General Learning Outcome B

Science, Technology, Society, and the Environment

Explore problems and issues that demonstrate interdependence among science, technology, society, and the environment.

Overview

Understanding the complex interrelationships among science, technology, society, and the environment (STSE) is an essential component of fostering increased scientific literacy. By studying the historical context, students come to appreciate ways in which cultural and intellectual traditions have influenced the questions and methodologies of science, and how science, in turn, has influenced the wider world of ideas.

Scientific knowledge is necessary, but not sufficient, for understanding the STSE relationships. To understand these relationships fully, it is essential that students consider the values related to STSE.

As a component of achieving scientific literacy, students must also develop an appreciation for the importance of sustainable development. Sustainable development is a decision-making model that considers the needs of both present and future generations, and integrates and balances the impact of economic activities, the environment, and the health and well-being of the community.

Specific Learning Outcomes

SLO B1: Describe scientific and technological developments, past and present, and appreciate their impact on individuals, societies, and the environment, both locally and globally.

SLO B2: Recognize that scientific and technological endeavours have been, and continue to be, influenced by human needs and by societal and historical contexts.

SLO B3: Identify the factors that affect health and explain the relationships of personal habits, lifestyle choices, and human health, both individual and social.

SLO B4: Demonstrate a knowledge of, and personal consideration for, a range of possible science- and technology-related interests, hobbies, and careers.

SLO B5: Identify and demonstrate actions that promote a sustainable environment, society, and economy, both locally and globally.

General Learning Outcome B	Specific Learning Outcome
Students will... Explore problems and issues that demonstrate interdependence among science, technology, society, and the environment.	**SLO B1:** Describe scientific and technological developments, past and present, and appreciate their impact on individuals, societies, and the environment, both locally and globally.

Suggestions for Instruction

Teacher Background

The desire to understand and explain natural phenomena as well as develop solutions to problems to meet a need or fulfill a want is deeply rooted in human nature and has developed along with society. Technology often has a more direct effect on society as it solves practical problems and serves human needs. New problems and needs may then arise. Science enlarges or challenges societal views of the world. A scientific explanation of a phenomenon may lead to a technological development that serves a societal need. Conversely, a societal need or want may result in a technological solution, which then leads to a scientific explanation.

Assessing the impact of a scientific or technological development involves asking questions: What alternate ways are there to achieve the same ends, and how do the alternatives compare to the plan being put forward? Who benefits and who suffers? What are the financial and social costs? Will these change over time and who bears them? What are the risks associated with using (or not using) the new technology? How serious are they? Who is at risk?

As we negotiate our way within our environment, we find an obvious interdependence of STSE, as science and technology work together to solve societal problems and issues. Scientific inquiry is driven by a desire to understand the natural world, and technological inventions result as society demonstrates wants and needs that must be met. Technology, by its nature, has a more direct effect on society than science does because its purpose is to solve human problems, help humans adapt, and fulfill human aspirations. Technological solutions may create new problems. Science, by its nature, answers questions and offers explanations for natural phenomena that may or may not directly influence humans (National Research Council, *NSES* 192). By exploring scientific and technological problems and issues, students will develop a rich sense of the relationships linking STSE.

We are seeing the impact of science and technology on our daily lives, in areas ranging from medical and health-related issues to computer and technological advancements. For this reason, science education can no longer be confined to developing basic science concepts and process skills. Students must experience and understand science and technology within the context of environmental quality and societal progress. Teachers can use an STSE approach in providing students with a foundation for making sound STSE decisions that recognize the interrelationships between scientific research, technological solutions, and the complex social and environmental impacts (*SYSTH* 4.3).

An STSE approach to learning science enables students to make connections between what they learn in science classes and what they experience in everyday life. Teachers make these STSE connections within their classrooms in many ways, through explanations, demonstrations, and lab activities. Researching and discussing controversial issues help students think critically, reason, argue logically, and develop opinions supported by evidence. These conflict-resolution and decision-making skills will enable students to become responsible citizens contributing to the future economic, social, and cultural life of Manitoba.

Students will examine the response of society to technological change, as we adopt new technologies or re-examine existing ones. Note that there is a natural connection between SLO B1 and SLO B2.

Suggestions for Instruction

Activating

Entry-Level Knowledge

- Throughout Kindergarten to Grade 8, students develop the design process (technological problem solving).
- Throughout Kindergarten to Senior 2, students develop the process of scientific inquiry.
- Students also acquire key attitudes, an initial awareness of the nature of science, and other skills related to research, communication, the use of information technology, and cooperative learning. Scientific inquiry and the design process are discussed in more detail in GLO C.

Prior Knowledge Activities

- Teachers may wish to examine students' understanding of the terms *science* and *technology*. How are they related? How are they different?
- Learning activities such as the following allow teachers and students to activate prior knowledge, recognize misconceptions, and relate new information to prior experiences.
  Examples (See Appendix 2):
  — Brainstorming examples of scientific and technological developments
  — Knowledge Chart (*SYSTH* 9.25)
  — KWL (Know-Want to Know-Learned) (*SYSTH* 9.18, 9.24)
  — LINK (List-Inquire-Note-Know) (*SYSTH* 9.18)
  — Listen-Draw-Pair-Share (*SYSTH* 9.15)
  — Rotational Cooperative Graffiti (*SYSTH* 3.15)

Acquiring and Applying

Article Analysis

- Students read and analyze an article describing a recent scientific or technological development using an Article Analysis Frame (*SYSTH* 11.30). They determine whether the development is scientific or technological, and how it will affect development of individuals, societies, and the environment.

Research

- Students research a technological invention, determining the need that was met. They analyze the science involved and describe the relationship between the science and the technology. Students determine what came first—the technology or the science. Students analyze, from various perspectives, the risks and benefits to society and the environment of applying the scientific knowledge or introducing the technology. Finally, students discuss the impact of the development on individuals, societies, and the environment. (See Appendix 4 for research techniques.)
  Examples:
  — changing the bonds formed by using ozone rather than chlorine to disinfect water, thus preventing toxic chlorinated hydrocarbons from forming in treated water supplies
  — alternately powered vehicles (electric, hydrogen cell)
  — technological developments in
    – households (light bulb, plumbing, refrigeration)
    – communication (telegraph, radio, telephone, satellite)
    – transportation (automobile, airplane, rocket, space shuttle)
    – electronics (radio, television, computer)
    – medicine (ultrasound, artificial limbs, electrocardiograms [ECG], MRI, vaccines)
- Alternatively, students may research a scientific development and determine what, if any, technologies have arisen from it.

Case Study

- Students examine a current technological or scientific development and assess its impact on individuals, society, and the environment.
  Examples:
  — cancer treatments
  — development of the automobile
  — organ transplants
  — space flight
  — the computer

Suggestions for Assessment

- Rubric for Assessment of Research Project (see Appendix 9)

General Learning Outcome B	Specific Learning Outcome
Students will... Explore problems and issues that demonstrate interdependence among science, technology, society, and the environment.	**SLO B2:** Recognize that scientific and technological endeavours have been, and continue to be, influenced by human needs and by societal and historical contexts.

Suggestions for Instruction

Teacher Background

Progress in science and invention depends heavily on what else is happening in society. Past history often influences current trends in scientific and technological developments. Individual and societal needs will dictate the type of technology these principles will yield. Students need to understand that science reflects history and is an ongoing, variable enterprise.

Technology, like science, is a creative human enterprise intertwined within the history and cultures of the world. Technology is concerned with proposing solutions to problems arising from human adaptation to the environment. Since there are many possible solutions, there are inevitably many requirements, objectives, and constraints.

Activating

Entry-Level Knowledge

Students have had some exposure to the historical development of scientific knowledge, such as the development of cell theory and microscopes in Grade 8.

Prior Knowledge Activities

- Learning activities such as the following allow teachers and students to activate prior knowledge, recognize misconceptions, and relate new information to prior experiences.
  Examples (see Appendix 2):
  — Brainstorming a list of technological and scientific developments (or use list generated for SLO B1) and connecting development to a particular human need
  — Knowledge Chart
  — KWL
  — LINK
  — Listen-Draw-Pair-Share
  — Rotational Cooperative Graffiti

Acquiring

Research

- Students research the historical and cultural development of a particular science or technology and determine how it may have arisen in response to individual, community, or societal needs and priorities.
  Examples:
  — transportation
  — footwear
  — housing

Applying

Case Study

- Students identify, explore, and analyze a social issue related to science and technology that raises ethical concerns or dilemmas.
  Examples:
  — stem cell research
  — cloning
  — space travel
  — nuclear power

Debate

- Students construct and defend a decision or judgement, and demonstrate that relevant arguments can arise from different perspectives.
  Examples:
  — need for land versus need for hydroelectricity in the construction of a hydroelectric dam
  — quest for knowledge versus ethical and moral dilemma of stem cell research or cloning
  — eradication of smallpox versus need to maintain study samples
  — nuclear power and storage of nuclear wastes

General Learning Outcome B	**Specific Learning Outcome**
Students will... Explore problems and issues that demonstrate interdependence among science, technology, society, and the environment.	**SLO B3:** Identify the factors that affect health and explain the relationships of personal habits, lifestyle choices, and human health, both individual and social.

Suggestions for Instruction

Teacher Background

The term *health* is not limited to an individual's mental and physical health but also includes social and environmental health. Both individual and societal choices affect human health. Students will examine the relationships between personal habits and choices and individual and social human health.

Activating

Entry-Level Knowledge

• The physical education/health education curriculum exposes students to a wide variety of health-related issues, including those of personal habits and lifestyle choices. The experience tends to be at a personal level.

Prior Knowledge Activities

• Learning activities such as the following allow teachers and students to activate prior knowledge, recognize misconceptions, and relate new information to prior experiences.

  Examples (see Appendix 2):

  — KWL
  — LINK
  — Listen-Draw-Pair-Share
  — Rotational Cooperative Graffiti

Acquiring

Research

• Students research and present a health-related issue. They examine the relationships between personal habits, lifestyle choices, and human health.

  Examples:

  — smoking
  — nutrition
  — pesticide use
  — fertilizer use

Applying

Role-Playing

• Students may assume the role of different people within a town or a city, such as in a town hall meeting, and respond to an issue affecting community health.

  Examples:

  — construction of a nearby landfill site
  — construction of a high-containment virology lab
  — ban on smoking in public places
  — use of pesticides to control mosquitoes
  — purchasing high-tech medical equipment for a northern community
  — leakage from a local sewage treatment plant
  — fee-for-use waste collection system
  — recycling

Case Study

• Students consider situations in which individual and societal choices affect human and environmental health.

  Examples:

  — Propose guidelines for selecting the most appropriate organ transplant recipient from a number of possible candidates.
  — Respond to a situation where mercury, a by-product of pulp and paper mills, ends up in the water and poisons humans who eat the fish from the water, causing mental illness and blindness.

Suggestions for Instruction

— Address the problems resulting from some hunters using shotgun pellets containing lead, which are eaten by waterfowl that get lead poisoning.

— Develop a personal wellness plan.

Debate

- Students construct arguments to support a decision or judgement, using examples and evidence and recognizing various perspectives.

  Examples:

  — Should a new housing development be permitted near a high-voltage power line?

  — Should a landfill site be built near your town?

  — Should nuclear waste be disposed of in the Canadian Shield?

  — Should a hog-farming operation be built next door?

  — Should farmers be using genetically modified seed (canola, wheat)?

Teacher Notes

General Learning Outcome B	Specific Learning Outcome
Students will… Explore problems and issues that demonstrate interdependence among science, technology, society, and the environment.	**SLO B4:** Demonstrate a knowledge of, and personal consideration for, a range of possible science- and technology-related interests, hobbies, and careers.

Suggestions for Instruction

Teacher Background

The value of any given technology may vary for different groups of people and at different points in time. Rarely are technology issues simple and one-sided. Relevant facts alone, even when known and available, usually do not settle matters entirely in favour of one side or another. This is because the contending groups may have different values and priorities. They may stand to gain or lose to different degrees, or make very different predictions about what the future consequences of the proposed action will be (AAAS, *Benchmarks for Science Literacy* 56).

Knowledge and personal consideration have strongly influenced the course of technology and continue to do so. It is largely the responsibility for the great revolutions in agriculture, manufacturing, sanitation and medicine, warfare, transportation, information processing, sports, and communication that have radically changed how people live. Societies influence what aspects of technologies are developed and how they are used. People control technology (as well as science) and are responsible for its effects (AAAS, *Benchmarks for Science Literacy* 56).

Activating

Entry-Level Knowledge

- Students have been exposed to a variety of career possibilities throughout the Kindergarten to Senior 2 science curriculum.

Prior Knowledge Activity

- Brainstorm a list of science and technology-related careers, interests, and hobbies. Use Concept Maps to link the careers to different fields of science.

Acquiring

Research

- Students research and present a career in a science- or technology-related field. They include educational requirements in addition to a job description.

  Examples:
  — Accountant
  — Aeronautical Engineer
  — Agricultural Economist
  — Astronomer
  — Biochemist
  — Biologist
  — Biosystems Engineer
  — Chemist
  — Computer Technologist
  — Doctor
  — Ecologist
  — Environmental Engineer
  — Environmental Scientist
  — Food Scientist
  — Forensic Scientist
  — Geneticist
  — Geological Engineer
  — Geologist
  — Immunologist
  — Industrial Technologist
  — Lab Technologist
  — Marine Biologist
  — Mathematician
  — Meteorologist
  — Microbiologist
  — Oceanographer
  — Pharmacologist
  — Physicist
  — Virologist
  — Zoologist

Suggestions for Instruction

Applying

Case Studies/Role-Playing

- Students explore science- and technology-related interests, hobbies, and careers through case studies and role-playing scenarios.

  Examples:

  — Act out "A Day in the Life of a _____."

  — Write an advertisement for a particular science- or technology-related job.

  — Spend a day working with someone in a science- or technology-related field.

  — Organize a science- and technology-related career symposium. This may be simulated, with students acting out the roles of various individuals.

Guest Speaker

- Invite a guest speaker who specializes in a particular science- or technology-related field or who has a particular science- or technology-related interest or hobby.

Teacher Notes

Suggestions for Assessment

See Appendices 9 for assessment rubrics:

- Rubric for Assessment of Research Project
- Rubric for Assessment of Student Presentation
- Rubric for Assessment of Class Presentations

General Learning Outcome B	Specific Learning Outcome
Students will... Explore problems and issues that demonstrate interdependence among science, technology, society, and the environment.	**SLO B5:** Identify and demonstrate actions that promote a sustainable environment, society, and economy, both locally and globally.

Suggestions for Instruction

Teacher Background

In Manitoba, sustainable development is regarded as economic development that is environmentally sustainable. Sustainable development resolves the perceived conflict between economic development and sustaining the natural world. The environment, the economy, and the health and well-being of society are interdependent and interrelated.

Social and economic forces strongly influence which technologies will be developed and used. Success is a result of many factors, such as personal values, consumer acceptance, patent laws, the availability of risk capital, the federal budget, local and national regulations, media attention, economic competition, and tax incentives. When proposals to introduce new technologies or to curtail existing ones are being considered, some key questions arise concerning alternatives, risks, costs, and benefits. What human, financial, material, and energy resources will be needed to build, install, operate, maintain, and replace the new technology, and where will they come from? How will the new technology and its waste products be disposed of and at what costs? What actions will promote a sustainable environment, society, and economy? And, ultimately, how do we determine whether or not we are maintaining a sustainable environment?

Activating

Entry-Level Knowledge

- Sustainable development has been incorporated into the Manitoba science curriculum from Grade 7 to Senior 2.

Prior Knowledge Activities

- Learning activities such as the following allow teachers and students to activate prior knowledge, recognize misconceptions, and relate new information to prior experiences. Teachers should investigate students' understanding of the term *sustainability*.

  Examples (see Appendix 2):
  — Knowledge Chart
  — KWL
  — LINK
  — Listen-Draw-Pair-Share
  — Rotational Cooperative Graffiti

Acquiring

Many of the following learning activities may involve the decision-making model (see SLO C3), as students use information to determine an appropriate course of action.

Research

- Students research economic activities that have an environmental impact. They analyze the economic potential of the action, as well as the environmental consequences.

  Examples:
  — A wood/forestry-products plant in Swan River boosted the local economy and was beneficial to the health and well-being of the local population. How do these benefits balance against the potential effects on the environment and the natural resources in the area?
  — Examine the effects of acid rain on the environment. Propose a course of action.
  — Examine the effects of the introduction of a new species (for example, zebra mussels, lamprey eels, starlings, purple loosestrife), including its impact on the economy, the environment, and human health and well-being.

Suggestions for Instruction

Applying

Debate/Town Hall Meeting

- Students discuss and debate factors and issues related to sustainability.

  Examples:

  — Debate the role of technology in the endangerment of species.

  — Discuss the impact of hunting on the environment, the economy, and the health and well-being of people.

  — Deliberate the role of chemical pesticides, herbicides, and fertilizers on the endangerment or extinction of species.

Case Study

- Students identify and examine, or propose new courses of action on, social issues related to science and technology, taking into account an array of perspectives, including that of sustainability.

  Examples:

  — Examine the process by which octane in gasoline was first achieved by adding tetraethyl lead, an environmental toxin, but is now achieved with unleaded blended gasolines.

  — Investigate the school operating system in terms of the origin, cost, use, and waste for each of water, light, heat, paper, and food.

  — Propose a plan to restore an area to its natural habitat (for instance, wetland, prairie grassland).

  — Examine methods of improving soil quality.

  — Examine the effects of pollution from mining in northern Manitoba on aquatic ecosystems.

  — Develop a personal plan for promoting sustainable development.

Suggestions for Assessment

- Rubric for Assessment Research Project (see Appendix 9)

Teacher Notes