Critical Thinking
IN SCIENCE

FIRST BOOK

Critical Thinking in Science

> The value of an education... is not the learning of many facts but the training of the mind.
>
> ALBERT EINSTEIN

Traditionally, science was presented as a body of knowledge — concepts, theories, and facts. These are all essential elements of scientific literacy, but so is knowing how to do science. Project-based and inquiry-based science education reverses the traditional model because students are active participants in posing questions, gathering evidence, considering assumptions, analyzing data, proposing theories, and reaching conclusions. When critical thinking is part of science education, students do more than memorize facts; they learn to think like scientists and ask pertinent questions like: *Why is that true? Why is that right? Why is this the only option?*

Best Practices: Critical Thinking in Science

Our understanding of the scientific method has evolved into a flexible model rather than a rigid set of steps because science, in practice, is not a linear process. The following best practices encourage curiosity, trial and error, strategic questioning, and reflection.

USE PROJECT-BASED LEARNING (PBL)

Project-based learning (sometimes called problem-based learning) activates student engagement and learning through the investigation of a real-world question or problem. This model of teaching supports language learning, science literacy, social-emotional learning, problem-solving in other subjects, and communication skills. PBL is especially effective for underserved populations and English language learners. This 3-minute video gives a tangible example of PBL in science lessons. This guide provides more information about the steps and benefits and gives real examples from the classroom.

An EdWeek Research Center survey of more than 1,000 school leaders and educators found that 92 percent say students are more motivated to learn math and science when lessons are present using a problem-solving approach.

Source: Young Students Gravitate to Math. How Teachers Can Build on That Curiosity (edweek.org)

Next Generation Science Standards

The Next Generation Science Standards (NGSS) emphasize critical thinking as a core component of science education. The NGSS shift the focus from memorizing facts and performing tasks to developing deeper understanding and applying knowledge. Examples include:

Science and Engineering Practices (SEPs). Several SEPs involve critical thinking skills, including:

- Asking questions and defining problems
- Analyzing and interpreting data
- Constructing explanations and designing solutions

Inquiry-Based Learning. The NGSS advocate for inquiry-based learning, where students engage in hands-on investigations, ask questions, and develop their understanding through exploration.

Performance Expectations. Students are expected to apply knowledge in real-world scenarios, such as designing a solution to an environmental problem, which requires considering both scientific practices and societal needs.

TEACH MATHEMATICAL MODELING

Modeling engages students in addressing real-world situations and teaches students to:

- refine their understanding of a problem by asking questions and making assumptions
- use mathematical tools to solve the problem
- make decisions about how to solve the problem
- justify their problem-solving strategies
- test or revise their solutions if necessary

MAKE TIME FOR REFLECTION

Add reflection questions to labs and activities so students think about concepts and practical applications as much as the basic steps.

- What did you conclude?
- What did you learn?
- Why is it important?
- How does it relate to real life?
- What assumptions did you examine and/or reassess?

FIRST BOOK EDUCATOR

In my science classes, they are constantly asked to think like scientists, and I often do not give them straight answers, but encourage them to look at data and evidence.

AMANDA, FIRST BOOK EDUCATOR

USE THE "NOTICE AND WONDER" TEACHING STRATEGY

Notice and Wonder is a great tool for presenting science as a journey of discovery fueled by curiosity. This technique can be adapted to use with existing lessons and units. Begin by showing students some type of phenomenon, such as an image, a video, or a real-life scenario. Ask students to record what they see or notice. Next, have them write down all the questions that occur to them. Learn more about this strategy on Sadler Science.

DO LAB ACTIVITIES WITH TRIAL-AND-ERROR

A fundamental aspect of doing science is regrouping when things do not go as planned. Having to redesign or redo an experiment or reevaluate data are common practices in science and should be modeled and taught in the classroom too. Creative problem-solving and persistence are important life skills and part of most scientific discoveries.

Lessons & Activities

The following inquiry based lessons and activities ask students to utilize interactive methods to observe, look for patterns, question assumptions, and draw conclusions.

ELEMENTARY SCHOOL

RAIN OR SHINE | MYPBLWORKS

This project-based weather lesson for kindergartners teaches students to observe, investigate, notice patterns, analyze data, synthesize their findings, and draw conclusions — key components of critical thinking and scientific inquiry.

COMMON CORE CONNECTION
ELA: Writing: Text Types and Purposes

CCSS.ELA-Literacy.W.K.2 Use a combination of drawing, dictating, and writing to compose informative/explanatory texts in which they name what they are writing about and supply some information about the topic.

ANIMALS AND IMAGES: WHAT DO YOU SEE?

This science and media literacy lesson asks students to notice, look for patterns, and determine if an image is real. The lesson includes follow-up questions that activate critical thinking: How do you know that? What makes you say that? Does anyone have a different idea?

COMMON CORE CONNECTION
ELA: Writing: Craft and Structure

CCSS.ELA-Literacy.RI.1.6 Distinguish between information provided by pictures or other illustrations and information provided by the words in a text.

MIDDLE SCHOOL

STEM LESSONS THAT INTEGRATE MULTIPLE SUBJECTS | SCIENCE BUDDIES

These NGSS-aligned lesson plans can be standalone or used with the Global Problem Solvers series of animated videos featuring a team of smart, STEM-savvy teenagers who work together to solve real-world problems. The characters are fun and relatable and contribute diverse skill sets and views. The lessons contain interactive, hands-on STEM activities that allow students to design and prototype solutions to problems that parallel GPS storylines.

EXPLORER CLASSROOM | NATIONAL GEOGRAPHIC SOCIETY

Critical thinking is activated when students are engaged, and they're engaged when learning is interactive and relevant. The National Geographic Society's Explorer Classroom offers live sessions that connect young people with National Geographic Explorers — to hear behind-the-scenes stories and interact with innovative scientists, researchers, and powerful storytellers from around the globe.

HIGH SCHOOL

HISTORY OF ENDANGERED SPECIES | PROJECT LOOK SHARP

This science, media literacy, and critical thinking lesson asks students to consider how endangered species have been perceived by people in the US and how the media has contributed to that public perception. Topics include indigenous perspectives, whaling, habitat destruction, and the Endangered Species Act.

COMMON CORE CONNECTION
ELA: Reading: Informational Texts: Integration of Knowledge and Ideas

CCSS.ELA-Literacy.RI.9-10.8 Delineate and evaluate the argument and specific claims in a text, assessing whether the reasoning is valid and the evidence is relevant and sufficient; identify false statements and fallacious reasoning.

CLIMATE CHANGE THROUGH MEMES | PROJECT LOOK SHARP

This multidisciplinary lesson (art, media literacy, and environmental science) asks students to carefully consider the impact of memes relating to climate change. This exercise is especially relevant because social media is a common source of climate change information (and misinformation) for students.

COMMON CORE CONNECTION
ELA: Reading: Informational Texts: Integration of Knowledge and Ideas

CCSS.ELA-Literacy.RI.11-12.7 Integrate and evaluate multiple sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a question or solve a problem.

Sources

Critical Thinking in Science: Fostering Scientific Reasoning Skills in Students | Accelerate Learning
Teaching Critical Thinking in Science: The Key to Success | Cambridge
What is Project Based Learning? | PBLWorks