Your competence will be assessed as you complete the Science, Technology, and Society performance and objective assessments for this course. This course covers 9 competencies and 2 competency units. It may take up to 8 weeks to complete.

Introduction

Overview
This course engages current and future educators in the study of the nature, processes, and applications of science and technology. Inquiry-based and engineering design models can be applied to effectively guide your students to solve open-ended problems and use science to make well-informed decisions.

Scientific inquiry starts with a question and leads to increased general understanding; engineering design starts with a problem and leads to a solution.

Science is both a body of knowledge and a process for growing that knowledge. Science evolves and refines its models of physical reality and scientific phenomena under a set of guidelines and rules of testable scientific theories. Understanding the rules and limitations of science is a necessary ingredient when teaching science, especially in its application to technology.

The engineering process works along with the scientific process, explicitly seeking to apply scientific knowledge to solve problems for society. Helping students make that connection from science to engineering is another necessary component of successful science teaching.

This course for current and prospective science teachers arms you with the knowledge and skills to explain important aspects of science and their application and use in technology. You will study the historical evolution of scientific inquiry as well as how science and engineering are being used to inform decision making on current issues and solve societal problems.

You will demonstrate your competency in a performance assessment and an objective assessment.

This course will cover the following general information:

- the importance and proper use of observations and experimentation
- the nature, processes, and applications of science and technology
- the processes, creativity, and critical thinking skills needed for engineering
- historical and contemporary perspectives on science and technology
- knowledge, skills, and dispositions needed to analyze socio-scientific issues
- the use of inquiry, engineering, research, and investigation to solve open-ended problems
- how to design, conduct, report, and evaluate investigations in science and engineering
- mathematics and technology necessary to process and report data from research
Getting Started

Science, Technology and Society is an important assessment in which you will consider how science and technology relate to the decisions made in our society, and how these interactions in our modern lives influence each other. Important topics in this assessment include themes of science, the historical development of science, analyzing issues and decision making, hypotheses and designing and conducting investigations using inquiry and the engineering design process of problem solving. In this course you will complete readings from *Understanding Science: How Science Really Works*, and *STEM: Student Research Handbook*. Helpful videos and resources provided to expand your understanding of these topics and how to communicate them to students. These resources are all embedded in the course of study. YourCourse Instructor is also available to answer questions and discuss concepts. To demonstrate your mastery of this content you will complete 3 performance tasks in Task Stream and pass an objective assessment. Begin by working through the course of study. You may then proceed with the tasks or prepare for the exam. Work with your course instructor to plan and achieve your study goals.

Competencies

This course provides guidance to help you demonstrate the following 9 competencies:

- **Competency 663.1.1: Common Themes in Science**
  The graduate analyzes the relationships among themes that appear across multiple scientific ideas.

- **Competency 663.1.2 Nature of Science**
  The graduate analyzes the nature of science, including how science distinguishes itself from other ways of knowing.

- **Competency 663.1.3: Historical Development of Science**
  The graduate analyzes the historical development of science, including how scientific knowledge evolves.

- **Competency 663.1.4: Interrelationship of Science, Technology and Society**
  The graduate analyzes the various ways in which science, technology, and society are interrelated.

- **Competency 663.1.5: Analyzing Issues and Making Decisions**
  The graduate analyzes socially relevant scientific issues to make informed decisions based on data and context.

- **Competency 663.1.6: Investigations in Science**
  The graduate analyzes the principles, processes, and assumptions of investigations in science to engage students in the nature of inquiry.

- **Competency 663.1.7: Improving Investigations and Communication**
  The graduate uses technology tools and mathematics to improve investigations and the communication of results.

- **Competency 663.1.8: Hypotheses and Scientific Investigations**
  The graduate formulates testable hypotheses for scientific investigations.

- **Competency 663.1.9: Carrying Out Investigations in Science**
  The graduate conducts investigations in science to solve open-ended problems using appropriate scientific methods.
Teaching Dispositions Statement
Please review the Statement of Teaching Dispositions.

Course Instructor Assistance
As you prepare to demonstrate competency in this subject, remember that course instructors stand ready to help you reach your educational goals. As subject matter experts, mentors enjoy and take pride in helping students become reflective learners, problem solvers, and critical thinkers. Course instructors are excited to hear from you and eager to work with you.

Successful students report that working with a course instructor is the key to their success. Course instructors are able to share tips on approaches, tools, and skills that can help you apply the content you’re studying. They also provide guidance in assessment preparation strategies and troubleshoot areas of deficiency. Even if things don't work out on your first try, course instructors act as a support system to guide you through the revision process. You should expect to work with course instructors for the duration of your coursework, so you are welcome to contact them as soon as you begin. Course instructors are fully committed to your success!

Preparing for Success
The information in this section is provided to help you become ready to complete this course of study. As you proceed, you will need to be organized in your studies in order to gain competency in the indicated areas and prepare yourself to pass the final assessments.

Learning Resources
The learning resources listed in this section will be required to complete the activities in this course. Follow the instructions provided to access these resources as early as possible in order to give yourself time to become familiar with them.

Automatically Enrolled Learning Resources
You will be automatically enrolled at the activity level for the following learning resources. Simply click on the links provided in the activities to access the learning materials.

Open Access E-Text
The following textbook is available to you as an e-text within this course of study. You will be directly linked to the specific readings required within the activities that follow. NOTE: The online e-reader for this text may not be optimal on your browser, but you will have the option to download a free PDF copy of the text from the linked website for your convenience.

Note: These e-texts are available to you as part of your program tuition and fees, but you may purchase hard copies at your own expense through a retailer of your choice. If you choose to do so, please use the ISBN listed to ensure that you receive the correct edition.

STEM: Student Research Handbook
This resource is written with science pedagogy in mind, but also covers the essential topics of defining what science is and how it is used, analyzed, and communicated. It does this by guiding you through the process of carrying out scientific investigations with the same rigor and under the same rules and guidelines used by the science community. It teaches the process of a student or group of students stepping through a STEM research project. This includes defining research, topic ideas, design, vocabulary, background research, hypothesis writing, proposal writing, note taking, descriptive measures, graphical representation, interpreting data, documentation, writing a paper, and presentation.

You be given access to a PDF copy of the following text in the activities that follow. You may wish to save the document to your computer to save time on repeated downloads.


Note: The resources you are using to master the competencies for this assessment will also be valuable as you as you prepare for future assessments and as you develop lesson plans to be used in your classroom in the future. Therefore, it is highly recommend that you complete each activity contained in this document.

Other Learning Resources

You will use the following learning resources for this course of study.

Understanding Science: How Science Really Works
This online resource contains eight separate chapters with detailed subtopics. It has a concise yet extensive coverage of the content. Links to the required chapters will be provided at the activity level.

You can access this resource using the following link, and in the activities that follow:

- Understanding Science: How Science Really Works

The Principal Elements of the Nature of Science: Dispelling the Myths
This resource is a collection of "what science is" myth busters. It is done within the framework of both how science really works as well as how it doesn't. The brief resource covers a wide spectrum of topics.

You can access this resource using the following link, and in the activities that follow:
• The Principal Elements of the Nature of Science: Dispelling the Myths

Earth System Science Modules
This resource is a collection of Earth System Science modules. Each module includes background information on the topic, hypotheses to be explored, findings so far, and additional resources. This builds an understanding of science in action by investigating through a real-life science project. There are also sample investigations that you can use for science projects in your classroom. These projects include science content standards that are helpful in guiding you to age-appropriate projects and coverage in your own school curriculum.

You can access this resource using the following link, and in the activities that follow:

• Earth System Science Modules by Title

Pacing Guide

The pacing guide suggests a weekly structure to pace your completion of learning activities. It is provided as a suggestion and does not represent a mandatory schedule. Follow the pacing guide carefully to complete the course in the suggested timeframe.

Week 1

• Preparing for Success
  ○ Book a call with your course instructor to learn about additional study helps and resources.
• Nature of Scientific Knowledge
  ○ Read chapter I and chapter II of Understanding Science.
  ○ Read the introduction and myths 1 and 3 in The Principal Elements of the Nature of Science.
• Science as a Humanistic and Social Endeavor
  ○ Read chapter V and chapter III of Understanding Science.
  ○ Read myths 9 and 15 in The Principal Elements of the Nature of Science.

Week 2

• Common Themes in Science
  ○ Read Frequently Asked Questions About How Science Works from Understanding Science.

Week 3

• Historical Development of Science
  ○ Review chapter III and read chapter VII of Understanding Science.
Week 4

- Interrelationships of Science, Technology and Society
  - Read chapter VI of *Understanding Science*.
  - Read the Summary, chapter 6 and chapter 7 of *A Framework for K-12 Science Education*.

- Analysis of SocioScientific Issues
  - Review chapter IV and chapter VI of *Understanding Science*.
  - Read Inquiry Strategies to Use in Your Classroom and one of the ESSEA modules.
  - Complete Task 1 through your course.

Week 5

- Methods of Investigation
  - Read Fair Tests.
  - Read myths 4, 5, and 8 from *The Principal Elements of the Nature of Science*.
  - Read at least three of the investigations in the Resource Library from *Understanding Science*.

- Explanation and Communication in Science
  - Read chapter VIII of *Understanding Science*.

- Role of Mathematics and Technology
  - Skim chapter 2, chapter 8, and chapter 9 of *STEM: Student Research Handbook*.

- Hypotheses and Scientific Investigations
  - Skim chapter 4 of *STEM: Student Research Handbook*.
  - Complete Task 2 through your course.

- Designing and Conducting Investigations
  - Review chapter 2 of *STEM: Student Research Handbook*.
  - Review Fair Tests.

- Formulating Explanations and Communicating Results
  - Skim chapter 10, chapter 11, and chapter 12 of *STEM: Student Research Handbook*.
  - Review chapter III and chapter V of *Understanding Science*.
  - Read Cells Within Cells.
  - Read Misconception: Investigations That Don't Reach a Firm Conclusion are Useless and Unpublishable.
  - Read Scientific Communication from Visionlearning.

Week 6

- The Engineering Design Process Compared to the Scientific Method
  - Read Why Engineering Problem Solving.
  - Read pages 201-204 of *A Framework for K-12 Science Education*.
  - Read Comparing the Engineering Design Process and the Scientific Method.

Week 7

- The Steps of the Engineering Design Process
Watch EiE Spotlight-The Engineering Design Process in Action.
Read pages 204-214 of *A Framework for K-12 Science Education*.
Read Defining the Problem and explore the related examples.
Read pages 69-75 and 79-84 of *Teaching Engineering*.
Read "Problem-Solving Matrix" and "Iteration" sections of *What is Engineering Problem Solving?*.
Complete Task 3 through your course.

- **Final Steps**
  - Complete and submit Tasks 1-3 through your course if you have not already done so.

**Week 8**

- **Final Steps**
  - Take the Pre-assessment and go over the Coaching Report with your Course Instructor.
  - Take the Objective Assessment.

*Note: This pacing guide does not replace the course. Please continue to refer to the course for a comprehensive list of the resources and activities.*

**Nature of Science**

What separates scientific knowledge from any other kind of knowledge? There is a big difference between knowing isolated facts and understanding concepts. Much of scientific knowledge is in understanding the mechanism of how something works. Science can often explain the processes of natural phenomena and predict what is expected to happen, but sometimes the underlying reasons or mechanisms are not so easy to explain.

**Nature of Scientific Knowledge**

This topic provides a broad foundation for understanding scientific knowledge and inquiry. It includes the language, tools, and processes commonly accepted to establish and advance the body of scientific knowledge.

**Nature of Science Introduction and Vocabulary**

Read the following chapter in *Understanding Science: How Science Really Works*.

- [chapter I ("Understanding Science 101: An Overview")](#)

Click some of the highlighted text terms and review the pop-up glossary definitions.

**Nature of Science Foundation**

Read the following chapter in *Understanding Science: How Science Really Works*.
chapter II ("What is Science?")

As you read, keep in mind the following science concepts.

- Terms and Concepts: Understanding the meaning of scientific terms will help in using them appropriately in the proper context. For example, what is the difference between a theory and a law, and what are the limitations of each?
- Testing Ideas: Science is not limited to just testing a hypothesis (a prediction). Not all scientific ideas are formulated or tested this way. There are several different routes for scientific knowledge to be accumulated.
- Science, Non-Science, and Poor Science: Science involves induction from empirical observation. Science has no place in such subjects as religion. Poor science occurs where explanations are off-base, such as the earth-centric planetary system.
- Determining What Science Can and Cannot Answer: Is there a God? What new energy sources are the best candidates for future development? These are just a couple of examples of what science cannot answer. Others are not so easy to distinguish.
- Examples of What Science Is and Isn't: Science is not the answer to many social issues. It may be able to determine an efficient and safe method of storing nuclear waste, for example, but science cannot determine if nuclear energy is the right thing for society.

Using Learning Resources Effectively

Recall the chapters that you read previously in Understanding Science: How Science Really Works.

Follow several of the sidebar links in chapter II ("What is Science?")

Myths About the Scientific Process

Read the following sections in The Principal Elements of the Nature of Science: Dispelling the Myths:

- Introduction
- Myth 1: "Hypotheses Become Theories That In Turn Become Laws"
- Myth 3: A Hypothesis is an Educated Guess

Compare the clarifications of "hypothesis," "theory," and "law" in the following two resources:

- Myth 1 and Myth 3 in The Principal Elements of the Nature of Science: Dispelling the Myths
- Misconception: If evidence supports a hypothesis, it is upgraded to a theory. If the theory then garners even more support, it may be upgraded to a law.

Reflect on these two explanations. Consider the following question:

- How will these explanations affect the way you will use the terms "hypothesis," "theory," and "law?"
Nature of Science Integration Activity

What topics can and what topics cannot be investigated scientifically?

1. power of prayer
2. effectiveness of a new drug
3. whether society should ban genetically modified food
4. life after death
5. the placebo effect
6. the best genre of music
7. the size of the universe

Compare your thoughts with the following document:

- [Nature of Science Integration Activity Answers](#)

Science as a Humanistic and Social Endeavor

All scientific knowledge begins with careful observations of natural phenomena and detailed records, then expands through sharing clear communication. All of this is affected by cultural views and expectations. The collaboration with people from different academic fields as well as different cultural backgrounds can help refine and advance scientific understanding.

Science As a Humanistic and Social Endeavor

Read the following chapter in *Understanding Science: How Science Really Works*:

- [chapter V ("The Social Side of Science: A Human and Community Endeavor")](#)

As you read, keep in mind the following science concepts. Important Social Aspects of Science: One important aspect of scientific discovery is its impact on society. For example, scientists may wish to un-invent a weapon. While a weapon may be a controversial subject, scientific advances in medicine and creature comforts also create unexpected consequences to society.

- Ethical Traditions in Science: Truth in science is important, as human lives and well-being are often at stake. Consider why ethical traditions have evolved and continue to evolve as new issues arrive hand in hand with new scientific discoveries.
- Healthy Skepticism, Checks, and Balances: Because of the possible falsification of scientific knowledge, checks and balances are appropriately and sometimes inappropriately applied. Healthy skepticism should be encouraged, even though it may rattle a few dearly held paradigms. For those curious about how far this can go, see the [Eotvos Experiment](#) article.

Working Alone Is Not How Science Is Done

Read the following sections in *The Principal Elements of the Nature of Science: Dispelling the Myths*:

9/30
Myth 9: Scientists Are Particularly Objective
Myth 15: Science Is a Solitary Pursuit

In light of this new information, revisit the following two items from the previous activity:

- Important Social Aspects of Science: One important aspect of scientific discovery is its impact on society. For example, scientists may wish to un-invent a weapon. While a weapon may be a controversial subject, scientific advances in medicine and creature comforts also create unexpected consequences to society.
- Ethical Traditions in Science: Truth in science is important, as human lives and well-being are often at stake. Consider why ethical traditions have evolved and continue to evolve as new issues arrive hand in hand with new scientific discoveries.

**The Scientific Method Is Not All There Is to Science**

Read the following chapter in *Understanding Science: How Science Really Works*:

- chapter III ("How Science Works")

Record another situation where further scientific research has upset or overturned a previously believed paradigm.

**Science As a Humanistic Endeavor Integration Activity**

Scientific growth is not a smooth, continuous process. Do you think the early pioneers of the automobile would have anticipated the impact on society, both good and bad?

What social impacts do you think would come from the following new discoveries? List a few ideas for each, and be creative.

1. making cold fusion work
2. the ability to change climate
3. a cure for cancer
4. selecting the characteristics of your offspring

*Note: Check out the "Take a Side Trip" links throughout chapters III and V of *Understanding Science: How Science Really Works*.*

Compare your thoughts with the following document:

- **Science as a Humanistic Endeavor Integration Activity Answers**

**Common Themes in Science**
As a science teacher, you need more than a firm understanding of subject matter. You will also need knowledge of how students learn, and a wide spectrum of approaches and activities to stimulate that learning.

**Common Themes in Science**

This section will help you consider how to bridge the gap between learning science content to considering the "big picture" and the interrelationships of fields and practices of science. You will also consider how to help your future students gain an appreciation for and a comprehensive and useful knowledge of science.

**The Framework of K-12 Science Education Document**

Read the following sections in *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*:

- Summary
- chapter 3 ("Dimension 1: Scientific and Engineering Practices")

Highlight in the text concepts and text that are key points or summary statements. This will help you relocate that information when you complete other activities in this topic.

Consider the following questions:

- Look at the topics in the course of study. How do you think these topics reflect the principles proposed in *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*?
- How does the phrase "engineering practices" have a different meaning in *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* from the word "technology" in this course?

**Translating the Framework Concepts to Classroom Practices**


Think carefully about the following topics, both their content as well as ways they may be taught for firm understanding.

How would you explain the following concepts to a 6th or 7th grade student?

- Cause and Effect: Scientific explanations are often about a relationship between variables, or, in other words, recognizing examples of cause and effect. Flipping a switch and the light
coming on is not a scientific explanation of cause and effect. A scientific explanation must include electrical circuits, the flow of electricity, the heating of a filament wire, among other elements.

- **Experiments:** While an experiment may illustrate a cause-and-effect relationship, it does not necessarily prove a specific cause-and-effect relationship. Previous scholars thought that heavier objects fell faster due to gravity, which is not a surprising explanation if the experiment compared the fall rates of a rock and a feather. The explanation of cause and effect needed to be investigated further, expanding the knowledge of falling bodies, before a more reasonable explanation could be deduced.

**Common Themes in Science**

Read the following chapter in *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*:

- chapter 4 ("Dimension 2: Crosscutting Concepts")

Read the following section in *Understanding Science: How Science Really Works*:

- Frequently Asked Questions About How Science Works

Think carefully about the following topics, both their content as well as ways they may be taught for firm understanding.

Choose one of the following topics and explain how it could be taught differently, 7th grade, high school Biology, and high school Geology.

- **Patterns in Investigations:** How do scientists use patterns to direct their investigations? A new piece of scientific knowledge rarely, if ever, results from a single investigation. It is usually the result of many investigations spanning a large time period and carried out by several different investigating teams. In engineering, the data from patterns of product failures are used to instigate design improvements.
- **Measurements:** Scale is an important concept in science and technology, especially in measuring things like the width of an atom versus the width of a galaxy. Accuracy and precision of measurements are factors when evaluating data.
- **Limitations of Science:** Science uses models to simplify the understanding of behaviors of certain phenomena. A model may only use data obtained over a limited time frame. What are the limitations of such models? Why should you question the use of a model that extrapolates a prediction of events from limited data?

**Cause/Effect/Experimentation Integration Activity**

Which of the following scenarios are good scientific explanations of the specified cause and effect? Categorize them as good science, non-science, or poor science, and explain why you chose each category.

1. Flip a switch and the light comes on: You have paid your utility bill, so the power is still on.
2. A car coming towards you makes a higher pitched noise than a car going away from you: Sound waves are compressed; therefore, they have a higher frequency and higher pitch as the car comes towards you, and they are stretched and have a lower frequency and lower pitch as the car moves away.
3. The speed of light from a distant star is the same when the earth moves towards the star as when it moves away from the star: The speed of light is measured relative to the stationary space and not a moving object.
4. Both your parents have brown eyes, but your eyes are blue: Both parents have one blue and one brown gene; brown is dominant, and you inherited one blue gene from each parent.
5. Noble gases rarely react with other elements: Oxygen is the only gas that readily reacts with other elements.

Compare your thoughts with the following document:

- **Cause/ Effect/Experimentation Integration Activity Answers**

**Historical Development of Science**

Some scientific advancements cause major shifts in the way people think and behave. These advancements and understandings also have impacts that ripple through society, and sometimes whole new branches of investigation are invented. The importance of these advancements can only be determined in a historical perspective.

**Historical Development of Science**

People all over the world have made careful observations of cause-and-effect relationships. Now that communication is easy, scientific knowledge can be shared and enhanced from many different academic fields and cultural perspectives.

One example of how science evolves is the scientific understanding of gravity. Newton’s model of gravity as a force and Newton’s Laws of Motion are more than adequate at predicting the behavior of moving bodies at low velocity. But at higher velocities, a more inclusive, relativistic theory is needed to model gravity as a curvature of space. The relativistic correction of the orbiting GPS satellites is an example of an application of further refinement of this scientific knowledge.

**Historical Development of Science**

Review the following chapter in *Understanding Science: How Science Really Works*. 
Follow links within the text or from the right-hand side bar to find information about the following topics. Write brief synopses of what you find.

- Important Advances in Science Impacting Society: Health and medicine, transportation, communication, etc; what discoveries have changed society into what it is today?
- Science Contributions from Diverse Cultures: Match scientists and their contributions from Marconi to Einstein, Eratosthenes to Galileo, and others that you learn about.
- Historical Development of Scientific Theories: What are some significant leaps in science’s understanding of the solar system, the universe, atomic structure, medicine, chemistry, evolution, etc., as it has evolved over many centuries?

**What Science Has Done for You Lately**

Read the following chapter in *Understanding Science: How Science Really Works*:

- chapter VII ("What has Science Done for You Lately?") (7 pages)

Choose one of the topics detailed in this chapter, or another of your choice, and draw a concept map of the significant developments in this scientific field. You might include the following elements:

- a timeline
- important researchers
- false paths (beliefs that were later disproven or significantly revised)
- significant side branches that developed in this field

*Note: For information on concept maps, review the "Concept Map" web page.*

**Historical Development of Science Integration Activity**

Read the following article:

- Modern Science: What's Changing?

List as many events as you can that have altered the understanding of the universe, starting with the flat earth hypothesis.

What technologies are currently changing scientific understanding?

Compare your thoughts with the following document:

- Historical Development of Science Integration Activity Answers

**Interrelationship of Science, Technology, and Society**
Technology strives to use science appropriately to help solve societal issues. Science can aid technological advancement, but it cannot determine solutions to many of the social issues these advancements may create.

Scientific observations are influenced by cultural expectations. This may include views on what is acceptable to investigate, explanations that may contradict cultural beliefs, or ideas about how new technologies should be used in society. The interrelationships are a continuous source of tension as science, technology, and society evolve.

**Interrelationship of Science, Technology, and Society**

Science enhances understanding to create technologies that change society. Society pushes technology to provide solutions, which in turn creates more problems. Technology provides new ways to explore for scientific knowledge. In this topic, you will examine some of these interrelationships and how each of these segments function.

**Interrelationships of Science, Technology, and Society**

Read the following chapter in *Understanding Science: How Science Really Works*:

- chapter VI ("Science and Society") (5 pages)

Read the following chapters in *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*:

- Summary
- chapter 6 ("Dimension 3: Disciplinary Core Ideas-Life Sciences")
- chapter 7 ("Dimension 3: Disciplinary Core Ideas-Earth and Space Sciences")

**Science Advancing Technology and Technology Advancing Science**

Consider the readings and notes you completed for chapters VI and VII of *Understanding Science: How Science Really Works*. Think about the role of science in society. Is it to advance human knowledge of the world and the surrounding universe, or is it to advance technology to improve the human condition?

Reflect upon the effects of space exploration on science, technology, and society. Answer the following questions:

- Were there societal pressures to pursue or stop space exploration?
- What scientific knowledge was needed to advance the exploration?
- What technology had to be built?
- Was new science knowledge needed to create the technologies?
- How were the new knowledge and technologies used by society in different ways than their original purpose?
Interrelationship of Science and Technology Integration Activity

Identify a technological application of the following scientific discoveries:

- the photoelectric effect
- relativity
- fission
- silicon
- DNA
- thermal expansion
- carbon 14

Compare your thoughts with the following document:

- Interrelationship of Science and Technology Integration Activity Answers

Analyzing Issues and Making Decisions

Communication technologies make science knowledge available to more people. This knowledge is accessed and relied upon when making policy decisions and directing actions of nations, states, communities, companies, families and individuals.

This section will help you learn how to search for reliable and relevant sources and apply what you learn to a decision or action. It will help you to evaluate the quality of information and make judgments when sources disagree. You will also consider how to instill these thoughtful behaviors in students.

Analysis of Socio-Scientific Issues

Problems and events far from you can affect your life, even if you are not aware of it. Because many people may be affected, these far-reaching consequences must be considered when scientific knowledge or technologies are put into action. In this topic, you will research and evaluate some of the many interlocking impacts of world events.

Analysis of Socio-Scientific Issues

Read the following chapters in Understanding Science: How Science Really Works:

- chapter IV (“The Core of Science: Relating Evidence and Ideas”) (5 pages)
- chapter VI (“Science and Society”) (5 pages)

Write an analysis of the social issues related to science and technology regarding medical research. Consider the following issues:
Prioritizing funding research versus hospice care for patients with a terminal illness. On the one hand, the search for a cure would benefit a lot of potential future suffers. But, accepting that funds are limited, should this be at the expense of those who currently have the disease?

- How are decisions made about which diseases to research?
- What about safety of the patients who will be used the research?
- What about humane treatment of animals used in research?

Complexity of Socio-Scientific Issues

Read Inquiry Strategies to Use in Your Classroom for an overview of a problem-based learning approach to inquiry-based learning.

Choose one of the following modules from the Earth Systems Science site that interests you. Note: these resources are freely available to teachers and can form valuable assets in building inquiry-based lessons. Read the web page, and think carefully about the complexity of the issues involved:

- Gulf of Mexico Dead Zone
- California Wildfires
- Global Climate Change

As you read your chosen scenario, think carefully about the complexity of the issues involved.

Most social issues for which science is asked to provide data or guidance are extremely complex. Usually this is because of social, economic, and political considerations. For example, the fuel crisis and the search for more fuel efficient transportation is rife with societal issues of transportation safety, fuel price wars, emissions concerns, the economy, international politics, and foreign trade.

These issues may seem like they are geographically distant from you, but they do impact you. Write about how these issues directly affect your life. What actions do you engage in that impact this issue? Where can you go to find additional reliable information? As a scientist, how does this knowledge affect the choices you make?

Integration Activity of Socio-Scientific Issues

A scientific investigation into mass transportation has concluded that the most efficient form of mass transport modes for commuters is a light rail system.

Outline some of the social issues that would need to be addressed before building a light rail system for commuters working in the city center. What additional information do you need to make a clear decision?

What issues would be most relevant to the following individuals?

1. the state governor
2. the city mayor
3. a transportation engineer
4. a city homeowner
5. a suburban homeowner

Compare your thoughts with the following document:

- Socio-scientific Issues Integration ActivityAnswers

**Task 1 Performance Task**

You are now ready to complete Task 1 in your course. For directions on how to receive access to performance assessments, see the Accessing Performance Assessments page.

**Investigations in Science**

Science encompasses much more than just lab experiments. Different fields of study have evolved standard practices and types of investigations. For example, medical studies include studies of characteristics of populations that have a particular medical issue. They also include pure chemical tests and biology lab experiments.

Then there are the ethical issues of testing on animals, and more complex issues when testing on people. There are even medical investigations that primarily use data from patient records and mathematical models to test procedures quite thoroughly to advance the knowledge long before any interface with patients. This section will present some of those scientific investigation practices.

**Methods of Investigation**

Science and technology encompass many different fields. The methods of investigation range from observational studies to qualitative surveys and quantitative experimental research. Science advances because each generation builds on previous knowledge. Scientific concepts are the foundation for technological advances, and technology enables more advanced scientific research. Each field has standards and procedures to ensure quality, ethical work.

**Methods of Investigation**

Read the following article:

- Fair Tests: A Do-It-Yourself Guide (4 pages)

Think carefully about the following topics:

- Analyzing Evidence: Evidence can be in the form of results of one or many experiments, surveys, observational studies, etc. Analysis of the evidence can result in a change in the understanding of a scientific phenomena or a confirmation of what is already known. It can also be inconclusive and lead to a further investigations.
• Complex Scientific Investigations: Is recent global warming a long-term trend? If so, what should be done to counter its negative impact? What methods of investigation would be used to answer these questions?

Review your notes for your reading of chapters II, III, and IV in Understanding Science: How Science Really Works.

Read the following section in The Principal Elements of the Nature of Science: Dispelling the Myths:

• Myth 4: A General and Universal Scientific Method Exists

List at least three methods of investigation that are used in scientific investigation besides a laboratory experiment.

**Observation in Scientific Investigation**

Science includes empirical observation modeled by self-consistent predictive mathematical models. Science cannot be proven, but it can be disproven with a single counter-example. Further observations can lead to refinement, so the result is a growing body of ever-improving knowledge.

Read the following section in The Principal Elements of the Nature of Science: Dispelling the Myths:

• Myth 5: Evidence Accumulated Carefully Will Result in Sure Knowledge

Describe how observations and mathematical models have been used to advance the science of weather prediction. Consider the following questions:

• What were some very early hypotheses?
• What hypotheses have been tested by observation?
• When have hypotheses been disproven by contradicting observations?
• What mathematical models have been used to predict weather outcomes?

**Common Reasons for Investigation**

Read the following section in The Principal Elements of the Nature of Science: Dispelling the Myths:

• Myth 8: Science and its Methods can Answer All Questions

Explain why science cannot answer every question.

In Understanding Science: How Science Really Works, read at least three of the investigations in the following section of the Resource Library:
• **Science in Action**

Science and technology often have different reasons for an investigation. Science is driven more by the need to know, whereas technology is driven more by the need to solve a particular problem, improve an existing product, or invent a new product.

Analyze whether the investigations you read about were motivated more by a pure scientific search for knowledge or by a search for a technological solution to a problem. Give examples of some technologies that have grown from each of these investigations.

**Explanation and Communication in Science**

There are many reasons for effectively communicating scientific investigations. Even to gain funding, researchers must communicate the importance of the investigation; later, they must communicate status updates. An interpretation of results is likely to be more accurate if the results are debated and a consensus is reached. That is not to say that reality is based on a majority vote, but an airing of all interpretations with all possible objections addressed is a far better, transparent process for determining a sound explanation. Peer review is an example of this important process.

**Explanation and Communication in Science**

Read the following chapter in *Understanding Science: How Science Really Works:*

- [chapter VIII (“A Scientific Approach to Life: A Science Toolkit“)](9 pages)

As you read, think carefully about the following topics:

- Important Criteria for Scientific Investigation: purpose, funding, resources, implications, etc. All of these are important considerations best reviewed before a scientific investigation is commenced. In most cases, important criteria for an investigation will need to be met as a condition for the investigation to commence.
- Replicating the Result of Scientific Investigations: one of the characteristics of a scientific law or theory is that replicating the investigation that determined it, within specified bounds, will return the same result. If it does not, the theory or law is ripe for being overturned or modified.
- Models as Scientific Explanations: Someone once said that science was a mathematical model of reality. Models are a convenient way of capturing a scientific law or theory. Science and technology use models of varying sophistication to understand the behavior of complex systems. The weather, finite element analysis, and population growth are a few examples.

Visit the sidebar links on the following web page:

- [Publish or Perish](

**Communication I-What Is the Investigation About?**
Outline the important topics you would cover in your communication or publication following an investigation of the following topic:

- You believe that a serious terminal disease is inherited from one parent, and if the gene were identified, it could be tested for during early term pregnancy. The result could then be shared with the prospective parents. How would you go about communicating your investigation, with funding in mind, where you are competing for limited resources?

Compare your thoughts with the following document:

- Communication I-What is the Investigation About? Answers

### Improving Investigations and Communication

Technology is useful in recording, analyzing, and presenting data from scientific investigations. Computer programs like MS Excel and hand-held graphing calculators (like the TI-83) can record and analyze data of incredible sophistication. These programs have the mathematical capability of analyzing data and presenting a final test statistic in a matter of seconds, accomplishing quickly that which could take several days by hand calculation. Graphical representations of the results as bar charts, histograms, and pie charts can also be produced by computer programs to present the results more clearly.

### Role of Mathematics and Technology

Different technologies are used throughout the process of scientific investigations. Some, like microscopes, improve observation capabilities. Automatic timers for periodic photography can aid data collection. In this topic, you will learn to use some statistical functions to quickly analyze data from a scientific investigation.

### Role of Mathematics and Technology

Skim the following chapters in the [STEM: Student Research Handbook](#):

- chapter 2
- chapter 8
- chapter 9

List the technologies that you have used for scientific investigations. Classify when these technologies were used:

- data gathering
- recording
- analyzing data
- presenting results
Technology Enables Leaps in Science Knowledge

Investigate technologies that have enabled significant leaps in knowledge of astronomy. How have these technologies been used to advance the science?

Include at least the following technologies:

- observations from ancient civilizations
- archeological sites with astronomical observatories
- various telescopes
- technologies required to repair the Hubble telescope

Hypotheses and Scientific Investigations

Well-written hypotheses are one way that scientists direct what they study. A hypothesis helps to organize thinking and categorize observations. Hypotheses can range from an educated guess to making a prediction. Understanding the context of a scientific investigation will help in determining the appropriate hypothesis.

Hypotheses and Scientific Investigations

Hypotheses guide scientific investigations. They should inform the investigation, and determine whether an idea is testable. If the results of the investigation are inconclusive, it does not mean that the hypothesis is not testable, but rather, that another investigation or approach may be necessary.

Hypotheses and Scientific Investigations

Read the following section of *The Principal Elements of the Nature of Science: Dispelling the Myths*:

- Myth 3: A Hypothesis is an Educated Guess

Skim the following chapter in *STEM: Student Research Handbook*:

- chapter 4

As you read the learning resources above, think carefully about the following topic:

- Testability of a Hypothesis: There are some things that can be tested scientifically and some things that cannot. Faith based phenomena such as the existence of God cannot be tested. On the other hand, it is possible to test to see if a new drug treatment is more effective. The former is not scientifically testable, but the latter is.

Hypotheses and Scientific Investigations Creation Activity
Refer to the following section of *The Principal Elements of the Nature of Science: Dispelling the Myths*:

- Myth 3: A Hypothesis is an Educated Guess

Review the following chapter in the *STEM: Student Research Handbook*:

- chapter 4

Write an appropriate hypothesis or hypotheses for each of the following investigations:

1. a new medical treatment
2. climate change
3. possibility of an asteroid strike
4. mortality rates
5. average adult body weight
6. the effectiveness of a new medicine

Compare your thoughts with the following document:

- **Hypotheses and Scientific Investigations Creation Activity Answers**

**Task 2 Performance Task**

You are now ready to complete Task 2 in your course. In this task, you will be analyzing and tracing the historical development of a theory of your choice. Many scientific theories are appropriate for this task, but avoid selecting a very *new* theory (one for which there is little historical development) or a very *obscure* theory (one for which there is little documented discourse available). Examples of theories that are appropriate include, but are not limited to, the following:

- light speed theory
- geocentric theory
- theory of relativity
- multiverse theory
- plate tectonics theory
- atomic theory
- heliocentric theory
- big bang theory
- theory of evolution
- cell theory
- germ theory of disease

For directions on how to receive access to performance assessments, see the "Accessing Performance Assessments" page.
Designing and Conducting Investigations

Well-designed scientific investigations involve numerous details or characteristics. Careful attention to all of the requirements is important to providing valid data, drawing useful conclusions, and making sound decisions based on the investigation.

Designing and Conducting Investigations

One of several considerations for a well-designed investigation is eliminating bias and collecting objective data. There are several controls that help ensure this fair and useful outcome.

Designing and Conducting Investigations

Read the following section of *The Principal Elements of the Nature of Science: Dispelling the Myths*:

- Myth 9: Scientists are Particularly Objective

Review the following chapter in *STEM: Student Research Handbook*:

- chapter 2

As you read the recommended sections of these learning resources, think carefully about the following topic:

- Variables and Controls: Many scientific investigations involve a relationship between variables. A control can be assigned as a basis for comparison. Investigating whether a new product is more effective than the current product involves variables. The products are one variable, and the outcome is another variable. The control is the current product, and its outcome is used to compare the outcome of the new product. It does not matter if you are considering the effectiveness of a new detergent or the efficiency of a new rocket fuel, variables and controls must be assigned or identified in a similar manner.

Answer the chapter questions and chapter applications and complete the Student Handout #2 located on the following page of *STEM: Student Research Handbook*:

- page 33

Fair Tests

Read the following website:

- Fair Tests: A Do-It-Yourself Guide (4 pages)

Follow the sidebar links, read the information in the "Snapshot" sections, and read about other sample tests.
Think carefully about the characteristics that allow for a fair test, that is, a fair scientific investigation.

Evaluate what was unique in these investigations that ensured they were fair tests.

**Well-Designed Experiment**

Consider the following scenario: Professor Fudge is asked to run a scientific study to see if a new energy drink actually provides more energy for exercising cyclists. Professor Fudge owns stock in the company that produces the energy drink, and so does his son, who will be one of the cyclists in the study.

Outline the details of the study to determine if the drink actually does provide more energy to cyclists so that neither Professor Fudge nor his son will bias the results.

Compare your thoughts with the following document:

- **Well-Designed Experiment Answers**

**Formulating Explanations and Communicating Results**

Describing what happened in a scientific investigation is different than explaining why it happened. Of course, a clear explanation is the first requirement, but the explanation needs a lot of evidence to back-up the conclusion. Clear communication—whether in a conference paper and presentation, a peer-reviewed journal, or in collaborative work with colleagues—will add to the body of scientific knowledge.

**Formulating Explanations and Communicating Results-I**

Skim the following chapters in *STEM: Student Research Handbook*:

- chapter 10
- chapter 11
- chapter 12

As you read the recommended sections of *STEM: Student Research Handbook*, think carefully about the following topics:

- The Benefits of Communication in Scientific Investigation: Important aspects of the interrelationship of science and technology include clear communication of methods, results, implications of the investigation, and how this research may be extended further.
- Descriptions versus Explanations: There is a difference between what happened and how or why it happened. Often, science can predict what will happen, but not why it will happen. A large proportion of scientific investigation is involved in uncovering underlying mechanisms and understanding how something happens. For example, recent global warming is an undeniable fact; a scientific explanation for it is a little harder to pin down.
Formulating Explanations and Communicating Results-II

As you read the following sections of the learning resources, compare your notes and learning with the STEM information.

Review the following chapters in *Understanding Science: How Science Really Works*:

- chapter III ("How Science Works") (especially pp. 10-21)
- chapter V ("The Social Side of Science: A Human and Community Endeavor") (8 pages)

Read the following article:

- [Cells Within Cells: An Extraordinary Claim With Extraordinary Evidence](#) (13 pages)

Read the following section of *Misconceptions about Science*:

- [Misconception: Investigations That Don't Reach a Firm Conclusion are Useless and Unpublishable](#)

Read the following article from Visionlearning:

- [Scientific Communication: Understanding Scientific Journals and Articles](#)

How can you use each of these levels of scientific communication to investigate an issue? How can you direct students to conduct investigations and to evaluate the validity of a resource they may find?

**Results of an Investigation**

Select one of the scientific journals that interest you:

- [Public Library of Science](#) (all articles are available for free)
- [Proceedings of the National Academy of Sciences](#) (articles more than six months old are available for free)
- [Directory of Open Access Journals](#) (journals on many different topics are available for free)

Read one research article completely. Outline the way you would write an article for a popular magazine that presents this research.

Write a sample newspaper article or radio report that disseminates this information in a 5-10 minute segment to a general audience.

**Communication II-Reporting an Investigation**

Your investigation to find a disease-causing gene has been successful, and you have isolated the gene. How would you communicate your result to a medical organization capable of developing a
method to test for this gene in an early-term pregnancy? Outline the important topics you would include in your communication.

Compare your thoughts with the following document:

- Communication II-Reporting an Investigation Answers

The Engineering Design Process

The Next Generation Science Standards call for explicit instruction and incorporation of the engineering design process, alongside the scientific method. While there exists different terminology for the steps of the design process, at its core is starting with a real-world problem or need, and working toward a working solution.

The Engineering Design Process Compared to the Scientific Method

Engineering methods are used to generate new and working solutions to real societal issues. Whereas the goal of the scientific method is to expand knowledge and understanding, engineering's goal is to apply such knowledge in finding and implementing solutions to challenges facing people.

Why Address Engineering?


As you read the learning resources above, think carefully about the following topic:

- Reasons for teaching engineering: students, educators, and schools all benefit from clear, explicit instruction in the engineering process and the conceptual link between scientific knowledge and problem-solving for the betterment of society.

Comparing Methods

Read Comparing the Engineering Design Process and the Scientific Method from Science Buddies.

As you read the learning resource above, think carefully about the following topic:
Methods and processes: the engineering design process and the scientific method have both been developed over time, with input and modifications from practitioners to refine each into best practices for their respective goals.

Identify the major differences in these processes, and try to explain why these differences exist. Note any questions that you have to help refine your understanding of these methods and why they differ. Some of these questions will be answered in the next topic, "The Steps of the Engineering Design Process." If you have other questions, you might ask your course instructor or other members of your learning community.

The Steps of the Engineering Design Process

Just as the scientific method includes clear, iterative steps leading toward its goal of enhancing knowledge, so too the engineering design process includes clear, iterative steps leading toward its goal of meeting needs.

Engineering Design Process

Watch "EiE Spotlight-The Engineering Design Process in Action" from Engineering is Elementary.


Brainstorm problems that seem appropriate to the engineering design process.

Defining and delimiting an engineering problem

Read Defining the Problem from Science Buddies, and explore their Examples.

Developing Possible Solutions

Once an engineer has defined the problem, the next step is developing solutions: brainstorming, evaluating solutions, and implementing a prototype solution. Chapter 5 of Teaching Engineering is a great resource for developing and optimizing solutions. Carefully explore the following sections and consider reading the full chapter and bookmarking it for future reference. Consider the differences between novice and expert problem solvers, how you can help your students become expert problem solvers, and the steps you can take to hone your own problem-solving abilities.

Read the following sections from chapter 5 of Teaching Engineering:

- Table 5-1 ("Comparison of Novice and Expert Problem Solvers"), pages 69-70
- Section 5.3 ("Problem-Solving Strategies"), pages 70-72
- Section 5.4 ("Getting Started or Getting Unstuck"), pages 73-75
- Section 5.6 ("Creativity"), pages 79-84
Note: make use of the skills and tips presented in this section as you work on your engineering project in Task 3.

**Optimizing the Design Solution**

The final stages of the engineering design process include analyzing alternatives, selecting the most viable alternative, and iterating the cycle until you find a solution to the defined problem. Evaluate your alternatives and measure their tradeoffs using a decision matrix. Read and explore The "Problem-Solving Matrix" and "Iteration" sections of What is Engineering Problem Solving? for a detailed example of how to use a decision matrix.

**Task 3 Performance Task**

You are now ready to complete Task 3 in your course.

You may use the Problem-Solving Matrix Template, based on the one from the Dartmouth project for Teaching Engineering Problem Solving, to demonstrate how you evaluated alternative ideas during the engineering design process.

For directions on how to receive access to performance assessments, see the Accessing Performance Assessments page.

**Final Steps**

Congratulations on completing the activities in this course! This course has prepared you to complete the assessments associated with this course. If you have not already been directed to complete the assessments, schedule and complete your assessments now.

**Performance Assessment**

Finalize Tasks 1, 2, and 3 and submit them in your course.

For directions on how to receive access to performance assessments, see the Accessing Performance Assessments page.

**Pre-assessment**

Complete the Science, Technology, and Society Pre-assessment. For direction how to receive access to pre-assessments, see the Accessing Pre-Assessments page.

Schedule a call with your course instructor to discuss your pre-assessment results and make plans to ensure you are fully prepared for the exam.

**Objective Assessment**
Complete the Science, Technology, and Society Objective Assessment exam. For directions on how to receive access to objective assessments, see the Accessing Objective and Outside Vendor Assessments page. For further information, watch Preparing for the Objective Assessment.