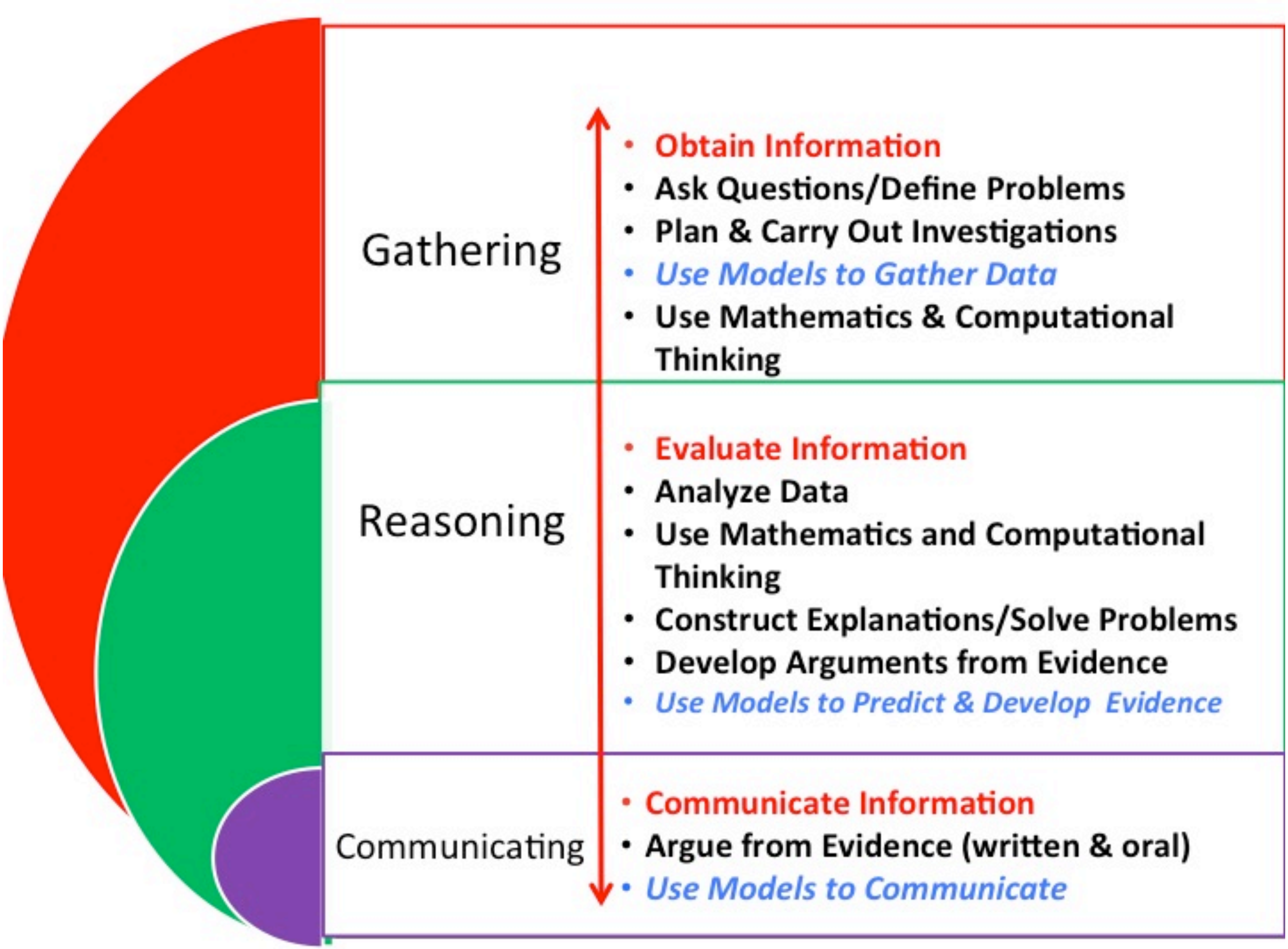
# Science and Engineering Practices




(Moulding, 2012)

# Science and Engineering Practices

1. **Asking Questions (Science) and Defining Problems (Engineering)**
   Students asking questions is fundamental to gather relevant information in the process of making sense of phenomena. Students should develop questions that can be answered using empiri evidence. In engineering, the process of gathering information begins with defining problems. Questions are asked by students to help gather information that can be used to make sense of problems.
2. **Developing and Using Models**
   Students use models in a number of ways to gather information using charts, graphs, or physical models that generate data (e.g., stream model, weather models). Students use models to reas and make sense of phenomena and make predictions (e.g., model of Earth, moon and sun to make sense of relative position and phases, equations F = ma, bridges with stress on key points), a communicate ideas using models (e.g., graphs, solar system, balanced chemical equations). Some models may be used across all three phases of gathering, reasoning, and communicating.
3. **Planning and Carrying Out Investigations**
   Students gather information and data through investigations in the field, laboratory, or mind. Planning an investigation requires significantly more knowledge and skills than carrying out an investigation. In the early grades, students generally carry out investigations planned for them, but often in the middle grades the investigations students do are ways to scaffold the tools anc abilities to plan future investigations. Some investigations require students to plan and carry out experiments requiring identification of variables to control, as well as selection of an independent variable and monitoring of the dependent variables. Students engage in investigations that test solutions to engineering designs. This process requires students to determine relevant variables, ways to measure and collect data, and the most useful analysis of data to provide evidence of the effectiveness, efficiency, and durability of various designs. This analysis m be done under the criteria and constraints of the problem.
4. **Analyzing and Interpreting Data**
   Investigations provide data that, when analyzed, provide greater insights into cause and effect relationships. Often, until analyzed, the data has little meaning. Students may use a number of tools and techniques (e.g., graphs, statistical analysis, charts, tables, models) to make sense of data. Often the tools are used to seek patterns in data or determine if a finding is significant or n significant. The ability to analyze data has been greatly enhanced (e.g., determining the accuracy of data, developing visualizations of data) by modern computational tools. Analyzing data fr testing engineering designs is useful to determine the best solution to a problem or provide a fair test to compare the efficiencies of multiple engineered systems.
5. **Using Mathematics and Computational Thinking**
   Mathematics and computational thinking are fundamental tools for representing physical variables and relationships. These tools are useful for a range of processes for reasoning to construc meaning by way of simulations, statistically analyzing data, and recognizing, expressing, and applying quantitative relationships. Statistical techniques are useful tools to analyze data and develop ways to recognize patterns in causal and correlational relationships. The mathematical models students use are critical for solving problems via engineering. Often the mathematica reasoning and computational thinking are the skills students use to engage in engineering design solutions. Mathematical representation of relationships of phenomena is important for stud making sense of cause and effect relationships. Utilizing computers to gather, analyze, and communicate information requires students to think of gathering data using electronic devices (e.g. motion detectors, pressure gages, pH meters, digital cameras), analyzing data using spreadsheets, and communicating the information via the web and social media tools. Students of the 21st century are quick to access and use these tools.
6. **Constructing Explanations (Science) and Designing Solutions (Engineering)**
   The central outcome of science education is for students to develop the skills to construct explanations supported by evidence for the causes of phenomena. The goal of an explanation is to provide an account of the most plausible mechanism for a phenomenon that is simple, logical, and consistent with existing data. Often individuals may have multiple explanations for the sam phenomenon that are somewhat or completely inconsistent. Students' explanations of phenomena are based on evidence from a personal set of core ideas, information from observations and/or investigations, and application of crosscutting concepts. Students should be able to construct coherent explanations of phenomena consistent with their evidence and accepted scienc theories. Designing solutions to engineering problems requires students to design a systematic process for considering the problem, determining constraints and accommodating criteria. "Solutions result from a process of balancing competing criteria of desired functions, technological feasibility, cost, safety, esthetics, and compliance with legal requirements." (Framework 20
7. **Engaging in Argument from Evidence**
   Arguments build from explanations and set forth the reasoning that connects evidence to explanations. Arguing in science is very different from the common playground use of the word. Arguing in science is the systematic line of evidence connecting the most logical (best) explanation for an observed natural phenomenon. Argumentation is an essential tool to reveal the strengths and weaknesses in reasoning that connects an explanation to available evidence. Students proficient in argument are able to produce arguments to defend their own explanations a well as accept reasoned arguments from others that lead to modifying or abandoning their own line of reasoning in light of new evidence or reasoned explanations. Additionally, and perhaps more importantly is for students to develop the skills and dispositions to offer reasoned and civic comments to others' arguments and remain focused on the explanation, reasoning, and evidence and not the person making the argument. Because argument is a two-way proposition, it should be done in a collaborative environment where everyone is seeking the best explanat for the available evidence. Engineering uses reasoned argument as well to determine the best solution to a problem. Argument is one of the tools to find the best solution to a problem given criteria and constraints. In engineering, it is not about the truth, but about the best solution to a problem. Argumentation is one of the tools to systematically compare alternative solutions tc problem and support one solution over others (See appendix A for additional insights into argumentation).
8. **Obtaining, Evaluating, and Communicating Information**
   Science and engineering depend upon the ability to add to the body of knowledge and to access that body to use when new phenomena or problems arise. The process of obtaining, evaluatin and communicating information requires students engage in all of the practices in their progression of gathering, reasoning, and communicating. Reading and listening are two ways student: obtain information, but they also gather information from asking questions, conducting investigations, making observations, considering mathematical relationships, phenomena, and using models to gather information on phenomenon. In the 21st century, students have devices they can use to gather information quickly and efficiently, but the information must be evaluated carefully before it should be used in science. The evaluation of the scientific validity of information has become an essential skill of the 21st century. Writing and speaking are critical ways students can communicate their findings and ideas, but models and argument are equally important tools to communicate science information.