

Science Evidence-Based Practices Brief

What are evidence-based practices?

Evidence-based practices are instructional strategies and approaches grounded in rigorous research and demonstrated to improve student learning outcomes. They rely on data from well-designed studies to solidify whether a practice is effective, rather than intuition. Using evidence-based practices means intentionally selecting methods that have been shown to be effective, implementing them with fidelity, and continuously monitoring student learning to make adjustments as needed.

The Every Student Succeeds Act (ESSA) references tiers of evidence, which provides districts and schools with a framework for determining which programs, practices, strategies, and interventions work in which contexts and for which students. This handout, [ESSA Tiers of Evidence](#) (REL Midwest, 2019), provides additional information on the ESSA tiers of evidence and the kinds of studies necessary to determine them.

Why is the use of evidence-based practices important?

The use of evidence-based practices is essential not only for classroom instruction but also for improved student learning, as it ensures that the teaching methods used are proven to support student learning rather than relying on trial and error. When educators use practices and strategies grounded in high-quality research, they are more likely to meet students' diverse needs, reduce achievement gaps and use instructional time effectively.

Introduction

Teaching science with respect to today's standards involves students actively making sense of the world around them. Students engage in the **Science and Engineering Practices (SEP)** as they make sense of the **Disciplinary Core Ideas (DCI)** and make connections among **Crosscutting Concepts (CCC)**. The use of relevant phenomena as a base for lessons and units helps drive cohesive science instruction in which students develop new understandings for the purpose of explaining the natural world.

Listed resources are examples intended to support educator understanding and implementation and are not intended as an endorsement of a specific program or product.

Practice: Student Sensemaking of Phenomena

Overview

Engaging students in sensemaking is an essential aspect of science teaching through the Iowa Academic Standards for Science. In a sensemaking classroom, students are not simply learning scientific facts; they are actively working to explain phenomena and solve problems using evidence, models and reasoning. Instruction begins with questions about observable events or patterns in the world, and students develop and refine explanations as they gather information and test their ideas.

This process is most meaningful when instruction is anchored in local phenomena that are familiar or relevant to students' lives (Lee, 2022). When students investigate events that occur in their communities, such as local weather patterns, water quality in nearby rivers, agricultural practices or the design of community infrastructure, they are more likely to see science as meaningful and applicable. These connections help students recognize that science is not just something that happens in textbooks or laboratories, but a tool for understanding and improving the world around them (Penuel, 2019).

Interest generated by these locally relevant phenomena often leads to deeper engagement in the learning process. When students are curious about explaining something they have personally observed or experienced, they are more motivated to ask questions, analyze evidence and revise their thinking (Walker, 2025). This sustained engagement supports stronger conceptual understanding and helps students build the ability to apply scientific ideas in new contexts. As a result, classrooms that emphasize sensemaking through relevant phenomena often see higher levels of student participation, persistence in problem solving and overall achievement in science learning.

What are teachers doing?	What are students doing?
<ul style="list-style-type: none"> • Introducing learning with an observable phenomenon that sparks curiosity and raises questions students want to answer • Encouraging students to ask questions about the phenomenon and helping them refine those questions into investigable problems • Structuring investigations and activities that allow students to gather evidence related to the phenomenon • Facilitating classroom discussions where students share ideas, critique explanations and build understanding together • Navigating from one investigation to the next using student questions and ideas 	<ul style="list-style-type: none"> • Developing initial models or explanations based on their prior knowledge and observations • Using scientific practices such as modeling, analyzing data, constructing explanations and arguing from evidence • Revisiting and refining models and explanations as they gather new evidence and deepen their understanding • Developing understanding to explain related phenomena or solve new problems

Resources to Support Educator Understanding

- [Sensemaking of Relevant Phenomena in the Iowa Academic Standards for Science](#) (Iowa Department of Education, 2025)
- [STEM Teaching Tool 28: Qualities of a Good Anchor Phenomenon for a Coherent Sequence of Science Lessons](#) (Bell & Penuel, 2016)
- [STEM Teaching Tool 42: Using Phenomena in NGSS-Designed Lessons and Units](#) (STEM Teaching Tool Initiative, 2016)
- [STEM Teaching Tool 72: How can arguing from evidence support sensemaking in elementary science?](#) (Schrauben et al., 2021)

Tools to Support Implementation

- [Iowa Science Phenomena Project](#) (Iowa PBS, 2026)
- [The Wonder of Science—Phenomena Examples](#) (The Wonder of Science, 2026)

Practice: Setting up a Need-to-Know

Overview

True engagement is driven by a clear, meaningful sense of purpose, not just by completing assigned tasks. When students understand why they are doing something, because it helps them answer a question they genuinely have or solve a problem they find interesting, they are more likely to invest effort and persist through challenges. This requires teachers to design learning experiences that feel coherent from the learner’s perspective, in which each activity logically builds from the last and contributes to a larger goal

(Penuel, 2022). Rather than presenting disconnected tasks, teachers can anchor instruction in compelling phenomena or problems that invite students to ask questions and seek explanations.

Attending to students' "need-to-know" is critical in shifting from compliance to authentic engagement. When teachers introduce tasks at moments when students recognize a gap in their understanding, the work becomes purposeful rather than procedural. This means listening carefully to student thinking, surfacing their questions and using those questions to guide the direction of instruction. In this kind of classroom, engagement is not about staying busy; it is about making sense of ideas, revising thinking and actively participating in the learning process because students see the value in what they are doing.

What are teachers doing?	What are students doing?
<ul style="list-style-type: none"> Encouraging students to ask questions about the phenomenon and helping them refine those questions into investigable problems Respecting student agency in the trajectory of the unit as they work to understand the phenomena or solve the problem Navigating from one investigation to the next using student questions and ideas 	<ul style="list-style-type: none"> Moving through activities with a purpose, gathering new information incrementally to solve a problem or understand a phenomenon Asking questions that lead to new tasks, where they gather new understandings

Resources to Support Educator Understanding

- [Call to Action for Science Education: Building Opportunity for the Future](#) (National Academies of Science, Engineering and Medicine, 2021)
- [Science and Engineering for Grades 6-12: Investigation and Design at the Center](#) (National Academies of Science, Engineering and Medicine, 2019)
- [Science and Engineering in Preschool Through Elementary Grades: The Brilliance of Children and the Strengths of Educators](#) (National Academies of Science, Engineering and Medicine, 2018)
- [Rise and Thrive with Science](#) (National Academies of Science, Engineering and Medicine, 2020)
- [Iowa Department of Education Video on Relevance](#) (Iowa Department of Education, 2025)

Tools to Support Implementation

- Driving Question Boards
 - [Driving Question Boards](#) (OpenSciEd, 2020)
 - [Driving Question Boards in Iowa](#) (Iowa PBS, 2019)
 - [Webinar: How Teachers Use a Driving Question Board](#) (Activate Learning, 2021)
- [Question Formulation Technique](#) (The Right Question Institute, 2026)
- [Project Zero Core Thinking Routines](#) (Project Zero, 2026)
- [Instructional Strategies for Asking Questions](#) (Instructional Leadership, 2026)

Practice: Student-Centered Investigations

Overview

For students to make sense of the world around them, they must have access to meaningful and relevant information. Scientific investigations are a primary way they gather it (Windshill et al, 2008). These investigations provide students with firsthand or credible secondhand evidence that they can use to build and

refine their understanding (Duschl & Bybee, 2014). When students collect data, observations, or analyze information, they are not just completing tasks; they are actively developing the evidence base needed to support explanations and answer their own questions about how the world works (Kanari, 2004; Lee, 2020).

These experiences can take many forms, from hands-on experiments and field observations to analyzing datasets, reading scientific texts or learning from experts and primary sources. What matters most is that the information students gather is purposeful and connected to the questions they are trying to answer (Sengupta et al, 2014). By engaging in a variety of investigative approaches, students learn that science is not limited to one method, but is instead a process of using multiple sources of evidence to make sense of phenomena and construct well-supported explanations.

What are teachers doing?	What are students doing?
<ul style="list-style-type: none"> • Positioning tasks as opportunities for students to gather evidence, rather than simply follow procedures • Providing a variety of investigative approaches (hands-on experiments, data analysis, texts, expert sources) that are relevant to the problem or phenomena • Supporting students in planning investigations and selecting appropriate tools or information sources • Guiding students in collecting, organizing and analyzing data for patterns and relationships • Engaging in consensus discussions where students compare and evaluate evidence from multiple sources • Encouraging students to use evidence to construct and revise their explanations over time • Focusing on sensemaking and evidence-based reasoning rather than arriving at a single “correct” answer 	<ul style="list-style-type: none"> • Gathering information from texts, datasets, or expert and primary sources, as well as planning and carrying out experiments • Organizing and analyzing data to look for patterns, trends and relationships • Comparing evidence from different sources to build a more complete understanding • Developing and communicating explanations using the evidence they have gathered • Revising their thinking and explanations as they encounter new evidence or ideas • Engaging in discussions with peers to make sense of information and refine their understanding

Resources to Support Educator Understanding

- [Science and Engineering for Grades 6-12: Investigation and Design at the Center](#) (National Academies of Science, Engineering and Medicine, 2019)
- [Science and Engineering in Preschool Through Elementary Grades: The Brilliance of Children and the Strengths of Educators](#) (National Academies of Science, Engineering and Medicine, 2018)
- *Rise and Thrive with Science* (National Academies of Science, Engineering and Medicine, 2020)
- [STEM Teaching Tool 19: Why should students learn to plan and carry out investigations in science and engineering?](#) (Wingert & Bell, 2025)
- [STEM Teaching Tool 56: Engaging Students in Computational Thinking During Science Investigations](#) (McGowan, Klein & Morrison, 2019)
- [STEM Teaching Tool 63: How to integrate the argumentation from evidence practice into engineering design projects](#) (Weaver & Tesoriero, 2019)

Tools to Support Implementation

- [Instructional Strategies for Planning & Carrying Out Investigations](#) (Instructional Leadership, 2026)
- [Instructional Strategies for Analyzing and Interpreting Data](#) (Instructional Leadership, 2026)
- [Instructional Strategies for Using Mathematics and Computational Thinking](#) (Instructional Leadership, 2026)
- [The I² Strategy](#) (Biological Sciences Curriculum Study, 2012)

Practice: Fostering Knowledge-in-Use

Overview

One of the primary goals of science education is for students to explain the world around them. This goes beyond memorizing facts to developing a deep understanding of phenomena through reasoning (Kubsch et al, 2020). A key way students do this is by following the procedure of question, claim and evidence (Hand & Cavagnetto, 2025). They begin by asking questions about what they observe, then make a claim or prediction based on their thinking, and finally gather and analyze evidence to support or revise that claim. This structured approach helps students connect their observations to scientific principles and build explanations that are coherent, evidence-based and meaningful.

Using the question-claim-evidence framework also mirrors the practices of real scientists, giving students a clear process for sensemaking. They learn to evaluate evidence critically, compare it to their claims and refine their explanations when new information arises. This approach encourages active engagement, critical thinking, and problem-solving, enabling students to reason scientifically not just in the classroom but in everyday life (He, Krajcik, & Schneider, 2023). By practicing this procedure, students gain the skills to construct explanations that make sense of the world and communicate their understanding effectively.

What are teachers doing?	What are students doing?
<ul style="list-style-type: none">• Designing lessons and activities that allow students to apply knowledge to explain real-world phenomena rather than just recall facts• Framing investigations around meaningful questions that students can explore using evidence• Guiding students in constructing claims based on observations and prior knowledge• Encouraging students to connect new evidence to their existing understanding and revise claims as needed• Facilitating discussions where students justify their explanations and engage with alternative ideas• Providing scaffolds and prompts that help students use knowledge in authentic contexts, not just procedural steps• Modeling how to reason scientifically, showing how claims are supported by evidence and connected to broader concepts• Continuously monitoring student thinking to ensure they are actively using knowledge to	<ul style="list-style-type: none">• Making claims or predictions based on their observations and prior knowledge• Gathering and analyzing evidence from experiments, observations, data, texts or experts• Applying existing knowledge to interpret new information and identify patterns or relationships• Revising their claims and explanations when evidence challenges or expands their understanding• Engaging in discussion and debate, defending their explanations and considering alternative viewpoints• Connecting what they are learning to broader concepts or everyday experiences• Using evidence to construct coherent, scientifically grounded explanations

What are teachers doing?	What are students doing?
make sense, rather than completing tasks passively	

Resources to Support Educator Understanding

- [STEM Teaching Tool 6: How Can I Get My Students to Learn Science by Productively Talking with Each Other?](#) (Bacolor et al., 2014)
- [STEM Teaching Tool 35: How can I foster curiosity and learning in my classroom? Through talk!](#) (Wingert, 2016)
- [STEM Teaching Tool 48: How can teachers guide classroom conversations to support students' science learning?](#) (Morrison & Rhinehart, 2017)
- [Talk Science Primer](#) (Michaels & O'Connor, 2026)
- [Doing and Talking Math & Science](#) (University of Wisconsin, 2026)
- [STEM Teaching Tool 1: Is it important to distinguish between the explanation and argumentation practices in the classroom?](#) (Bell & Shouse, 2014)
- [Integrating Literacy Strategies in Science Education](#) (American Museum of Natural History, 2026)

Tools to Support Implementation

- [Instructional Strategies for Obtaining, Evaluating and Communicating Information](#) (Instructional Leadership, 2026)
- [Instructional Strategies for Constructing Explanations & Designing Solutions](#) (Instructional Leadership, 2026)
- [STEM Teaching Tool 17: Beyond the Written C-E-R: Supporting Argumentative Talk about Investigations](#) (Chowning & Peterman, 2015)
- [Incorporating Scientific Argumentation into Your Classroom](#) (STEM Teaching Tool Initiative, 2026)
- [Instructional Strategies for Engaging in Argument from Evidence](#) (Instructional Leadership, 2026)

Practice: Integrated Three-Dimensional Instruction and Assessment

Overview

Effective science teaching integrates all three dimensions (science and engineering practices, disciplinary core ideas, and crosscutting concepts) rather than teaching them in isolation (NRC, 2012; Fick, 2018). Science education is not just about memorizing facts; it is about helping students learn how to think critically, solve problems and make sense of the world. When students engage in a practice, like analyzing data or constructing explanations, they are simultaneously applying core ideas from physics, biology or earth science and noticing patterns or systems through crosscutting concepts. This integrated approach allows students to develop both deep content knowledge and the reasoning skills needed to use that knowledge effectively. Learning in this way helps students see science as a dynamic process of thinking and problem-solving rather than a set of disconnected facts.

Focusing on the three dimensions together is particularly powerful when exploring a phenomenon. Students ask questions, plan investigations and use evidence to explain why something happens, all while drawing on relevant scientific ideas and noticing patterns, cause-and-effect relationships or system interactions (Chesnutt et al, 2019). By weaving the dimensions together, teachers create learning experiences that mirror how science actually works and foster deeper understanding (Badrinarayan, 2025). Students do not just

learn about a core idea, they experience it in action and develop the skills to reason, predict and explain the world around them (Fulmer, Tanas, & Weiss, 2018).

What are teachers doing?	What are students doing?
<ul style="list-style-type: none"> • Designing learning experiences around real-world phenomena that naturally require the use of all three dimensions • Planning lessons that integrate science and engineering practices, core ideas, and crosscutting concepts rather than teaching them separately • Scaffolding investigations so students apply practices to explore core ideas and recognize patterns, systems or cause-and-effect relationships • Posing questions and prompts that encourage students to connect evidence to core ideas and think across conceptual frameworks • Modeling how to reason scientifically, showing how practices, core ideas and crosscutting concepts work together to explain phenomena • Facilitating discussions where students use evidence and crosscutting concepts to support claims and compare ideas • Continuously monitoring student thinking to ensure they are engaging with all three dimensions simultaneously and meaningfully • Adjusting instruction based on student responses to maintain coherence across practices, ideas, and concepts 	<ul style="list-style-type: none"> • Applying core scientific ideas while noticing patterns, relationships or system interactions • Using crosscutting concepts to connect evidence and ideas across different contexts • Engaging in critical thinking and problem-solving, evaluating evidence and considering alternative explanations • Practicing applying knowledge and reasoning to novel or real-world situations • Reflecting on how their understanding grows as they integrate practices, ideas, and concepts

Resources to Support Educator Understanding

- [STEM Teaching Tool 41: Prompts for Integrating Crosscutting Concepts Into Assessment and Instruction](#) (Penuel & VanHorne, 2018)

Tools to Support Implementation

- [EQulP Rubric for Science](#) (Achieve, 2015)
- [Science Assessment Task Screener](#) (Achieve, 2016)
- [Wonder of Science Resource Cards](#) (The Wonder of Science, 2026)

Practice: Bundling and Sequencing of Units

Overview

All students need access to the full set of standards in each grade or grade band to build a complete and coherent understanding of science. Skipping or isolating standards can create knowledge gaps that make it harder for students to engage with more complex ideas in later grades. Because the standards spiral from kindergarten through high school, concepts and skills introduced early are revisited and expanded in

subsequent years. Missing key standards in earlier grades can have ripple effects, limiting students' ability to engage fully with phenomena or solve problems in later grades (Penuel et al, 2022; Krajcik et al, 2014).

Bundling standards around a phenomenon or problem is essential for meaningful science learning. Standards should never be taught in isolation; when presented one at a time, they risk becoming disconnected facts rather than tools for understanding the world. By organizing standards around a compelling phenomenon or real-world problem, teachers help students see how different scientific ideas and practices work together to explain what they observe. This approach allows the three dimensions (science and engineering practices, disciplinary core ideas and crosscutting concepts) to be redistributed and integrated in ways that make sense for investigating the phenomenon, rather than being confined to separate lessons (Haas et al, 2021).

What are teachers doing?	What are students doing?
<ul style="list-style-type: none"> • Identifying phenomena or problems that naturally connect multiple standards across a grade or grade band • Analyzing how disciplinary core ideas, science and engineering practices, and crosscutting concepts can be integrated to investigate the phenomenon • Bundling standards in ways that make sense for student understanding, rather than teaching them in isolation • Ensuring that all students will engage with all relevant standards in the grade or grade band • Sequencing lessons so that learning builds coherently and spirals appropriately from prior grades • Continuously reflecting on unit plans to ensure standards are taught in an integrated, meaningful way rather than as disconnected skills or facts 	<ul style="list-style-type: none"> • Revising explanations as they gather new evidence or insights, integrating multiple standards • Exploring how ideas build on prior knowledge and connect to concepts from previous grades • Solving problems and answering questions that require applying multiple standards together • Reflecting on their learning to understand how different ideas, practices and concepts work together • Developing the skills to reason, think critically and communicate explanations across all relevant standards

Resources to Support Educator Understanding

- [Iowa Academic Standards for Science](#), pp. 12-13 (Iowa Department of Education, 2025)

Tools to Support Implementation

- [Iowa Academic Standards for Science](#), pp. 137-139 (Iowa Department of Education, 2025)

Practice: Examining Effective Instructional Models

Overview

Cohesive units are most effective when they are structured around a central phenomenon or problem that captures students' curiosity and drives inquiry. Within these units, lessons are not isolated activities but are designed to help students explore big core ideas in depth. Students make sense of these ideas most effectively when they encounter a "need-to-know," a moment when they recognize a gap in their understanding that must be filled to explain the phenomenon (Nordine et al., 2019; Reiser et al., 2021; Penuel et al., 2022). This approach ensures that knowledge is not learned in isolation but is knowledge-in-

use, applied purposefully as students gather evidence, analyze data and develop explanations (Cherbow et al, 2026; Helker et al, 2025). Through this process, students are actively engaged in crafting claims, connecting evidence to ideas and refining their understanding as new information emerges (Doulouger et al, 2024).

What are teachers doing?	What are students doing?
<ul style="list-style-type: none"> Sequencing lessons so that each activity builds coherently from the student’s perspective, responding to their questions and emerging understanding Designing opportunities for students to experience a “need-to-know,” creating authentic motivation for learning and investigation Integrating science practices, core ideas and crosscutting concepts in ways that support sensemaking and application of knowledge Providing structures that promote student agency, allowing learners to make decisions about how to investigate, gather evidence and develop explanations Planning formative assessments that monitor understanding in real time, capturing how students are applying knowledge-in-use rather than just recalling facts Including scaffolds and supports to help all students access complex investigations while maintaining opportunities for choice and exploration Using assessment data to adjust instruction, responding to student thinking and maintaining a trajectory that supports meaningful, connected learning 	<ul style="list-style-type: none"> Making claims and supporting them with evidence, revising as new information is collected Exercising agency by making decisions about how to investigate, what questions to pursue and how to represent their findings Collaborating with peers to analyze data, discuss reasoning and refine explanations. Reflecting on their learning to connect evidence to ideas and build a coherent understanding Monitoring their own thinking and progress, recognizing how each step contributes to understanding the larger phenomenon Using feedback from teachers and peers to improve explanations and deepen reasoning

Resources to Support Educator Understanding

- [What are storylines?](#) (Next Generation Storylines, 2026)
- [OpenSciEd’s Instructional Approach](#) (OpenSciEd, 2018)
- [Anchored Inquiry Learning from BSCS](#) (Biological Sciences Curriculum Study, 2026)
- [Challenge Based Learning](#) (Challenge Based Learning, 2026)

Tools to Support Implementation

- [NGSS Storyline Tools](#) (Next Generation Storylines, 2026)
- [Anchored Inquiry Learning from BSCS](#) (Biological Sciences Curriculum Study, 2026)
- [Challenge Based Learning Toolkit](#) (Challenge Based Learning, 2026)

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