Science Practices Continuum – Students' Performance

This continuum is intended for teachers and administrators to use in guiding and evaluating student performance in the science practices. The levels reflect increasingly sophisticated engagement in the practices and are not grade-level specific; students can engage in the practices in developmentally appropriate ways at any of these levels. Appendix F in the NGSS provides significantly more detail for each practice (that should be integrated as both students and teachers develop greater fluency with each practice). The practices are grouped into the "Investigating" "Sensemaking" and "Critiquing" practices.

		Level 1	Level 2	Level 3	Level 4
Investigating Practices	1. **Asking questions**	Students do not ask questions.	Students ask questions. Students' questions are both *scientific* and *non-scientific* questions (i.e., not answerable through the gathering of evidence or about the natural world).	Students ask questions. Students' questions are typically *scientific* (i.e. answerable through gathering evidence about the natural world). Students *do not evaluate* the merits and limitations of the questions.	Students ask questions. Students' questions are typically scientific (i.e. answerable through gathering evidence about the natural world). Students *do evaluate* the merits and limitations of the questions.
	3. **Planning and carrying out investigations**	Students do not design or conduct investigations.	Students conduct investigations, but these opportunities are typically *teacher-driven*. Students do *not* make decisions about experimental variables or investigational methods (e.g. number of trials).	Students *design or conduct* investigations to gather data. Students make decisions about experimental variables, controls *or* investigational methods (e.g. number of trials).	Students *design and conduct* investigations to gather data. *Students make decisions* about experimental variables, controls *and* investigational methods (e.g. number of trials).
	5. **Using mathematics and computational thinking**	Students do not use mathematical skills (i.e., measuring, estimating) or concepts (i.e., ratios).	Students use mathematical skills or concepts but these are *not connected to answering a scientific question.*	Students use mathematical skills or concepts to *answer a scientific question.*	Students *make decisions* about what mathematical skills or concepts to use. Students use mathematical skills or concepts to answer a scientific question.

Sensemaking Practices	2. **Developing and using models**	Students do not create or use models.	Students create or use models. The models focus on *describing* natural phenomena rather than predicting or explaining the natural world. Students *do not evaluate* the merits and limitations of the model.	Students create or use models focused on *predicting or explaining* the natural world. Students *do not evaluate* the merits and limitations of the model.	Students create or use models focused on *predicting or explaining* the natural world. Students *do evaluate* the merits and limitations of the model.
	4. **Analyzing and interpreting data**	Students may record data, but do not analyze data.	Students work with data to organize or group the data in a table or graph. However, students *do not recognize patterns or relationships* in the natural world.	Students work with data to organize or group the data in a table or graph. Students make sense of data by *recognizing patterns or relationships* in the natural world.	Students *make decisions* about how to analyze data (e.g. table or graph) and work with the data to create the representation. Students make sense of data by *recognizing patterns or relationships* in the natural world.
	6. **Constructing explanations**	Students do not create scientific explanations.	Students attempt to create scientific explanations but students' explanations are *descriptive* instead of explaining how or why a phenomenon occurs. Students do *not* use appropriate evidence to support their explanations.	Students attempt to create scientific explanations but students' explanations are *descriptive* instead of explaining how or why a phenomenon occurs. Students *use appropriate evidence* to support their explanations.	Students construct explanations that focus on explaining *how or why a phenomenon occurs* and *use appropriate evidence* to support their explanations.

Critiquing Practices	7. **Engaging in argument from evidence**	Students do not engage in argumentation.	Students engage in argumentation where they support their *claims with evidence or reasoning*, but the discourse is primarily *teacher-driven*.	Students to engage in *student-driven argumentation.* The student discourse includes *evidence and reasoning* to support their claim. Students also agree and disagree, but rarely engage in critique.	Students engage in *student-driven argumentation*. The student discourse includes evidence, reasoning that links the evidence to their claim and *critique* of competing arguments during which students build on and question each other's ideas.
	8. **Obtaining, evaluating, and communicating information**	Students do not read text for scientific information.	Students read text to *obtain* scientific information, but do *not evaluate* this information. Students also do *not* compare or combine information from multiple texts considering the strengths of the information and sources.	Students *read and evaluate* text to obtain scientific information. Students do *not* compare or combine information from multiple texts considering the strengths of the information and sources.	Students *read and evaluate* text to obtain scientific information. Students *compare and combine* information from multiple texts considering the strengths of the information and sources.

Classroom Culture Prioritizing Science Practices

Less --More

Connected to the Natural World
Focused on Scientific Evidence
Student Directed and Collaborative
Informed by Critique

Instructional Strategies – Asking Questions

Scientific questions lead to explanations of how the natural world works and can be empirically tested using evidence.

Potential Instructional Strategies for *Asking Questions*
1. Ask students to share ideas of scientific questions about a specific topic. Emphasize that scientific questions should be questions that can be answered using data from investigations. 2. Provide examples and non-examples of scientific questions. Ask students to work in groups to sort the questions. 3. Model the writing of scientific questions. Demonstrate that since scientific questions can be answered using data from investigations the question should contain two variables. 4. Provide fill-in-the-blank questions for students. (Example: How does the __________ affect _________?) 5. Have students identify the variables in scientific questions (i.e. underline the independent variable, circle the dependent variable). Scaffold if necessary by doing several as a whole class and then having students practice with their own (or peers') scientific questions. 6. Provide opportunities for students to work together to write scientific questions that will be used for in-class investigations. Encourage students to critique each other's ideas and pose questions to each other as part of the discussion. 7. Have students ask scientific questions they have about a demonstrated phenomenon. Remind students that scientific questions are answerable by doing experiments. 8. Ask students to explain how they would go about answering a scientific question.

For a classroom example of instruction using this science practice, visit our website at www.sciencepracticesleadership.com and click on the Grade 2 Exemplar under Case Studies.

Instructional Strategies – Developing and Using Models

A model is an abstract representation of phenomena that is a tool used to predict or explain the world. Models can be represented as diagrams, 3-D objects, mathematical representations, analogies or computer simulations.

Potential Instructional Strategies for *Developing and Using Models*
1. Have students work in groups to create models of non-observable phenomenon (e.g., lunar cycles, erosion). Be explicit that models offer explanatory accounts – they show how or why a phenomenon occurs. 2. Show students an example of a scientific model and a non-example, such as a labeled diagram. Have students compare and contrast the two. Highlight for students that the scientific model shows how a phenomenon occurs, while the labeled diagram does not. 3. Provide opportunities for students to make decisions about the type of model they will create, such as a picture, a physical creation, or a computer animation. Emphasize that there is no one "right" way to create a model, but that models should show how or why the phenomenon under study occurs. 4. Provide graphic organizers to support students in planning their models. Sections of the graphic organizer might include "key ideas" and room to sketch the model. At the end of the graphic organizer provide a checklist so that students can be sure their proposed model shows how or why the phenomenon occurs and is not only descriptive. 5. Provide a range of materials and computer access so students can choose the type of model to create. Before students select their medium, facilitate a discussion about the benefits and drawbacks to each type of material. 6. Have students do a "gallery walk" of the different models they create. Provide students with a chart to use to make notes about how the various models do and do not explain the phenomenon being modeled. Give students sticky notes to post suggestions and comments for their peers. 7. Ask students to critique models from various sources, such as texts, the internet, and physical representations in the classroom. Facilitate a discussion of the benefits and drawbacks of the different models. Emphasize for students that all models have benefits and drawbacks. 8. Ask students to apply a model to a different example and then revise the model to reflect the new information (e.g. apply a model for sinking and floating of objects to the floating of a boat).

For a classroom example of instruction using this science practice, visit our website at www.sciencepracticesleadership.com and click on the Grade 7 Exemplar under Case Studies.

Instructional Strategies – Planning and Carrying Out Investigations

An investigation is a systematic way to gather data about the natural world either in the field or in a laboratory setting.

Potential Instructional Strategies for *Planning and Carrying Out Investigations*
1. Put students in small groups to complete investigations. Assign each student a job to do during the investigation. Model the job responsibilities before beginning the investigation so students understand what is expected of them while performing the investigation. 2. Assign groups to specific spaces in the classroom to conduct their investigations. This helps ensure each group has sufficient space to conduct their investigation and that the groups will not disturb each other. 3. Give students sticky notes to use to label materials in an investigation. This can help younger students or students who struggle with writing to show the outcome of an investigation without the demands of recording in a data table. 4. Have students vote on their prediction for the outcome of an experiment. Record predictions on the board. Ask students to revisit their predictions after they have gathered data. 5. Provide a scientific question and have groups of students design an investigation to answer the question. Provide students with a graphic organizer to record the variables (independent, dependent, constants), procedure, materials, and data table. 6. Show students several procedures for investigations that have varying numbers of trials, materials, or types of data tables. Ask students to critique the procedures based on the scientific question being explored. 7. Show students several procedures for investigations in which one only changes 1 variable while the others alter multiple variables at the same time. Ask students to critique the procedures to discuss the idea of a fair test and only changing one variable at a time. 8. Provide a choice of 3-4 scientific questions to explore about a specific topic. Have small groups of students select their question and design and carry out an investigation to answer that question. 9. Provide a general experimental procedure but allow student choice in terms of variables to be manipulated (e.g. materials to test, length of time).

For classroom examples of instruction using this science practice, visit our website at www.sciencepracticesleadership.com and click on the Grade 2 Exemplar and Grade 5 Exemplar under Case Studies.

Instructional Strategies – Analyzing and Interpreting Data

Analyzing and interpreting data includes making sense of the data produced during investigations. Because patterns are not always obvious, this includes using a range of tools such as tables, graphs and other visualization techniques.

Potential Instructional Strategies for *Analyzing and Interpreting Data*
1. After an investigation, ask each group of students to briefly state a pattern they see in the data. Provide sentence starters such as "As the amount of ________ increases…" and "We saw that changing _______ caused…" 2. Provide written steps for students to follow to scaffold analyzing complex data tables. For example, students might be asked to first state how many trials were conducted, then asked what pattern they see in the first column of the data table. As student capability with finding the patterns in data improves through the school year, slowly remove the scaffold. 3. Ask students to vote (thumbs up/thumbs down) whether they agree with a fellow student's interpretation of the patterns in data. 4. To practice figuring out patterns in the data give groups of students a data table and sentence strips with various statements about the patterns in the data. Have students decide whether each statement is accurate or inaccurate based on the data table. 5. Have groups of students compare and contrast their data tables. If differences exist in the data, ask student hypothesize about why these differences exist. Have students make a plan to reduce sources of error in future iterations of the investigation (i.e. dropping a ball from the same height, having the same students operate a stopwatch through the investigation, etc.). 6. Ask students to graph their data to visually represent the patterns in the data. Provide checklists for students to use to ensure their graphs contain key components, such as labels on the axes and a title. 7. Conduct a gallery walk for students to view and critique each other's data tables or graphs. Encourage students to use sticky notes to ask questions and provide feedback about how well their data tables show the patterns in the data. Give students time to use the feedback to improve their work. 8. Model for students how to construct a graph. Talk about what decisions must be made when creating a graph (e.g. bar graph vs. line graph) and the reasons for one choice or another. Point out aspects of graphs that enable other to comprehend patters in the graph (e.g. reasonable intervals on the axes).

9. Hang posters in the classroom with examples of different types of graphs (bar, line, etc.) that students can reference as they decide what type of graph to construct and as they make their graphs.
10. After students construct a graph for data, ask them to defend their choice of that type of graph. Facilitate a discussion about the differences in how each graph type shows the patterns in the data.
11. Have students write 1-2 sentences that summarize the pattern(s) in a graph. Provide sentence starters such as “My graph shows...” and “Over time, plant A…”.

For a classroom example of instruction using this science practice, visit our website at www.sciencepracticesleadership.com and click on the Grade 5 Exemplar under Case Studies.

Instructional Strategies – Using Computational and Mathematical Thinking

Mathematical and computational thinking involves using tools and mathematical concepts to address a scientific question.

Potential Instructional Strategies for *Using Computational and Mathematical Thinking*
1. Provide opportunities for students to perform calculations on their gathered data, such as finding the mean (average) of several trials of data. 2. Engage older students in using computer programs such as excel to analyze large data sets from scientific organization (e.g. NASA, NOAA). 3. Create activities in which students are given a scientific question and must decide how to use mathematical or computational thinking to address the question. 4. Use various tools to gather data such as graduated cylinders, thermometers, balances, etc. 5. Have older students decide whether to represent their data in different ways such as using ratios, percents, etc. 6. Engage students in investigations that require them to use mathematical operations (e.g. subtract quantities to determine the volume of an object).

For a classroom example of instruction using this science practice, visit our website at www.sciencepracticesleadership.com and click on the Grade 2 Exemplar under Case Studies.

Instructional Strategies – Constructing Explanations

A scientific explanation is an explanatory account that articulates how or why a natural phenomenon occurs that is supported by evidence and scientific ideas.

Potential Instructional Strategies for *Constructing Explanations*
1. Discuss key features of explanations in science: explanatory account, science ideas and evidence. An explanatory account describes how or why a phenomenon occurs. Science ideas are key concepts or principles students apply to make sense of a specific phenomenon (e.g. example). Evidence is scientific data such as measurements and observations. 2. Create a poster with the key features for a scientific explanation, such as that it shown how or why something occurs. 3. Revise explanation questions in curriculum or lessons to ensure that students need to answer with more than a simple "yes" or "no"; rather, they require an explanatory account. 4. Provide examples of strong and weak examples (e.g. describes a phenomenon instead of explaining it). Critique the examples as a class. 5. Provide students with scaffolds such as sentence starters, questions or graphic organizers that highlight the key features. For example, a graphic organizer could include three sections labeled: 1) Your explanation – the how or why?, 2) Big science ideas that support your explanation, 3) Evidence that supports your explanation 6. Ask students to highlight the key features of an explanation (explanatory account, science ideas and evidence) in their own or a peer's writing. 7. Ask students to give feedback to each other about written explanations. Provide sentence starters to students to help them make specific statements about the explanations. Examples of sentences starters can include "I have a question about your evidence…", "I am not sure that your writing explains why _____ occurs. Can you explain that to me?, or "How can we use our big science ideas to help explain _____?"

For a classroom example of instruction using this science practice, visit our website at www.sciencepracticesleadership.com and click on the Grade 5 Exemplar under Case Studies.

Instructional Strategies – Engaging in Argument from Evidence

Scientific argumentation is a process that occurs when there are multiple ideas or claims (e.g. explanations, models) to discuss and reconcile. An argument includes a claim supported by evidence and reasoning, and students engage in debates to evaluate and critique competing arguments.

Potential Instructional Strategies for *Engaging in Argument from Evidence*
1. Introduce students to the argumentation framework of claim, evidence and reasoning (CER). A claim answers a question or problem, which could be an explanation or model. Evidence is data that supports the claim, such as observations and measurements. Reasoning explains why the evidence supports the claim using scientific ideas or principles. 2. Provide students with scaffolds such as a graphic organizer, sentence starters or questions that highlight the CER components to help them craft their arguments. 3. Revise argumentation questions in lessons or curriculum to ensure that there is more than one possible claim that students could potentially support with evidence. When students have multiple competing claims, there is more opportunity for critique. 4. Facilitate a discussion about the norms for argumentation. Explain to students that they should be talking directly to each other, and not through the teacher. In addition, they should be questioning and critiquing each other's ideas. However, it is also important for students to be willing to change their minds if new ideas or evidence are presented by their peers that convinces them of the strength of a competing claim. 5. Create a poster in the classroom that supports the CER structure as well as students critiquing different ideas. It could include sentence starters such as, "My evidence is…" and "I disagree because...", as well as questions such as "What are some other possible claims? Do we have support for those claims?" and "Why did you decide to use that evidence to support your claim? Could the data be interpreted in a different way?" 6. Model for students what it looks like to question or critique another person's idea. For example, "I disagree with Maria's claim, because I interpreted the data in a different way. I think the data shows that lung capacity is important for…." 7. Limit teacher talk during argumentation by physically removing yourself from the discussion (e.g. sit in the corner of the room) and/or telling students that you have a specific task during the discussion. For example, you can tell the class that your job is to record the different evidence that comes up during the conversation and that you will not be actively talking during the discussion.

For a classroom example of instruction using this science practice, visit our website at www.sciencepracticesleadership.com and click on the Grade 7 Exemplar under Case Studies.

Instructional Strategies – Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating and communicating information occurs through reading and writing texts as well as communicating orally. Scientific information needs to be critically evaluated and persuasively communicated as it supports the engagement in the other science practices.

Potential Instructional Strategies for *Obtaining, Evaluating, and Communicating Information*
1. Have students read a text in small groups that contains evidence and science ideas (DCIs in NGSS) about a specific topic. Ask students to underline the evidence and put a star next to the science ideas. 2. Explicitly remind students of the definition of scientific evidence (measurements and observations). Create a poster with this definition for students to reference in the classroom. 3. Provide students with two or more texts on the same topic. Ask students to compare and contrast the texts, focusing on how well the authors defend their claim. Have students decide which is the most persuasive text. Tell students they will need to explain why they think that text is most persuasive. 4. Do a jigsaw activity with multiple texts. Put students into groups and give each group a different text on a related topic. When students have completed reading the text, mix up the groups so one person who has read each text is in each group. Ask students to briefly summarize their text to their group. 5. Develop a checklist of questions can ask as they evaluate texts. For example, Does the text have a clear claim? Does the text use scientific evidence to support the claim? Does the text have enough scientific evidence to support the claim? 6. Watch two short videos (or listen to two podcasts) about a similar topic. Ask students to compare and contrast the different perspectives on the same topic (e.g. genetically modified food).

For a classroom example of instruction using this science practice, visit our website at www.sciencepracticesleadership.com and click on the Grade 7 Exemplar under Case Studies.