Using a Claim, Evidence, and Reasoning Platform With Next Generation Science Standards

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Introduction

Next Generation Science Standards (NGSS) enable students to understand science on a deeper level by using a three-dimensional approach that integrates 1) disciplinary core ideas, 2) crosscutting concepts, and 3) science and engineering practices. These three dimensions are woven into the standards to help students meet rigorous performance expectations at all grade levels.

NGSS also identifies eight practices of science and engineering that are essential for all K–12 students to learn. Practice seven, "engaging in argument from evidence," requires students to gather evidence, formulate arguments, and critique other arguments in much the same way English language arts students might. This practice emphasizes using evidence and reasoning to support claims and using critical-thinking skills when evaluating alternative explanations.

The Claim, Evidence, and Reasoning (CER) Framework for writing scientific explanations offers students guidance for how to do this well. CER teaches students to answer scientific questions by stating what they believe to be true and then providing evidentiary data and rationale to support that belief. The CER Framework can be applied to almost any scientific explanation, making it an excellent tool for engaging K–12 students in evidence-supported argumentation.

Overview of the NGSS

The *Next Generation Science Standards* were written over the course of two years with the cooperation of national organizations, higher education, industry experts, and state leaders. The foundation of this work was the National Research Council publication *A Framework for K–12 Science Education* in 2012. The Framework represents a profound pedagogical shift from science being perceived as a collection of facts and lower-level cognitive tasks to science being recognized as a process whereby students learn to apply practices and make connections between all disciplines of science.

Beyond encouraging students to become hands-on learners, NGSS also asks that they use the same standard practices of scientists and engineers in the "real world." There are eight science and engineering practices outlined in the *Next Generation Science Standards*, Appendix F:

1. Asking questions (for science) and defining problems (for engineering)
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 (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Ideally, science educators will find natural ways to incorporate these practices into each lesson, while remembering that not every practice belongs in every lesson. Scientists and engineers engage in these practices regularly and use them in interconnected ways to solve problems. In order to teach students to do the same, science teachers must be smart about how they present them within the instructional process. Laboratory investigations or classroom activities should not be limited to only one practice nor should practices be separated from the instructional process.

Although all practices are important and play a vital role in meaningful K–12 science instruction, practice seven is essential for developing the critical-thinking skills that are required of successful scientists and engineers. Practice seven, "engaging in argument from evidence," ensures that students will be able to write quality explanations and meet *Common Core State Standard* expectations surrounding argumentation.

The Nexus of Science and Writing

The *Common Core State Standards in English Language Arts Writing* require secondary-level students to engage in evidence-based argumentation. Specifically, middle-school standards CCSS.ELA-Literacy.W.6.1, CCSS.ELA-Literacy.W.7.1 and CCSS.ELA-Literacy.W.8.1 state: "Write arguments to support claims with clear reasons and relevant evidence."

As students progress into high school, CCSS.ELA-Literacy.W.9-10.1 and CCSS.ELA Literacy.W.11-12.1 ask them to: "Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence."

Similar wording is used for each standard at the middle-school and high-school levels, however the expectation is that there will be more sophistication and complexity in each student's writing as he or she nears graduation. NGSS standards set a comparable path for science students, and they are also expected to become more adept at writing scientific arguments from evidence as they progress.

The Claim, Evidence, and Reasoning Framework provides educators with a highly effective tool for engaging students in writing scientific arguments. It asks students to construct their own explanations, provide more detailed insight into phenomena, and use evidence-based logic to make connections. This is a departure from more traditional science instruction that stresses building vocabulary and memorizing facts realized through direct instruction and teacher-contrived experimental procedures.

In addition, the CER Framework naturally integrates additional science and engineering practices. For example, students may use models (practice two) as a piece of evidence, analyze and interpret data (practice four) as evidence and/or reasoning, apply computational thinking (practice five) in developing a reasoning statement, construct an explanation (practice six) for justification, and learn to communicate their analysis effectively (practice eight).

How to Engage Students in Argument from Evidence

The CER Framework is an excellent structure for teaching students at all grade levels how to construct arguments from evidence. *A Framework for K–12 Science Education* provides a rationale for this practice and is referenced in *Next Generation Science Standards:*

The study of science and engineering should produce a sense of the process of argument necessary for advancing and defending a new idea or an explanation of a phenomenon and the norms for conducting such arguments. In that spirit, students should argue for the explanations they construct, defend their interpretations of the associated data, and advocate for the designs they propose (p. 73).

Utilizing this practice in science instruction increases rigor by incorporating a greater cognitive complexity of thinking. When first teaching this practice in the classroom, it is beneficial to focus on the structure of claim, evidence, and reasoning arguments while making certain that students understand the difference and can properly write an example of each term. As students become more fluent in this skill, they will use the structure in more complex ways by integrating several crosscutting-concepts and more disciplinary core ideas.

Students should be given a clear understanding of how claim, evidence, and reasoning differ from each other before they are asked to use this structure to engage in scientific argumentation.

Claim

A claim is a complete statement of what is known. It differs from a hypothesis because a claim focuses on what has been concluded, whereas a hypothesis may or may not be proven through controlled experimentation. Students can still design experiments beginning with a hypothesis, but as they begin to draw conclusions, making a claim should be the first step.

Evidence

Data that supports a claim is evidence. Appropriate evidence may be qualitative or quantitative, and it should be substantial enough to address the claim. Typically, students should include two or three pieces of evidence when possible. Evidence can come from student-designed investigations, from documented research, or from a student's own observations. Evidence should of course be accurate and appropriately support the claim. At higher levels, teachers may also explore how multiple claims may be made using the same data sets and use that as a basis to evaluate an argument.

Reasoning

Reasoning explains why the evidentiary data set supports the claim. Students should be provided with opportunities to obtain evidence which may include first-hand observation of experimental data, teacher-provided data sets with tables and graphs, reading passages, etc. Students can then reference that evidence throughout their arguments in addition to information they glean from other sources. Appropriate scientific principles can be included at this stage based upon prior knowledge. Students should understand that steps in logical thinking can be used to connect their reasoning to the evidence and back again to the claim.

Engaging in Argumentation in Grades 6–8

States that adopted the *Next Generation Science Standards* determined their own timelines for implementation. As a result, some middle-school students may have experience in engaging in argumentation from evidence, while others may not. Strategies for helping first-timers include providing definitions for claim, evidence, and reasoning, and offering simple examples that reinforce the fundamentals of writing a claim, supporting it with evidence, and connecting appropriate reasoning. Consider the following Performance Expectation as it appears in the *Next Generation Science Standards*, along with a sample claim, evidence, and reasoning response:

Example:

Performance Expectation: MS-ESS3-4 Earth and Human Activity:
Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

Claim:
As the population of Cityville increases, resulting air pollution caused a change in Earth's systems.

Evidence:

1. According to the Census, the population of Cityville has increased by 20,000 over the past 10 years.
2. According to a recent article by the Associated Press, air quality in Cityville has worsened over the past 10 years as a result of increased coal-burning at the power plant.
3. Rain barrels recently tested positive for slightly acidic water.

Reasoning:
Human population growth affects consumption of natural resources. As the population of Cityville grew, more coal was used to keep up with increasing electricity demands. Burning this natural resource releases compounds that cause acid rain, which negatively impacts Earth's systems. Changes in population caused changes in the hydrosphere, atmosphere, and biosphere.

At the middle-school level, students typically begin by providing a claim, evidence, and reasoning either in a graphic organizer or in a format similar to that above. As students become more proficient in this skill, they can progress into a clearly written paragraph or concise oral argument.

Teachers can use their discretion as to the science content or disciplinary core ideas included in the argument. For instance, it may make sense to include prior-knowledge of Earth's systems or to conduct student research leading to the connection of acid rain and coal burning. The details of the argument will change according to each assignment, but the process of using the Claim, Evidence, and Reasoning Framework should be consistent.

When grading this type of performance task, the CER should be evaluated separately, because a student may have an accurate claim with appropriate supporting evidence, but their reasoning might be weak. In such cases, students should be given meaningful feedback to help them grow as learners and scientists.

Engaging in Argumentation in Grades 9–12

Argumentation at the high-school level is similar to that at the middle-school level. However, as students progress further in their education and become more fluent in evidence-based argumentation, tasks deepen to connect more concepts, include varying disciplinary core ideas, and explain conclusions from original experimentation. For high-school students who do not have experience using the Claim, Evidence, and Reasoning Framework, the first-use strategies described in the section above may be used.

The following example from the *Next Generation Science Standards* connects argumentation to design of experiment in a basic way:

Example:

Performance Expectation: HS-PS1-5:
Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

Design of Experiment:
As a means to meet this performance task, students will design an experiment to determine the effect of temperature on reaction rate. A classic, inexpensive, and simple activity could involve a sodium bicarbonate tablet (such as Alka-Seltzer®) and water. Students would first need to determine if hot or cold water speeds up the reaction, and then design a method to collect and measure gas evolution that occurs as a product of the reaction. Prior to beginning work, students would pose a question, hypothesis, and detailed controlled experimental procedure for teacher approval. The teacher would check that proper safety requirements are followed, that the structure of the experiment is sound, and that a method for data collection has been determined.

Claim, Evidence, Reasoning:
Once the approved experiment is completed, students will analyze both qualitative and quantitative data and make a claim about the effect of temperature on reaction rate. As evidence, students will use their experimental findings. Finally, in the reasoning phase, students will use prior knowledge along with their experiment to explain how changing temperature affects reaction rate. Students should also use the collision theory in their explanation as they write a well-constructed paragraph.

Extension: Students can repeat the same process to test concentration rather than temperature and provide a similar argument. They can also propose the ideal temperature and concentration conditions for a particular reaction that has either been discussed in class or is new to them.

Applications for Parents

Parents can support students as they learn to engage in argumentation using evidence by looking at factual information with students and asking them questions about what that information means or implies. Helping students learn to take their time to review all information and make a logical, concise claim is a good first step. In addition, parents can review sets of information with students (graphs, videos, readings, etc.) that surround a topic or phenomenon to help them make connections. This will give them the practice they need to draw and support appropriate conclusions and the foundation to participate in quality argumentation.

Conclusion

Next Generation Science Standards require students to engage in argument from evidence, but not all students have experience gathering evidence, formulating written arguments, and critiquing other arguments. The Claim, Evidence, and Reasoning Framework for writing scientific explanations supports students as they learn to master these critical skills.

Teachers must be clear about how the CER Framework is used and should model it when necessary. Eventually, students will gain confidence using it, and, as a result, will become better scientific thinkers and communicators.

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