Pennsylvania STEELS Standards: What is Multi-Dimensional Learning?

The Science, Technology & Engineering, and Environmental Literacy & Sustainability (STEELS) Standards, adopted in Pennsylvania in 2022, guide the study of the natural and human-made world through inquiry, problem-solving, critical thinking, and authentic exploration. A major difference between the STEELS Standards and previous standards is multi-dimensional learning.

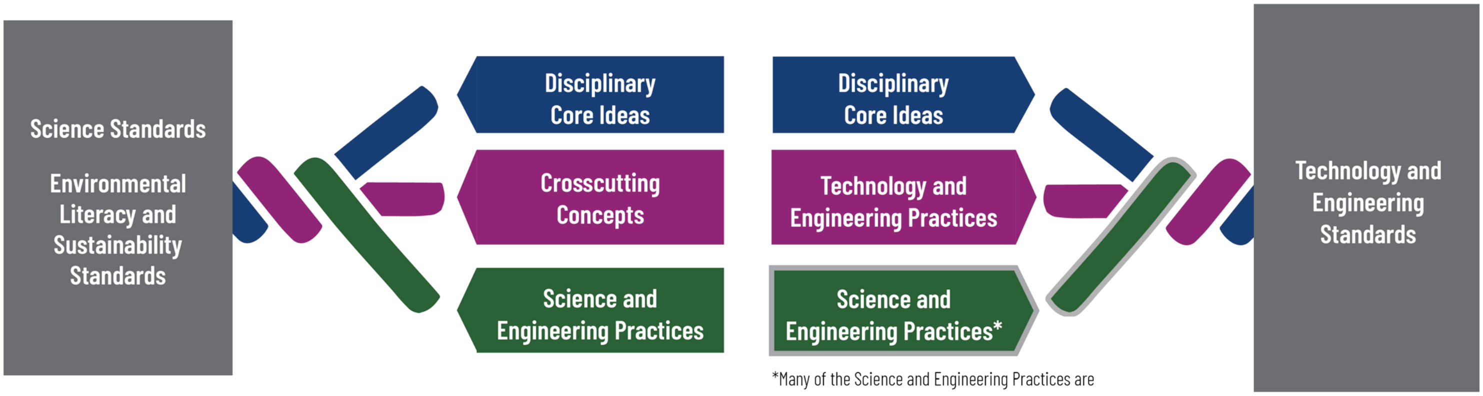
How does Multi-Dimensional Learning Work?

Multiple dimensions are combined to form each STEELS Standard. Multi-dimensional learning refers to the thoughtful and deliberate integration of several dimensions:

- Scientific and Engineering Practices (SEPs)
- Technology and Engineering Practices (TEPs)
- Disciplinary Core Ideas (DCIs)
- Crosscutting Concepts (CCCs)

The STEELS Standards require students to use ideas and practices represented by these dimensions at the same time — not separately — to make sense of the world and solve problems, reflecting how these fields are practiced in the real world and leading to deeper learning. **This indicates not just a change in *what* is taught and learned, but also *how* it is taught and learned.**

Students develop and use:



*Many of the Science and Engineering Practices are included in the T&E Standards to provide additional alignment and connections for educators.

In order to:

Make Sense of a Phenomenon

Example Phenomenon

When Melody hit the plunger against the wall, it stuck.

Design a Solution to an Engineering Problem

Example Problem

People are getting sick when eating fish from the Susquehanna River.

What are the Dimensions of the STEELS Standards?

Each of the dimensions of the STEELS Standards has a distinct purpose. Descriptions of each dimension are below:

Disciplinary Core Ideas

Explanatory ideas in each science discipline that scientists, technologists, and engineers use.

Life Science

Core ideas include:

- From Molecules to Organisms: Structures and Processes
- Ecosystems: Interactions, Energy and Dynamics
- Heredity: Inheritance and Variation of Traits
- Biological Evolution: Unity and Diversity

Physical Science

Core ideas include:

- Matter and Its Interactions
- Motion and Stability: Forces and Interactions
- Energy
- Waves and Their Applications in Technologies for Information Transfer

Earth and Space Science

Core ideas include:

- Earth's Place in the Universe
- Earth's Systems
- Earth and Human Activity

Engineering, Technology, and Applications of Science

Core ideas include Engineering Design and links among Engineering, Technology, Science, and Society. Definitions include:

- **Technology** is any modification of the natural world made to fulfill human needs or desires.
- **Engineering** is a systematic and often iterative approach to designing objects, processes, and systems to meet human needs and wants.
- **An application of science** is any use of scientific knowledge for a specific purpose, whether to do more science; to design a product, process, or medical treatment; to develop a new technology; or to predict the impacts of human actions.

* Environmental Literacy and Sustainability standards include life science, earth and space science, and engineering, technology, and applications of science DCIs.

Crosscutting Concepts

Concepts that scientists, technologists, and engineers use to deepen their understanding of situations and make connections across subject areas.

Patterns

Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.

Cause and Effect

Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.

Scale, Proportion, and Quantity

In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.

Systems and System Models

Defining the system under study — specifying its boundaries and making explicit a model of that system — provides tools for understanding and testing ideas that are applicable throughout science and engineering

Energy and Matter

Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.

Structure and Function

The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.

Stability and Change

For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.

Science and Engineering Practices

A set of skills used by scientists, technologists, and engineers to build, deepen, and apply scientific knowledge.

Asking questions and defining problems

- **In science:** Ask questions about the texts they read, the features of the phenomena they observe, and the conclusions they draw from their models or scientific investigations.
- **In engineering:** Ask questions to define the problem to be solved and to elicit ideas that lead to the constraints and specifications for its solution.

Planning and carrying out investigations

- **In science:** Investigations may be undertaken to describe a phenomenon, or to test a theory or model for how the world works.
- **In engineering:** Investigations might be to find out how to fix or improve the functioning of a technological system or to compare different solutions to see which best solves a problem.

Constructing explanations and designing solutions

- **In science:** Scientists construct logically coherent explanations of phenomena that incorporate their current understanding of science, or a model that represents it, and are consistent with the available evidence.
- **In engineering:** While there is usually no single best engineering solution but rather a range of solutions, engineers determine the optimal choice through a process of balancing competing criteria of desired functions, scientific understanding, technological feasibility, cost, safety, esthetics, and compliance with legal requirements.

Engaging in argument from evidence

- **In science:** Scientists must defend their explanations with reasoning and argument, formulating evidence based on a solid foundation of data, examining their own understanding in light of the evidence and comments offered by others, and collaborating with peers in searching for the best explanation for the phenomenon being investigated.
- **In engineering:** Reasoning and argument are essential for finding the best possible solution to a problem. Engineers collaborate with their peers throughout the design process, with a critical stage being the selection of the most promising solution among a field of competing ideas.

Developing and using models

- **In science:** Models are used to represent a system (or parts of a system) under study, to aid in the development of questions and explanations, to generate data that can be used to make predictions, and to communicate ideas to others.
- **In engineering:** Models may be used to analyze a system to see where or under what conditions flaws might develop, test possible solutions to a problem, visualize and refine a design, or communicate a design's features to others.

Analyzing and interpreting data

- **In science:** Investigations produce data that must be analyzed in order to derive meaning. Scientists use a range of tools — including tabulation, graphical interpretation, visualization, and statistical analysis — to identify the significant features and patterns in the data so they may be used as evidence.
- **In engineering:** Engineers analyze data collected in the tests of their designs and investigations; this allows them to compare different solutions and determine which design best solves the problem within the given constraints. Like scientists, engineers require a range of tools to identify the major patterns and interpret the results.

Using mathematics and computational thinking

- **In science:** Mathematics and computation are fundamental tools for representing physical variables and their relationships. They are used for a range of tasks, such as constructing simulations, statistically analyzing data, and recognizing, expressing, and applying quantitative relationships.
- **In engineering:** Mathematical and computational representations of established relationships and principles are an integral part of design. For example, structural engineers create mathematically based analyses of designs to calculate whether they can stand up to the expected stresses of use and completed within acceptable budgets.

Obtaining, evaluating, and communicating information

- **In science:** A major practice of science is thus the communication of ideas and the results of inquiry — orally, in writing, with the use of tables, diagrams, graphs, and equations, and by engaging in extended discussions with scientific peers. Science also requires the ability to derive meaning from scientific texts, to evaluate the scientific validity of the information thus acquired, and to integrate that information.
- **In engineering:** Engineers need to be able to express their ideas, orally and in writing, with the use of tables, graphs, drawings, or models and by engaging in extended discussions with peers. They also must derive meaning from colleagues' texts, evaluate the information, and apply it usefully.

Technology and Engineering Practices

Abilities and dispositions that are fundamental in order to successfully apply technology and engineering ideas in different contexts.

Systems Thinking

All technologies contain interconnected components and these technologies interact with the environments in which they operate. Systems consist of inputs, processes, outputs, and feedback.

Creativity

Creativity is the use of investigation, imagination, innovative thinking, and physical skills to create new products and strategies to accomplish goals, including design goals.

Making and Doing

This practice refers to the skills and abilities to safely and effectively produce technological products, systems, and processes with appropriate tools and materials.

Critical Thinking

Critical thinking involves questioning, logical thinking, reasoning, and elaboration in the process of making informed decisions. Evidence and computational thinking help better understand and solve problems and defend technological decisions.

Optimism

Optimism is a commitment to finding better solutions to design challenges through experimentation, modeling, and adaptation. It also reflects a positive view in which opportunities can be found in every challenge, as well as persistence in looking for solutions to technological problems.

Collaboration

Collaboration is having the perspectives, knowledge, capabilities, and willingness to seek out and include team members when working on design challenges.

Communication

Communication in technology and engineering can be considered in two ways: to define problems by gaining an understanding of the wants and needs of the users of technology, and as a means of developing and explaining choices made in the design process.

Attention to Ethics

In technology and engineering, attention to ethics means focusing on the impact of technological products, systems, and processes on others and on the environment. Students should evaluate risks and consider trade-offs and the role of regulation in their decision making.

See the grade-level learning expectations for Science and Engineering Practices (Link to Download PDF 722KB), Crosscutting Concepts (Link to Download PDF 464KB), Technology and Engineering Practices (Link to Download PDF 433KB), and Disciplinary Core Ideas.