make them make sense... Teachers should be allowed the freedom to modify curriculum to best meet the needs of their students.

Suggested Revisions

- (d) This teaching practice seems a bit narrow. If the K-12 Framework is to be cited, it seems that core ideas, crosscutting concepts, and practices -- in science and engineering -- should be mentioned.
- (e) Not every lesson can "focus" on the core concept, because certain details are important for understanding. Hence my rewording: Teacher plans lessons with clear learning goals that connect strongly to core science concepts and theories and help build understanding of them.

Practice Title: Using Science Textbooks

Existing Description: The teacher creates opportunities for students to read from and use their science textbook to develop and reinforce content knowledge and practice text analysis skills.

Summary of Feedback: Ranked #9: A majority of participants recognized the role that textbooks play in the classroom and the role that different text types should play in science learning. However, the limitations of current textbooks (difficult to read, authoritative, dull) indicated that most participants would rather have teachers focus on presenting a variety of different text types rather than focus on the textbook.

Note: This practice is dropped in Round 2.

Illustrative Feedback

- (a) Most textbooks are incoherent and do not help students learn science.
- (b) Whilst I agree, I take issue with your articulation of the practice. Students need to learn to read informational text for the purpose of learning. The challenge with such texts are numerous. They are lexically dense, use unfamiliar genres, rely on multi-modal methods of communication and require specific strategies which have to be taught and learnt to understand how to comprehend and read them critically. So the core practice is not so much creating opportunities to read from the text but creating opportunities to teach students how to read such texts.
- (c) I don't consider science textbooks, in all their dry and dusty glory, to be an essential part of science teaching. I say this both as a science education researcher and also as a former science teacher. While helping students to read science textbooks is an unfortunate necessity of science teaching, I don't think it rates as a 'core practice.'

Suggested Revisions

- (d) Reword: "The teacher creates opportunities for students to read from and use a variety of texts to develop and reinforce content knowledge and practice text analysis skills.

Practice Title: Test Preparation

Existing Description: The teacher provides opportunities to practice local, state, or national standardized science tests. The teacher models strategies for answering science-specific standardized test questions and reviews content that will be tested.

Summary of Feedback: Ranked #10: In general, participants described test preparation not as a core science teaching practice, but rather a “necessary evil” within the existing educational environment. Participants noted that effective teaching, using many of the above core practices, would prepare students far more than teaching test taking strategies.

Note: This practice is dropped in Round 2.

Illustrative Feedback

- (a) If students have mastered scientific thought and content by other core practices, direct test prep should not be necessary.
- (b) Unfortunately this is how students get tested, so we must prepare them for it. I do not agree in wasting the time preparing students that will not be part of a college career in such practices.
- (c) Test preparation is NOT a core science teaching practice!! Putting this on par with things like modeling, argumentation, and drawing out students' prior ideas diminishes the importance of THOSE core practices.

Suggested Revisions

- (d) This practice is too narrow. Preparing students for external tests is only one aspect of teacher assessment repertoire. How about "Assessing student learning?"