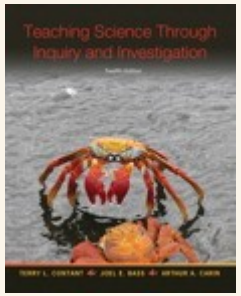

CHAPTER 1: Framing Science and Science Education

Teaching Science Through Inquiry and Investigation

Twelfth Edition

Contant/Bass/Carin

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What Do *Science* and *Science Education* Mean to You?

Science is a way of thinking much more than it is a body of knowledge.

Carl Sagan

Science is simply common sense at its best.

Thomas Huxley

Equipped with his five senses, man explores the universe around him and calls the adventure Science.

Edwin Powell Hubble, The Nature of Science, 1954

What do you think it is?

Is it a way of looking at or observing natural phenomena?

Is it just another school subject, like math and English, but with a much larger textbook?

Is it activities done in a lab with beakers and test tubes?

Is it about memorizing a multitude of facts about chemistry, physics, astronomy, biology, etc.?

I am among those who think that science has great beauty. A scientist in his laboratory is not only a technician: he is also a child placed before natural phenomena which impress him like a fairy tale.

- Marie Curie (1867-1934)

What is Science ?

Over the course of human history, people have developed many interconnected and validated ideas about the physical, biological, psychological, and social worlds. Those ideas have enabled successive generations to achieve an increasingly comprehensive and reliable understanding of the human species and its environment. The means used to develop these ideas are particular ways of observing, thinking, experimenting, and validating. These ways represent a fundamental aspect of the ***nature of science*** *and reflect how science tends to differ from other modes of knowing.*

Science for All Americans

Rather than define science, consider its key characteristics…

- It focuses on explaining the natural (not the supernatural) world.
- It involves testable ideas.
- It relies on evidence.
- It involves the scientific community.
- It utilizes scientific behavior.

Scientists display certain attitudes and habits of mind when doing science.

- Scientific investigations use a variety of methods. (Science and Engineering Practices)
- Science is a way of knowing. (Cross-cutting Concepts)
- Scientific knowledge is based on empirical evidence. (Science and Engineering Practices)
- Scientific knowledge assumes an order and consistency in natural systems. (Cross-cutting Concepts)

Frame 1 of 2

Attitudes and habits of mind when doing science continued…

- Scientific knowledge is open to revision in light of new evidence. (Science and Engineering Practices)
- Science is a human endeavor. (Cross-cutting Concepts)
- Science models, laws, mechanisms, and theories explain natural phenomena. (Science and Engineering Practices)
- Science addresses questions about the natural and material world. (Cross-cutting Concepts)

Source: Achieve, 2013 a.

Frame 2 of 2

Children are Natural-born Scientists

They begin recognizing and sorting out their world from the moment of birth, and perhaps even earlier.

They exhibit natural curiosity.

They wonder where the wind, rain, snow, and hail come from.

They wonder why mold grows on strawberries.

They wonder why fish can breathe in water and why birds can fly.

The attitudes and habits of mind displayed by scientists should be modeled and taught by teachers when they teach science.

Curiosity

Desire for Knowledge

Placing a Priority on Evidence

Willingness to Modify Explanations

Cooperation in Investigating Questions and Solving Problems

Honesty

Attitudes/Habits of Mind	Description
Curiosity	An enduring interest and fascination about the natural and human-constructed worlds is vital, yet personal, ingredient in the production of scientific knowledge.
Desire for Knowledge	An urge, even “rage” to know and understand the world.
Placing a Priority on Evidence	Using data as the basis for testing ideas and respecting the facts as they accrue.

Attitudes/Habits of Mind	Descriptions
Willingness to Modify Explanations	Changing initial conceptions and explanations when the evidence suggests different ones.
Cooperation in Investigating Questions and Solving Problems	Working in collaboration with others is fundamental to the scientific process.
Honesty	Presenting data as they are observed, not as the investigator wishes them to be.

Science goes on in many different settings.

Scientists are employed by:

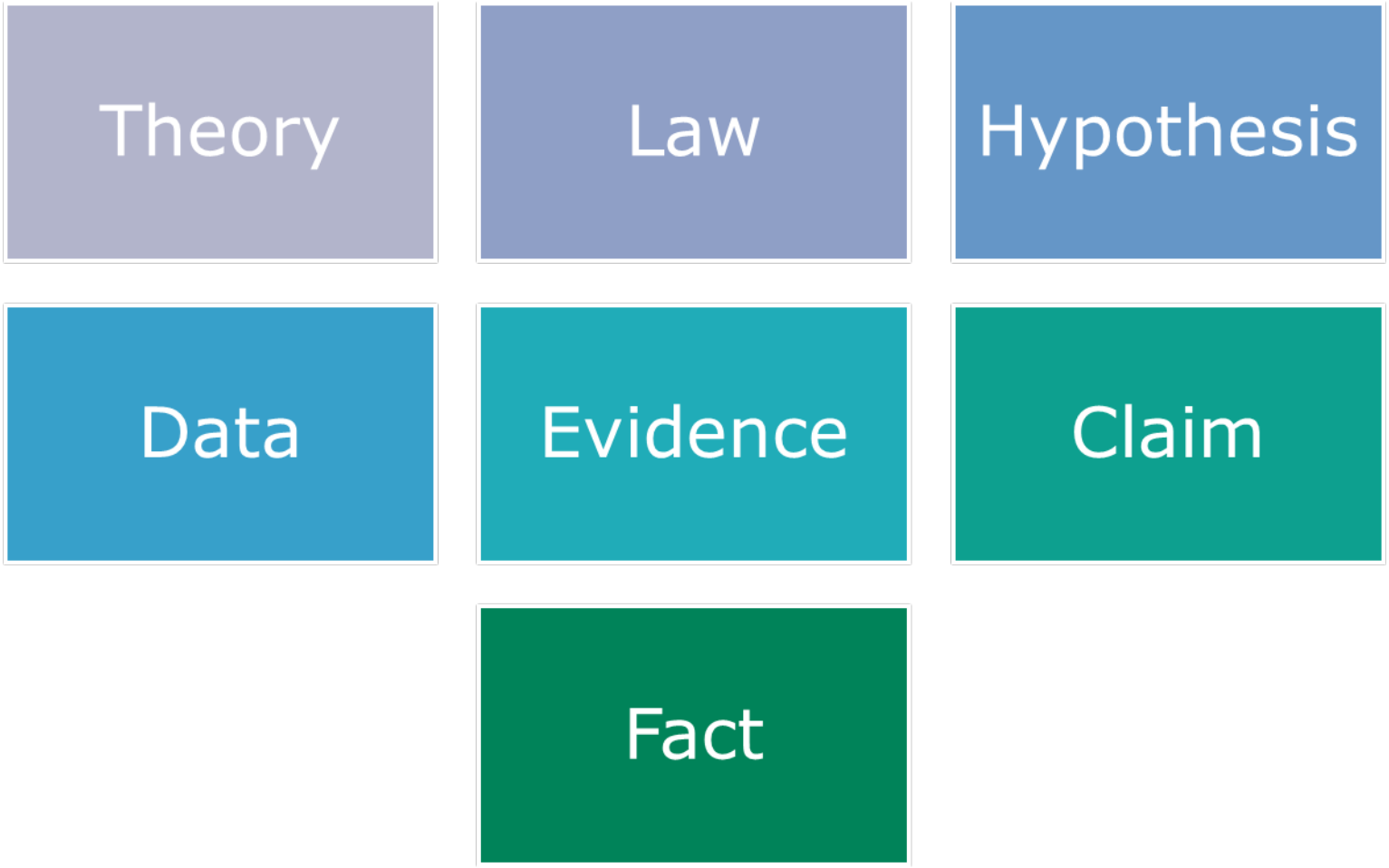
- universities,
- hospitals,
- business and industry,
- government,
- independent research organizations, and
- scientific associations.

They may work alone, in small groups, or as members of large research teams. Their places of work include:

- ✓ classrooms,
- ✓ offices,
- ✓ laboratories, and
- ✓ natural field settings from space to the bottom of the sea.

Science for All Americans

Words with Special Meanings in Science



Theory

A complex explanation about how nature works that has been well tested and is supported by evidence. A theory is so well established that it is unlikely that new data will totally discredit it.

In simple words:

...an untested idea or conjecture; a guess, speculation, opinion, or belief.

Law

A description of what happens naturally under certain conditions. It will predict what will happen as long as those conditions are met. A scientific law only describes; it doesn't explain.

Or simply:

...a rule; something that must be followed;

Two More "Special Meaning" Words…

Hypothesis

A testable idea that may contribute to the development of a scientific theory.

(Not generally used outside of science)

Data

Observations, measurements, or inferences recorded for later analysis.

Otherwise known as:

…information

Evidence

The cumulative body of data or observations of a phenomenon.

...what detectives look for and use to solve a crime.

Claim

Always based on evidence. May or may not stand the test of time; some will eventually be shown to be false.

...anything people say is true.

Fact

A claim that is demonstrated to occur forever and always in any context. Evidence and claims of phenomena that come together to develop and refine or to challenge explanations.

...anything that is considered true. (Unfortunately, some information is considered factual because it appeared in the newspaper, it was on the internet, or an authority said so!)

Why Should Science Be Taught in Elementary and Middle Schools?

"Lifelong scientific literacy begins with understandings, attitudes, and values established in the earliest years."

(NRC, 1996, p. 114)

"Our species needs, and deserves, a citizenry with minds wide awake and a basic understanding of how the world works."

- Carl Sagan

For students in the early grades, the emphasis should overwhelmingly be on gaining experience with natural and social phenomena and on enjoying science.

Benchmarks~Project 2061~AAAS (Chapter 1)

Carl Sagan, in S. W. Hawking, *A Brief History of Time* (New York: Bantam Books, 1988

Except for children (who don't know enough not to ask the important questions), few of us spend much time wondering about why nature is the way it is; where the cosmos came from, or whether it was always here; if time will one day flow backward and effects precede causes; or whether there are ultimate limits to what humans can know… In our society it is still customary for parents and teachers to answer most of these questions with a shrug.

Characteristics of Science

For its part, science education—meaning education in science, mathematics, and technology—should help students to develop the understandings and habits of mind they need to become compassionate human beings able to think for themselves and to face life head on. It should equip them also to participate thoughtfully with fellow citizens in building and protecting a society that is open, decent, and vital.

NSTA Position Statement on
The Nature of Science

All those involved with science teaching and learning should have a common, accurate view of the **nature of science**. Science is characterized by the systematic gathering of information through various forms of direct and indirect observations and the testing of this information by methods including, but not limited to, experimentation. The principal product of science is knowledge in the form of naturalistic concepts and the laws and theories related to those concepts.

Declaration
NSTA

The **N**ational **S**cience **T**eachers **A**ssociation endorses the proposition that science, along with its methods, explanations and generalizations, must be the sole focus of instruction in science classes to the exclusion of all non-scientific or pseudoscientific methods, explanations, generalizations and products.

The following premises are important to understanding the nature of science:

- Scientific knowledge is simultaneously reliable and tentative.
- Although no single universal step-by-step scientific method captures the complexity of doing science, a number of shared values and perspectives characterize a scientific approach to understanding nature.
- Creativity is a vital, yet personal, ingredient in the production of scientific knowledge.
- Science, by definition, is limited to naturalistic methods and explanations and, as such, is precluded from using supernatural elements in the production of scientific knowledge.
- A primary goal of science is the formation of theories and laws, which are terms with very specific meanings.

What are Habits of Mind?

Habits of Mind are dispositions that are skillfully and mindfully employed by characteristically intelligent, successful people when they are confronted with problems, the solutions to which are not immediately apparent. When we draw upon these mental resources, the results are more powerful, of higher quality, and of greater significance than if we fail to employ those habits.

"While there may be more, 16 characteristics of effective problem-solvers have been derived from studies of efficacious problem-solvers from many walks of life." (Costa and Kallick, 2009).

Persisting

Managing Impulsivity

Remaining open to continuous learning

Thinking flexibly

Listening with understanding and empathy

Thinking Independently

Finding Humor

Thinking about your thinking (metacogntion)

Taking responsible risks

Responding with wonderment and awe

Striving for accuracy

Questioning and problem posing

Gathering data through all senses.

Applying past knowledge to new situations

Thinking and communicating with clarity and precision

Inquiry in the Daily Curriculum

The National Science Teachers Association (NSTA) advocates that inquiry science must be a basic part of the daily curriculum of every elementary school student at every grade level because the science education reform reports, published in the 1990s, stress the importance of early experiences in science in developing problem-solving skills needed to be productive citizens in the twenty-first century (NSTA, 2002).

The Science Learning Journey

NSTA also considers middle school to be a critical time in students' science learning journey. Studies indicate that if students aren't interested in and excited by science by seventh grade, they probably never will be.

Science Learning Journey Continued…

It is important that middle school teachers present science concepts in ways that are both **age-appropriate and engaging** so that students continue to build on their prior knowledge and attain the necessary background to participate successfully and responsibly in our highly scientific and technological society (NSTA, 2003).

Scientific Literacy

The *National Science Education Standards* (NSES) define *scientific literacy* as:

> ...the knowledge and understanding of scientific concepts and processes required for personal decision-making, participation in civic and cultural affairs, and economic productivity (NRC, 1996, p. 22).

According to the NSES, *"Lifelong scientific literacy begins with understandings, attitudes, and values established in the earliest years"* (NRC, 1996, p. 114).

National Concerns

The National Academies of Science produced a report, *Rising Above the Gathering Storm* (National Academies of Science, 2006), that details some of the global issues our nation faces.

Committee Findings
Since the early 1990s, The United States has become a net importer of high-technology products.
Other nations are graduating considerably more engineers, computer scientists, and information technologists than the United States.
Lower labor costs and the availability of highly trained scientists and engineers have led to the location of factories by U.S. companies in foreign countries and the outsourcing of many jobs.
International assessments in math and science indicate that U.S. K–12 students lag behind students from other countries.

Science Education for the Future

In the mid-1990s, the National Research Council commissioned a panel to examine the state of science education in elementary and middle schools in our nation. In the report, *Taking Science to School: Learning and Teaching Science in Grades K–8* (NRC, 2007), the panel critiqued and evaluated the standards movement and made recommendations about science education for the future.

Slide 1 of 2

Science Education for the Future

The panel also reviewed contemporary studies from psychologists and educators about how children develop understanding in science. Among the recommendations of the committee was the call to reduce the K–12 science content taught and to emphasize fewer well-chosen core concepts to focus more on understanding rather than just accumulating knowledge.

Slide 2 of 2

What Does It Mean to be Proficient in Science? NRC's Recommended New View…

"Students who are proficient in science:
1. know, use, and interpret scientific explanations of the natural world;
2. Generate and evaluate scientific evidence and explanations;
3. Understand the nature and development of scientific knowledge; and
4. Participate productively in scientific practices and discourse" (NRC, 2007, p.36).

National Science Education Reform Documents

- *Science for All Americans*
- *Benchmarks for Science Literacy*
- *National Science Education Standards*
- *Atlas of Science Literacy, Volumes 1 and 2*
- *Inquiry and the National Science Education Standards*
- *Rising Above the Gathering Storm*
- *Taking Science to School: Learning and Teaching Science in Grades K–8*
- *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*
- *Next Generation Science Standards*

Next Generation Science Standards

Marking the culmination of a three-year, multiphase process, on April 10th, 2013, a 26-state consortium released the Next Generation Science Standards (NGSS), a detailed description of the key scientific ideas and practices that all students should learn by the time they graduate from high school.

The standards are based largely on the 2011 National Research Council report A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas

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Description of NGSS

Next Generation Science Standards identifies the science all K-12 students should know. These new standards are based on the National Research Council's *A Framework for K-12 Science Education*.

The National Research Council

The National Research Council, the National Science Teachers Association, the American Association for the Advancement of Science, and Achieve have partnered to create standards through a collaborative state-led process. The standards are rich in content and practice and arranged in a coherent manner across disciplines and grades to provide all students an internationally benchmarked science education.

Final Thoughts

"Science and technology may be advancing at a supersonic pace, but elementary science education is still frozen in the past."

-William DiPuccio Akron Beacon Journal December 2007

"Unless someone like you cares a whole awful lot, nothing is going to get better. It's not."

~The Lorax