

Secondary Science Core Teaching Practices Delphi Study Round 2 Summary

Round 2 Ratings Summary

Panelist ratings (n=24) on a 5-pt. Likert scale (1=Strongly Disagree...5=Strongly Agree).

Practices shaded in green had a mean rating ≥ 4.00 , the criteria for Round 2 moving toward consensus.

Science Core Teaching Practice	mean	mode	S.D.	R1 mean	Δ mean
1. Facilitating Classroom Discourse	4.75	5	0.44	4.54	+0.21
2. Building Classroom Community	4.58	5	0.65	--*	
3. Planning Scientific Investigations	4.54	5	0.59	4.08	+0.46
4.** Focusing on Core Ideas and Practices	4.54	5	0.78	3.96	+0.58
5. Eliciting/Assessing Student Thinking	4.46	5	0.66	--	
6. Constructing, Using, Interpreting Models	4.42	5	0.72	4.71	-0.29
7. Linking Science Concepts to Phenomena	4.25	5	1.15	4.67	-0.42
8. Providing Feedback	4.17	4	0.82	--	
9. Establishing Relevant Connections	4.04	5	1.00	--	
10. Managing Materials and Lab Equipment	4.00	4	0.88	4.00	0.00
11. Adapting Instruction	3.92	5	1.10	--	
12. Scaffolding Academic Language	3.83	4	0.87	--	
13. Explaining Science Concepts & Practices	3.79	4	1.02	--	
14. Introducing and Modeling Strategies	3.75	4	0.99	--	
15. Differentiating Science Instruction	3.63	4	1.01	--	
16. Integrating the Sciences	3.63	4	1.17	--	

* Practices added to the second round based on participant's Round 1 suggestions will not have comparison means.

** Practices with equal means were ordered by increasing standard deviation.

Further Feedback

No new practices were added to the comments section of Round 2. Furthermore, only one suggested practice that was added in Round 1 that was not used in Round 2 was supported. Therefore, no new practices are considered for the final round.

A summary of the feedback and exemplar responses for each of the above practices follows below.

Practice Title: Facilitating Classroom Discourse

Existing Description: The teacher creates opportunities for students to engage in science-related talk with the teacher and among peers. This practice focuses on the extent to which the teacher both provides opportunities for classroom discourse and facilitates science-related discussion that values evidence and involves students taking up, clarifying, and justifying the ideas of others. Furthermore, the practice focuses on the extent to which the teacher engages all students in discussing ideas established by the community to develop more in-depth understandings of the material world.

Rank: Round 1: #4; Round 2: #1

Summary of Feedback: The support for this practice increased from round 1 to round 2. Most comments focused on support for the reworded description and several respondents suggested further revisions.

Illustrative Feedback

- (a) I find this rewording to be much clearer.
- (b) I would change sentence two to: "This practice focuses on the extent to which the teacher provides opportunities for small group and whole class discussions; facilitates students' sharing of evidence-based explanations and arguments; encourages students to pose questions and justify their ideas; and provides adequate time for students to think before responding." I would add a third sentence about teachers making visible and helping students practice the discursive forms and functions of science.
- (c) Real scientific discussion and argument rarely take place in classrooms... Teachers normally use the initiate-response-evaluate triad (Mehan, 1979)... Therefore, this practice is vital to getting our students to think rather than just respond.

Note: The description has been slightly revised, notably in the final sentence, to address the wording suggestions from Round 2.

Practice Title: Building Classroom Community

Existing Description: The teacher creates and maintains safe, collaborative learning communities wherein students are willing to take academic risks, adhere to class norms, and work together toward common learning goals. The practice focuses on the extent to which the teacher continually establishes expectations for behavior in the classroom and lab and discursive participation in science learning activities.

Rank: Round 1: N/A; Round 2: #2

Summary of Feedback: This practice was suggested panelists in round 1 and had high uptake by the panel in round 2. Suggested revisions focused on improving the clarity of the constructs, especially the second sentence. Although many participants justified the importance of this practice, five panelists argued that this teaching practice is not unique to science, but rather applicable to all disciplines and classrooms and, therefore, was not rated more highly.

Illustrative Feedback

- (a) This is a foundational teaching practice regardless of content area. I rated this as neither agree nor disagree because it is important, but not necessarily more important as a science teaching practice.
- (b) 'Academic risks' is ill defined, perhaps change to: "students are willing to venture ideas, discuss their confusions, and participate regardless of language level or other perceived limitation."
- (c) The last sentence seems awkward. Suggestion revision: "The practice focuses on the teacher continually establishing expectations for behavior in the classroom and lab as well as providing support for discursive participation for all students."

Note: Based on panelist recommendations, the word 'science' was added to the title, the term 'academic risks' was changed to a more explicit description of the construct.

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<p>Practice Title: Planning Scientific Investigations</p> <p>Existing Description: The teacher engages students in investigations of the material world, including but not limited to investigations planned by the students. This practice focuses on the extent to which teachers provide opportunities for students to investigate phenomena and engage in the practices of science that include the posing of questions, collecting of evidence, arguing from evidence, building explanations, and communicating ideas. Furthermore, this practice focuses on the extent to which investigations planned by the teacher are designed to facilitate understanding a concept, or confronting an alternate conception, and leave space for student questions and student initiated variations in procedure.</p>
<p>Rank: Round 1: #6; Round 2: #3</p> <p>Summary of Feedback: Three participants suggested a revised title focused on ‘Engaging Students in Scientific Investigation.’ Furthermore, participants found some revisions to be an improvement, but suggested removing the final sentence as it detracts from the overall construct.</p> <p>Illustrative Feedback</p> <ul style="list-style-type: none">(a) The more detailed description is an improvement if the final sentence is dropped. The former sentences clarify the teaching practice while the final sentence does not.(b) I would reword the title, it does not match the text. The title should be more like, ‘engaging students in scientific investigations.’(c) This practice has become too broad. You include “the posing of questions, collecting of evidence, arguing from evidence, building explanations, and communicating ideas.” This seems much broader than the new Frameworks or NGSS that focus on collection of evidence while the other practices are included other under headings. <p><i>Note: In light of the feedback, the title has changed to ‘Engaging Students in Scientific Investigation’ and the third sentence has been shortened and significantly revised. Other small changes reflect the feedback as well.</i></p>

<p>Practice Title: Focusing on Core Ideas and Practices</p> <p>Existing Description: The teacher plans lessons and units that integrate the core science ideas of the discipline (e.g. Biological Evolution), concepts that cut across disciplines (e.g. Energy Flows), and scientific practices (e.g. Engaging in Argument from Evidence). This practice focuses on the extent to which instruction, activities, and assessments connect and focus on ideas of and about science that are central to developing deep understandings of the disciplines and how they relate to the world.</p>
<p>Rank: Round 1: #8; Round 2: #4</p> <p>Summary of Feedback: Panelists noted the vastly improved description of this practice. One panelist noted that the new description sounded similar to the overall core practice definition used in this study (see (b) below). Five panelists commented on the importance of science planning reflecting the interdisciplinary nature of science.</p> <p>Illustrative Feedback</p> <ul style="list-style-type: none">(a) Based on the title’s combination of ideas, I thought there would be no way the description would warrant a Strongly Agree. I was wrong. The description is both clear and concise.(b) In some ways, this sounds very similar to me to the overarching definition of “core science teaching practices” that you provided at the beginning – “Core science teaching practices include the instructional repertoire (strategies, routines, goals)...”(c) It is essential to constantly include interdisciplinary concepts in order to make students aware of connections. <p><i>Note: The term ‘engineering’ was added to the definition as well as a few other small wording changes.</i></p>

Practice Title: Eliciting/Assessing Student Thinking

Existing Description: The teacher elicits student thinking about scientific concepts and practices. This practice focuses on the extent to which the teacher frequently probes student thinking, both formally and informally, and through a variety of assessment practices, such as questioning, identifies students' mental models and conceptions of the material world and scientific practices that can inform future instruction.

Rank: Round 1: N/A; Round 2: #5

Summary of Feedback: This practice was suggested by nine panelists in Round 1. In round 2, five panelists stated that the description needed no changes. Many panelists also noted the importance of formative assessment and eliciting student thinking, but that this construct cannot be separated from how the elicitation informs or changes future practice.

Illustrative Feedback

- (a) This is huge, I don't know why I did not think of this in the first round. The research on formative assessment points to the value of understanding student thinking throughout a unit of instruction, not only to give feedback to the student on their reasoning, but to give the teacher a measure of the effectiveness of their instructional decisions to that point. Adaptive forms of instruction are predicated on this.
- (b) This goes hand in hand with feedback. Teachers need to be eliciting what students are thinking in order to know what students have or have not learned. It is crucial that feedback from student thinking is used in planning further instruction.

Note: Small changes were made to the existing description for Round 3. Although two participants asked for the combination of this practice with the practices 'Providing Feedback' and 'Adapting Instruction' into one large practice, 'Assessing Student Understanding', it was decided that while all part of an assessment strand, the grain size of combining all three practices is inconsistent with the other practices in this survey.

Practice Title: Constructing, Using, Interpreting Models

Existing Description: The teacher uses models in his/her science teaching and provides opportunities for students to construct, use, and interpret models. This practice focuses on the extent to which the teacher presents evidence-based scientific models in explaining science concepts and provides opportunities for students to construct – via words, diagrams, graphs, or mathematics – use, test against evidence, and refine models in conjunction with scientific investigations, readings, or discussion.

Rank: Round 1: #1; Round 2: #6

Summary of Feedback: The rank and overall rating of this core practice dropped more than any other practice despite the justifications and feedback providing positive support for the revisions and the practice itself. One theme that emerged was suggested caution toward what counted as a scientific model as well as having a specific core practice for a single scientific practice mentioned in the new frameworks.

Illustrative Feedback

- (a) I have maintained my Strongly Agree evaluation. The description is an improvement.
- (b) To me this seems more like trying to define the "scientific practice" of "modeling", which is different than defining a "teaching practice". The other teaching practices explicitly talk about both scientific knowledge and scientific practices as desired learning outcomes. It seems like this should encompass all 8 scientific practices included in the Frameworks.
- (c) I agree with the model emphasis, but would caution against "using models" (which every science teacher would say they already do) and having students construct/revise based on evidence. The latter is the core of what scientists do--it embodies the conceptual, social, epistemic and material dimensions of disciplinary activity. The former may be as simple

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as the teacher him/herself using a globe to show where different ecosystems are. The skill differences pedagogically for the former and the latter are as wide as the Grand Canyon.
Note: Given panelist feedback, the teacher use of models was eliminated for fear it could promote the use of representations that are not really models (e.g. globes or a paper mache volcano). The practice now focuses on the moves the teacher must make in order for students to generate, test, and revise a scientific model.

Practice Title: Linking Science Concepts to Phenomena

Existing Description: The teacher engages students with phenomena of the material world through demonstrations, hands-on activities, and laboratory investigations and provides opportunities for students to develop a scientific understanding of the phenomena. This practice focuses on the quality of the phenomena the teacher chooses that exemplifies scientific concepts based on the material world and students' prior knowledge and experiences.

Rank: Round 1: #2; Round 2: #7

Summary of Feedback: This practice decreased the most in rating and rank from round 1 to round 2. Feedback from panelists suggests continued support for the practice, although two panelists believed that this practice was covered in other practices in the study. Several suggestions were made to improve the clarity of the description including what counts as a phenomena and what counts as 'quality'.

Illustrative Feedback

- (a) This is an essential aspect of teaching science that I think is particularly unique to science. This is not a teaching practice that you would encounter in another discipline.
- (b) Suggested rewording for second sentence: This practice focuses on how the phenomena are used to either challenge students' existing conceptions or to illustrate key features of the scientific account of the material world.
- (c) I think this practice is covered by practices #2, #5, #8, and #9. For example, to teach science as modeling, teachers have to build from students' prior/current ideas and engage them in investigations of the material world.
- (d) The use of the word "quality" is subjective and complicates the determination of what is quality. What is valued is "...scientific concepts based on the material world..." so there's not need to suggest a "quality." Reword: "This practice focuses on the variety of [or range of?] phenomena the teacher chooses that exemplifies scientific concepts based on the material world and students' prior knowledge and experiences.

Note: The word 'quality' has been removed in the second sentence has been revised to reflect the importance of how the chosen phenomena impacts student understanding.

Practice Title: Providing Feedback

Existing Description: The teacher provides feedback in response to student application of science concepts or practices. This practice focuses on the extent to which the teacher provides feedback, based on elicited student thinking, that gauges the quality of student work or student progress toward a goal and the means by which students can improve their science understanding and performance.

Rank: Round 1: N/A; Round 2: #8

Summary of Feedback: Feedback was seen as an important part of the assessment process for teachers; however, several panelists found the description under-developed and needing more emphasis on peer and self-reflection. Two panelists argued for combining Eliciting/Assessing Student Thinking, Feedback, and Adapting Instruction into one Assessment core practice.

Illustrative Feedback

- (a) Constructive feedback is essential in student assessment. The goal is always to improve learning and without feedback a student has little hope of correcting errors in their thought processes.
- (b) I would reword the title to "Assessing Students' Ideas." The teacher implements formative and summative assessments to determine what students have learned about core ideas, crosscutting concepts, and practices; provide feedback to students; inform future instructional decisions; and determine what students have ultimately learned.
- (c) Consider including, 'timely feedback' and something about planning time for students to analyze teacher feedback. Teachers spend hours grading and writing valuable feedback to promote student's learning but then we don't plan for the time for students to actually read and analyze that feedback in a manner that will promote further understanding of the concepts.

Note: The description was revised to include peer and self-reflection as well as the importance of providing students opportunities to use or respond to the given feedback.

Practice Title: Establishing Relevant Connections

Existing Description: The teacher makes relevant connections among scientific concepts and practices and students' personal and cultural experiences. This practice focuses on the extent to which the teacher designs classroom activities that highlight the significance of scientific accounts and practices, such as connections to science in current events, or draw on students' funds of knowledge to make explicit the relevance of science in their lives.

Rank: Round 1: N/A; Round 2: #9

Summary of Feedback: This practice was suggested by panelists in Round 1 and received support above the rating threshold to move to Round 3. Panelists showed support of this practice as well as raised questions about redundancy with other practices such as Focusing on Core Ideas and Integrating the Sciences. Six questions were raised about the use of the term 'funds of knowledge' and the idea of 'culturally relevant connections'.

Illustrative Feedback

- (a) This is an essential aspect of engaging all students in science. I was glad to see it added to this list.
- (b) 'Connections' is a weak word; I think what is meant here is applications of the science in real world contexts including news and student's lives. I would call this item "connecting science concepts to their applications"
- (c) What does it mean to "draw on students' funds of knowledge"? Does this mean work with students' prior knowledge. I believe this area is generally important, but not all connections are valuable; what matters are how and which connections are promoted.
- (d) I only question if this should be combined with practice 13.

Note: This practice will remain a distinct practice in Round 3 to allow for further feedback on

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whether making connections to student lives is different enough from making connections between ideas in science. The description has been revised to remove undefined terms like 'funds of knowledge' and better represent the feedback of the panel.

Practice Title: Managing Materials and Lab Equipment

Existing Description: The teacher manages classroom materials, especially lab equipment, in a way that facilitates academic work and a safe environment. This practice focuses on the extent to which the teacher follows guidelines for the preparation, storage, use, and disposal of dangerous chemicals or physical equipment, and the set-up and arrangement of materials both in the classroom and in the lab that best facilitates student science learning.

Rank: Round 1: #7; Round 2: #10

Summary of Feedback: Panelists generally found this practice important, but on the borderline of being a 'core practice' for which time and money would be a significant invest in teacher education or PD. Several small changes capturing safety issues were also suggested.

Illustrative Feedback

- (a) As with other practices here, it is totally necessary, almost a prerequisite to being able to work with data, however if the purpose of this Delphi is to come to relative consensus on what we should invest time on in professional development or in teacher preparation, this would not rise to the top.
- (b) While I think this is an important practice, I didn't check 'strongly agree' because I don't know that it is core in the way other teaching practices are.
- (c) Understanding lab safety is a concept that students can benefit from. Suggested rewording: "...and the set-up and arrangement of materials both in the classroom and in the lab that best facilitates student's understanding of safe investigation procedures."

Note: The word 'dangerous' was removed from the description, as all chemicals require proper disposal. This practice is the lowest rated practice moving on to Round 3.

Practice Title: Adapting Instruction

Existing Description: The teacher uses data that indicate students' scientific knowledge and ability to engage in scientific practices to adapt and revise future instruction. This practice focuses on the extent to which teachers recognize the learning needs of students and adapt instructional methods or the instructional plan to match those needs. Decisions are based on students' partial and alternate understandings of scientific concepts as well as the academic language needs of students.

Rank: Round 1: N/A; Round 2: #11

Summary of Feedback: The strongest, most frequent response from panelists argued that adapting instruction as a result of eliciting student ideas could not exist as a distinct practice from the latter. Furthermore, several participants wanted better clarification on what counted as 'data' before agreeing about this practice. Similarly, there was some confusion as to why 'academic language' was included in this description.

Illustrative Feedback

- (a) While the use of data can be helpful in evaluating the big picture of student learning, I'm afraid it emphasizes a student's success or failure on high stakes tests. Assessing student understanding must be from both formative and summative assessment methods.
- (b) I think this practice unnecessary. Adapting instruction should be connected to eliciting students' ideas. Meeting the needs of different learners falls under differentiation. Attending to academic language is already noted under Scaffolding Academic Language.
- (c) Again, here I am torn about whether this should be part of the assessing "strand"--perhaps we should have strands of practice to look at and comment on? Practices 5, 6, and 7 in my mind for a strand that you would create professional development around or base part of teacher preparation on.

Note: This practice has been eliminated from voting in Round 3.

Practice Title: Scaffolding Academic Language

Existing Description: The teacher introduces, defines, prompts, incorporates, and highlights key scientific terms and discourse structures. This practice focuses on the extent to which teachers explicitly connect the specialized language of science to students' everyday language and identify for students specific ways in which oral and written scientific discourse are used. The teacher appropriately scaffolds scientific discourse in ways that help English speaking and English Learning students.

Rank: Round 1: N/A; Round 2: #12

Summary of Feedback: Many panelists saw the value of addressing the vocabulary and discourse practices of science in explicit ways. However, several felt that scaffolding was too loosely defined and that addressing the development of the language of science occurs as elements of other practices.

Illustrative Feedback

- (a) I would call this, "supporting the development of the language of and for science". "Scaffolding" too easily gets reduced to vocabulary lists and sentence prompts. Academic language is too limiting.
- (b) I think this is very important and that it is important that you included both "terms" and "discourse structures". Science discourse has its own set of norms that can be foreign to students, particularly English Language Learners.
- (c) This is an issue that is implicit in virtually all the other practices. It is important, but the problem with listing it as a separate practice is that it implies it might be done at a separate time (e.g., vocabulary lessons). Teaching language out of scientific and experiential context is NOT a core practice.

Note: This practice has been removed from voting in Round 3.

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<p>Practice Title: Explaining Science Concepts & Practices</p> <p>Existing Description: The teacher coherently and accurately explains scientific concepts, content, and practices that help students construct their own scientific accounts. This practice focuses on the extent to which teachers' explanations are developmentally appropriate, logical, and use appropriate analogies, metaphors, and examples to make connections among scientific ideas within and across units.</p>
<p>Rank: Round 1: N/A; Round 2: #13</p> <p>Summary of Feedback: Three panelists believed the description and practice were fine as is. However, the majority of responses questioned the role the teacher-constructed explanations play in science classrooms and what a focus on explanations might result, pedagogically. Those who supported the practice also had caveats of when the explanations could occur.</p> <p>Illustrative Feedback</p> <ul style="list-style-type: none">(a) I don't like explaining practices. Modeling practices, coaching practices, and demonstrating practices would be better I believe. This is the cognitive, epistemic, and social 'doing' of science.(b) This sounds like it would justify lectures--a method shown to be ineffective and inefficient.(c) I am not sure I completely understand this practice. Is the teacher presenting the explanations to students, or providing guidance to students who are doing the construction of explanations with guidance? I selected neither, since I am unsure exactly who is doing which pieces of the construction. <p><i>Note: This practice has been removed from voting in Round 3.</i></p>

<p>Practice Title: Introducing and Modeling Strategies</p> <p>Existing Description: The teacher explicitly teaches and models aspects of scientific thinking and practice. This practice focuses on the extent to which the teacher introduces and models strategies for scientific tasks like posing scientific questions, interpreting data, and arguing from evidence. Explicit strategy instruction and modeling includes both cognitive (e.g. generating inferences from data) and procedural (e.g. running a titration) tasks and opportunities for students to use the practice during guided practice.</p>
<p>Rank: Round 1: N/A; Round 2: #14</p> <p>Summary of Feedback: Some confusion occurred with this practice because it focused on modeling certain strategies and the term 'model' was used differently for practice #8 on the survey (constructing scientific models). While many participants felt that modeling different strategies were important, many justified their lower ratings based on the inclusion of modeling in the other, more science specific practices.</p> <p>Illustrative Feedback</p> <ul style="list-style-type: none">(a) Students frequently learn through observing the examples set forth by their teacher. If the teacher does not set forth an appropriate model in scientific endeavors then any direct oral instruction will possess little value.(b) This should happen as part of engaging students in investigations, engaging students in model-based activities, attending to students' academic language, and facilitating classroom discourse.(c) This is like practice 11 in that it needs to be incorporated into many of the other practices, and strategy instruction out of context (e.g., laboratory skills instruction) can do more harm than good. However, I agree that explicit modeling and scaffolding of scientific practices is essential. Note that "models" is used in Practice 8 with a different meaning. <p><i>Note: This practice has been removed from voting in Round 3.</i></p>

Practice Title: Differentiating Science Instruction

Existing Description: The teacher changes the pace, level, and/or kind of instruction/resources to address student differences in learning science. This practice focuses on the extent to which teachers differentiate learning by providing content, process, and/or product options that align to student needs across the achievement continuum in order for all students to achieve the learning goals.

Rank: Round 1: N/A; Round 2: #15

Summary of Feedback: Two main themes emerged from panelist feedback. First, the distinction between Adapting Instruction and Differentiating Instruction is not clear enough to warrant two separate practices. If instruction is adapted effectively, it will include differentiation, when necessary. Second, like other practices ranked in this survey, several panelists argued that differentiation is common across every subject and not specific to science.

Illustrative Feedback

- (a) Practice 7 Adapting Instruction and Practice 12 Differentiating Science Instruction can be seen as overlapping.
- (b) The practice of differentiating instruction should be part of good teaching practices, not necessarily unique to science.
- (c) This is important, but taken to an extreme, this can make the teacher's job very challenging.

Note: This practice has been removed from voting in Round 3.

Practice Title: Integrating the Sciences

Existing Description: The teacher integrates multiple disciplinary perspectives into science teaching. This practice focuses on the extent to which the teacher of a particular discipline (e.g. biology) explicitly incorporates how models, knowledge, and practices in other scientific domains/disciplines (e.g. chemistry or physics) can inform understanding and help address scientific questions.

Rank: Round 1: N/A; Round 2: #16

Summary of Feedback: This practice had six panelists 'disagree' with the core nature of the practice. The most common comment from about eight panelists was the overlap between this practice and the practice focused on Core Ideas. Although some panelists saw this practice as crucial, others saw it as a sub-component of planning effective science units.

Illustrative Feedback

- (a) I like this, but I am given pause because this overlaps with the 'crosscutting ideas' teaching practice, which is more consistent with the language in the new common core standards.
- (b) Increasingly, the boundaries between the disciplines of science are becoming more permeable, and topics, such as Climate Change, require discussions and data/experiments that draw from a wider variety of traditional disciplines.
- (c) Based on our academic teacher preparation programs and state certification, our teachers are not prepared to do this. I think this suggested core teaching practice represents a goal for science teaching, but I don't think it reflects current practice of even exemplary science teachers.

Note: This practice has been removed from Round 3. However, the interdisciplinary nature of the sciences is captured in the "Focus on Core Ideas, Crosscutting Concepts, and Science Practices" construct.

Summarized Comments From the End of the Survey

- (a) Several comments focused on combining practices to produce a more manageable list for teacher education and professional development.
- (b) There are suggestions of articulating how scientific practices are different from teaching practices and how the core teaching practices might similarly address science content and science practices.
- (c) Multiple panelists alluded to the collation of practices into different strands. For example, an assessment strand, a planning strand, a discourse strand.
- (d) Three individuals indicated that technology is a major part of the science classroom and should somehow be represented in the practices.
- (e) One response articulated the difficulty in rating some practices since practice is a combination of knowledge and skill and the teacher knowledge component is underrepresented in this survey.