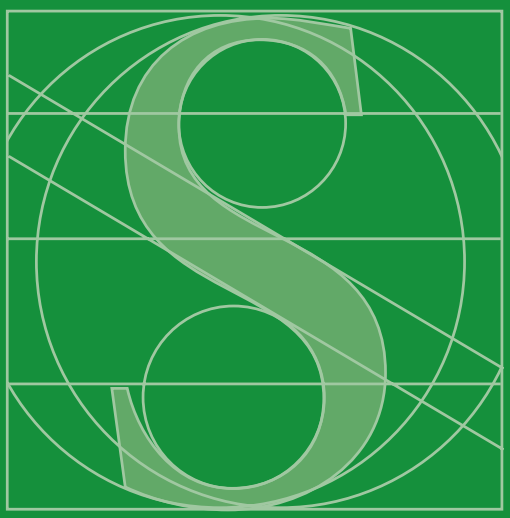
9TH GRADE-12TH GRADE

History and Nature of Science



Content Standard G:

As a result of activities in grades 9-12, all students should develop understanding of

- **Science as a human endeavor**
- **Nature of scientific knowledge**
- **Historical perspectives**

Content Summary

National Science Education Content Standards

K-4

Science as a human endeavor

5-8

Science as a human endeavor

Nature of science

History of science

9-12

Science as a human endeavor

Nature of scientific knowledge

Historical perspectives

Minnesota Graduation Standards

Primary Level

Intermediate Level

Historical Events:
Understand historical events and contributions of key people from different time periods

Middle Level

Career Exploration:
Explore career and education options to make informed decisions for future life choices

High School Level

History of Science:
Understand the interaction between social, economic, technological, and/or environmental factors and the occurrence of scientific advances

Cultures Across Time:
Understand the significance of events and themes across cultures and time

Focus K-12

Grade	Early	Late
K-4	The focus of instruction for all students early in this grade range is on developing an awareness that science is something that students do and relating that to what scientists do.	The focus of instruction for all students later in this grade range is on developing an understanding that science is an ongoing process and that many men and women are involved in the advancement of scientific understandings.
5-8	The focus of instruction early in this grade range is on providing all students opportunities to understand the nature of science by examining their own inquiry investigations and historical examples.	The focus of instruction for all students later in this grade range is on using student investigations, case studies, and historical examples from a variety of cultures to help students understand scientific inquiry, the nature of scientific knowledge, and interactions between science and society.
9-12	The focus of instruction for all students at the high school level is on using historical examples to understand the human dimension of science and technology, the nature of scientific knowledge, and the enterprise of science and technology in a variety of historical and cultural perspectives.	The focus of instruction for students pursuing further study is on providing opportunities for students to analyze and replicate historical and contemporary scientific investigations and explore their cultural and historical implications.

Close-up 9-12

The focus of instruction at the high school level is on using historical examples to understand the human dimension of science and technology, the nature of scientific knowledge, and the enterprise of science and technology in a variety of historical and cultural perspectives.

Scientific inquiry, what scientists do, is central to the *National Science Education Standards.* The history of science provides a window on the understanding of the enterprise of science. The inclusion of a historical perspective allows all students to see how science has worked in the past, that science is something a great variety of people just like themselves do, how science operates as a subculture, and how change occurs in science. Students identify examples of the impact of science and technology on their lives and trace its origins. By investigating the historical development of a specific law or theory, students can gain an understanding of how new discoveries are incorporated and how they change our understanding and that many 'facts' are tentative. Students grasp the importance of chance discoveries, understand the necessity of an open-minded attitude and see the importance of perseverance through adversity. Student investigations should mirror ethical practices, peer review, truthful reporting, and making public their results. They investigate and analyze how scientific breakthroughs are influenced by the societal, economic, political, technological and environmental context of the time, and that science has both immediate and long term effects on society. Students and teachers observe established science safety procedures.

The focus of instruction for students pursuing further study is on providing opportunities for students to analyze and replicate historical and contemporary scientific investigations and explore their cultural and historical implications.

Students pursue further study in a course of study or through independent explorations. In addition to the teacher, they use a variety of community and/or electronic resources. They explore in-depth the views of historical figures and gain a perspective of the historical context, and evolution of important ideas in science. As students recreate historical experiments and review primary documents, they explore and experience the changing nature of scientific knowledge and how scientists construct knowledge about natural phenomena. Students examine how the needs and priorities of society influence the direction and support of scientific research. Students and teachers observe established science safety procedures.

On Location 9-12

Understanding "science as a way of knowing" has a long history as an objective for science instruction. The vision presented by the National Science Education Standards (NSES) continues this tradition, making this outcome much more explicit than it has been in the past. According to the NSES, the purpose of the history and nature of science standard is to "use history to elaborate various aspects of scientific inquiry, the nature of science, and science in different historical and cultural perspectives."

Ms. O approaches science from a historical point of view. Her science units are developed with an eye to tracing the history of important science concepts and the relationship between the study of nature and culture.

Her students construct a time line on which scientists and important scientific concepts are recorded. The timeline is used throughout the course to relate concepts students are learning to how concepts and theories changed when new evidence and new tools for scientific investigation were developed. This provides students insights into how knowledge develops in science as well as how scientists make judgments. Students begin to appreciate the nature of scientific ideas, especially the lack of absolute certainty that accompanies the construction of scientific knowledge. In addition, students learn about the role of human imagination and creativity in science.

One of the side benefits for students is that historical approaches give science a human face. Students easily identify with Newton when they learn that although his father died, his mother remarried and he grew up in a poor household, he went on to revolutionize understanding of the physical world. When students study the structure of the atom, the excitement of doing science is encapsulated by Pierre Curie's practice of carrying a piece of pitchblende in his pocket, and learning about the personal relationships among Rutherford, Bohr, and Thompson.

As students study measurement and time, current, historical, and ancient calendars from different cultures are used to help students learn that periodic phenomena are recognized by almost all human societies although various societies have chosen to record and use them in a variety of ways. Students also learn that various cultures have focused on a variety of phenomena on which to base their calendars and that different cultures made very systematic observations which were recorded in a variety of ways. Students compare Newton's ideas about absolute time with other ideas about time.

Through such experiences students can begin to understand the importance of social and cultural influences on the kind of science that developed and the role that science played in particular cultures as well as cultural influences on science.

National Science Education Content Standards

9-12 Content Standard G

Science as a Human Behavior

- Individuals and teams have contributed and will continue to contribute to the scientific enterprise. Doing science or engineering can be as simple as an individual conducting field studies or as complex as hundreds of people working on a major scientific question or technological problem. Pursuing science as a career or as a hobby can be both fascinating and intellectually rewarding.
- Scientists have ethical traditions. Scientists value peer review, truthful reporting about the methods and outcomes of investigations, and making public the results of work. Violations of such norms do occur, but scientists responsible for such violations are censured by their peers.
- Scientists are influenced by societal, cultural, and personal beliefs and ways of viewing the world. Science is not separate from society but rather science is a part of society.

Nature of Scientific Knowledge

- Science distinguishes itself from other ways of knowing and from other bodies of knowledge through the use of empirical standards, logical arguments, and skepticism, as scientists strive for the best possible explanations about the natural world.
- Scientific explanations must meet certain criteria. First and foremost, they must be consistent with experimental and observational evidence about nature, and must make accurate predictions, when appropriate, about systems being studied. They should also be logical, respect the rules of evidence, be open to criticism, report methods and procedures, and make knowledge public. Explanations of how the natural world changes based on myths, personal beliefs, religious values, mystical inspiration, superstition, or authority may be personally useful and socially relevant, but they are not scientific.
- Because all scientific ideas depend on experimental and observational confirmation, all scientific knowledge is, in principle, subject to change as new evidence becomes available. The core ideas of science, such as the conservation of energy or the laws of motion, have been subjected to a wide variety of confirmations and are therefore unlikely to change in the areas in which they have been tested. In areas where data or understanding are incomplete, such as the details of human evolution or questions surrounding global warming, new data may well lead to changes in current ideas or resolve current conflicts. In situations where information is still fragmentary, it is normal for scientific ideas to be incomplete, but this is also where the opportunity for making advances may be greatest.

Historical Perspectives

- In history, diverse cultures have contributed scientific knowledge and technologic inventions. Modern science began to evolve rapidly in Europe several hundred years ago. During the past two centuries, it has contributed significantly to the industrialization of Western and non-Western cultures. However, other, non-European cultures have developed scientific ideas and solved human problems through technology.
- Usually, changes in science occur as small modifications in extant knowledge. The daily work of science and engineering results in incremental advances in our understanding of the world and our ability to meet human needs and aspirations. Much can be learned about the internal workings of science and the nature of science from study of individual scientists, their daily work, and their efforts to advance scientific knowledge in their area of study.
- Occasionally, there are advances in science and technology that have important and long-lasting effects on science and society. Examples of such advances include the following: *Copernican revolution, Newtonian mechanics, Relativity, Geologic time scale, Plate tectonics, Atomic theory, Nuclear physics, Biological evolution, Germ theory, Industrial revolution, Molecular biology, Information and communication , Quantum theory, Galactic universe, Medical and health technology.*
- The historical perspective of scientific explanations demonstrates how scientific knowledge changes by evolving over time, almost always building on earlier knowledge.

Minnesota Graduation Standards

High School Level

History of Science:

Understand the interaction between social, economic, technological and/or environmental factors and the occurrence of scientific advances.

What students should know:

1. Understand the significance of a number of major scientific advances of recorded history

What students should do:

1. Gather information on at least three major scientific breakthroughs (i.e., new ideas that challenge accepted ways of thinking)
2. Investigate and analyze the social, economic, technological and/or environmental context in which a scientific breakthrough occurred
3. Analyze the immediate and long-term effect of the scientific breakthrough on the social, economic, technological and/or environmental contexts

In Addition:

1. Tasks must represent an intensive study of the history of science.
2. Examples of major scientific breakthroughs are: Copernican Revolution, Newtonian Mechanics, quantum theory, aspects of medical technology, atomic theory and plate tectonics.

Cultures Across Time:

Understand the significance of events and themes across cultures and time.

What students should know:

1. Understand historical developments of world cultures:
   a. contributions of significant people
   b. key events which precipitate development and/or change
   c. factors which influence the outcomes of historical events (e.g., geographic location, chance occurrences, social movements, technology, environmental changes)
   d. development of ideas, beliefs and cultural expressions
   e. development of social and political institutions
   f. interactions and conflicts within or across cultures

What students should do:

1. Gather information to examine major historical developments or turning points in world history:
   a. describe significance of the event in its historical context
   b. examine cause-and-effect relationships
   c. discuss impact on other cultures and/or time periods
   d. compare historical interpretations and perspectives

In Addition:

1. This standard is open to a historical or cultural approach.
2. Include tasks which address both western and non-western cultures.