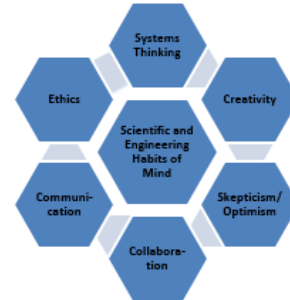


# Scientific and Engineering Habits of Mind

Scientific and Engineering Habits of Mind refer to the values, attitudes, and thinking skills associated with science and engineering. Many consider these habits of mind essential 21<sup>st</sup> century skills<sup>1</sup>.

**Systems thinking** provides learners with the skills to recognize important relationships among the various parts of a system. It is important for learners to understand that systems may have unexpected effects that cannot be predicted from the behavior of the individual sub-systems alone and any system model created incorporates assumptions and approximations that affect reliability and precision. Systems thinking is a skill that helps scientists construct explanations of natural phenomena and engineers design smart and enduring solutions to problems.



**Creativity** is a necessary element in scientific and engineering practices. Creative thinking is an important skill that is used in science and engineering to come up with alternative explanations /solutions, devise new ways of testing ideas, look at old data in a new light, create new products of value to society (engineering) and identify new scientific questions that have yet to be answered (science).

**Skepticism / Optimism** Skepticism refers to the nature of scientific knowledge. It is inherently tentative and can be modified if new evidence, interpretations, or better explanations are constructed. Scientists encourage others to thoroughly analyze the strengths and weaknesses of scientific explanations and scientific tests. Optimism refers to the infinite possibilities and opportunities inherent in every challenge that lead to thoughtful, socially relevant solutions.

**Collaboration** Scientists and Engineers belong to and practice within global communities. These communities provide cultural norms, expectations, and accumulated knowledge, which are essential to progress. Collaboration or teamwork is a skill that leverages each member's perspective, capabilities, and knowledge to address questions and challenges.

**Communication** skills are essential to successful teamwork, understanding consumer/societal needs, and explaining design decisions or interpretations of data related to the challenge or question being investigated.

**Ethics** In science and engineering, rules of good behavior are essential for maintaining the quality of scientific explanations or engineering products. Because science and engineering is a human activity, what is valued in society influences what is valued in those disciplines. Scientists and Engineers work within a culture where they expect each other to scrutinize their explanations and solutions, be honest and objective in reporting data and ideas, and credit the data and ideas from those that influence their work. When applications of scientific research could pose risks to society, scientists' decisions to participate in that research are based on personal as well as professional ethics. It is crucial for scientists and engineers to understand issues related to intended and unintended consequences of their work. This framework provides a flexible structure of meanings to the study of integrated STEM education.

<sup>1</sup> This phrase has its origins in the work of the American Association for the Advancement of Science (AAAS) Science for All Americans (1989) and the 2009 National Academy of Engineering's Committee on K-12 Engineering Education (NRC, 2009).