Chapter

6

Mathematics, Science and Technology

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Science and technology have left their mark on our way of life and our environment and are among the most revealing examples of human ingenuity. Scientific discoveries and technological achievements affect major aspects of our existence. Computers, for example, have revolutionized the way we work and communicate, and even the way we think, and have become the principal tool for acquiring knowledge in many fields.

Moreover, science and technology would not have reached their current level of development without the contribution of mathematics. Although each subject area followed its own course of development, they have become more closely related as they have evolved. More often than not, technical objects with any measure of sophistication work by making use of components that operate according to the principles of mathematical logic. However, widespread use of mathematics has not been limited to the fields of science and technology. Countless situations require us to decode numerical information, estimate, calculate and measure, all of which are operations that belong to the world of mathematics.

Mathematics, science and technology each develop according to their own dynamic, but this development is also a function of the external pressure exerted by a society seeking ways to meet some of its needs. Mathematical developments, scientific discoveries and technological achievements must be placed in their historical, social, economic and cultural context if we are to understand how these three areas have evolved.

For the most part, scientific and technological advances contribute to our individual and collective well-being, but some of these advances may also threaten the ecological balance of our environment or introduce new elements whose long-term environmental effects are difficult to foresee. Only by acquiring a broad general knowledge of science and technology will students be able to take a critical look at these changes and appreciate the ethical issues they raise.

General Objective in Mathematics, Science and Technology

To provide access to a specific set of knowledges related to the methods, conceptual fields and languages specific to each of the subjects in this subject area.

Core Learnings in Mathematics, Science and Technology

- Understands information and conveys it clearly using language appropriate to mathematics, science and technology: terminology, graphics, notation, symbols and codes
- Uses inductive and deductive reasoning
- Establishes connections between the learnings he/she acquires in each subject in this particular subject area and the learnings related to other subjects
- Views this knowledge as a tool that can be used in everyday life
- Analyzes data resulting from observations or found in a problem and uses appropriate strategies to achieve a result or to find a solution that can then be explained, verified, interpreted and generalized
- Appreciates the importance of mathematics, science and technology in human history
- Exercises critical judgment in assessing the impact of mathematics, science and technology on individuals, society and the environment

Introduction

It is essential to learn about science and technology if we are to understand the world in which we live and adapt to it. Scientific and technological development is pervasive, and students must be introduced to these advances at a very early age. It is important that they understand the difference between natural phenomena and man-made objects, but even more crucial that they become aware of how humanity's relationship with nature has changed throughout history, how human beings have come to understand nature and explain various natural phenomena and how different manufacturing processes were devised and improved over time.

... making a more enlightened contribution when it comes to decisions that will shape society now and in the future.

Science and technology are distinct, yet complementary fields of endeavour, and their development is closely interrelated. Science attempts to describe and explain the world. It looks for relationships that allow us to make predictions and determine the causes of natural phenomena. For its part, technology applies the discoveries of science, while contributing to its development by providing it with new tools or instruments as well as new challenges and topics for research. Technology attempts to change the world so it can be adapted to meet humanity's needs.

This program provides an introduction to scientific and technological activity by using learning contexts involving situations in which students can apply science and technology, both of which make use of intellectual processes such as questioning, systematic observation, trial-and-error, experimental investigation, the assessment of needs and constraints, model building and the creation of prototypes. Scientific and technological work also calls for creativity, a concern for efficiency, rigour, initiative and the ability to think critically. By engaging in these types of intellectual processes while exploring problems in their environment, the students will gradually learn to use the types of reasoning associated with scientific and technological activity, come to appreciate the nature of these activities and acquire the languages used in science and technology.

Through these introductory activities, the program aims to develop the students' knowledge of science and technology. Science and technology can be found in every aspect of our daily lives. It is important to become aware of this and to appreciate how science and technology have contributed to the development of society. To do this, we must first learn to recognize scientific and technological applications in our immediate environment and become familiar with specific ways of observing the phenomena around us. We must also study the evolution of science and technology throughout history and identify the various factors that influence their development. Lastly, we must step back so we can gain the perspective needed to recognize the values underlying science and technology, identify the social issues resulting from science and technology, recognize their limitations and measure their positive and negative impact on our lives.

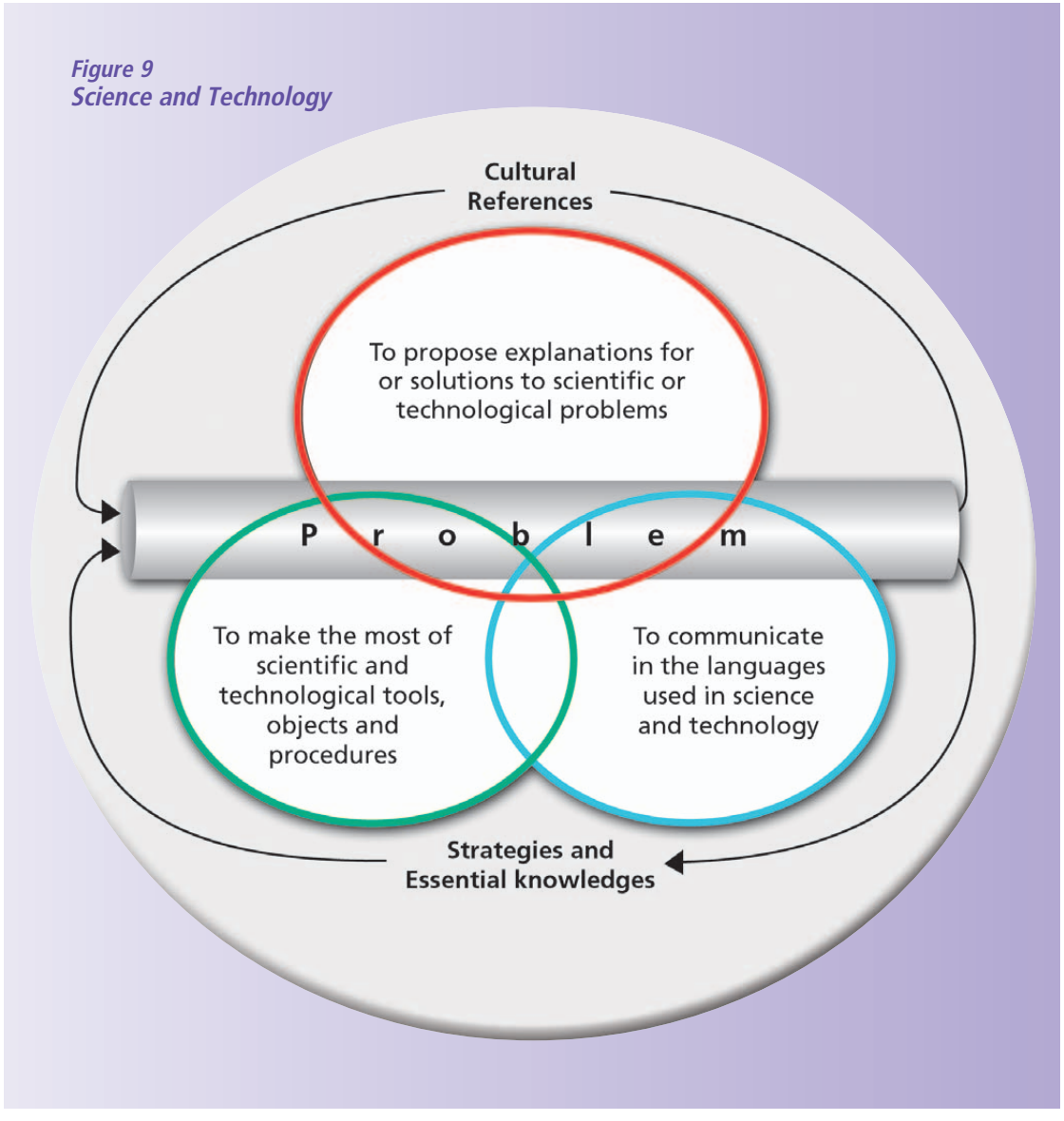
Although science and technology are not part of the timetable in Elementary Cycle One, it is important to introduce Cycle One students to their rudiments through activities involving observation, manipulation and the ability to formulate questions or use different types of logical reasoning such as classification and seriation. At this age, children are usually interested in various phenomena related to the world around them. Through the other subjects and the broad areas of learning, the students will be introduced to scientific and technological activity by developing the following competency: "To explore the world of science and technology."

In Cycles Two and Three, the science and technology program is based on fundamental learnings and organized around the following three competencies:

- To propose explanations for or solutions to scientific or technological problems
- To make the most of scientific and technological tools, objects and procedures
- To communicate in the languages used in science and technology

These competencies emphasize distinct, yet complementary aspects of science and technology. Scientific and technological activities, like all human activities, take place in a social, cultural and historical context that affects these activities, but is also in turn influenced by them. Science and technology represent a specific way of understanding the world. In developing the first competency, the students become familiar with the types of reasoning that make it possible to deal with scientific and technological problems. The other two competencies are closely related to the very nature of the activities for which science and technology provide means of achievement and communication. Understanding the nature of scientific and technological tools, objects and procedures is essential if we are to measure both the positive and negative impact of science and technology. Communicating in scientific and technological languages makes it possible to ensure continuity between already acquired learnings and the learnings that will result from discussions with other people. All three competencies are developed in relation to certain cultural references that enable the students to see how subject-specific learning relates to various fields of human activity and to a social and historical context that may clarify this learning.

Figure 9
Science and Technology



Elementary Cycle One

Competency • To explore the world of science and technology

Focus of the Competency

Meaning of the Competency

Exploring the world of science and technology involves becoming familiar with ways of reasoning and doing things, learning how to use tools or to shape materials by means of simple procedures and becoming familiar with various aspects of languages used in science and technology. The students develop this competency by learning how to handle objects in order to discover their properties or characteristics. They observe phenomena in their immediate environment, formulate questions and use their senses to find answers. They devise experiments using simple techniques or procedures and formulate explanations or propose solutions using scientific or technological language. Through these activities, they slowly begin the process of constructing scientific and technological knowledge. Little by little, they learn to differentiate between these two types of knowledge, while recognizing that they are complementary. The students also acquire a certain number of skills and attitudes needed to understand the material covered in Cycles Two and Three. By becoming aware of their actions or the procedures they are using, they gradually learn about an important dimension of science and technology.

In preschool, children had the opportunity to learn about experimental games, trial-and-error and the handling of materials that are easy to work with or transform. The material covered in Cycle One builds on what the students learned in preschool, while providing a more systematic introduction to the knowledge they will have to integrate in subsequent cycles.

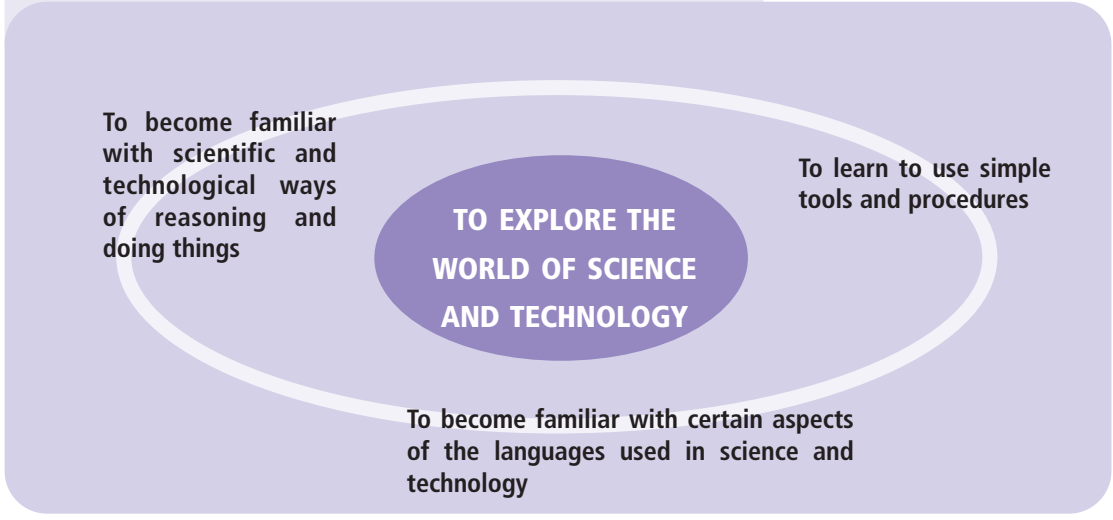
Context for Learning

This competency is developed through the other subjects, but especially through the broad areas of learning, which involve many different topics that can be examined from a scientific or technological point of view. The students are placed in a stimulating environment that piques their curiosity and encourages their active participation by providing them with materials, instruments or tools that are at their level.

Developmental Profile

By exploring simple problems related to everyday situations, the students learn how to ask themselves questions, to observe, to describe, to handle objects, to devise, to construct, to propose explanations or solutions and to find ways of validating them. When describing or explaining phenomena they have observed, students gradually become familiar with certain aspects of the languages used in science and technology. In discussions with classmates, they learn to share information, compare their ideas and justify their explanations. They learn to reflect on what they have done and its impact on their immediate environment.

Key Features of the Competency



Evaluation Criteria

- Use of language appropriate to the description of phenomena or objects in his/her immediate environment ❶
- Formulation of explanations or possible solutions ❶

Legend: ❶ Cycle One

End-of-Cycle Outcomes

Students are able to formulate questions and propose explanations concerning various phenomena related to their immediate environment. They conduct simple experiments to answer a question or solve a problem. They can distinguish between the natural world and man-made objects. They understand the workings of simple objects that are relatively easy to handle. They spontaneously use elements of scientific and technological languages to formulate questions, propose explanations, explain ways of doing things, describe objects and explain how they work.

Essential Knowledges

The essential knowledges in Cycle One are related to simple concepts and phenomena in the students' immediate environment. The following list is neither prescriptive nor exhaustive, but provides an overview of the material that can be covered at this stage of the students' development.

Learnings

• The material world

– Classification of objects according to their properties and characteristics *(e.g. shape, size, colour, texture, smell)* 1

– Conservation of matter *(e.g. mass, shape, surface, liquid quantity, length)* 1

– Mixtures
  - Miscible and nonmiscible substances (*e.g. water and milk; water and oil)*
  - Soluble and nonsoluble substances 1

– Absorption 1

– Permeability and impermeability 1

– Solid, liquid, gaseous state; phase changes *(e.g. evaporation)* 1

– Friction *(e.g. pushing an object, letting an object slide, letting an object roll)* 1

– Transparence *(e.g. translucence, opaqueness)* 1

– Magnets (characteristics and uses) 1

– Common household products *(e.g. properties, uses, safety-related symbols)* 1

– Everyday technical objects 1

  - Description of parts and mechanisms 1

  - Identification of the needs this object was originally designed to meet 1

• Earth and Space

– Light and shadow 1

– Temperature (measuring instruments and seasons) 1

– Water in all its forms (clouds, rain, rivers, lakes, oceans) 1

– System involving the Earth, the moon, and the sun 1

• Living things

– External anatomy of human beings 1

– Food production techniques *(e.g. making butter, bread)* 1

– Plant growth (needs of a plant) 1

– Foods of domesticated and wild animals 1

– Animal's adaptation to its environment *(e.g. anatomy, behaviour)* 1

– Consumption of living things (food, housing, everyday products) 1

Cycles Two and Three of Elementary School

Competency 1 • To propose explanations for or solutions to scientific or technological problems

Focus of the Competency

Meaning of the Competency

Science and technology attempt to solve problems resulting from a host of questions, to which there are no perfectly clear or satisfactory answers. Finding scientific and technological solutions to these problems requires the ability to observe, measure, interpret data and perform verifications. These activities are aimed at explaining the world and shaping it to meet people's needs. Science and technology must provide answers to questions that arise from careful observation of the environment and from the difficulties involved in adapting to it. Many of these questions and difficulties are related to everyday situations and may represent relatively simple problems or be part of a more wide-ranging and often more complex set of problems.

If we are to succeed in proposing explanations for or solutions to scientific and technological problems, we must first learn how to ask ourselves questions. Problems do not arise in a vacuum. Consequently, scientific or technological activities cannot be reduced to the application of methods. Open-mindedness and creativity are often required to identify a relevant set of problems and to determine which of these individual problems lend themselves to observation and analysis. In essence, the students develop this competency by learning to explore different aspects of their environment, to examine nature using appropriate exploration strategies, to gather relevant information and to analyze it with a view to proposing relevant explanations for or providing solutions to problems. The students can begin to develop this competency at an early age, but will continue to do so throughout their schooling.

Connections to Cross-Curricular Competencies

When they propose explanations for or solutions to scientific and technological problems, the students use several cross-curricular competencies, particularly intellectual and methodological competencies. When applying the different types of reasoning specific to science and technology, they are especially required to use creativity, problem solving and critical thinking. When making observations, handling objects and gathering information, they are developing effective work methods.

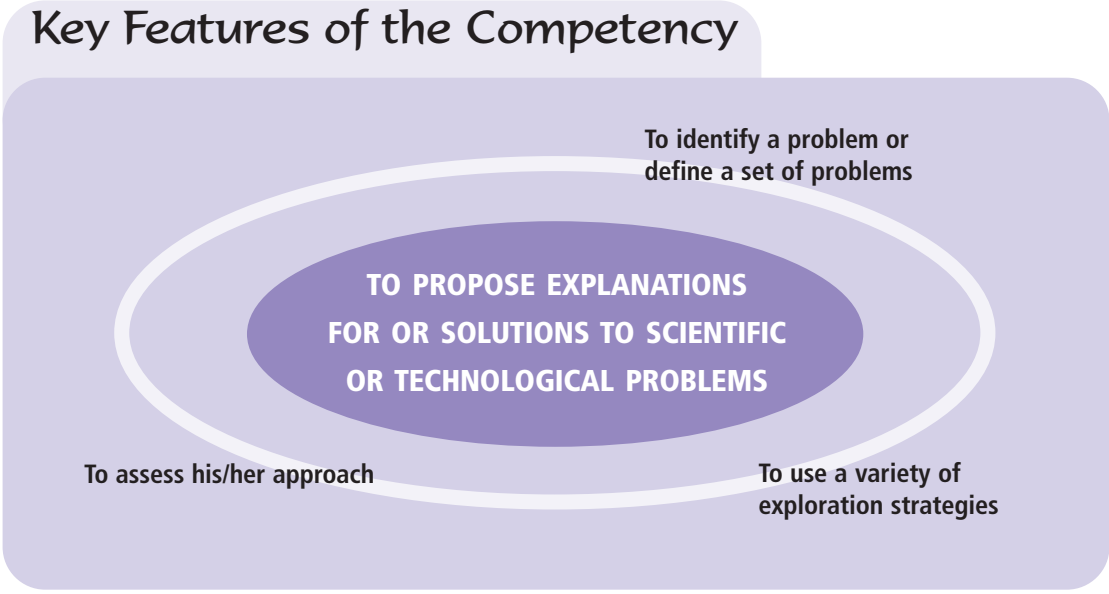
Context for Learning

When faced with situations that lead them to ask themselves questions, the students learn to define problems that they themselves have recognized or that have been presented to them. On the basis of simple observations and manipulations, they study different problems using instruments, tools or techniques appropriate to the situation. They have access to sources of information and people that help them find ideas, explanations or solutions. They explore courses of action, formulate proposed solutions, implement them and assess the results. They ponder over questions, reflect, gather information, discuss ideas with others, handle materials and do things by trial and error. In so doing, they construct their own knowledge, become familiar with concepts that allow them to better understand their environment and gradually develop scientific and technological ways of doing things. They also expand their general knowledge and cultural awareness by studying the historical foundations as well as the social and ethical aspects of science and technology. They become aware of the effects and limitations of these activities.

Developmental Profile

During Cycle Two, the students deal with relatively simple sets of problems and problems related to their immediate environment. When making observations and handling or making objects, they make discoveries, compare their representations, propose explanations and look for solutions. During Cycle Three, they deal with sets of problems and problems related to the broader environment. When making more complex observations and handling, designing or making more complex objects, they find it easier to establish more accurate connections between their explanations and their approaches to solving problems. They realize that there are often several possible solutions. They learn to recognize the respective roles of science and technology when examining a problem. They apply more advanced scientific and technological knowledge and develop more complex skills.

Key Features of the Competency



Evaluation Criteria

- Appropriate description of the problem or set of problems from a scientific or technological point of view ❷ ❸
- Use of an approach geared to the nature of the problem or set of problems ❷ ❸
- Development of relevant explanations or realistic solutions ❷ ❸
- Justification of explanations or solutions ❷ ❸

Legend:* ❷ Cycle Two ❸ Cycle Three

* This legend also applies to the Evaluation Criteria for the other competencies and to the sections entitled Essential Knowledges and Suggestions for Using Information and Communications Technologies.

End-of-Cycle Outcomes

Cycle Two

By the end of this cycle, the students explore problems that require relatively simple and concrete approaches and strategies. They gather information, plan their work and take notes relating to a number of parameters. They validate their approach by taking into account a number of scientific and technological elements. They still find it difficult to distinguish between the scientific and the technological aspects of a problem.

Cycle Three

By the end of this cycle, the students explore problems requiring approaches and strategies that are more complex and that may be somewhat more abstract. They gather information, plan their work and collect data relating to a greater number of parameters. They validate their approach by taking into account a greater number of elements. When analyzing a problem, they consider both its scientific and technological dimensions.

Competency 2 • To make the most of scientific and technological tools, objects and procedures

Focus of the Competency

Meaning of the Competency

To study the world around us, science uses many different techniques, instruments and procedures that consist of physical tools as well as mental representations. These range from the simplest (e.g. measuring a length with a ruler) to the most complex (e.g. calculating density), and from the most concrete (e.g. adjusting gears) to the most abstract (e.g. devising a model). For its part, technology advances as a result of scientific knowledge, but also develops new tools or procedures, the possible uses of which cannot all be assessed beforehand. Technology is not simply the application of scientific discoveries, since the invention of technical objects often precedes the establishment of scientific theories, as the history of science and technology has shown. Moreover, objects, techniques or procedures initially designed to be used in certain ways and in certain situations may eventually be used in other ways and in other situations. Knowing about these tools and procedures, learning to use them, identifying different situations in which they can be used and evaluating their repercussions or effects on various spheres of human activity are important dimensions of scientific and technological culture.

Among other things, this competency refers to the ability to use the objects, tools and procedures of science and technology to construct tangible representations of the world around us or to refine our understanding of that world. This competency also enables us to comment on questions regarding the social uses of science and technology and to make a more enlightened contribution when it comes to decisions that will shape society now and in the future. This competency is used to perform concrete tasks like drawing plans, building environments and prototypes, measuring quantities, and observing small or distant objects. It also manifests itself as the ability to recognize the various uses of scientific and technological objects, tools or procedures in different situations and to recognize their positive and negative effects, especially on everyday life.

Context for Learning

The students use this competency in various situations. When they explore sets of problems, they are naturally inclined to use different scientific or technological tools and procedures, be it to draw plans, take measurements, conduct experiments, gather information, simulate phenomena, make tables of results or draw graphs. When engaging in other activities such as starting a collection, reading, visiting a science museum, a business or a factory, or making a presentation, the students can use observational instruments, take notes, display data in different forms (e.g. tables, graphs, diagrams) and communicate information. When they learn how to recognize and use various technical objects, tools or procedures, they are asked to relate them to the situation in which they are used, to discover their different uses, and to describe their development throughout history. This may give them the opportunity to examine the impact of various objects on our way of life (e.g. development of means of transportation, heating and lighting systems, home appliances) and the different consequences of using these objects.

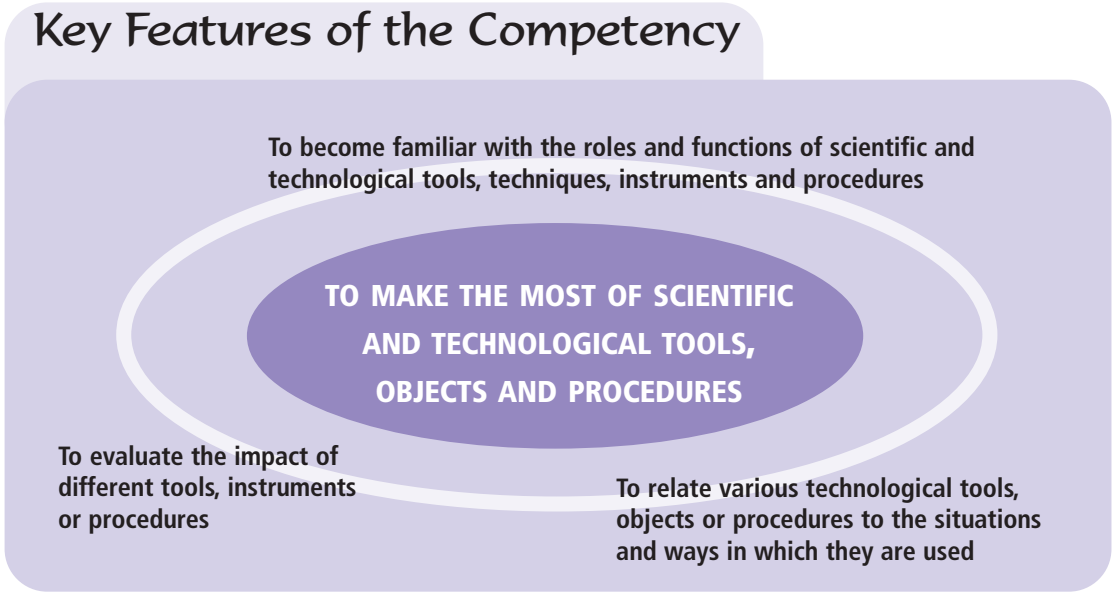
Connections to Cross-Curricular Competencies

Making the most of scientific and technological tools, objects and procedures implies knowing how to use them, which involves, in particular, the use of methodological competencies. Students will also be called upon to frequently exercise their critical judgment, since Competency 2 implies the ability to appreciate the ethical issues related to the use of these tools, objects and procedures.

Developmental Profile

During Cycle Two, the students become familiar with relatively simple and concrete tools, techniques, instruments and procedures. They begin to discover the advantages of relying on something other than their five senses and everyday methods. During Cycle Three, they become familiar with more complex and more abstract tools, techniques, instruments and procedures. They take an interest in the design, production and marketing processes. They master the use of simple tools, instruments and procedures. More and more, they develop an appreciation for the advantages of these tools, instruments and procedures, but they also begin to understand their limitations.

Key Features of the Competency



Evaluation Criteria

- Association of instruments, tools and techniques with appropriate uses ❷ ❸
- Appropriate use of instruments, tools or techniques ❷ ❸
- Design and making of instruments, tools or models ❷ ❸
- Identification of the effects of using various tools, instruments or procedures ❷ ❸

End-of-Cycle Outcomes

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Cycle Two

By the end of this cycle, the students use relatively simple and concrete tools, techniques, instruments and procedures, exploiting their basic potential and briefly assessing the results they have obtained. They design rudimentary tools, instruments and techniques and are aware of the most obvious examples of how science and technology have shaped the living conditions of human beings.

Cycle Three

By the end of this cycle, the students use tools, techniques, instruments and procedures that are more complex and abstract than those used in the previous cycle, making greater use of their potential and a more sophisticated assessment of the results they have obtained. They design more elaborate tools, instruments and techniques and recognize the main areas in which science and technology are applied (e.g. computer technology, biotechnology, medical engineering, pharmacology, energy transformation and exploitation, robotics, astronautics).

Competency 3 • To communicate in the languages used in science and technology

Focus of the Competency

Meaning of the Competency

Communication is an essential facet of scientific and technological activity. Every aspect of the work of scientists, engineers, technologists and technicians involves researching and examining various types of information, providing a clear and complete presentation of results and comparing ideas. This form of communication requires knowing different types of languages, which make it possible to express concepts, laws, theories and models, using the formalism of mathematics in particular. These languages are composed of everyday words, some of which take on a specific meaning, specialized terms and expressions, and different types of representations such as symbols, diagrams, tables and graphs.

This competency refers to the ability to interpret and convey messages using different components of the languages specific to science and technology. The students use various types of representations such drawings, diagrams, graphs and symbols. Throughout their schooling, the students become more proficient at using the languages and types of representations employed in science and technology. This enables them to better organize and express their thoughts.

Connections to Cross-Curricular Competencies

By paying more attention to the accuracy and clarity of their message, the medium used to present their message and the people to whom the message is addressed, the students develop certain cross-curricular competencies, especially the ability to communicate and to use information.

Context for Learning

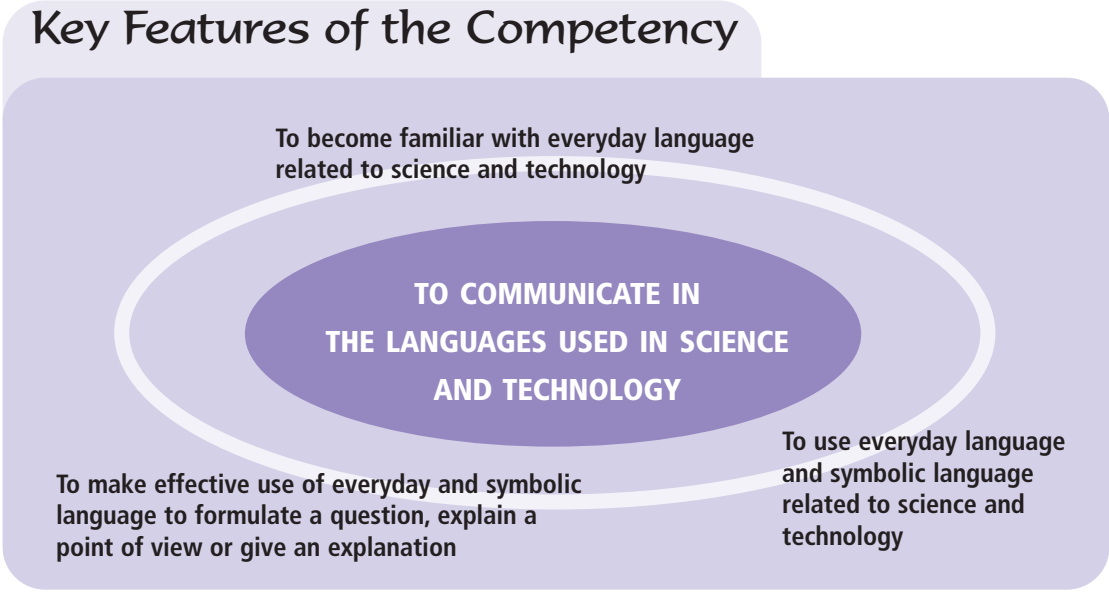
The students must communicate during different activities. They employ various types of representations to support a line of questioning, to try to understand other people's ideas, to provide a demonstration or to propose an explanation. They use different elements of the languages specific to science and technology in order to explain phenomena and describe objects, procedures or tools. They are asked to include cultural and historical references when conveying information.

Developmental Profile

During Cycle Two, the students use everyday language and symbolic language to express their ideas, explanations and solutions related to scientific and technological problems, concepts or sets of problems. They gradually become familiar with everyday language and symbolic language used in its scientific and technological sense and use this language correctly when taking part in discussions with classmates or when proposing an idea, an explanation or a solution. On the one hand, they associate new scientific and technological terms with everyday language and on the other hand, they associate their new scientific and technological knowledge with symbolic language (rules, syntax, terms, symbols, drawings, diagrams, graphs).

During Cycle Three, the students continue to become more familiar with scientific and technological languages by using what they learned in Cycle Two. They make more and more exact use of the different aspects of everyday language and symbolic language when discussing their point of view with their classmates. They are both creative and methodical when choosing and using the most appropriate types of representations.

Key Features of the Competency



Evaluation Criteria

- Understanding of scientific and technological information 2 3
- Correct transmission of scientific and technological information 2 3

End-of-Cycle Outcomes

Cycle Two

By the end of this cycle, the students correctly interpret and convey simple scientific and technological information involving some facets of the language of science and technology (everyday words whose scientific meaning is the same as their everyday meaning, everyday words whose scientific meaning is different from or more precise than their everyday meaning, some specialized terms and expressions as well as simple diagrams, tables and graphs).

Cycle Three

By the end of this cycle, the students correctly interpret and convey more complex scientific and technological information involving a greater number of the more elaborate facets of the language of science and technology (a greater number of specialized terms and expressions; a greater number of more elaborate symbols, formulas, diagrams, tables and graphs).

Cultural References

In order to acquire the competencies to be developed in the science and technology program, the students need a particularly rich and stimulating environment containing many cultural references. These references help to enrich, personalize, qualify and integrate essential knowledges as well as keep them in perspective. The following is a partial list of proposals that reflect the underlying philosophy of the program.

Science, technology and the other areas of human activity: Science and technology have always developed symbiotically and in constant interaction with other areas of human activity. For example, many discoveries were closely related to the invention of measuring instruments *(e.g. clock, thermometer)* observational instruments *(e.g. magnifying glass, microscope, telescope).* Moreover, a wide variety of human activities (e.g. agriculture, animal husbandry, metallurgy or architecture) have made important contributions to the development of science and technology and, in turn, benefited from scientific and technological discoveries.

History: Climate as well as economic, social and political conditions and religious beliefs largely determine the development of science and technology, which dates back to the beginning of time. For example, the sundial, the calendar, metal casting and plowing methods were discovered well before Jesus Christ. All ordinary objects, such as the knife or the bicycle, have a history that often goes back many years and that teaches us a great deal about the curiosity, tenacity and imagination of human beings.

People: Scientific discoveries and technological inventions have always resulted from the work of people or groups of people influenced by the constraints of their time and their environment. Scientists like Galileo, Newton, Lavoisier, Pasteur, Darwin, Marie Curie and Einstein, to name but a few, used the work of their predecessors and their contemporaries to contribute to fundamental progress in science and technology. Closer to home, Québec and Canadian scientists, engineers and technologists have been recognized in their respective fields. Men and women from every country and culture work in scientific and technological fields. While most people are familiar with professionals such as biologists, meteorologists, chemists and engineers, there are other occupations that are less well known, but just as interesting and useful (e.g. geologist, cartographer, agricultural technologist and forestry technician).

Values: Science and technology are based on fundamental values such as objectivity, rigour and precision, which ensure the credibility of results.

Ethics: Even scientists and technologists with the best of intentions sometimes conduct research projects or produce results that are questionable or controversial. Consequently, research methods as well as the use of scientific and technological discoveries and applications must be examined in light of strict rational and ethical criteria and, even more importantly, must be open to public debate.

Impact: The impact of science and technology is far-reaching. Our way of life is now radically different from what it was a few centuries ago. For example, heating, transportation, communications, health and hygiene have improved tremendously. However, some of the effects of science and technology, such as environmental degradation, can be very harmful. An awareness of nature and the severity of these consequences have sparked efforts to curb the most harmful effects of science and technology in order to protect the environment and improve life for all living things on this planet.

Limitations: Despite their enormous potential to explain and predict phenomena and their capacity to profoundly change our environment, science and technology are neither perfect nor omnipotent. They can answer many questions, but these answers often raise new questions that can sometimes remain unanswered for a very long time. Moreover, several factors can limit the development of science and technology, including the state of the economy, current knowledge and ethical concerns.

Essential Knowledges

The essential knowledges that students must acquire are divided into three main categories: the material world, Earth and space, and living things. These knowledges are structured around a set of unifying concepts that make it possible to see connections between these three categories. These unifying concepts are as follows: matter; energy; forces and motion; systems and interaction.

The unifying concepts combine a certain number of ideas specific to each category. These ideas, the choice of which is left up to the teacher, must be examined through the study of concrete problems that the students will explore using manipulative materials. Opening activities *(e.g. discussion, brainstorming, reading)* may be used to introduce these problems, and consolidation of learning *(e.g. concept networks, reports, presentations)* may be employed to complete this work.

Examples in parentheses following a given idea provide guidelines indicating the scope of the essential knowledges in question. They illustrate the level of complexity of the ideas that can be studied at the elementary level.

Material World

• Matter

– Properties and characteristics of matter in different states (solid, liquid, gas):		
- shape	2	
- colour	2	
- texture	2	
- mass and weight	2	
- density *(e.g. small objects that are light and heavy, big objects that are light and heavy)*	2	
- relative density and buoyancy	2	3
- other physical properties *(e.g. elasticity, hardness, permeability and impermeability, solubility)*		3
- materials of which an object is made		3
– Changes in matter		
- physical changes *(e.g. breaking, grinding, phase changes)*	2	
- chemical changes *(e.g. simple chemical reactions: rust, combustion, acid-base)*		3
- manufacturing household products *(e.g. soap, paper, cement)*	2	3

• Energy

– Forms of energy:		
- forms of energy *(e.g. mechanical, electrical, chemical, heat, solar, sound, nuclear)*	2	
- sources of energy *(e.g. moving water, chemical reaction in a battery, sunlight)*		3
– Transmission of energy:		
- thermal conductivity *(e.g. conductors and insulators)*		3
- electrical conductivity *(e.g. conductors and insulators)*		3
- simple electric circuits		3
- sound waves *(e.g. volume, timbre, echo)*	2	
- light radiation *(e.g. reflection, refraction)*		3
- convection *(e.g. in gases and liquids)*	2	
– Transformation of energy:		
- consumption and conservation of energy by human beings *(e.g. electric meter, insulation)*	2	3
- transformations of energy from one form to another *(e.g. transformation by machines)*	2	3

• Forces and motion

– Effect of gravitational attraction on an object *(e.g. free fall, pendulum)*		3
– Effect of electrostatic attraction *(e.g. paper attracted by a charged object)*	2	
– Effect of electromagnetic attraction *(e.g. magnet, electromagnet)*		3

Material World (cont.)

– Pressure *(e.g. pressure in a balloon, airplane wing)*		3
– Effects of a force on the direction of an object *(e.g. pushing, pulling)*	2	
– Combined effects of several forces on an object *(e.g. reinforcement, opposition)*		3
– Characteristics of motion *(e.g. direction, speed)*	2	
• Systems and interaction		
– Simple machines *(e.g. lever, inclined plane, screw, pulley, winch)*	2	
– Other machines *(e.g. cart, waterwheel, windmill)*		3
– How manufactured objects work *(e.g. materials, shapes, functions)*	2	3
– Servomechanism and robots		3
– Transportation technology *(e.g. car, airplane, boat)*	2	3
– Electron technology *(e.g. telephone, radio, sound recording, television, transistor, microprocessor, computer)*	2	3
• Techniques and instrumentation		
– Manufacturing *(e.g. reading plans, marking out, cutting, assembling, finishing)*	2	3
– Use of simple measuring instruments *(e.g. rulers, dropper, balance, thermometer)*	2	3
– Use of simple machines	2	3
– Use of tools *(e.g. pliers, screwdriver, hammer, wrench, simple template)*	2	3
– Design and manufacture of instruments, tools, machines, structures *(e.g. bridges, towers)*, devices *(e.g. water filtration device)*, models *(e.g. glider)* and simple circuits	2	3
• Appropriate language		
– Terminology related to an understanding of the material world	2	3
– Conventions and types of representations specific to the concepts studied		
- Symbols (H_2O)		3
- Graphs *(e.g. pictograph, histogram)*	2	3
- Tables	2	3
- Drawings, sketches	2	3
- Norms and standardization	2	3

Earth and Space

• Matter		
– Properties and characteristics of matter on Earth		
- soil, water and air	2	
- traces of living things and fossils	2	
- classification of rocks and minerals		3
– Organization of matter:		
- crystals	2	
- structure of the Earth *(e.g. continents, oceans, ice caps, mountains, volcanoes)*		3
– Transformation of matter		
- water cycle	2	
- natural phenomena *(e.g. erosion, lightning)*		3

Earth and Space (cont.)

• Energy		
– Sources of energy:		
- solar energy	2	
- hydraulic energy *(e.g. hydroelectric dam, tidal energy)*	2	
- wind energy	2	
- fossil fuel-based energy		3
– Transmission of energy *(e.g. radiation)*		3
– Transformation of energy:		
- renewable forms of energy	2	
- nonrenewable forms of energy		3
• Forces and motion		
– Rotation of the Earth *(e.g. day and night, visible motion of the Sun and the stars)*	2	
– The tides		3
• Systems and interaction		
– System involving the sun, the Earth and the moon	2	
– Solar system		3
– The seasons		3
– The stars and the galaxies *(e.g. constellations)*	2	3
– Meteorological systems *(e.g. clouds, precipitation, storms)* and climates	2	3
– Technologies related to the Earth, the atmosphere and outer space *(e.g. seismograph, prospection, weather forecasting, satellites, space station)*	2	3
• Techniques and instrumentation		
– Use of simple observational instruments *(e.g. binoculars, telescope)*	2	3
– Use of simple measuring instruments *(e.g. rulers, balance, thermometer, weather vane, barometer, anemometer, hygrometer)*	2	3
– Design and manufacture of measuring instruments and prototypes	2	3
• Appropriate language		
– Terminology related to an understanding of the Earth and the universe	2	3
– Conventions and types of representations *(e.g. globe, constellations)*	2	3
– Drawing, sketches	2	3

Living Things

• Matter		
– Characteristics of living things:		
- metabolism of plants and animals *(e.g. nutrition, respiration, growth, death)*	2	3
- reproduction of plants and animals	2	3
– Organization of living things:		
- classification of life forms *(e.g. microorganisms, fungi, plants, animals)*	2	
- anatomy of plants *(e.g. parts of a plant)*	2	
- anatomy of animals *(e.g. parts and principal systems)*	2	
- senses *(sight, hearing, smell, taste, touch)*	2	
- human reproductive system		3
– Transformations of living things		
- growth of plants and animals	2	
- metamorphoses *(e.g. butterfly, frog)*		3

Living Things (cont.)

- human growth and development — 3
- evolution of life forms — 3

• Energy

– Sources of energy for living things:
  - nutrition for animals *(e.g. need for water, sugars, lipids, proteins, vitamins, minerals)* — 2
  - photosynthesis in plants *(e.g. need for water and carbon dioxide)* — 3
  - agricultural and food technologies *(e.g. crossbreeding of plants and their propagation by cuttings, selection and breeding of animals, food production, pasteurization)* — 2 3

– Transformation of energy in living things:
  - food chains — 2
  - ecological pyramids — 3

• Forces and motion

– How animals move *(e.g. reptation, walking, flying)* — 2

– Motion in plants *(e.g. phototropism, hydrotropism, geotropism)* — 3

• Systems and interaction

– Interaction between living organisms and their environment
  - living things and their habitats — 2
  - parasitism, predation — 2
  - adaptation *(e.g. mimicry)* — 3

– Interaction between humans and their environment — 2 3

– Environmental technologies *(e.g. recycling, composting)* — 2 3

• Techniques and instrumentation

– Use of simple observational instruments *(e.g. magnifying glass, binoculars, microscope)* — 2 3

– Use of simple measuring instruments *(e.g. rulers, dropper, balance, thermometer)* — 2 3

– Design and manufacture of environments *(e.g. aquarium, terrarium, incubator, greenhouse)* — 2 3

• Appropriate language

– Terminology related to an understanding of living things — 2 3

– Conventions *(e.g. plant and animal identification key)* — 2 3

– Graphs *(e.g. pictograph, histogram)* — 2 3

– Tables *(e.g. plant and animal classification tables)* — 2 3

– Drawings, sketches — 2 3

Strategies

The strategies associated with scientific and technological thought make it possible to solve a problem and explore a set of problems. These strategies are not all used in every situation, and the order in which they are used may differ from the one given below, but they are useful for carrying out efficient and well-organized scientific and technological work.

• Exploration strategies

– Studying a problem or a phenomenon from different points of view

– Distinguishing between the different types of information useful for solving the problem

– Recalling similar problems that have already been solved

– Becoming aware of his or her previous representations

– Drawing a diagram for the problem or illustrating it

– Formulating questions

– Putting forward hypotheses

STRATEGIES (cont.)

- Exploring various ways of solving the problem
- Anticipating the results of his or her approach
- Imagining solutions to a problem in light of his or her explanations
- Taking into account the constraints involved in solving a problem or making an object
- Examining his or her mistakes in order to identify their source
- Using different types of reasoning *(e.g. induction, deduction, inference, comparison, classification)*
- Using empirical approaches *(e.g. trial and error, analysis, exploration using one's senses)*

- **Strategies for recording, using and interpreting information**

- Using different sources of information
- Validating sources of information
- Using a variety of observational techniques and tools
- Using technical design to illustrate a solution
- Using different tools for recording information *(e.g. diagrams, notes, graphs, procedures, logbook)*

- **Communication strategies**

- Using different means of communication to propose explanations or solutions *(e.g. oral presentation, written presentation, procedure)*
- Using tools to display information in tables and graphs or to draw a diagram
- Organizing information for a presentation
- Exchanging information
- Comparing different possible explanations for or solutions to a problem in order to assess them *(e.g. full-group discussion)*

Suggestions for Using Information and Communications Technologies

- Using electronic mail to exchange information
- Using the Internet to access Web sites related to science and technology
- Using CD-ROMs to gather information on a topic he/she is studying
- Organizing and presenting data using different types of software
- Using simulation software
- Using graphics software
- Producing a graphical representation of data
- Conducting experiments with the help of a computer
- Robotics and automation