Applied Science and Technology

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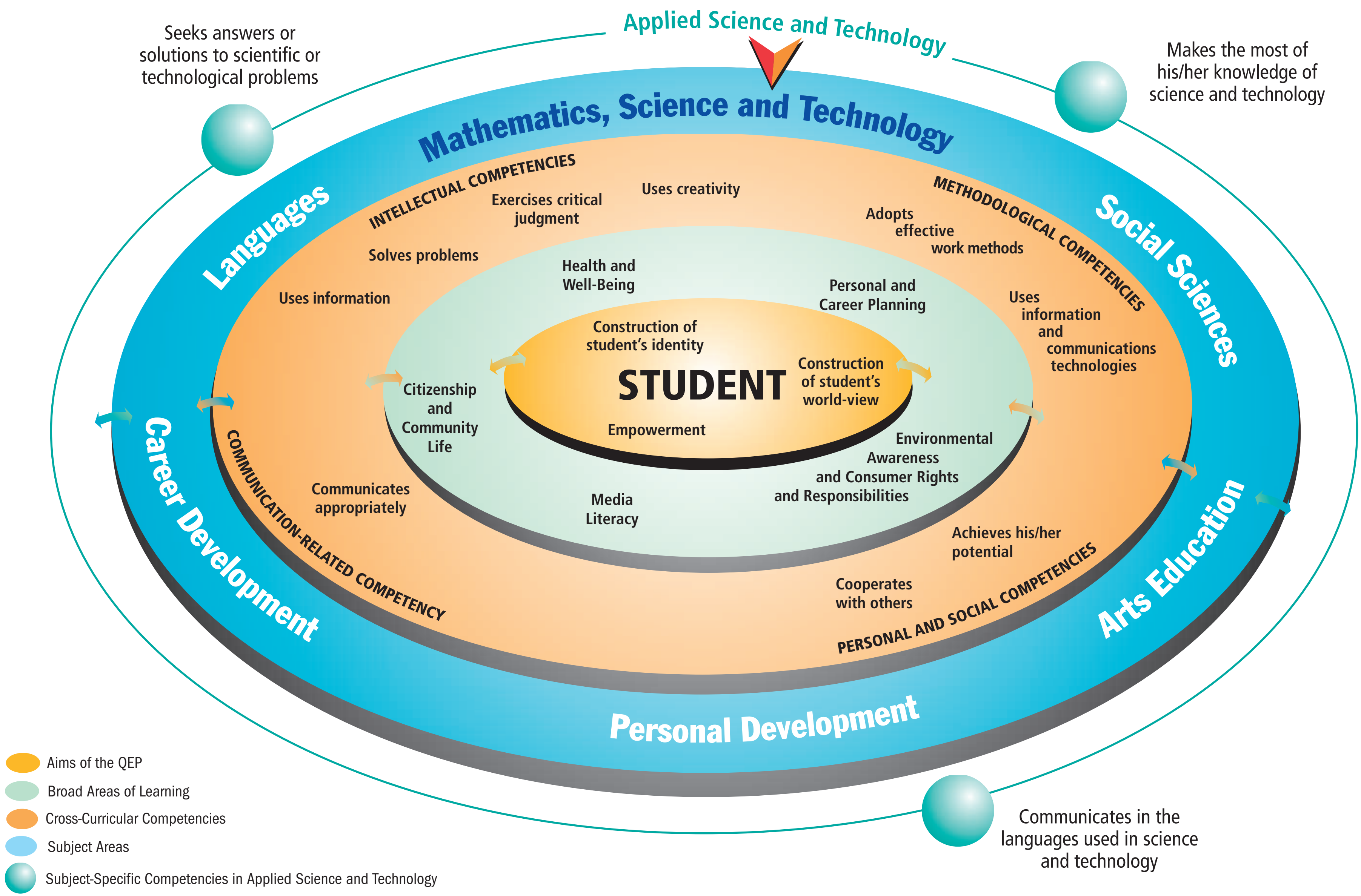

Québec Education Program

Introduction to the Applied Science and Technology Program

Science and technology are playing an increasingly important role in our lives and have made a key contribution to the transformation of societies. Their influence extends to a multitude of achievements that can be found everywhere in our environment. The associated methodologies and the knowledge they have generated apply to many different spheres of human activity. Their applications influence our lifestyle and help us learn more about our universe.

Scientific and technological activities are embedded in the social and cultural context and are the result of a community's efforts to build new knowledge. As in other fields of activity, knowledge in these areas is not developed in a linear or cumulative manner. Strongly influenced by the social and environmental context in which it emerges, scientific and technological knowledge sometimes progresses slowly, through successive approximations, and sometimes expands by leaps and bounds; it may go through periods of stagnation, only to be followed by spectacular advances.

Faced with the rapid emergence of large amounts of complex scientific and technological knowledge and the proliferation of its applications, people must acquire specific knowledge, as well as strategies that enable them to adapt to new constraints. This requires that they see the achievements of science and technology in perspective and appreciate the impact, scope and limitations of this knowledge. It also requires the ability to adopt a critical attitude vis-à-vis the ethical questions raised by these issues.

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Vision of Science and Technology

Science is a means of analyzing the world around us. Its aim is to describe and explain certain aspects of our universe. Made up of a set of theories, knowledge, observations and methods, it is characterized by its attempt to develop simple, intelligible models to explain our complex world. These models can then be combined with existing models to arrive at increasingly complex visions. As we construct new knowledge, these theories and models are constantly being tested, modified and reorganized.

Technology, on the other hand, focuses more specifically on action that helps us interact with the environment, of which we are an integral part. The technological fields[1] addressed in this program are medical, agricultural and agri-food, energy, information and communications, transportation, manufacturing and construction technologies.

Technology, which focuses more specifically on action, helps us interact with the environment in a number of technological fields.

The word *technology* encompasses a wide variety of achievements, from the most simple to the most sophisticated. These include techniques, processes, tools, machines and materials. Technology aims to provide the ultimate in rigorously designed products and is based on scientific and nonscientific principles and concepts, depending on the needs it aims to meet. Nevertheless, it makes use of its own knowledge and practices. Its more pragmatic aspect leads to the development and use of more specific methods.

Science and technology are becoming increasingly interdependent, so much so that it is often difficult to draw a clear line between the two. In its attempt to understand the world around us, science often relies on technological developments and achievements. Conversely, when technology seeks to meet a need by developing technical objects,[2] systems,[3] products[4] or processes,[5] it makes use of scientific principles, laws and theories and provides opportunities for their application.

Science and technology are becoming increasingly interdependent, so much so that it is often difficult to draw a clear line between the two.

1. The technological fields are presented under *Program Content: Constructing and Using Resources.*
2. A *technical object* is a simple, practical object that has been manufactured, as opposed to an object found in nature (e.g. hammer, spoon, tweezers).
3. A *system* is a set of more or less complex elements organized in such a way that they interact to meet a specific need (e.g. bicycle, dishwasher, heating and ventilation system).
4. A *product* is a substance created by transformations effected by human beings (e.g. food product, beauty care product).
5. A *process* is the means and methods used to perform a task or obtain a result (e.g. technical, industrial, manufacturing process).

Sometimes, technological advancements precede the scientific theories that explain them. Compasses had been in use for some time before the first modern study of magnetism took place. The first engines operated without the benefit of the study of thermodynamics, just as the first airplanes flew without the help of aerodynamic theory. In such cases, technology can provide extraordinary opportunities for exploration and questioning that lead to the development of new theories. The complementarity of science and technology can also be seen in their respective practical and design approaches to the physical world.

As integral parts of the societies they have played a major role in shaping, science and technology represent both an important aspect of our cultural heritage and a key factor in our development.

Scientific and Technological Literacy

As integral parts of the societies they have played a major role in shaping, science and technology represent both an important aspect of our cultural heritage and a key factor in our development. It is important to help students gradually develop their scientific and technological literacy and to understand the role that such a literacy plays in their ability to make informed decisions and in their discovery of the pleasures of science and technology and their applications.

Curiosity, imagination, the desire to explore and the pleasure of experimentation and discovery are just as much a part of scientific and technological activities as the need to acquire knowledge and understand, explain, create and act. In this regard, the field of science and technology is not the preserve of a small group of experts. We all have a certain degree of curiosity about the phenomena around us and a fascination with scientific and technological invention and innovation.

The history of science and technology is an integral part of this literacy and should be drawn upon. It puts scientific discoveries and technological innovations in perspective and enriches our understanding of them.

Museums, research centres, engineering firms, health care facilities, local factories, businesses and other community organizations provide a wealth of resources for the development of scientific and technological literacy.

The Program

The program recommends four different approaches to teaching science and technology. The democratic approach is concerned with developing citizenship skills. The humanist approach aims to help students develop their intellectual potential. The technocratic approach to teaching focuses on scientific skills, while the utilitarian approach is based on the everyday uses of science and technology. The Applied Science and Technology program pays special attention to the technocratic and utilitarian approaches.

The program creates a single discipline by integrating five scientific fields (astronomy, biology, chemistry, geology, physics) and technology. The curriculum is organized in this way because it is often necessary to refer to subject matter and methods from several fields at once to solve problems or explore the different facets of the many applications of science and technology.

The program creates a single discipline by integrating five scientific fields (astronomy, biology, chemistry, geology, physics) and technology.

The program focuses on the development of the same three competencies as the Secondary Cycle One program:

– Seeks answers or solutions to scientific or technological problems
– Makes the most of his/her knowledge of science and technology
– Communicates in the languages used in science and technology

These closely interrelated competencies are associated with various complementary aspects of science and technology (i.e. practical and methodological aspects; theoretical, sociohistorical and environmental aspects; and aspects relating to communication). Although the overall goals connected with these three competencies are essentially the same at both the elementary and secondary levels, the requirements pertaining to their development become progressively more demanding in Secondary Cycle Two, while focusing more closely on scientific and technological applications.

The first competency focuses on the methodology used to solve scientific and technological problems. The students become familiar with concepts and strategies in a hands-on approach.

The students must ask themselves questions and solve problems through observations, hands-on activities, measurements, construction or experimentation, be it in a lab, a workshop or the real world.

The second competency emphasizes the control of objects and systems, and focuses on the students' ability to conceptualize and apply what they have learned in applied science and technology, especially when dealing with everyday issues. It also involves examining the very nature of scientific and technological knowledge, its evolution and its numerous societal and environmental consequences.

The students become familiar with the concepts involved in analyzing and understanding the construction and inner workings of technical objects and technological systems and, where necessary, the principles involved in their maintenance and repair. These concepts are regarded as tools that help students gain a better understanding of the world and make informed judgments. They are not studied separately, but rather in terms of the ways in which they are interrelated when it comes to solving certain problems or designing or analyzing specific objects or systems.

The third competency involves the different types of languages used in science and technology, which are essential for sharing information as well as interpreting and producing scientific or technological messages. It involves not only knowledge of specialized terminology and symbolism, but also the ability to use them intelligently, for example, by learning to adapt one's level of language to a specific audience.

The students participate actively in exchanges using the languages of science and technology, in accordance with established rules and conventions. They build arguments and express their point of view.

These competencies are developed and evaluated together and not in isolation or sequentially. In order to master scientific and technological methods, students need to know and be able to use the related concepts and languages. They become familiar with these methods in different contexts that give them meaning and importance.

These competencies are inextricably linked to the topics covered in the program. The topics are related to various branches of science and technology divided into four areas: The Technological World, The Living World, The Material World and The Earth and Space. They are studied in relation to scientific and technological applications and the seven technological fields. Each of them is presented in detail under *Program Content* and provides essential resources for the development of competencies.

The three competencies are developed and evaluated together and not in isolation or sequentially.

Making Connections: Applied Science and Technology and the Other Dimensions of the Québec Education Program

In a variety of ways, the Applied Science and Technology program is related to the other dimensions of the Québec Education Program (i.e. the broad areas of learning, the cross-curricular competencies, the Mathematics program and the other subject areas).

The broad areas of learning are related to major issues of today. In its specific way of dealing with reality, each subject sheds a different light on these issues, helping students develop a broader world-view.

Connections With the Broad Areas of Learning

Because of the ways in which science and technology affect human health and well-being, the environment and the economy, there is significant overlap between the issues and challenges associated with the broad areas of learning and those raised by scientific and technological discoveries and achievements.

Health and Well-Being

The knowledge that students acquire in studying science and technology can be of great help in understanding the many issues related to adolescent health, well-being and sexuality. Science and technology make a significant contribution to this broad area of learning, for example, by giving students the chance to learn more about their body and encouraging them to adopt healthy lifestyle habits. For example, they can study the biochemical and energy-related aspects of nutrition, the principles of toxicology associated with smoking, or the biomechanical principles underlying good posture. Technological developments in the field of medicine are a good source of learning and evaluation situations.

Environmental Awareness and Consumer Rights and Responsibilities

Scientific and technological knowledge helps young people increase their awareness of specific issues pertaining to their environment, such as the use of natural resources, human impact on the environment, waste management, the resources available in different places, the ethical issues related to biotechnologies, the complexity of climate change and biodiversity. Many advancements in science and technology have led to consumer habits that have various consequences for the environment. For example, in analyzing a hydroelectric power plant or designing a wind turbine, students may study the social, ethical, economic or environmental impact of the project. It is also important to encourage students to learn about these issues, to question their own consumer habits and to adopt responsible behaviour.

Media Literacy

Whether it be to learn, to obtain information or to communicate, students use the various media with which they are already familiar. They learn to take a more critical view of the information they find. They become proficient in using media-related materials and communication codes and gradually come to understand the impact the media have in society and in their own everyday lives. Teachers should make extensive use of these media. Movies, newspapers and television address scientific and technological topics that can be linked to the students' everyday lives in many different ways. The current fascination with information and communications devices such as radios, televisions, computers, cell phones and communications satellites can be used to contextualize learning and increase students' motivation.

Career Planning and Entrepreneurship

The variety of activities that students are asked to carry out in this program can help them better understand the nature of scientific and technological work and apply it to their personal planning.

Since the technological fields are associated with employment sectors, the design and study of related objects, systems, products and processes help familiarize students with these sectors, enabling them to identify their aptitudes, preferences and aspirations. Learning and evaluation situations focusing on objects, systems, products and processes are conducive to the project-based approach. For example, students who use the *industrial process* can experiment with mass production and learn about different roles in the workplace.

Citizenship and Community Life

The scientific and cultural literacy that students gradually acquire gives them a new perspective on certain social issues, which may improve the quality of their participation in the classroom, the school or society in general. Launching a recycling campaign or setting up a repair shop for objects or systems are examples of situations that can help students learn about responsible citizenship.

Connections With the Cross-Curricular Competencies

The development of scientific and technological literacy as described in this program involves the development of subject-specific competencies, which is intimately linked with the development of cross-curricular competencies.

Intellectual cross-curricular competencies

Intellectual cross-curricular competencies play a crucial role in the development and application of competencies related to science and technology. The search for answers or solutions to scientific or technological problems requires that students use information judiciously and question the reliability of their sources. It also helps them develop problem-solving skills and adapt them to specific situations. Considering alternative solutions in the design and development of a technical object or a technological system, developing and implementing a plan of action to solve a problem, and taking into account different views on a scientific or technological issue are all ways of using creativity.

Cross-curricular competencies are not developed at a theoretical level; they are rooted in specific learning contexts, usually subject-related.

Today's society is characterized by the emergence of pseudosciences. Students must therefore learn to exercise critical judgment, especially when analyzing, however briefly, advertisements, scientific opinions or the consequences of science and technology. They must try to keep media influences, social pressures and conventional wisdom in perspective in order to determine what has been validated by the scientific community and what is being reported by other groups.

Methodological cross-curricular competencies

The precision associated with the methods used in this program requires that students adopt effective work methods and comply with related standards and conventions.

The rapid development of information and communications technologies has played a significant role in recent advances in the world of science and technology. Using various technological tools (e.g. data-acquisition interfaces with sensors, computer-aided drafting, simulation software) in conducting experiments and solving scientific or technological problems helps students learn to use information and communications technologies. In addition, by joining a virtual scientific community, students can share information, communicate with experts on-line, present the results of their work and compare them with those of their peers by taking part in a discussion group or video conference.

Personal and social cross-curricular competencies

When they take hypotheses or solutions into consideration, when they move from the abstract to the concrete or from decision to action, students are open to the range of human possibilities. They can see a greater variety of options and agree to take risks. With time, they learn to trust themselves and to learn from their mistakes, which allows them to achieve their potential.

To develop their knowledge of science and technology, students must cooperate with others, since the sharing of ideas or points of view; peer or expert validation; and various collaborative research, experimental or design and manufacturing activities are part and parcel of the learning process.

Communication-related cross-curricular competencies

Learning concepts and the inextricably linked scientific and technological languages enable students to develop their ability to communicate appropriately. They must gradually discover the codes and conventions of these languages and familiarize themselves with their uses.

Connections With the Other Subject Areas

To ensure that students receive an integrated education, it is important to connect applied scientific and technological learning to learning in other subjects. Any subject is defined, at least in part, by the way in which it perceives reality and by its particular view of the world. Other subjects can shed additional light on applied science and technology just as applied science and technology can help us gain a better understanding of other subjects.

Mathematics, Science and Technology

The field of mathematics is closely related to the science and technology programs. It provides a body of knowledge useful for the study of science and technology. For example, when students follow a scientific or technological method, they must often measure, count, calculate averages, apply geometric concepts, visualize space and choose different types of representation. Mathematics can be used in the design, maintenance and repair of technical objects or technological systems, to model relations between variables. Its vocabulary, graphs, notation and symbols also make mathematical language a tremendous asset to science and technology.

Mathematics also requires the development of competencies focusing on reasoning, problem solving and communication, which are related to the competencies in the Applied Science and Technology program. Their combined use fosters the transfer of learning and the development of the cross-curricular competencies, in particular, the intellectual cross-curricular competencies. Technological applications also help students understand certain mathematical concepts, such as variables, proportional relationships, the principles of geometry and statistical concepts.

Reality can rarely be explained by concepts related to a single subject. Its multiple facets can only be understood by combining the different fields of knowledge.

Languages

English and French provide students with tools essential to the development of their competencies in science and technology. Analyzing and producing oral or written texts are closely related to the competency *Communicates in the languages used in science and technology.*

Whether the students are reading, writing or communicating verbally, the competencies they develop in English Language Arts are indispensable for interpreting information correctly, describing or analyzing a technical object in order to explain how it works, or justifying a methodological decision. Moreover, the different terms used in science and technology, which are often specific to the field, help enrich the students' vocabulary.

A certain level of competency in French is useful for participating in a virtual community or in national or international activities such as science fairs.

Social Studies

The study of scientific and technological developments can shed new light on the history of different societies, since the problems that prompted them were the result of specific and often complex and diversified social conditions. Conversely, historical perspective makes it possible to contextualize developments in science and technology and determine their impact. Looking at the past can also help answer questions about the source of certain scientific explanations or technological achievements.

Arts Education

Science and technology benefit from the creativity promoted by arts education. Some of the methods used in this program are related to the creative dynamic shared by the four arts education programs, for example, the design process, which incorporates aesthetic considerations.

In turn, science and technology contribute to a better understanding of the arts. For example, the scientific concepts related to waves can be used to gain a better understanding of certain musical instruments. Materials, products, tools and instruments used in the arts, all of them technological achievements, are another example.

Personal Development

The competencies developed in the Ethics and Religious Culture program can be of great use in studying science and technology, especially because of the many ethical questions examined, for instance, the construction of a hydroelectric dam raises a number of questions concerning biodiversity and human lifestyles.

Connections can also be made with physical education and health. By studying the biomechanical forces and principles associated with physical activity or the materials used in the manufacture of different types of equipment, students are able to better understand how they affect performance.

Career Planning and Entrepreneurship

The many fields of applied science and technology can be associated with the fields students are exploring as part of their personal orientation project. In this respect, these two programs are highly complementary. The learning situations proposed in the Applied Science and Technology program give students an opportunity to explore various occupations while carrying out their process of career exploration. For example, students who participate in a mass production scenario will be able to determine their level of interest in manufacturing and the associated trades and occupations. In return, the learning acquired during the career exploration activities associated with the personal orientation project can be applied to this program. For example, students exploring the electrotechnology sector might be interested in technological problems involving electricity.

The Applied Science and Technology program can therefore easily be adapted to interdisciplinary activities. An integrated application of the different areas of learning in the Québec Education Program is recommended for a well-rounded education adapted to the realities of the 21st century.

Pedagogical Context

The Applied Science and Technology program encourages the active participation of students, who are required to demonstrate initiative, creativity, independence, critical sense and rigour in their various activities. Competencies are acquired in learning and evaluation situations oriented toward the design, analysis, maintenance or repair of objects and systems.

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Resources

A number of personal, information, material, institutional and human resources are used in the development of competencies. Personal resources include knowledge, skills, strategies, attitudes and techniques. Those that involve knowledge from a variety of subject areas are referred to as "conceptual resources." Information resources include textbooks and other relevant documents and tools for finding information. Material resources comprise instruments, tools and machines, as well as everyday objects. Institutional resources, i.e. public and parapublic agencies such as museums, research centres, engineering firms, health care facilities, local factories and businesses and other community organizations, provide a wealth of resources for the development of scientific and technological literacy.

Teachers are the most immediately accessible human resources. Like lab and workshop technicians, they are indispensable at a number of levels, especially as concerns laboratory and workshop safety. They can be assisted by teachers in other subjects or different experts, who can share good ideas or collaborate in the development of learning and evaluation situations.

Role of the Teacher

Teachers play many different roles. The competency-based approach requires that they be versed in the art of teaching and in their subject area, and that they demonstrate creativity and professional judgment. They are responsible for developing learning and evaluation situations that foster competency development, adjusting their teaching practices in order to ensure educational differentiation and choosing the teaching strategies most likely to meet students' needs.

Teachers propose learning and evaluation situations to foster competency development, adjust their teaching practices to ensure educational differentiation and choose teaching strategies likely to meet students' needs.

Ensuring competency development

The learning and evaluation situations developed by the teacher should enable the teacher to judge the level of competency development at the end of each year in the cycle. To this end, they should vary in complexity from one year to the next, based on certain parameters.

The parameters are presented in tables at the end of each competency, under *Development of the Competency.*

As defined in the Québec Education Program,[6] competencies comprise three aspects—mobilization in context, availability of resources and reflection—which make it possible to target the parameters of the suggested situations. The section concerning mobilization in context explains certain parameters related to the tasks involved in the learning situation. The resources section provides suggestions for mobilizing personal, information, material, institutional and human resources. Lastly, the section on reflection presents instructions for helping students develop metacognitive skills.

These parameters, which are deemed conducive to competency development, should be taken into consideration in the development of stimulating learning and evaluation situations involving realistic and feasible challenges and demanding a certain amount of precision.

6. See Chapter 1, p. 16.

Developing meaningful learning and evaluation situations adapted to the program's requirements

Contextualized, open-ended and integrated situations

Contextualized, open-ended and integrated learning and evaluation situations help give meaning to learning and foster the integration of knowledge, skills and attitudes.

A learning and evaluation situation is contextualized when it focuses on current events, scientific and technological achievements related to the students' everyday lives or the major issues of the day, for example, climate change.

> *Learning and evaluation situations should enable students to develop every aspect of the targeted competency. In this program, they involve scientific and technological applications.*

A situation is open-ended when it is based on information that can lead to different possible solutions. The initial situation can involve complete, implicit or superfluous information. In cases where there is not enough information to solve the problem, students will have to do additional research, which will contribute to their learning.

An integrated situation is based on concepts from different areas of the program. For example, a situation focusing on the construction of a thermal power plant will foster the integration of knowledge and skills provided the teacher encourages the students to apply knowledge, skills, perceptions and attitudes related to the technological world (e.g. analysis of an energy production system), the living world (impact of the greenhouse effect on biodiversity) and the material world (e.g. production and transformation of energy). A learning and evaluation situation is totally integrated only when it involves a variety of types of knowledge and skills.

Complex situations adapted to program requirements

Learning and evaluation situations should enable students to develop every aspect of the targeted competency. In this program, they involve scientific and technological applications. Whether students are analyzing a hydroelectric power plant or designing a scale model of a wind turbine, they are dealing with a technological system. The human body itself can be considered a system that might demonstrate a need for a technological application, for example, when a limb needs to be replaced with a prosthesis. Moreover, like any biological product, certain human tissues can be manufactured.

Whenever possible, in developing these situations, teachers must take into account the particular characteristics of the school or focus on current events related to certain broad areas of learning. They should emphasize a hands-on approach and ensure that safety rules are followed.

In order to help students develop Competency 1, *Seeks answers or solutions to scientific or technological problems,* teachers should propose learning and evaluation situations that encourage them to adopt a problem-solving approach involving the experimental method or the design process. These situations require a hands-on approach. They may also involve modelling or the observation or empirical method.

The problems must help the students develop Competency 2, *Makes the most of his/her knowledge of science and technology.* In presenting a complex problem, teachers can propose a variety of tasks that speak to different learning styles. Different teaching strategies used to help students solve problems, such as the problem-solving approach, case studies, debate and the project-based approach, encourage students to reflect on what they are doing, provided they are obliged to ask questions and gain a new perspective on their approach. The analysis of data and information enables students to pursue the development of their cognitive skills in increasingly complex situations.

In order to help students develop Competency 3, *Communicates in the languages used in science and technology,* teachers should present learning and evaluation situations that allow them to select an appropriate method of presentation, add relevant scientific and technological terms to their oral and written vocabulary, and make connections between concepts and their various graphic or symbolic representations. Teachers should always focus on the quality of oral and written language, whether in an oral presentation, a schematic diagram of a technical object or technological system, a written technical or lab report or an essay on the social impact of science and technology.

Although the three competencies are interrelated, teachers may decide to shift the focus from one to the other.

Guiding students in the process of competency development

Teachers should encourage students to ask questions and guide them in their choices by focusing on those aspects of the process that, in their opinion, require more attention (e.g. building a model, designing a prototype,[7] providing an initial explanation, understanding the concept of variable, measuring, presenting results). Although the situations are initially open-ended, they must eventually be specifically defined in terms of a task that can be completed or a goal that can be achieved with the help of the appropriate resources. If students are asked to design a prototype, teachers should provide the necessary specifications. They can also use pre-prepared jigs to facilitate certain machining operations or to accelerate the manufacturing process in the case of mass production. They must adapt tasks to the students' level of competency, providing the necessary explanations, answering questions, proposing ideas for solving problems, providing less independent students with additional support and making sure that laboratory or workshop safety rules are followed. It is also important that students learn from their mistakes and understand that they are rarely chance occurrences.

Teachers must provide students with a framework that is both flexible and rigorous. They must ensure that the students do not become overwhelmed by the quantity of information to be processed and encourage them to select the information needed for the task or problem at hand and to seek new information as well.

Teachers are always an important resource for students, particularly with respect to the regulation of learning and strategies involving the entire class. The latter can be an ideal opportunity for reframing learning and making connections between new and prior learning. Teachers also play an active role in reviewing and synthesizing learning.

The examples in the appendix illustrate learning and evaluation situations related to technological applications. These situations should enable students to give meaning to their learning and to assimilate subject-specific concepts in a meaningful context. They involve a number of connections with the educational aims of the broad areas of learning, as well as with learning in other subjects. Lastly, they enable students to apply both cross-curricular and subject-specific competencies. The number and nature of the connections made will depend on the educational aim.

Role of the Student

In order to participate actively in the development of their competencies, students must make use of a variety of personal resources (prior knowledge, skills, strategies, attitudes and techniques). If necessary, they may search for a range of information, select the material resources that might help them in their learning process or consult human resources in their immediate environment. In some cases, they might find it useful to go beyond the school and home. Experts, museums and businesses provide an opportunity to explore the world and to consider other points of view.

Each student is responsible for his or her own learning and must participate actively in competency development, using a variety of resources.

When they use instruments, tools or machines, students must be aware of the applicable safety standards and work carefully in the lab or the workshop. When in doubt, they should ask the teacher or technician to confirm that they are working safely or that they are using materials properly. It is also important that they be familiar with the appropriate techniques for carrying out their plan of action.

Lastly, whether they are carrying out a project, writing a research report, formulating questions or suggesting explanations or solutions, students should think about how they will communicate their results or share their opinion and express themselves using the appropriate scientific and technological language. After designing, analyzing or repairing a technical object, a system, or a product, or developing a process, they should be capable of explaining and justifying the steps in their procedure in light of their analysis of the situation.

7. Here, a prototype is any constructed object or device that could be mass-produced. It can be a design, manufacturing, production, experimental or trial prototype.

Focus of the Competency

The field of science and technology is characterized, among other things, by a rigorous approach to problem solving. The problems always involve initial information, a goal to be achieved and specifications describing the nature, meaning and scope of the problem. Seeking answers or solutions to problems related to applied science and technology involves using different types of reasoning and methodological procedures, which make use of strategies for exploring or analyzing and require creativity, a methodological approach and perseverance. Learning how to use these methods appropriately helps students gain a better understanding of the nature of scientific and technological activity.

The first competency focuses on the assimilation of concepts and strategies using a hands-on approach.

Although they are based on systematic processes, these methods are not foolproof and may involve trial and error. To apply them, the students must be aware of their actions and capable of reflecting on them, and ask questions for the purpose of validating the work in progress so that necessary adjustments can be made in accordance with the stated goals or the selected options. Since their results may raise new problems, achievements are always considered temporary and are a part of a continuous process of acquiring and expanding their knowledge.

As in Secondary Cycle One, a student who is able to find answers or solutions to scientific or technological problems can solve relatively complex problems requiring the application of a variety of methods. In Cycle One, a distinction is made between the experimental method and the technological design process: emphasis is placed on their specific characteristics, their distinct objectives and their complementary nature. In Cycle Two, the observation and empirical methods, modelling and the industrial and design processes are added. The goal is to eventually combine these methods when seeking answers or solutions to scientific or technological problems.

As they do in the workplace, the design and industrial processes focus on the design and production of technical objects or technological systems. It will be easier for students to learn these methods if visual and auditory information is accompanied by physical exploration and a hands-on approach.

Usually relatively complex, the initial problems are generally based on a specific technological need.[8] They raise a number of more specific questions and can be grouped together in subproblems according to their specific scientific principles or technological processes.

Finding answers or solutions to problems related to applied science and technology involves a **process that is dynamic and nonlinear.** This makes it necessary to move from one phase of the problem-solving process to another and to apply the appropriate methods, strategies, techniques, principles and concepts. If these resources are to be used in combination, they must be adapted to the situation and its context.

The first step in solving a problem is to determine a way of representing it based on meaningful indicators and relevant elements. At first, this representation can be rough and may require a number of adjustments throughout the process. New learning, the use of prior knowledge and information that has not yet been taken into account, discussions with peers or the teacher, and unexpected experimental results often lead to more refined reformulations that come closer to achieving the goal in question. The initial representation of a problem may therefore be modified over the course of the process. Sometimes, however, the initial representation needs little or no modification, if it is based on a solid foundation of knowledge.

8. A need is a state of dissatisfaction that causes a person to desire what he or she does not have and, therefore, to take action. All technological problems are based on needs. The need gives rise to a problem, which is addressed in order to find a solution in the form of a technical object, a system or a product. For example, the microwave oven was an answer to the need to reheat foods quickly, while the automobile was the answer to the need to move around comfortably and quickly.

The representation of the problem is used to explore various problem-solving scenarios in order to select the best option. This is followed by planning that takes into account material limitations and constraints and the availability of resources. Given the orientation of the program, this plan of action is often based on the design and manufacture of a prototype or product.

The students then follow the steps in the plan of action, taking care to record all observations that might prove useful later on. New data can require a reformulation of the representation, adaptation of the plan of action or a search for a more appropriate solution.

Analyzing results involves the organization, classification, comparison and interpretation of results obtained during the problem-solving process. It consists in identifying patterns and significant relationships in the results themselves or between the results and the initial data. This comparison makes it possible to formalize the problem and to validate or invalidate hypotheses and draw conclusions. In the case of applied science and technology, the result is a product, a prototype or a specific achievement.

In order to ensure better use of methods and strategies, students should systematically review what they have done throughout the problem-solving process. This metacognitive task should also apply to the conceptual and technical resources used and their adaptation to the requirements of the different contexts.

Most of the methods used in the development of this competency must be applied in the lab or workshop. Because of the inherent risk involved in handling certain instruments, tools, substances and materials, the intervention of competent individuals may be required at any time. The materials should be carefully prepared, the students must follow the instructions and be rigorous. Safety should be a constant concern.

This competency is inextricably linked to the other two and cannot be developed independently. The acquisition and use of specific knowledge is part and parcel of the process of finding answers and solutions to problems related to applied science and technology. Scientific and technological laws, principles and concepts are used to define a problem and formulate it in terms that approach an answer or solution. This competency cannot be developed without the mastery of communication strategies. The peer validation process is an inherent part of science and technology, as is the understanding and use of the language shared by members of the scientific and technological community.

Key Features of Competency 1

Defines a problem

Considers the context of the situation • Represents the problem • Identifies the initial data • Identifies the elements that seem relevant and the relationships between them • Reformulates the problem in terms of scientific and technological concepts • Proposes a possible explanation or solution

Develops a plan of action

Explores some of the initial explanations or solutions • Chooses an explanation or solution • Identifies the necessary resources • Plans the steps involved in its implementation

Seeks answers or solutions to scientific or technological problems

Analyzes his/her results

Looks for significant patterns or relationships • Judges the appropriateness of the answer or solution found • Makes connections between his/her results and scientific and technological concepts • Suggests improvements if necessary • Draws conclusions

Carries out the plan of action

Follows the steps in his/her plan • Uses the appropriate techniques and resources • Does tests, if applicable • Gathers all useful data and takes note of observations • If necessary, adjusts the plan of action or its implementation • Carries the plan of action through

Evaluation Criteria

– Appropriate representation of the situation
– Development of a suitable plan of action for the situation
– Appropriate implementation of the plan of action
– Development of relevant conclusions, explanations or solutions

End-of-Cycle Outcomes

By the end of Secondary Cycle Two, students are able to apply a problem-solving process. They start by defining the goal to be achieved or the need to be identified as well as the conditions involved. They formulate or reformulate questions based on data related to the problem. They come up with realistic hypotheses or possible solutions that they can justify.

They develop their plan of action by selecting methods and strategies in order to achieve their goal. They control important variables that could have an effect on their results. In the development of their plan of action, they select the relevant conceptual tools, equipment and materials from among those made available.

They apply their plan of action in a safe manner and make any necessary adjustments. They collect valid data by correctly using the selected materials and equipment. They take the precision of the tools and equipment into account. In science, they analyze the data collected, using it to formulate relevant conclusions or explanations. In technology, they test their solution to make sure that it meets the need identified or the requirements in the specifications. If necessary, they propose new hypotheses, improvements to their solution, or new solutions. If necessary, they use information and communications technologies.

Development of the Competency *Seeks answers or solutions to scientific or technological problems*

As indicated under *Pedagogical Context,* subject-specific competencies comprise three aspects: mobilization in context, availability of resources and reflection. The following table contains parameters that characterize, for each of these aspects, the learning and evaluation situations proposed for each year of the cycle. These parameters make it possible to vary the level of complexity and difficulty of the situations throughout the cycle in order to help each student develop the targeted competency.

	FIRST YEAR OF CYCLE TWO	SECOND YEAR OF CYCLE TWO
Context	– The problem is well defined: students are informed of most of the steps involved. – The situation proposes verifiable hypotheses based on the initial data.	– The problem is not as well defined: students are informed of only some of the steps involved. – The students must propose verifiable hypotheses based on the initial data.
Availability of resources	– Students must use related content learned in the first year of the cycle. – Students must gain a qualitative understanding of the concepts addressed, some of which require a certain mathematical formalism. – The students have access to limited material resources, so they must make choices. – When the problem requires the use of different methods, strategies or techniques, the students are told explicitly which ones they should use.	– Students must use related content learned in the second year of the cycle. – Students must gain a qualitative and quantitative understanding of the concepts addressed, many of which require a certain mathematical formalism. – The students have access to extensive material resources, so they must make choices. – When the problem requires the use of different methods, strategies or techniques, the students are not told explicitly which ones they should use; they must justify their choice.
Reflection	– The situation incorporates periods of reflection and metacognitive review in which the teacher intervenes with individual students or groups. – The nature and form of the reflection and metacognitive reviews are clearly specified.	– The situation incorporates periods of reflection and metacognitive review, in which the students participate individually or in groups. – The nature and form of the necessary reflection and metacognitive reviews are not clearly specified. Students must provide oral or written evidence of their work.

Focus of the Competency

The various applications of science and technology affect our lives. In some ways, they have helped significantly improve our quality of life but, in other ways, they have given rise to ethical issues, and we must decide where we stand in relation to these questions. Every facet of human existence, be it personal, social or work-related, is influenced by science and technology to varying degrees. Their impact is so profound that they now appear to be indispensable tools for understanding and adapting to the world in which we live. To be able to function in society and fulfill our role as well-informed citizens, we must acquire scientific and technological literacy, which involves the ability to make the most of our knowledge of science and technology in various situations.

This competency requires that students put applications in context, analyze them in order to identify the related scientific and technological principles and maintain or repair them.

In Cycle One, students learned to apply their scientific and technological knowledge by attempting to identify the consequences of science and technology and to understand natural phenomena and the inner workings of certain technical objects. In Cycle Two, they must learn to integrate theory and practice by examining the context of discoveries, inventions and innovations, as well as the materials involved and the underlying concepts. They are called upon to analyze various applications from different points of view, including future maintenance or repair needs of a technical object or technological system. Moreover, they are called upon to use previously acquired conceptual resources and to develop new ones in order to analyze the inner workings of technical objects or technological systems.

In Cycle Two, students must put applications in context. This means that they must construct a systemic representation of the applications, taking into account the different aspects (e.g. social, historical, economic) of the objects, systems, products and processes. This analysis also allows students to examine certain long-term consequences, compare them with short-term consequences and, if applicable, identify the ethical questions at stake.

The contextualization of various applications also makes it possible to identify related scientific principles. This competency is therefore based on the assumption that the students have assimilated the basic concepts needed to understand these principles. This understanding, however, is not limited to the mastery of mathematical formalism or the application of formulas. To understand a principle or a phenomenon, we must first represent it qualitatively, and sometimes quantitatively, explaining it using the appropriate laws and models, describing it, understanding the relationships involved and, occasionally, predicting new phenomena. The empirical and observation methods and modelling are resources students can use to gain a better understanding of scientific principles.

The study of an application also involves technological analysis. This analysis entails understanding the overall function of the object, system, product or process as well as the operation of each component, its technical characteristics and the underlying scientific principles. Lastly, students must consider solutions for developing the object, system, product or process.

When analyzing the operation of the components of the object or system, the aim is to find any defects and to correct them by making the necessary repairs or doing the necessary maintenance. If the students had to disassemble the object or system to analyze it, they put it back together in working condition.

In order to ensure better use of methods and strategies, students should systematically review what they have done throughout the problem-solving process. This metacognitive task should also apply to the conceptual and technical resources used and their adaptation to the requirements of the different contexts.

Lastly, this competency could not be developed without using the communication skills needed to produce, interpret and share scientific and technological messages, and the appropriate scientific and technological language.

Key Features of Competency 2

Makes the most of his/her knowledge of science and technology

Puts applications in context
Identifies aspects of the context (e.g. social, environmental, historical) • Makes connections between these aspects • Identifies any ethical questions related to the application • Foresees long-term consequences

Understands the scientific principles underlying the application
Recognizes scientific principles • Describes them qualitatively or quantitatively • Makes connections between the principles using concepts, laws or models

Understands the technological principles underlying the application
Identifies the overall function of the application • Identifies the different components and determines their respective functions • Describes the principles underlying the construction and operation of the application • Makes connections between the principles using concepts, laws or models • Makes a schematic representation of the principles underlying the construction and operation of the application

Inspects the technical object or technological system to ensure that it is in working order
Completely or partially disassembles the object or system • Identifies any defects • Does the necessary maintenance or, in certain cases, makes the necessary repairs • Correctly reassembles the object or system

Evaluation Criteria

- Formulation of appropriate questions
- Appropriate use of scientific and technological concepts, laws, models and theories
- Relevant explanations, solutions or actions
- Suitable justification of explanations, solutions or actions

End-of-Cycle Outcomes

By the end of Secondary Cycle Two, students are capable of analyzing a technological or scientific application (technical object, technological system, product or process) and making an adequate representation of it. They must take social, environmental and historical aspects into account and identify any ethical questions at stake. They demonstrate discernment in their analysis of both the positive and negative consequences of a technological innovation.

When students analyze an application from a scientific point of view, they attempt to recognize the underlying principles. They propose explanations or tentative solutions and validate them using the relevant concepts, laws, theories and models. They can describe these scientific principles in qualitative terms and, when necessary, use mathematical formalism to justify their explanation.

When students analyze an application from a technological point of view, they determine its overall function. They examine it in order to observe its main components. They handle the object or system and, if necessary, take it apart to understand its main subsystems and mechanisms. They describe its operating principles using relevant concepts, laws and models. They explain the solutions they chose for designing or making the object or system.

The students indicate and evaluate their design solutions. They justify them by explaining the operating principles of the object or system. They can also do maintenance and make repairs when necessary.

Development of the Competency *Makes the most of his/her knowledge of science and technology*

As indicated under *Pedagogical Context,* subject-specific competencies comprise three aspects: mobilization in context, availability of resources and reflection. The following table contains parameters that characterize, for each of these aspects, the learning and evaluation situations proposed for each year of the cycle. These parameters make it possible to vary the level of complexity and difficulty of the situations throughout the cycle in order to help each student develop the targeted competency.

	FIRST YEAR OF CYCLE TWO	SECOND YEAR OF CYCLE TWO
Context	– The problem is well defined: students are informed of most of the steps involved. – The situation provides guidelines on how to maintain or repair the technical object or technological system.	– The problem is not as well defined: students are informed of only some of the steps involved. – The situation does not explain how to maintain or repair the technical object or technological system: the students must determine what type of maintenance or repair the object or system needs, if any.
Availability of resources	– Students must use related content learned in the first year of the cycle. – Students must gain a qualitative understanding of the concepts addressed, some of which require a certain mathematical formalism. – The students are given documents containing all the information they need to solve the problem: they must recognize which ones are relevant. – The situation specifies the types of material resources (e.g. tools, instruments) to be used in analyzing, maintaining or repairing the object or system. – When the problem requires the use of different methods, strategies or techniques, the students are told explicitly which ones they should use.	– Students must use related content learned in the second year of the cycle. – Students must gain a qualitative and quantitative understanding of the concepts addressed, many of which require a certain mathematical formalism. – The documents provided do not cover all the information the students need to solve the problem: they must determine the missing information and find additional documentation. – The situation does not specify the types of material resources (e.g. tools, instruments) to be used in maintaining or repairing the object or system: the students must choose them themselves. – When the problem requires the use of different methods, strategies or techniques, the students are not told explicitly which ones they should use; they must justify their choice.
Reflection	– The situation incorporates periods of reflection and metacognitive review in which the teacher intervenes with individual students or groups. – The nature and form of the reflection and metacognitive reviews are clearly specified.	– The situation incorporates periods of reflection and metacognitive review, in which the students participate individually or in groups. – The nature and form of the necessary reflection and metacognitive reviews are not clearly specified. Students must provide oral or written evidence of their work.

COMPETENCY 3 Communicates in the languages used in science and technology

Focus of the Competency

Communication plays an essential role in the construction of scientific and technological knowledge. To the extent that such knowledge is developed and instituted socially, a set of common meanings is required so that people can exchange ideas and negotiate points of view. This calls for a standardized language, i.e. a code that defines linguistic and graphical signs in accordance with the way they are used in the scientific and technological community. The dissemination of knowledge is also governed by certain rules. For example, research results must be validated by means of a peer review process before they are made public. Information can be communicated in different ways depending on whether it is meant for an audience of experts or nonexperts.

This competency is developed in situations in which students participate in exchanges of information, and in the interpretation and production of scientific or technological messages.

As in Secondary Cycle One, students must be capable of communicating in the languages used in science and technology and using the standards and conventions associated with these fields in order to participate in exchanges on scientific or technological issues, or to interpret or produce scientific or technological information. They must also learn to respect the intellectual property rights of the people whose ideas and results they borrow. Although interpretation is particularly important in Cycle Two, participation in exchanges and the production of messages also play an important role.

This competency is developed in situations in which students participate in the exchange of scientific or technological information, whether they are sharing the results of their work with peers, consulting experts to find answers to certain questions, participating in activities involving the analysis or design of objects, systems or products, presenting a project or preparing a science fair exhibit. Particularly useful in learning to refine their presentations or validate a point of view by comparing it with others, these situations must also help students develop an open-minded and receptive attitude toward the diversity of knowledge, points of view and approaches.

The fact that the everyday meaning of a term is sometimes different from its meaning in scientific or technological language deserves special attention. Similarly, the meaning of concepts can differ depending on the context in which they are used. It is therefore essential to take into account the context of the communication situation in order to determine the issues under debate and to adapt one's discourse accordingly.

Interpretation, another important feature of the competency, is involved in reading scientific or technical articles, listening to oral presentations, understanding lab reports, and using specifications, technical manuals and drawings. All of these activities require that the students understand the precise meaning of words, definitions, statements, graphs, diagrams and detail drawings. They must also make explicit connections between concepts and their various graphic or symbolic representations. When consulting documents or listening to presentations, students must verify the reliability of these sources and select the appropriate information.

Producing scientific or technological messages is also an important aspect of this competency, since the situations may require that students develop a research procedure, write a lab report, prepare a technical manual, design a prototype, summarize an article, make a detail drawing of a part or give a presentation on a scientific or technological topic. The target audience must be taken into account in order to determine the context of the message, that is, the appropriate level of complexity, structure and means of presentation. The proper use of concepts, formalisms, symbols, graphs, diagrams and drawings also adds to the clarity, coherence and precision of the message. Information and communications technologies can be exceptionally useful and enriching in this type of communication.

In order to ensure better use of production and interpretation strategies, students should review what they have done throughout their participation in the exchange. This metacognitive task should also apply to the conceptual and technical resources associated with communication, and their use and adaptation to the requirements of the different contexts.

This competency cannot be developed in isolation from the other two competencies in the program, to whose development and scope it contributes. It is enriched by the increased understanding resulting from the associated research and productions. The first competency, which focuses on scientific or technological problem solving, involves following certain standards and conventions, whether in developing a research procedure or production scenario, or in explaining laws and principles or presenting the results of an experiment. Tables, symbols, graphs, diagrams, detail and general drawings, mathematical equations and models can all be used to present information, but it is important to use them in accordance with the rules specific to the fields of science, technology and mathematics.

The scientific and technological concepts involved in the second competency cannot be learned or used in isolation from a language and a certain type of discourse. For example, scientific laws are a way of modelling phenomena and are usually expressed through definitions or mathematical formalism. Understanding these laws means being able to associate them with the phenomena they represent.

Key Features of Competency 3

Communicates in the languages used in science and technology

Participates in exchanging scientific and technological information

Is open to other points of view • Validates his/her point of view or solution by comparing it with others • Integrates appropriate scientific and technological terms into his/her oral and written vocabulary

Interprets scientific and technological messages

Makes sure the sources are reliable • Identifies relevant information • Understands the precise meaning of words, definitions and statements • Makes connections between concepts and their various graphic or symbolic representations • Selects the significant elements

Produces and shares scientific and technological messages

Takes the target audience and context into account • Structures his/her message • Uses the appropriate types of language in accordance with established standards and conventions • Uses the appropriate forms of presentation • Demonstrates rigour and coherence

Evaluation Criteria

- Accurate interpretation of scientific and technological messages
- Appropriate production or sharing of scientific and technological messages
- Use of appropriate scientific and technological terminology, rules and conventions

End-of-Cycle Outcomes

By the end of Secondary Cycle Two, students can interpret and produce oral, written or visual messages relating to science and technology.

When interpreting messages, they use the languages associated with science and technology. They correctly use scientific, technological, mathematical, symbolic and everyday language depending on the situation. They take the reliability of their sources into account. If necessary, they define the words, concepts and expressions used by referring to reliable sources. They review all the information consulted and then identify and use the elements they deem relevant and necessary for an accurate interpretation of the message.

They produce clear, well-structured and well-worded messages and follow conventions, while using the appropriate means of presentation. They select and adequately use tools such as information and communications technologies, which help them deliver their message. If necessary, they adapt their messages to their target audience. Using everyday language, they are able to explain the messages they have produced or interpreted. When necessary, they compare their ideas with those of others. They defend their ideas, but adjust them when other people's arguments can help fine-tune their thinking. They always respect intellectual property rights in producing their messages.

Development of the Competency *Communicates in the languages used in science and technology*

As indicated under *Pedagogical Context,* subject-specific competencies comprise three aspects: mobilization in context, availability of resources and reflection. The following table contains parameters that characterize, for each of these aspects, the learning and evaluation situations proposed for each year of the cycle. These parameters make it possible to vary the level of complexity and difficulty of the situations throughout the cycle in order to help each student develop the targeted competency.

	FIRST YEAR OF CYCLE TWO	SECOND YEAR OF CYCLE TWO
Context	– The problem is well defined: students are informed of most of the steps involved. – The situation clearly indicates the characteristics of the message to be produced or shared. – The situation clearly indicates the elements related to the analysis of the message. – The situation clearly indicates the possible means of presentation (e.g. research paper, poster, Web page, lab or workshop report, oral presentation).	– The problem is not as well defined: students are informed of only some of the steps involved. – The situation contains few guidelines for the production or sharing of the message. – The situation contains few guidelines for the elements related to the analysis of the message. – The situation contains few guidelines concerning possible means of presentation (e.g. research paper, poster, Web page, lab or workshop report, oral presentation).
Availability of resources	– Students must use related content learned in the first year of the cycle. – Students must gain a qualitative understanding of the concepts addressed, some of which require a certain mathematical formalism. – The students have access to limited material resources, so they must make choices. – When the problem requires the use of different methods, strategies or techniques, the students are told explicitly which ones they should use.	– Students must use related content learned in the second year of the cycle. – Students must gain a qualitative and quantitative understanding of the concepts addressed, many of which require a certain mathematical formalism. – The students have access to extensive material resources, so they must make choices. – When the problem requires the use of different methods, strategies or techniques, the students are not told explicitly which ones they should use; they must justify their choice.
Reflection	– The situation incorporates periods of reflection and metacognitive review in which the teacher intervenes with individual students or groups. – The nature and form of the reflection and metacognitive reviews are clearly specified.	– The situation incorporates periods of reflection and metacognitive review, in which the students participate individually or in groups. – The nature and form of the necessary reflection and metacognitive reviews are not clearly specified. Students must provide oral or written evidence of their work.

Program Content: Constructing and Using Resources

Like the Science and Technology program, the Secondary Cycle Two Applied Science and Technology program is aimed at consolidating and enriching students' scientific and technological literacy. This is a more practical program, however, and should enable students to gain a better understanding of scientific phenomena and technological achievements in order to be able to deal more effectively with the technical objects, technological systems, products and processes in their environment. Such scientific and technological literacy is based on the development of the targeted competencies and on the construction and use of different types of resources. This section is divided into three parts:

- applications related to the main technological fields
- methods, strategies, attitudes and techniques
- compulsory concepts

The first part addresses applications, in other words, practical achievements (objects, systems, products or processes), which are characterized by their operation, the materials of which they are made, the associated scientific and technological principles and the way in which they are built or manufactured. Whatever form they take, these applications are associated with one of the seven technological fields addressed in the program.

The second part addresses the strategies, attitudes and techniques introduced in Cycle One. For Cycle Two, a new heading, "Methods," has been added. It is important to point out that scientists and technologists sometimes use methods other than the experimental method and the design process. The method used depends on the context and is not predetermined.

The compulsory concepts, methods, strategies, attitudes and techniques in this program are resources for competency development.

The third part presents the program's compulsory concepts. As in Cycle One, this part is divided into four areas: The Technological World, The Living World, The Material World and The Earth and Space. The concepts associated with the Earth and Space area are addressed only in the second year of Cycle 2. The program is organized in this way to make it easier for teachers to identify the key concepts that students should learn. However, since these areas are but interrelated, they should not be addressed separately or sequentially. The same applies to the concepts, which should not be covered in a predetermined chronological order, but through integrated learning and evaluation situations.

Each of the four areas is presented in a two-column table. The first column lists the general concepts and orientations, which develop, set and specify the conceptual foundations for each year in the cycle, while giving teachers a certain amount of latitude. Occasionally, additional notes provide information about the scope of the concepts under study. The second column lists the compulsory concepts, but teachers should in no way feel bound by this list. The learning and evaluation situations should in fact be designed to go beyond these minimum requirements.

A table of cultural references is presented at the end of each area. These references can enrich learning and evaluation situations and contribute to the development of integrative educational activities that reflect the students' social, cultural and everyday reality. They can often be related to the broad areas of learning and other subjects.

Lastly, a summary table provides an overview of all of the compulsory concepts for each year in the cycle.

Applications Related to the Main Fields of Technological Activity

To foster the integration of the different areas, the compulsory concepts have been divided into applications related to seven major technological fields: medical, agricultural and agri-food, energy, information and communications, transportation, manufacturing and construction technologies. The achievements in these fields are a concrete expression of knowledge, skills, attitudes and perceptions and therefore enable us to make connections between theoretical concepts and technological and scientific applications.

Medical technologies help prolong life and improve its quality. Like the other technologies, they combine knowledge and strategies from several areas. For example, in the first year of Cycle Two, students study the stethoscope, which helps them develop subject-specific competencies by applying knowledge related to the living world (circulatory and respiratory systems), the material world (e.g. relationship between pressure and volume, characteristics of waves) and the technological world (e.g. technical drafting, mechanical engineering, metals, manufacturing). The objects, systems and products associated with medical technologies also provide an opportunity for students to learn about preventive medicine and proper nutrition.

To foster the integration of the different areas, the compulsory concepts have been divided into applications associated with the different technological fields.

Agricultural and agri-food technologies involve agricultural production and the processing and preservation of foods and other products. Biotechnology plays an important role in this field. Agricultural machinery, methods of food preservation and the pasteurization process can be studied as a means of applying many of the compulsory concepts in the first year of the cycle.

Energy technologies involve the accessibility, transformation and use of energy. The types of energy we use have social and environmental consequences. Students could learn about various energy production methods by designing a scale model of a hydroelectric power plant or by analyzing a ventilator. The transformation and use of energy could also be addressed in an analysis of household appliances.

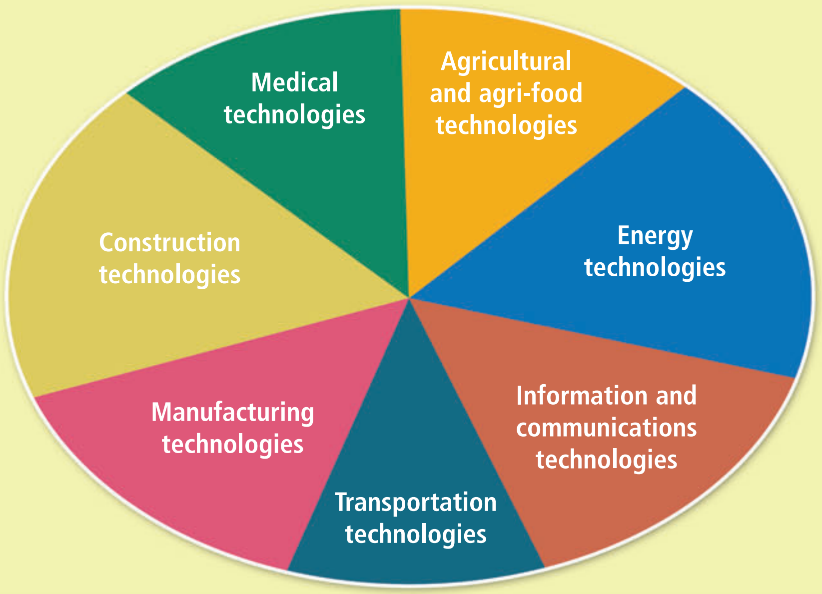
Information and communications technologies make it possible to handle, convert, control, store, manage and transmit information. This increasingly important field is radically changing our society. The study of the microphone, for example, would provide an opportunity for students to apply several concepts associated with the material world (e.g. frequency, wavelength, amplitude, decibel scale), the living world (e.g. relationships, sensory receptors, anatomy of the ear) and the technological world (e.g. graphical language, engineering, materials, manufacturing).

Transportation technologies involve a complex network of interrelated components related to travel on land, in the water, in the air and in space. The transportation of cargo and passengers is an important issue for today's society. Some of the concepts associated with the material world are particularly useful in studying how land vehicles move, how boats float and how air flows over the wings of an airplane. The concepts associated with the living world are also involved in the study of the impact of different means of transportation, particularly on ecosystems.

Manufacturing technologies involve the effective and competitive mass production of objects, systems and products. In the global marketplace, these technologies have a considerable influence on business performance and consumer habits. In the learning and evaluation situations associated with this field, emphasis could be placed on the various means of increasing the number and quality of manufactured products (e.g. transfer machines, automated systems).

Finally, **construction technologies** determine the processes and materials used to design and build structures. While manufacturing makes ample use of the production line, construction technologies are more likely to use a specific process for each project. Building a tunnel, for example, combines concepts related to the technological world (graphical language, engineering, materials, manufacturing), the material world (e.g. force, types of forces, equilibrium between two forces) and the Earth and space (lithosphere, hydrosphere).

Examples of Objects, Systems, Products and Processes Related to the Main Fields of Technological Activity



MEDICAL TECHNOLOGIES

- Prescription drugs
- Vaccines
- Antiseptics
- Hormones
- Contraceptive pill
- Vitamins
- Artificial organs: heart, kidney, etc.
- Devices and instruments: stethoscope, microscope, ultrasound device, X-ray machine, CT scanner, anaesthetic apparatus, surgical apparatus, etc.
- Bionic technology: signals and electronics
- Devices for people with handicaps
- Sterilization
- Grafts and organ transplants
- Blood transfusions
- Tissue cultures
- Functional foods

AGRICULTURAL AND AGRI-FOOD TECHNOLOGIES

- Agricultural machinery
- Fertilizers
- Insecticides
- Genetically modified organisms (GMOs)
- Production of bread, pasta, canned goods, milk, butter, cheese, margarine, edible oils, fruit juices, chocolate, coffee, etc.
- Food preservation: freezing, vacuum packing, etc.
- Pasteurization
- Enzymes
- Cosmetics: soap, perfume, etc.
- Waste treatment
- Soil irrigation equipment

ENERGY TECHNOLOGIES

- Oil industry equipment: extraction, refining, distribution, use
- Wind turbines
- Steam engines
- Internal combustion engines
- Electric motors
- Turbines
- Turbojets
- Laser
- Batteries
- Electric power plants
- Electrical household devices: lighting, heating, various appliances (washing machine, dryer, stove, refrigerator, dishwasher, microwave, vacuum cleaner, iron, stereo, television, computer, etc.)

INFORMATION AND COMMUNICATIONS TECHNOLOGIES

- Printing equipment
- Reprography
- Photoengraving
- Cameras and video cameras
- Telegraph
- Telephone
- Radio
- Television
- Film
- Film projector and screen
- Sound recording and production equipment: tape recorder, speaker, microphone, mixer, etc.
- Video recording and production equipment: video camera, videotape recorder, editing table, etc.
- Computer and peripherals
- Communications satellites
- Radar and sonar
- Optical devices: binoculars, telescope, periscope

TRANSPORTATION TECHNOLOGIES

- Bicycle
- Railway systems: locomotive, train, network
- Hot air balloons and zeppelins
- Boats, submarine, air cushion vehicle, etc.
- Automobile
- Airplane
- Spacecraft: rocket, shuttle, space station, etc.
- Hybrid vehicles
- Tires
- Electronic road maps

MANUFACTURING TECHNOLOGIES

- Manufactured goods in general
- Instruments and devices: thermometer, barometer, anemometer, micrometer, dial gauge, scale, clock, chronometer, compass, etc.
- Tools: hand, electric, air, hydraulic, etc.
- Machines: agricultural machinery, diggers, machine tools, etc.
- Systems: mechanical, electrical, hydraulic, pneumatic, electronic, computer, etc.
- Everyday objects: household appliances, locks, faucets, furniture, pumps, skis, musical instruments, toys, etc.
- Motor vehicles
- Loom and sewing machine
- Natural and artificial fibres
- Clothing

CONSTRUCTION TECHNOLOGIES

- Buildings: house, skyscraper, commercial building, etc.
- Road network: road, highway, etc.
- Street lights
- Bridges
- Tunnels
- Dams
- Locks
- Aqueducts
- Water supply
- Wastewater purification
- Airport
- Aerial tramway
- Elevator
- Escalator

Methods, Strategies, Attitudes and Techniques

This section addresses the methods, strategies, attitudes and techniques recommended in the program. While they are different from concepts, these elements are just as important in the development of competencies and so require special attention.

Methods

The methods described in this section include modelling, the observation, experimental and empirical methods, technological analysis, the design process and the industrial process, which comprises the technological design and production processes. They are essentially different ways of solving a scientific or technological problem. These methods should not be applied in isolation, but in learning and evaluation situations in which several of them are combined. They are not linear, in that students must learn to move back and forth between the various steps of the investigative process. The ability to apply these methods in combination is an indicator of proficiency.

Modelling

Modelling consists in constructing a representation of an abstract situation, one that is difficult to observe or impossible to see. This representation can be a text, a drawing, a mathematical formula, a chemical equation, a software program or a scale model. Over time, the model becomes more refined and complex. It may be valid only for a certain amount of time and in a specific context and, in many cases, it must be modified or rejected. It is also important to consider the context in which it was created. A model must have certain characteristics. Among other things, it must help people understand a given reality, explain certain properties of that reality and predict new observable phenomena.

Observation method

The observation method is an active process intended to help the observer interpret facts on the basis of his or her predetermined criteria and generally accepted criteria within a given field. In light of the information collected, the students gain a new understanding of the facts, which is inextricably linked to the context in which the observations were made. In his or her interpretation and organization of information, the observer reinterprets the physical world on the basis of his or her assumptions and the conceptual schemes that are an integral part of what he or she brings to the observation process. All observations involve a theoretical model established by the observer.

Experimental method

The experimental method begins with the formulation of preliminary explanations. Then students can begin looking for an answer and defining the framework of the experiment. It then becomes necessary to develop an experimental procedure in order to identify a certain number of variables to be manipulated. The aim of the procedure is to identify and compare observable or quantifiable elements and check them against the initial hypotheses. Moving back and forth between the different stages of the experimental method raises new questions and allows students to formulate new hypotheses, adjust the experimental procedure and take the limitations of the experiment into account.

Empirical method

The empirical method involves finding a situation in which there is no manipulation of variables. Its spontaneity does not detract from the methodology involved (for example, a survey is an empirical approach that leaves nothing to chance). Often based on intuitive models, this method sometimes provides a way of exploring and representing the elements of a problem. Often, it can lead to a number of preliminary ideas, hypotheses and theories, as well as new techniques and possible avenues for other research projects.

Technological analysis

To analyze a technical object or technological system, students must determine its overall function so that they can identify the need it satisfies. They must identify the different components in order to determine their respective functions. If necessary, the technical object or technological system can be disassembled in order to provide a better understanding of its construction and operation. This process reveals the object or system as a concrete and tangible combination of solutions adapted to meet a need.

Design process

The design process is a creative activity involving the conceptualization and production of a universe of shapes, colours, materials and textures in response to a need. When developing and producing an object or system, students must consider more than outward appearances. The structural and functional relationships that make a product a coherent unit must also meet manufacturing and consumer needs. In design, functional elements, construction methods, materials, drawings, scale models, techniques and manufacturing methods must take both context and constraints into account.

In designing a product to meet a need, students must both think and act. Whether they are studying specifications, doing creative research, seeking a solution, preparing for mass production, developing a prototype or considering industrialization and marketing, there is certainly room in the design process for the students to demonstrate autonomy. They are given the opportunity to consider a range of viewpoints, formulate hypotheses and make deductions about a situation or question.

Industrial process

The industrial process is a combination of the technological design and production processes.

Technological design process

This process is used when a need has been identified. The resulting study of the technological problem must take into account any conditions and constraints in the specifications. Then the real design process begins: finding solutions to operational and construction problems, defining shapes, determining the necessary materials, and designing the parts.

Creating, testing and validating a prototype complete the process. By carefully examining the prototype they have designed and the results of the tests, students can evaluate their solution and check it against the requirements in the specifications. This process, which requires logic, precision, abstraction and execution, enables students to move from the reasoning stage to the practical stage. Reflection during and at the end of the process enables them to analyze their progress, validate their choices and, if necessary, suggest improvements to the chosen solution.

Production process

The development phase ends with the approval of the prototype. Normally, the production process follows. The first and one of the most important steps in this process is to conduct a manufacturing study. This involves analyzing general and detail drawings and reading process and assembly sheets in order to plan the production process: parts to be made, workstations, materials, jigs and so on. The final step involves the manufacturing operations per se.

Once objects or systems have been mass-produced, they are marketed. They are then used alone or in combination with other objects or systems. At the end of its life cycle, the product is either recycled or destroyed.

This process requires abstraction and organizational skills, as well as dexterity. It gives students an accurate idea of how things work in the real world while they learn to work closely with peers. Lastly, its application requires logic, rigour and precision.

Strategies

Some strategies used in science and technology can help students develop the program's three competencies.

EXPLORATION STRATEGIES	ANALYTICAL STRATEGIES
– Collecting as much scientific, technological and contextual information as possible to define a problem or predict patterns – Referring to similar problems that have already been solved – Generalizing on the basis of several structurally similar cases – Anticipating the results of a method – Developing various scenarios – Exploring various possible solutions – Considering various points of view on scientific or technological issues	– Identifying the constraints and important elements related to the problem-solving situation – Dividing a complex problem into simpler subproblems – Using different types of reasoning (e.g. inductive and deductive reasoning, comparison, classification, prioritization) in order to process information – Reasoning by analogy in order to process information and adapt scientific and technological knowledge – Selecting relevant criteria to help him/her determine where he/she stands on a scientific or technological issue

Attitudes

The adoption of a variety of attitudes makes it easier for students to invest in the methods used and to develop a sense of responsibility for their own actions and with respect to society in general. Attitudes are an important factor in the development of the competencies.

INTELLECTUAL ATTITUDES	BEHAVIOURAL ATTITUDES
– Curiosity	– Discipline
– Sense of initiative	– Independence
– An inclination to take intellectual risks	– Perseverance
– Interest in comparing different ideas	– Concern for a job well done
– Receptivity to original solutions	– Sense of responsibility
– Intellectual rigour	– Willingness to work hard
– Objectivity	– Willingness to cooperate effectively with others
– Methodical approach to their work	– Concern for health and safety
– Concern about using proper and precise language	– Respect for life and the environment
	– Attentiveness
	– Respect for themselves and others
	– Team spirit
	– International solidarity in dealing with major issues

Techniques

Often essential, techniques involve methodical procedures that provide guidelines for the proper application of theoretical knowledge. These procedures are divided into two major categories: scientific techniques and technological techniques.

TECHNOLOGICAL TECHNIQUES		SCIENCE
Graphical language	**Manufacturing**	
Techniques: – Using scales – Constructing a graph using instruments (multiview orthogonal projection, isometric representation, perspective drawing) – Drawing schematic diagrams – Using vector graphic software (2D and 3D)	**Techniques:** – Safely using machines and tools (e.g. band saw, drill, sander, hammer, screwdriver, pliers) – Measuring and laying out – Machining (e.g. sawing, drilling, filing, stripping, splicing, soldering, welding) – Finishing – Performing verification and control tasks – Assembling and disassembling – Making a part	**Techniques:** – Safely using laboratory materials and equipment – Using measuring instruments – Using observational instruments – Preparing solutions – Collecting samples

Compulsory Concepts (First Year of Cycle Two)

Most of the compulsory concepts in the Applied Science and Technology program are similar to those in the Science and Technology program so that students who so desire can easily make the transition from the applied general education path to the general education path after the first year of Cycle Two.

The concepts addressed in the first year of Cycle Two are more closely related to medical and agricultural and agri-food applications. The table on page 24 contains examples of objects, systems, products and processes associated with each of these technological fields. These examples are not compulsory content.

The Technological World (First Year of Cycle Two)

In the first year of Cycle Two, the technological world is characterized by general concepts related to graphical language, engineering, materials, manufacturing (which is also addressed in the section on techniques) and biotechnology. The first four concepts involve knowledge and practices essential for designing or studying technical objects or technological systems. For this reason, the same information and resources will often be used throughout the cycle to solve design or analysis problems. The fifth general concept involves a special dimension: that of technology as it applies to living beings.

Everyday and specialized objects, systems, products and processes are the result of the practical application of knowledge. They are the common thread that enables students to understand, integrate and test different concepts. Applications related to the different technological fields provide innumerable examples. The compulsory concepts are intended to help students gain a better understanding of their environment and learn to act on it.

Orientations	Compulsory Concepts
Graphical language Based on conventional geometrical representations and inextricably linked to invention and innovation, technical drafting is a language that enables students to develop, refine and give concrete expression to their ideas. All the lines and information in a technical drawing have a purpose and a meaning, which are often associated with geometry, the principles underlying scale drawings and the purpose of the different forms of representation. The theory of orthogonal projection makes it possible to create detail drawings and isometric representations. Exploded views illustrate each part of an object. Sections are sometimes needed to show the specific characteristics of a part. Dimensioning completes the information about each component of the object or system. Finally, some drawings include information about industry standards, noted according to set rules.	– Geometric lines – Forms of representation (sketch, perspective drawing, oblique projection) – Basic lines – Scales – Orthogonal projections (multiview, isometric) – Axonometric projection: exploded view (reading) – Sections – Dimensioning and tolerances – Standards and representations (diagrams and symbols)

Orientations (cont.)	Compulsory Concepts (cont.)
Engineering The design or analysis of a technical object or technological system is based on fundamental concepts of mechanics and electricity and on design and analysis processes specific to the field of engineering. In mechanics, these concepts involve the linking of parts and the most common mechanical functions, as well as the transmission and transformation of motion (familiar types of links, guiding controls and mechanisms that allow for rotational or translational motion). In the design and analysis of an object or a system, such technical knowledge makes it possible to justify the use of different shapes and materials, to apply or explain operating principles and to use or suggest construction solutions. In electricity, the compulsory concepts are related to the different components and their functions (power supply, conductivity, insulation, protection and control). A close study of these components enables students to select and combine them appropriately.	***Mechanical engineering*** – Linking of mechanical parts – Typical functions – Function, components and use of motion transmission systems (friction gears, pulleys and belt, gear assembly, sprocket wheels and chain, wheel and worm gear) – Speed changes – Function, components and use of motion transformation systems (screw gear system, cams, connecting rods, cranks, slides, rotating slider crank mechanisms, rack-and-pinion drive) ***Electrical engineering*** – Power supply – Conduction, insulation and protection – Typical controls (lever, push button, flip-flop, magnetic controller)
Materials The discovery that it is possible to change the properties of matter was a powerful incentive for exploring and controlling its use. To use a material properly, we must be familiar with its functional characteristics and structure so that we can get an accurate idea of its behaviour when it is used. The concepts related to metals, plastics and wood tell us about their composition and properties, and how they can be used. Ferrous metals and alloys are very important technological assets. They can be found in one form or another in many sectors of human activity. The technical evolution of civilization is closely linked to the development of these metals. Because of their properties and the fact that they are relatively easy to find and work, nonferrous metals and alloys are used in many applications. The advent of plastics was a veritable revolution. Their excellent physical properties and numerous qualities, such as resistance and durability and the fact that they lend themselves to high-precision machining, help explain their growing use.	– Constraints (tension, compression, torsion) – Mechanical properties – Types and properties • Ferrous alloys • Nonferrous metals and alloys • Plastics (thermoplastics) • Wood and modified wood – Cell (cell components, cell membrane, nucleus, chromosomes, genes)

Orientations (cont.)	Compulsory Concepts (cont.)
Materials **(cont.)** Wood is also a very common material. Although its properties differ depending on the species (softwood, hardwood), it has many uses. Recent biotechnological developments have found technological applications for a new type of material, living cells, ranging from *in vitro* fertilization to gene sequencing for commercial applications and the development of tests to diagnose certain genetic diseases. If we are to understand the different types of gene manipulation, we need to be familiar with the cell, in particular, the role of the cell membrane (protection and input and output control) and the nucleus and its constituents, such as chromosomes and genes (control of genetic information), in genetic manipulations.	
Manufacturing The concepts associated with manufacturing are important prerequisites for the application of techniques. Machines and tools give an accurate idea of shaping. Manufacturing involves roughing and finishing, as well as the various aspects of laying out. Elements of measurement are indispensable for validating and inspecting any manufactured part.	– Shaping • Machines and tools – Manufacturing • Roughing and finishing • Characteristics of laying out – Measurements • Direct measurement (ruler)
Biotechnology The hopes and fears associated with recent spectacular advances in biotechnology make it a major issue. The study of the related content should therefore combine the conceptual, ethical and practical aspects of biotechnology, in particular the processes involved. Some of these will be examined more closely: pasteurization, the manufacture of vaccines, artificial insemination and cell culture. Pasteurization prevents the alteration of food products and preserves their nutritional properties. The process has been in use for decades, in particular to treat milk and fruit juices. The main goal of vaccination is to enable the body to produce certain natural biological agents, thereby improving the organism’s defence against identified pathogenic elements. Artificial insemination is a possible solution to the problem of infertility. Its use in animals (e.g. cattle, sheep, poultry and fish) has led to the development of sophisticated equipment, instruments and techniques. *In vitro* fertilization offers renewed hope as a treatment for sterility and contributes to our understanding of the mechanisms of human reproduction. As the possible answer to infertility problems, gene pool conservation and food self-sufficiency, artificial insemination merits careful consideration.	– Processes • Pasteurization • Manufacture of vaccines • Artificial insemination • Cell culture

Orientations (cont.)	Compulsory Concepts (cont.)
Biotechnology **(cont.)** The study of the cell should include cell cultivation, growth, behaviour and preservation. Other aspects, such as the sterilization of materials, the characteristics of culture media, physicochemical parameters and ethical standards, should also be considered. When studying concepts of biotechnology, it is important to remember that there are still many unexplored avenues, which should justify a cautious approach. Consider, for example, the genome, which has not yet been codified and is not fully understood. Genetic manipulation can also result in new resistance to various viruses and bacteria. In the agri-food business, the creation of new transgenic species has modified the dynamic of food webs, which has direct and indirect consequences at various levels. All of the potential effects on health, particularly as concerns the immune system and the new metabolized proteins, remain fertile ground for scientific and technological research.	

Cultural References			
History	**Community resources**	**Applications**	**Events**
Alexander Graham Bell Henry Bessemer John Dunlop Guglielmo Marconi Gustave Eiffel Gregor Mendel Louis Pasteur	Invention Québec Schools and faculties of engineering Institut de recherche en électricité du Québec Centre de recherche industrielle du Québec Institut Armand-Frappier	Food preservation Plastics Genetic manipulation Home automation	Printing World fairs

The Living World (First Year of Cycle Two)

In Secondary Cycle Two, the concepts related to the living world focus on the study of how the different functions of the principal systems of the human body sustain life. Five general concepts are presented in this section: the digestive, respiratory, circulatory, excretory and reproductive systems. They are grouped together according to their function in the human body: nutrition, relationships or reproduction.

These concepts are put to use in various scientific and technological applications. Whether students are learning about the prevention and treatment of illness, diagnostic aids or means of prolonging life, medical technologies associated with the fields of agriculture and agri-food and manufacturing technologies offer numerous examples of achievements that have significantly changed health care practices.

Orientations	Compulsory Concepts
Systems – Nutrition	
Digestive system Human beings rely on a regular intake of food garnered from other organisms. This intake is necessary and makes it possible to build and repair tissues and produce heat and energy in different forms (e.g. mechanical, thermal). The mechanical and chemical transformation of food takes place in the digestive system. Ingestion, digestion, absorption and elimination are the four steps in the processing of food. The digestive glands are responsible for the chemical decomposition of food. The salivary glands produce saliva, which has several functions (e.g. humidification, partial digestion of carbohydrates, antibacterial functions). Gastric secretions (e.g. hydrochloric acid, mucus, pepsin) help digest proteins. The small intestine and its ancillary structures (the pancreas and the liver) secrete a variety of juices to begin the digestion of fats. Bile salts play an important role in the digestion of fats. The small intestine also plays a major role in the digestion of carbohydrates, proteins and fats and in the absorption of nutrients. The absorption of water and electrolytes is one of the essential functions of the large intestine. The final segment of the large intestine, the rectum, stores fecal matter for elimination. Many technological and scientific applications contribute to the treatment of digestive system disorders. The number of individuals whose lives have been saved by the discovery of insulin is constantly growing. Moreover, techniques such as laparoscopy and endoscopy enable physicians to actually see the organ in question and make a quicker diagnosis. Other techniques, such as cholecystectomy, can considerably shorten hospital stays. In the field of food processing, research has had a significant impact on the diversity of products available at the grocery store. Organic foods are becoming increasingly popular among those who are concerned about the influence of certain foods on their health. Newly rediscovered natural substances might be able to prevent or delay the onset of cancer or cardiac disease.	– Types of foods (water, proteins, carbohydrates, fats, vitamins, minerals) – Energy value of different foods – Digestive tract (mouth, esophagus, stomach, small intestine, large intestine, anus) – Transformation of food (mechanical, chemical) – Digestive glands (salivary glands, gastric glands, pancreas, liver, intestinal glands)

Orientations (cont.)	Compulsory Concepts (cont.)
Systems – Nutrition (cont.)	
Circulatory and respiratory systems In order to carry out their metabolic activities, human cells need a constant supply of oxygen and an effective means of eliminating carbon dioxide. The transportation (respiratory, circulatory and lymphatic) systems, which allow organs and cells to exchange substances and energy, are essential for sustaining life. The respiratory system is responsible for supplying oxygen and eliminating carbon dioxide. The exchange of oxygen and carbon dioxide makes cellular respiration possible. The circulatory system makes these exchanges possible through the use of different types of vessels. Blood constituents play an important role in the transfer of substances to the organism. The immune system allows the human organism to defend itself against viruses, bacteria and other extracellular threats. Active immunity can be acquired naturally (production of antibodies) or artificially (vaccination). Immune system disorders can cause illnesses such as allergies and immune deficiency. In medical applications, access to artificial organs significantly increases the chances of survival of patients awaiting a transplant. Thanks to instruments such as the cardiac cannula, it is now possible to avoid opening the thoracic cavity to repair certain types of coronary lesions. Positive-pressure ventilation devices prevent sleep apnea and improve the quality of life of patients with chronic lung disease. The discovery and production of vaccines helped eradicate serious diseases such as smallpox and control the propagation of the influenza virus. New DNA-based vaccines may revolutionize the treatment of metabolic diseases such as diabetes.	– Respiratory system (nasal cavity, pharynx, trachea, bronchi, lungs) – Functions of blood constituents (plasma, formed elements) – Compatibility of blood types – Circulatory system (types of blood vessels) – Lymphatic system (lymph, antibodies)
Excretory system The urinary system plays an essential role in the internal regulation of organisms. Its key functions are filtration of the blood and the elimination of waste. The kidneys retain or excrete water and electrolytes, which helps maintain an internal balance. The sweat glands also regulate body fluids and eliminate waste. The circulatory system and lungs help stabilize the blood's pH level through the transportation of gases and the elimination of carbon dioxide. The regulation of bodily fluids and the elimination of metabolic waste help maintain hemodynamic and ionic balance. Semipermeable membrane technology led to the invention of dialysers. Semipermeable membranes can replace damaged organs that are no longer able to effectively regulate bodily fluids. In terms of the production of prescription drugs, diuretics are essential for patients whose kidneys can no longer filter their blood. The use of energy and hydrating drinks enables us to maintain the proper hemodynamic and ionic balance during all types of physical activity.	– Urinary system (kidneys, ureters, bladder, urethra) – Components of urine (water, mineral salts, urea) – Maintaining a balanced metabolism (kidneys, lungs, sweat glands)

Orientations (cont.)	Compulsory Concepts (cont.)
Systems – Relationships	
Nervous and musculoskeletal systems The nervous system and the musculoskeletal system regulate internal bodily functions and human behaviour. They enable human beings to enter into relationships with the external world and to adapt to it. The nervous system is made up of complex networks of specialized cells, called neurons. Complex behaviours are made possible by the central nervous system, which coordinates motor control through the peripheral nervous system. The sensory and motor divisions of the peripheral nervous system ensure homeostasis. The highly complex nervous system collects vast amounts of information using different sensory receptors in the sensory organs, which ensure sight, hearing and balance, taste and smell, movement and locomotion. This information is then integrated into the sensory zones located in the central nervous system. The nervous system also plays an important role in coordination and locomotion. Sensory saturation can result from excessive use of new information and communications technologies. It is important that the students understand that they should use video games and MP3 players judiciously. The skeleton supports and protects the body. It plays an essential role in movement because of the muscles that act on it by contracting. Some bones are fused, while others are connected by joints, which provide a certain freedom of movement. Technological applications sometimes provide solutions for serious problems, in particular in the field of mental illness, which affects a significant portion of the population. The synthesis of antidepressants and antipsychotic medication for specific ailments now offers hope for the treatment and social reintegration of mental health patients. Technological applications also help deal with problems associated with an aging population. For example, prostheses enable senior citizens with hip or knee problems to remain autonomous and pursue their usual activities. Wheelchairs, some of which are now motorized, have long been part of the medical landscape and provide a better quality of life for people with handicaps or illnesses who have trouble getting around.	– Central nervous system (brain, spinal cord) – Peripheral nervous system (nerves) • Neuron (synapse, axon, dendrite) • Neural inflow (voluntary act, reflex arc) – Sensory receptors (eye, ear, skin, tongue, nose) – Musculoskeletal system (bones, joints, muscles) • Functions of bones, joints and muscles • Types of muscles • Types of joint movements
Systems – Reproduction	
Reproductive system **Cell division** In Cycle One, students learned that there are two types of reproduction (sexual and asexual). They were introduced to a wide range of living organisms in the plant and animal worlds. The perpetuation of life is based on cell division, which involves mitosis and meiosis. Studying these processes and their functions helps students understand the specific role of the cell in maintaining and reproducing life.	– Mitosis – Meiosis – Genetic diversity

Orientations (cont.)	Compulsory Concepts (cont.)
Systems – Reproduction (cont.)	
Reproductive system **(cont.)** **Cell division (cont.)** Mitosis produces daughter cells that are genetically identical to the mother cell. This type of division is part of a cellular cycle that involves reproduction, growth and regeneration. Meiosis produces the sexual gametes (spermatozoa and ova) needed for sexual reproduction, which ensures that descendants are genetically different from their parents. It is important to understand the impact and the ethical aspects of the applications of genetic manipulation. Cloning and its consequences for human identity and biodiversity is the subject of heated debate. On the other hand, most people are in favour of using stem cells to grow living tissue in order to accelerate the healing process among burn victims. This is a good example of the potentially positive consequences of genetic manipulation. **Note:** The compulsory content includes only the general characteristics of mitosis and meiosis, not their respective phases. The main objective is to enable students to differentiate between the two types of cell division and to understand the basis of genetic diversity. For this reason, the phases of embryonic development are not compulsory content.	
Hormone regulation as it relates to human reproduction In Secondary Cycle One, the study of human reproductive organs familiarized students with certain aspects of their reproductive system such as fertilization, pregnancy and the main stages of human development. However, the development of sexual characteristics in adolescents and the fact that puberty is when reproduction becomes possible were not addressed. The study of hormones produced by the pituitary gland (FSH, LH) sheds light, among other things, on spermatogenesis in men, and on the maturation of the ovarian follicle and ovulation in women. The study of the hormones produced by reproductive glands reveals how testosterone, estrogen and progesterone regulate growth, development, the reproductive cycle and human sexual behaviour. This new knowledge gives adolescents a more in-depth understanding of the changes they are undergoing and can help them make informed decisions concerning birth control or fertility treatments. **Note:** This part of the program offers a more in-depth view of the concepts studied in Cycle One. It should be considered a means of providing adolescents with a better understanding of puberty.	– Puberty (male and female) – Hormone regulation in men • Spermatogenesis • Erection • Ejaculation – Hormone regulation in women • Oogenesis • Ovarian cycle • Menstrual cycle

Cultural References			
History	**Community resources**	**Applications**	**Events**
Jonas Salk Ivan Pavlov Rachel Carson Thomas Malthus Sir Alexander Fleming Sir Frederick Banting Karl Landsteiner	World Health Organization Canada Food Guide Directions régionales de la santé publique	Grafts and organ transplants Blood transfusions Sterilization Tissue cultures Biosynthesis of human insulin Vaccination Contraception	Creation of the Red Cross

The Material World (First Year of Cycle Two)

In the first year of Secondary Cycle Two, the compulsory content associated with the material world has been divided into five general concepts: properties of matter, changes in matter, organization of matter, fluids and waves. The first three (properties of matter, changes in matter and organization of matter) provide a more in-depth view of subject matter introduced in Cycle One. The identification of new properties and different types of changes allows the students to make connections with the content addressed in Cycle One and to formulate new hypotheses about the organization of matter. Similarly, the introduction of the particle model is of significant help in explaining a variety of phenomena.

The fourth concept concerns fluids and provides a more precise explanation of the transportation of intake and waste in the body and the exchange of matter at the cellular level. Osmosis and diffusion, two concepts studied in Cycle One, are also used to explain these exchanges. The fifth general concept (waves) contains several basic concepts related to wave phenomena. While these concepts relate to the properties of any type of wave motion, waves are used here as resources in the specific context of the study of certain sensory receptors in the human body.

Orientations	Compulsory Concepts
Properties of matter The human organism is made up of a wide variety of substances. Whether they are in the body's cells or in bodily fluids, natural or synthetic, they have their own characteristic properties. Because of the role they play and their concentration in the body, some substances (water, oxygen, carbon dioxide, certain nutrients, mineral salts and various waste products) are major factors in a person's health. Medical objects, systems and products can be used to measure their concentration. The characteristic properties of a pure substance or group of substances are determined under certain temperature or pressure conditions. Tables listing the characteristic physical and chemical properties of matter can help us identify substances and understand their roles and uses and the risks they represent. Substances in the body are mostly mixtures, many of them solutions. Their physical properties vary in accordance with the nature and proportion of their constituents.	– Characteristic physical properties • Melting point • Boiling point • Density – Characteristic chemical properties • Reaction to indicators – Properties of solutions

Orientations (cont.)	Compulsory Concepts (cont.)
Changes in matter Human beings exchange substances with their environment, constantly transforming matter and energy. We survive because these changes provide energy in an accessible form and matter to repair and produce tissues and to maintain our mineral reserves. Students also learn about physical and chemical changes. These changes involve the transfer and transformation of energy. During physical changes, the mass and the number of atoms of each element remain the same. The molecules are not altered and the matter retains its characteristic properties. Depending on the mean kinetic energy of its molecules, a substance can be in liquid, solid or gaseous form. A variation in kinetic energy results in reversible changes. Observing the behaviour of matter during these changes is the starting point for the particle model of matter, which combines all the qualities of a good model: it compares different observations and explains the behaviours observed. In addition, it can be used to predict new behaviours and can be perfected. The preparation and dilution of solutions are common operations in everyday life.	– Physical changes – Chemical changes – Forms of energy – Particle model
Organization of matter Matter circulates from the inert to the living and vice versa. Indeed, whether it is inert or living, matter is made up of atoms that combine according to their affinities to form molecules of elements or more or less complex compounds. When a substance contains only one type of molecule, it is a pure substance that can be identified by its characteristic properties. More often than not, however, matter in the environment and in the human organism is a mixture of several types of molecules of elements and compounds. The properties of a mixture are different from those of its constituent parts, which each retain their own characteristic properties.	– Pure substance (compound, element) – Homogeneous and heterogeneous mixtures

Orientations (cont.)	Compulsory Concepts (cont.)
Fluids By means of an internal transportation system, substances selected by the organism (water, oxygen, carbon dioxide, certain nutrients, mineral salts and various waste products) circulate toward specialized areas for transformation, storage or elimination. The circulatory system provides the pressure and pressure variations needed for the blood to circulate. Respiration provides the necessary variations in volume, which allow the diffusion of oxygen and carbon dioxide in the pulmonary alveoli. In medicine, artificial pumping systems are used to take over from the body when necessary. Generally speaking, when pressure is exerted on a solid or fluid (regardless of whether or not it is compressible), it is directly proportional to the force distributed over a surface and inversely proportional to the surface to which the force is applied. Students should gain a qualitative and quantitative understanding of this relationship. In the case of fluids (compressible or incompressible), the pressure is also the result of the molecules bouncing off each other and off the sides of a constricting surface (blood vessels and alveoli). Pressure variations cause matter to move from high-pressure to low-pressure areas. At a given temperature, the volume of a compressible fluid is inversely proportional to the pressure exerted.	– Compressible and incompressible fluids – Pressure – Relationship between pressure and volume
Waves The human organism is equipped with different structures that enable it to receive information from its environment. Two external stimuli picked up by sensory organs will be examined: sound waves and visible light waves. The latter are part of the electromagnetic spectrum, which contains waves of different lengths. The exploration of transverse mechanical waves in a metal spring or in water can help students understand wave motion. Frequency, wavelength and amplitude can help us identify the qualitative and quantitative properties shared by all waves, as well as some of their differences. As deformations propagating at a given velocity in an elastic medium, mechanical waves carry energy from one point to another. The matter itself, however, is not transported. Sound waves are longitudinal mechanical waves. They are produced by a vibrating elastic body and propagate in a medium that is periodically compressed and rarefied. The wave moves, carrying the energy produced by the vibrating body. The matter itself, however, is not transported.	– Frequency – Wavelength – Amplitude – Decibel scale – Electromagnetic spectrum – Deviation of light waves – Focal point of a lens

Orientations (cont.)	Compulsory Concepts (cont.)
Waves **(cont.)** Although they are very different, in some ways light waves behave similarly to sound waves and mechanical waves in general. Like other waves, light waves are characterized by their frequency, wavelength, amplitude and velocity of propagation. However, light propagates in a vacuum and in transparent media. When a light wave comes into contact with another transparent medium, part of the light is reflected. The rest penetrates the medium and is usually deviated from its original trajectory. Our natural and artificial environments contain objects that demonstrate this property of light. Two types of lenses will be studied: convergent and divergent. Students should gain a qualitative understanding of this phenomenon. **Note:** The study of reflection is limited to plane mirrors and quantitative aspects. The quantitative aspects of refraction are not addressed.	

Cultural References			
History	**Community resources**	**Applications**	**Events**
Dmitri Mendeleev Louis and Antoine Lumière Sir Joseph John Thomson Heinrich Hertz René Descartes Wilhelm Konrad Roentgen	Museums of science and technology Science clubs Faculties of science and engineering	Periodic table of elements Medical interventions using fibre optics	Nobel Prize Science fairs

Note: The summary table of the compulsory concepts for the first year of Cycle Two can be found on the following two pages.

SUMMARY TABLE OF THE COMPULSORY CONCEPTS (FIRST YEAR OF CYCLE TWO)

The Technological World	The Living World	The Material World
Graphical language – Geometric lines – Forms of representation (sketch, perspective drawing, oblique projection) – Basic lines – Scales – Orthogonal projections (multiview, isometric) – Axonometric projection: exploded view (reading) – Sections – Dimensioning and tolerances – Standards and representations (diagrams and symbols) **Mechanical engineering** – Linking of mechanical parts – Typical functions – Function, components and use of motion transmission systems (friction gears, pulleys and belt, gear assembly, sprocket wheels and chain, wheel and worm gear) – Speed changes – Function, components and use of motion transformation systems (screw gear system, cams, connecting rods, cranks, slides, rotating slider crank mechanisms, rack-and-pinion drive) **Electrical engineering** – Power supply – Conduction, insulation and protection – Typical controls (lever, push button, flip-flop, magnetic controller) **Materials** – Constraints (tension, compression, torsion) – Mechanical properties – Types and properties • Ferrous alloys • Nonferrous metals and alloys • Plastics (thermoplastics) • Wood and modified wood – Cells (cell components, cell membrane, nucleus, chromosomes, genes)	**Systems** **Nutrition** **Digestive system** – Types of foods (water, proteins, carbohydrates, fats, vitamins, minerals) – Energy value of different foods – Digestive tract (mouth, esophagus, stomach, small intestine, large intestine, anus) – Transformation of food (mechanical, chemical) – Digestive glands (salivary glands, gastric glands, pancreas, liver, intestinal glands) **Circulatory and respiratory systems** – Respiratory system (nasal cavity, pharynx, trachea, bronchi, lungs) – Functions of blood constituents (plasma, formed elements) – Compatibility of blood types – Circulatory system (types of blood vessels) – Lymphatic system (lymph, antibodies) **Excretory system** – Urinary system (kidneys, ureters, bladder, urethra) – Components of urine (water, mineral salts, urea) – Maintaining a balanced metabolism (kidneys, lungs, sweat glands) **Relationships** **Nervous and musculoskeletal systems** – Central nervous system (brain, spinal cord) – Peripheral nervous system (nerves) • Neuron (synapse, axon, dendrite) • Neural inflow (voluntary act, reflex arc)	**Properties of matter** – Characteristic physical properties • Melting point • Boiling point • Density – Characteristic chemical properties • Reaction to indicators – Properties of solutions **Changes in matter** – Physical changes – Chemical changes – Forms of energy – Particle model **Organization of matter** – Pure substance (compound, element) – Homogeneous and heterogeneous mixtures **Fluids** – Compressible and incompressible fluids – Pressure – Relationship between pressure and volume **Waves** – Frequency – Wavelength – Amplitude – Decibel scale – Electromagnetic spectrum – Deviation of light waves – Focal point of a lens

The Technological World	The Living World	The Material World
MANUFACTURING – Shaping • Machines and tools – Manufacturing • Roughing and finishing • Characteristics of laying out – Measurements • Direct measurement (ruler) **BIOTECHNOLOGY** – Processes • Pasteurization • Manufacture of vaccines • Artificial insemination • Cell culture	– Sensory receptors (eye, ear, skin, tongue, nose) – Musculoskeletal system (bones, joints, muscles) • Function of bones, joints and muscles • Types of muscles • Types of joint movement – Reproduction – Reproductive system – Cell division • Mitosis • Meiosis • Genetic diversity – Hormone regulation as it relates to human reproduction – Puberty (male and female) – Hormone regulation in men • Spermatogenesis • Erection • Ejaculation – Hormone regulation in women • Oogenesis • Ovarian cycle • Menstrual cycle	

Compulsory Concepts (Second Year of Cycle Two)

The compulsory concepts in the second year of Cycle Two are more closely related to the applications of energy and transportation technologies. The table on page 24 presents a few examples of objects, systems, products and processes associated with each of these technological fields. These examples are not compulsory content. Note that the area Earth and space is included in this year of the cycle.

The Technological World (Second Year of Cycle Two)

The general concepts associated with the world of technology in the second year of Cycle Two are again related to graphical language, engineering and materials. Aspects of manufacturing are addressed in the section on techniques. Since the problems to be solved this year are more diverse and difficult, the concepts must be addressed in greater detail. Also, new aspects of mechanical linking and electricity, and new materials such as thermosetting plastics, ceramics and composites have been introduced in order to allow for a greater variety of possible solutions to a design or analysis problem.

Objects, systems, products and processes related to the different technological fields are also addressed in the second year of Cycle Two. They all involve specific knowledge and practices and reflect scientific, technical, social, environmental and ethical possibilities and constraints.

An in-depth study of technological concepts and the associated achievements should help students integrate and assimilate compulsory concepts from all four areas, gain a better understanding of objects, machines and systems, and develop a broader view of industrial activity.

Orientations	Compulsory Concepts
Graphical language Based on conventional geometrical representations, technical drafting is a language that enables students to develop, refine and give concrete expression to their ideas. All the lines and information in a technical drawing have a purpose and a meaning, which are associated with the different forms of representation. The theory of orthogonal projection makes it possible to create detail and general drawings and isometric representations. Functional dimensioning provides greater precision at the manufacturing stage. It completes the information about the characteristics of each component of the object or system. Drawings of certain objects produced using flat stock illustrate the flat surfaces and help determine how the final shapes will be formed by bending. Finally, some drawings include information about industry standards, noted according to set rules.	– Multiview orthogonal projection (general drawing) – Functional dimensioning – Developments (prism, cylinder, pyramid, cone) – Standards and representations (diagrams and symbols)

Orientations (cont.)	Compulsory Concepts (cont.)
Engineering The design or analysis of a technical object or system is based on fundamental concepts of mechanics and electricity and on design and analysis processes specific to the field of engineering. In mechanics, these concepts involve the adhesion and friction of parts, the most common links and mechanical functions, and the transmission and transformation of motion, all of which are examined in detail. Formal study of these concepts enables students to consider solutions based on specific types of links, guiding controls and mechanisms that allow for rotational or translational motion. In electricity and electronics, the compulsory concepts are related to the different components and their function (power supply, conduction, insulation, protection, control and transformation). A close study of these components enables students to select and combine them appropriately. In the design and analysis of an object or system, such technical knowledge makes it possible to determine or justify the use of different shapes and materials, to apply or explain operating principles and to use or suggest construction solutions.	***Mechanical engineering*** – Adhesion and friction of parts – Linking of mechanical parts (freedom of movement) – Guiding controls – Construction and characteristics of motion transmission systems (friction gears, pulleys and belt, gear assembly, sprocket wheels and chain, wheel and worm gear) – Speed changes, resisting torque, engine torque – Construction and characteristics of motion transformation systems (screw gear system, cams, connecting rods, cranks, slides, eccentrics, rotating slider crank mechanisms, rack-and-pinion drive) ***Electrical engineering*** – Power supply – Conduction, insulation and protection (resistance and coding, printed circuit) – Typical controls (unipolar, bipolar, unidirectional, bidirectional) – Transformation of energy (electricity and light, heat, vibration, magnetism) – Other functions (condenser, diode, transistor, solid-state relay)

Orientations (cont.)	Compulsory Concepts (cont.)
Materials The discovery that it is possible to change the properties of matter was a powerful incentive for exploring and controlling its use. To select an appropriate material, we must be familiar with its properties, advantages and limitations. We must also be familiar with its functional characteristics and structure so that we can get an accurate idea of its behaviour when it is used. Heat treatments, such as quenching and tempering, improve the mechanical properties of steel. For example, quenching increases hardness but makes the metal more fragile, while tempering improves toughness but reduces elasticity. Annealing restores the initial properties of a material. The three characteristic elements of the heat treatment of metals are heating to the critical point, maintaining a uniform temperature and ensuring fairly rapid cooling. The concepts related to plastics, ceramics and composites tell us about their composition and properties, as well as how they are used and classified. The advent of plastics was a veritable revolution. Their excellent physical properties and numerous qualities, such as resistance and durability and the fact that they lend themselves to high-precision machining, help explain their growing use. The term “ceramic” covers a wide range of materials used in traditional sectors such as construction and the production of consumer goods, as well as in other sectors such as electrotechnology and mechanical construction. Every composite material has specific properties and characteristics. Their strong mechanical properties and low density make them particularly useful. They can be found in a number of modern technological applications. All materials degrade more or less quickly. They can react in one of three ways to their environment: they can undergo a chemical reaction (plastics, ceramics), corrosion or oxidation (metals). Means used to prevent degradation include electrochemical protection, protective coatings and surface treatments.	– Constraints (deflection, shearing) – Characteristics of mechanical properties – Heat treatments – Types and properties • Plastics (thermoplastics, thermosetting plastics) • Ceramics • Composites – Modification of properties (degradation, protection)

Orientations (cont.)	Compulsory Concepts (cont.)
Manufacturing Drilling, threading and bending are some of the most common manufacturing operations. Materials, rotation speed and cutting angles are characteristic elements of drilling. The selection of thread profile and pitch (number of threads per inch) make it possible among other things to determine the pitch centre diameter before tapping. Types of materials and the neutral fibre are two of the parameters to be taken into account in establishing the length of a part before bending. Measuring and inspection operations, which include using instruments such as vernier callipers and checking surfaces, improve precision. The students must therefore learn the related principles.	– Manufacturing • Characteristics of drilling, tapping, threading and bending – Measurement and inspection • Direct measurement (vernier calliper) • Control, shape and position (plane, section, angle)

Cultural References			
History	**Cultural Resources**	**Applications**	**Events**
Alessandro Volta Leonardo da Vinci Joseph Brown and Lucian Sharp Le Corbusier Alfred Nobel Rudolph Diesel Henry Ford Frederick Winslow Taylor	Canadian Intellectual Property Office Canadian Patent Database Ordre des ingénieurs du Québec	Production line Interchangeability of parts Robotics Remote sensing Street lights Clothing Refrigeration Road network	Industrial revolution Establishment of labour standards Globalization

The Living World (Second Year of Cycle Two)

Although the main goal of scientific and technological applications is to improve the quality of life of human beings, they can also have negative consequences in the short or long term and affect the balance of communities. A systemic look at ecosystems is part and parcel of the study of relationships between living organisms and their environment.

The different issues raised by technological applications in the fields of transportation, construction, manufacturing and energy are some ways of introducing students to the dynamics of ecosystems and the populations that inhabit them.

From the more specific view of construction and manufacturing, the materials needed for human achievements (e.g. houses, machine tools, various instruments) are provided by the ecosystem. Thus, their use always has an impact on relationships within communities. Consider, for example, the importance of wood as a construction material and the dramatic impact of deforestation on biodiversity.

Generally speaking, scientific and technological applications are developed with a view to obtaining various materials and controlling energy resources. Population growth and demand for industrial products has resulted in an increase in energy consumption, which must be addressed. Today, technological discoveries offer new hope. Certain objects, systems and products (gasoline engine, petroleum products) that meet our needs also have negative consequences. Meteorological data collected in the past fifty years show climate changes at least partly due to the use of such objects, systems and products. While research into energy technologies provides hope for better resource management (hydrogen batteries, hybrid engine, wind turbines), we need to make the right choices in terms of the types of energy we use given their consequences for the dynamics of ecosystems.

Orientations	Compulsory Concepts
Dynamics of ecosystems When several individuals of a single species occupy the same territory, they form a population. The density of organisms and their distribution are the main characteristics of populations. The influence of abiotic and biotic factors is an essential aspect of the study of population dynamics. Many of these factors, such as natality, mortality, immigration and emigration, play an important role in the biological cycle of populations. Reproduction and survival are closed linked to the accessibility of resources. Populations are never alone in their territory. Several types of biotic interactions occur between these populations, which constitute a community. Each community is characterized by a trophic structure and a relative abundance of constituent species (biodiversity). The trophic structure, in which organisms interact and form food webs, is an important concept for explaining the dynamics of communities. These food webs are influenced by the nutrients available at the bottom of the food chain and by the major predators at the top. Modifications in the structure and composition of communities occur when disturbances cause an imbalance. At that point, a series of changes gradually takes place in order to re-establish a balance in the community: this is referred to as ecological succession. Human activity and natural calamities are the main causes of disturbances in communities.	– Disturbances – Trophic relationships – Primary productivity – Material and energy flow – Chemical recycling – Factors that influence the distribution of biomes – Ecosystems

Orientations (cont.)	Compulsory Concepts (cont.)
Dynamics of ecosystems **(cont.)** Another factor can also play an important role in the disturbance of community relationships: the presence of pathogenic microorganisms in the environment (bacteria, viruses, fungi, parasites). Some of these agents can be allergenic, toxic or even deadly in some cases. Ecosystems are all characterized by the relationships between the organisms in a community and abiotic factors. Autotrophic organisms introduce energy into the ecosystem, where it becomes organic matter. This primary productivity (biomass) influences the total amount of energy in the ecosystem. Solar energy is converted into chemical energy, transmitted from one trophic level to the other through the food chain and dissipated in the form of heat. At every trophic level, biological and geological processes return various nutrients to the environment. This is referred to as chemical recycling. Microorganisms and decomposers play an essential role in the process of organic decomposition, which allows various inorganic elements to reenter circulation. **Note:** The study of microorganisms and decomposers should be limited to their role in the organic decomposition cycle and the return of nutrients to circulation. Their taxonomy should not be addressed.	

Cultural References			
History	**Community resources**	**Applications**	**Events**
Charles Darwin Alfred Wallace Hermann Muller Alfred Hershey Martha Chase	Museums of natural science Montréal Biodôme Protected areas Zoos UNESCO world reserves Environmental groups	Depollution activities Environmental protection	Discovery of the structure of DNA Great scientific expeditions

The Material World (Second Year of Cycle Two)

In the second year of Cycle Two, the compulsory content associated with the material world has been divided into five general concepts. Many of them are similar to the content of the Science and Technology program, because they lead to the same secondary school diploma. Others were chosen for their contribution to the study of applications related to the different technological fields. The first general concept, *chemical changes,* addresses certain manufacturing processes, pollutants and fumes.

The next general concept, *electricity and electromagnetism,* helps students gain a better understanding of simple electrical and mechanical phenomena and provides new opportunities for technological projects involving several subject areas. The concepts associated with these phenomena are applied to the study of objects and systems containing electrical components.

The third general concept involves *the transformation of energy* and the principle of energy conservation. Applications related to energy and transportation technologies are particularly fertile ground for the contextualization of this general concept. Several connections are made with the general concepts *electricity and magnetism* and *force and motion.*

The fourth general concept, *fluids,* was introduced in the first year of Cycle Two. Here it gains in importance because of its usefulness in the study of many hydraulic and pneumatic applications. A few basic principles of fluids enable students to understand why flotation and flight are possible and to appreciate the nature and contribution of science and technology to the development of navigation and aerodynamics.

The fifth general concept, *force and motion,* is drawn from the technological world in Cycle One. Its introduction into the material world opens the door to a certain mathematical formalism and the understanding and use of Newton's laws in a variety of applications: design, operation and use of objects and systems. Most of these objects and systems are drawn from the fields of energy, transportation and manufacturing.

The general concepts are therefore approached as resources to be used in the study of technological applications. The material world gains in importance in the second year of the cycle, not only because students' understanding of the concepts addressed in previous years must be enriched, but also because certain concepts are often necessary for the study of the technological world.

Orientations	Compulsory Concepts
Chemical changes The chemical properties of a substance or group of substances are based on the chemical changes that occur when they come into contact with each other. Since the products are different from the reagents, they are characterized by different properties. The number of atoms of each element and their mass, however, remain the same. Several chemical reactions related to applications will be studied. They show that the atoms of different elements and ions have the ability to bond with other atoms depending on their atomic structure.	– Combustion – Oxidation

Orientations (cont.)	Compulsory Concepts (cont.)
Electricity and electromagnetism The study of matter would be incomplete without an exploration of its electrical properties. Electrical charges can appear on certain neutral materials after they are rubbed with other materials. These charges attract when they are of opposite signs and repel when they are of the same sign. The appearance of electrical charges can be explained by the mobility of negative charges and their accumulation on the surface of certain substances. The affinity of different materials for negative charges helps explain a number of everyday electrical phenomena. Some elements and materials are good conductors of electricity. They are used to allow electrons to move through electrical circuits. Electrical circuits can be made up of various elements connected in series or parallel. Ohm’s law establishes the relationship between the voltage, resistance and intensity of the current in a circuit. Each of these has its own unit of measurement. Certain elements of a circuit also transform part of the electrical energy into another form of energy. Relationships are established between the consumption of electrical energy and voltage, current intensity and time. The electrical power of a device is determined by how much energy it consumes in a given unit of time. Each element has its own unit of measurement. Learning only formal mathematical principles is insufficient; students must also have a qualitative understanding of these relationships. Matter also has magnetic properties. Some types of matter produce a magnetic field. Different poles attract, while similar poles repel. An electrical current also produces a magnetic field. Conventionally speaking, the magnetic field lines produced by a magnet, whether natural or artificial, are determined by the orientation (direction) of the north pole of a compass placed in the same field. The direction of magnetic field lines can be quickly identified by applying the right-hand or left-hand rule, depending on whether we are measuring the conventional or actual direction in which electrons travel. The same rules apply, whether the wire is straight, bent or wound. Conversely, the movement of a magnet or the variation in intensity of a magnetic field induct electrical current, which travels in the opposite direction. **Note:** Students are not required to work on series-parallel circuits. Only the qualitative aspects of electromagnetism are addressed.	***Electricity*** – Electrical charge – Static electricity – Ohm’s law – Electrical circuits – Relationship between power and electrical energy ***Electromagnetism*** – Forces of attraction and repulsion – Magnetic field of a live wire – Magnetic field of a solenoid – Electromagnetic induction

Orientations (cont.)	Compulsory Concepts (cont.)
Transformation of energy Energy occurs in a number of forms in the environment, but it always corresponds to the amount of work a system is likely to produce. Work involves force and motion. Using the appropriate methods, it is possible to convert one form of energy to another. In an isolated system, the total amount of energy is maintained during these changes. If the system is not isolated, it will lose a certain amount of energy, which is absorbed by the environment and neighbouring systems. A warm body exhibits a characteristic behaviour: as it cools, it warms cooler bodies with which it is in contact. Although "heat" and "temperature" are often used to mean the same thing in everyday language, students must make a clear distinction between the two, especially when they are studying applications related to the field of transportation. **Note:** Only the qualitative aspects of the transformation of energy are addressed.	– Law of conservation of energy – Energy efficiency – Distinction between heat and temperature
Fluids At the beginning of Cycle Two, students learned about the characteristic properties of matter and examined the concept of density as an indicator for identifying certain substances. They applied the concept of pressure to the study of the internal transportation system between the body's organs. In the second year of Cycle Two, these concepts are used to study the operation of various mechanical applications (jack, weight indicator and hydraulic brake) or to understand phenomena such as flotation and flight. Human beings have demonstrated boundless ingenuity in the construction of floating and flying devices. Through research and experiments on prototypes, students must learn to recognize the forces at work and examine the impact they have on their model. They consider adjustments that might help control movement and ensure lift. Some content related to *forces and motion* will be used to determine the resultant force and the stabilizer of a set of forces. **Note:** These principles will be studied qualitatively.	– Archimedes' principle – Pascal's law – Bernoulli's principle

Orientations (cont.)	Compulsory Concepts (cont.)
Force and motion Matter in our environment is subject to different forces, be they gravitational, electrical, magnetic or friction. When these forces act on a body, they cause deformation and modify its state of movement. The content in this section deals mainly with the second effect. Practically speaking, no mechanical system is subject to only one force. In general, several forces act simultaneously on a body. The result of these forces is a virtual force that produces the same dynamic effect as the forces acting simultaneously. When the resultant of the forces is nil, the body is in equilibrium. Everything is as if there were no force acting on it. The state of movement of the body does not change: its speed remains constant (sometimes nil). When the resultant force is not nil, the state of movement changes and the body accelerates. Here students will consider cases in which speed increases or decreases in scalar terms. They will examine the effect of the force of gravity on a mass and learn to distinguish between mass and weight. **Note:** Cases in which the action of a force causes a change in direction of velocity will not be considered, nor will cases of uniform acceleration.	– Force – Types of forces – Equilibrium of two forces – Relationship between constant speed, distance and time – Mass and weight

Cultural References			
History	**Community resources**	**Applications**	**Events**
Svante Arrhenius Archimedes Thomas Edison Blaise Pascal Orville and Wilbur Wright Isaac Newton Hans Oersted Joseph Henry Michael Faraday Albert Einstein James Watt Ernest Rutherford Niels Bohr	Faculties of science and engineering Museums of science and technology	Automobile industry Development of the electrical network	Breaking of the sound barrier

The Earth and Space (Second Year of Cycle Two)

In Cycle Two, the compulsory concepts related to the Earth and space are grouped into four general concepts: *lithosphere, hydrosphere, atmosphere* and *space.* The first three involve a more in-depth look at concepts introduced in Cycle One and are used in the analysis or design of applications.

These concepts enable students to consider the study of applications from different angles. The evaluation of the consequences of the development of certain consumer goods or civil engineering accomplishments reflect a growing concern for environmental issues. The study of the lithosphere is very important, especially since the substances needed to manufacture a number of technical objects are extracted from the Earth's crust. An understanding of the dynamics of atmospheric and marine systems enriches the study of energy production methods. Finally, the concepts related to space are addressed with respect to applications in the field of energy.

Orientations	Compulsory Concepts
The Earth	
Lithosphere The lithosphere contains a wide variety of mineral resources essential to the development of civilization. The subsoil of Québec contains rich metal deposits and large reserves of materials needed for construction and land-use planning. Various metals such as aluminum, iron and copper can be refined and used in energy technologies and in the manufacture of a number of consumer goods. Whether they are metals, industrial minerals or construction materials, these resources are available in limited quantities, hence the growing interest in residual materials. Consequently, designing an object involves selecting materials. The materials should be recyclable once the object has served its purpose. The depletion of natural resources has led to the development of new materials and the modification of existing materials such as alloys, plastics and composites. Combustion engines and thermal power plants burn fossil fuels, which are nonrenewable sources of energy, as are the radioactive materials used in nuclear power plants. The search for new energy sources and the use of renewable resources are both major concerns in today's world.	– Minerals – Energy resources

Orientations (cont.)	Compulsory Concepts (cont.)
The Earth (cont.)	
Hydrosphere A catchment area is a territory bounded by crest lines (geomorphology) surrounding a waterway, into which ground and surface water flow. Human activity in a catchment area, for example the creation of a reservoir upstream of a hydroelectric power plant, can disturb ecosystems. When building a bridge, engineers must take into account the characteristics of the land and possible consequences for the catchment area. Development and excavation work at the bottom of waterways stir up sediment, which has an impact on the aquatic environment, both upstream and downstream. Marine currents and tides create large quantities of energy. Tidal power plants use tides to produce electrical energy.	– Catchment area – Energy resources
Atmosphere The different types of air masses can be distinguished by their temperature and humidity. Convective movements carry air masses around the world. Winds are air currents resulting from variations in atmospheric pressure and the rotational movement of the Earth. Cloud systems are the result of the meeting of air masses with different characteristics. A cyclone is a large area of rotating cloud, winds and storms that rotates around a centre of low atmospheric pressure. Cyclones form over warm tropical seas and cause abundant precipitation accompanied by strong winds and generally devastating effects. An anticyclone is a system that rotates around a centre of high atmospheric pressure where the air is relatively warm and dry, and therefore cloudless. Certain construction standards take atmospheric constraints on infrastructures and buildings into account. Wind is also a resource. Whether it be to move around, perform mechanical tasks or produce electrical energy, humans take advantage of wind energy by using sails and blades whose shapes, materials and dimensions vary depending on the application. Wind is an abundant source of soft energy.	– Air mass – Cyclone and anticyclone – Energy resources

Orientations (cont.)	Compulsory Concepts (cont.)
Space	
Space The Sun emits a phenomenal amount of energy in every region of the electromagnetic spectrum. Humans have been using the Sun's heat to meet their needs for a very long time. The photovoltaic sensors on solar panels transform radiation energy into electrical energy. The gravitational pull of the Moon on the Earth's large surfaces of water is in large part responsible for the tides. The energy of the tides is captured in tidal power plants. This is one of the means humans have of meeting their energy needs.	– Solar energy flow – Earth-Moon system (gravitational effect)

Cultural References			
History	**Community resources**	**Applications**	**Events**
Joseph Henry Gaspard-Gustave Coriolis	Geological Survey of Canada Agence de l'efficacité énergétique Natural Resources Canada	Observation satellites Global positioning systems	Meteorological phenomena

Note: The summary table of the compulsory concepts for the second year of Cycle Two can be found on the following two pages.

SUMMARY TABLE OF THE COMPULSORY CONCEPTS (SECOND YEAR OF CYCLE TWO)

The Technological World	The Living World	The Material World	The Earth and Space
Graphical language – Multiview orthogonal projection (general drawing) – Functional dimensioning – Developments (prism, cylinder, pyramid, cone) – Standards and representations (diagrams and symbols) **Mechanical engineering** – Adhesion and friction of parts – Linking of mechanical parts (freedom of movement) – Guiding controls – Construction and characteristics of motion transmission systems (friction gears, pulleys and belt, gear assembly, sprocket wheels and chain, wheel and worm gear) – Speed changes, resisting torque, engine torque – Construction and characteristics of motion transformation systems (screw gear system, cams, connecting rods, cranks, slides, eccentrics, rotating slider crank mechanism, rack-and-pinion drive) **Electrical engineering** – Power supply – Conduction, insulation and protection (resistance and coding, printed circuit) – Typical controls (unipolar, bipolar, unidirectional, bidirectional) – Transformation of energy (electricity and light, heat, vibration, magnetism) – Other functions (condenser, diode, transistor, solid-state relay) **Materials** – Constraints (deflection, shearing) – Characteristics of mechanical properties	**Dynamics of ecosystems** – Disturbances – Trophic relationships – Primary productivity – Material and energy flow – Chemical recycling – Factors that influence the distribution of biomes – Ecosystems	**Chemical changes** – Combustion – Oxidation **Electricity** – Electrical charge – Static electricity – Ohm's law – Electrical circuits – Relationship between power and electrical energy **Electromagnetism** – Forces of attraction and repulsion – Magnetic field of a live wire – Magnetic field of a solenoid – Electromagnetic induction **Transformation of energy** – Law of conservation of energy – Energy efficiency – Distinction between heat and temperature **Fluids** – Archimedes' principle – Pascal's law – Bernoulli's principle **Force and motion** – Force – Types of forces – Equilibrium of two forces – Relationship between constant speed, distance and time – Mass and weight	**Lithosphere** – Minerals – Energy resources **Hydrosphere** – Catchment area – Energy resources **Atmosphere** – Air mass – Cyclone and anticyclone – Energy resources **Space** – Solar energy flow – Earth-Moon system (gravitational effect)

The Technological World	The Living World	The Material World	The Earth and Space
– Heat treatments – Types and properties • Plastics (thermoplastics, thermosetting plastics) • Ceramics • Composites – Modification of properties (degradation, protection) **MANUFACTURING** – Manufacturing • Characteristics of drilling, tapping, threading and bending – Measurement and inspection • Direct measurement (vernier calliper) • Control, shape and position (plane, section, angle)			

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An Educational Toy

1. Educational aim

This activity is designed to help students fully develop Competency 1 and partially develop Competencies 2 and 3 by designing an educational toy.

2. Student group targeted

Students in the first year of Secondary Cycle Two (Applied Science and Technology)

3. Broad area of learning and focus of development

Career Planning and Entrepreneurship

Adoption of strategies related to planning (through the completion of the steps involved in making the toy)

4. Description of the task

Introduction

It is not surprising that, like tools and utensils, toys production figures significantly among other objects manufactured by humans.

Proposed activity

Design an educational toy for children aged two to five using the materials of your choice. You must pay special attention to the elements of design directly related to the child's age (e.g. interest, durability, safety). The toy must include a spring-activated mechanism that produces a sound. All assemblies that produce an effect (movement or sound) or those that require various manipulations should be activated manually without difficulty. The toy must combine functional and aesthetic considerations. It should not involve mischief. The use of toxic products such as paint is prohibited. Finally, the dimensions of the toy should not exceed 50 cm × 50 cm × 50 cm.

Steps involved

- Hand the specifications out to the students.
- Each student develops two proposals.
- Students form teams of two and examine their teammate's proposal: they choose, plan and implement one of the four solutions proposed.
- The group discusses ideas.
- In pairs, the students make the toy (the teacher begins by explaining and demonstrating machining processes and safety measures).
- Following information and demonstrations regarding machining, procedures and security, the team carries out the steps involved in the production of their prototype.
- Using a few of the spring-activated mechanisms developed by students as examples, the group studies the related principles of science and technology.
- Review and conclusion
- Each team prepares a document about its prototype including all the necessary information: drawing and characteristics of the toy, proof of adherence to specifications, maintenance, etc.
- Certain toys are selected for donation to a child-care centre.

5. Productions

- Prototype (one toy per pair of students)
- Document containing the necessary information (one document per pair of students)

6. Targeted subject-specific competencies

Competency 1 – *Seeks answers or solutions to scientific or technological problems*

- **Defines a problem**
  Definition of important elements and constraints

– **Develops a plan of action**
Creative search and choice of solution

– **Carries out the plan of action**
Production of prototype

– **Analyzes his/her results**
Examination of toy: observations and conclusion

Competency 2 – *Makes the most of his/her knowledge of science and technology*

– **Understands the scientific principles underlying the application**
Acquisition of concepts associated with the object (nervous system and waves)

– **Understands the technological principles underlying the application**
Acquisition of technological principles associated with their object and those of their classmates (e.g. links, transformation of motion)

Competency 3 – *Communicates in the languages used in science and technology*

– **Interprets scientific and technological messages**
Study of the data related to the problem, reading of documents, etc.

– **Produces and shares scientific and technological messages**
Development of drawings and definition of the characteristics of the toy

7. Cross-curricular competencies

Solves problems – Uses creativity – Adopts effective work methods – Cooperates with others – Communicates appropriately

8. Resources (specified in the program content)*

Compulsory concepts

The Technological World	The Living World
– Orthogonal projections (multiview) – Dimensioning	***Relationships*** – Peripheral nervous system (nerves) • Neuron (synapse, axon, dendrite)

The Technological World (cont.)	The Living World (cont.)
– Standards and representations (diagrams and symbols) – Linking of mechanical parts – Function, components and use of motion transmission systems (friction gears) – Function, components and use of motion transformation systems (cranks, cams) – Constraints (tension, compression, torsion) – Mechanical properties – Manufacturing • Roughing and finishing • Characteristics of laying out	***Relationships* (cont.)** • Neural inflow (voluntary act, reflex arc) • Sensory receptors (eye, ear, skin, tongue, nose) **The Material World** – Frequency – Wavelength – Amplitude – Decibel scale

Methods

– Design process (aesthetic considerations, functional aspect, construction, etc.)

– Technological analysis (technological concepts and scientific principles)

9. Approximate duration

Eighteen 75-minute periods

10. Avenues for evaluation

– Evaluation of teamwork (students)

– Evaluation of prototype (teacher, students)

– Evaluation of document (teacher)

– Self-evaluation (student)

* Other resources presented in the program content (e.g. strategies, attitudes, techniques) can also be taken into consideration.

The Bicycle: A Practical Invention, a Universal Means of Transportation

1. Educational aim

This activity is intended to help students fully develop Competency 2 and partially develop Competency 3 by analyzing a bicycle.

2. Student group targeted

Students in the second year of Secondary Cycle Two (Applied Science and Technology)

3. Broad area of learning and focus of development

Health and Well-Being

Active lifestyle and safe behaviour (through the repair or maintenance of a bicycle)

4. Description of the task

Introduction

The school organizes a 25-km bike tour, mostly on bike paths. The day begins with a 5-km race. Two types of bicycles are made available to the students. Their job is to analyze the two models in order to determine their principal technical characteristics and select the more appropriate model for the tour. They must pay special attention to the crankset (gear wheels, derailleurs, chain, etc.) and the braking system. Then, they must inspect the bicycle and make the necessary adjustments.

Proposed activity

The students should be provided with a document containing the itinerary and information about the parts of the bicycle they must analyze: steering, transmission, brakes, lighting, materials, etc. Details associated with the drive train, impulse and motion will be given. Finally, the document will also contain a list of the operations involved in the inspection and maintenance of the bicycle.

Steps involved

– Students form two groups, each made up of two teams: two Model A bikes are studied by the two teams in one group and two Model B bikes are studied by the other two teams.

– The teams perform a technological analysis of one type of bike using the analysis form provided.

– The teams share the result within their group then present them to the class.

– The class determines which type of bicycle is more appropriate given the itinerary.

– The class studies the scientific principles used in the study of the bicycle's drive train.

– The teacher demonstrates the inspection and maintenance of a bicycle and the teams perform the tasks.

– The students do a complementary project on the history and development of the bicycle or one of its components.

5. Production

– Documents: analysis form, document on the drive train, inspection and maintenance sheet, history and development of the bicycle

6. Targeted subject-specific competencies

Competency 2 – *Makes the most of his/her knowledge of science and technology*

– **Puts applications in context**
Uses of the bicycle and needs met

– **Understands the scientific principles underlying the application**
Study of motion: concepts of force, speed, etc.

– **Understands the technological principles underlying the application**
Study of the bicycle: operating and construction characteristics, etc.

– **Inspects the technical object or technological system to ensure that it is in working order**
Maintenance and adjustments

Competency 3 – *Communicates in the languages used in science and technology*

– **Interprets scientific and technological messages**
Reading of documentation provided

– **Produces and shares scientific and technological messages**
Form, inspection sheet, etc. to be filled out and production of an essay on the history and development of the bicycle

7. Cross-curricular competencies

Uses information – Adopts effective work methods – Uses information and communications technologies – Cooperates with others – Communicates appropriately

8. Resources (specified in the program content)*

Compulsory concepts

The Technological World	The Material World
– Orthogonal projections (isometric) – Standards and representations (diagrams and symbols) – Adhesion and friction of parts – Construction and characteristics of motion transmission systems (sprocket wheels and chain) – Speed changes – Constraints (deflection, shearing)	– Force – Types of forces (gravitational, friction) – Relationship between constant speed, distance and time – Mass and weight

The Technological World (cont.)	The Material World (cont.)
– Types and properties • Composites – Modification of properties (degradation, protection)	– Minerals

Methods

– Technological analysis (characteristics of the bicycle: components, operation, construction, materials, etc.)

– Observation method (the bicycle and motion: related scientific concepts and principles)

9. Approximate duration

Seven 75-minute periods

10. Avenues for evaluation

– Evaluation of documents (teacher)

– Evaluation of essay on the history and development of the bicycle (teacher, students)

– Self-evaluation (student)

* Other resources presented in the program content (e.g. strategies, attitudes, techniques) can also be taken into consideration.