Science and Technology

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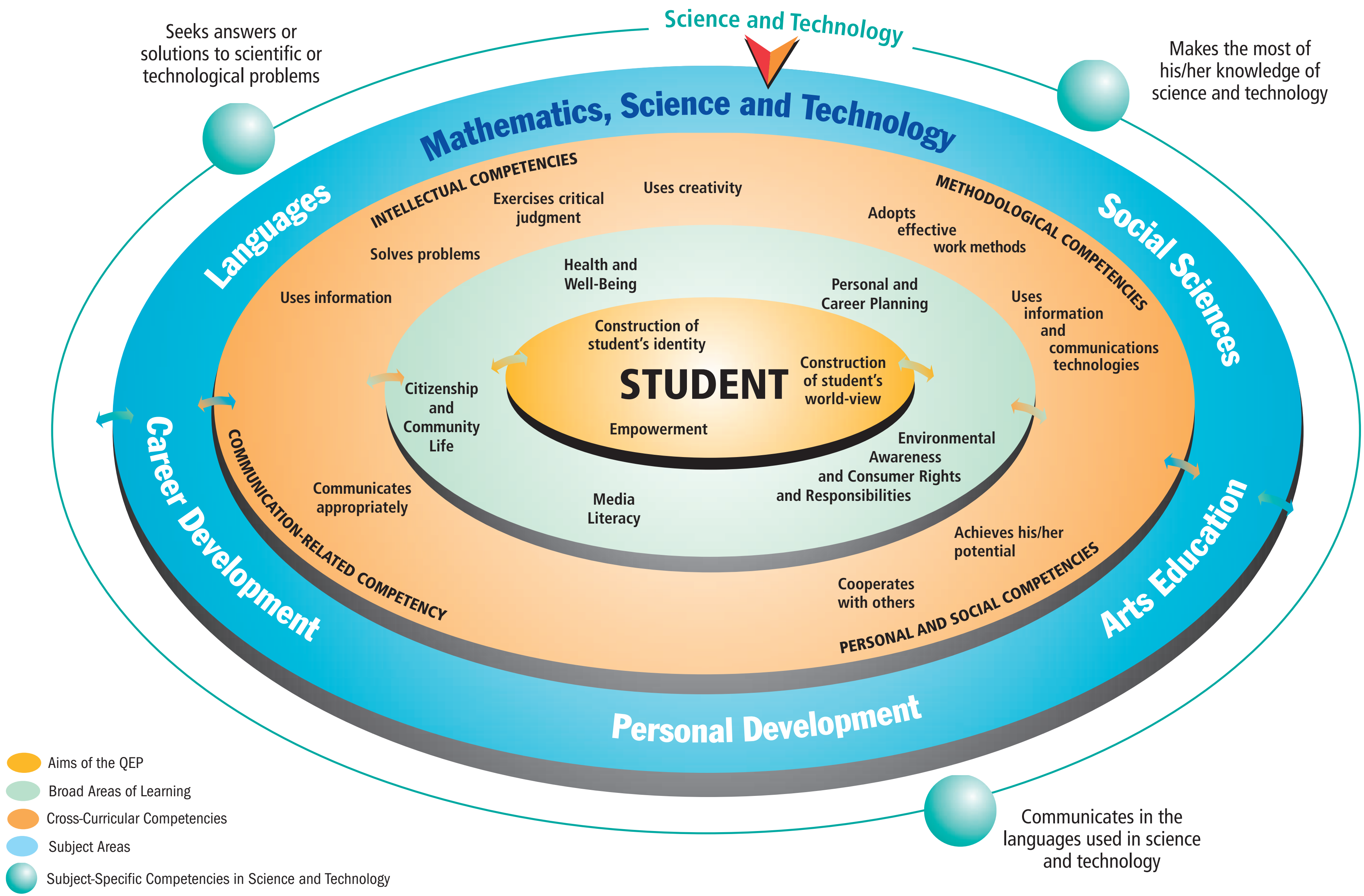

Introduction to the Science and Technology Program

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.

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. Its fields of application extend to every sphere of human activity. In fact, 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.

Technology, which focuses more specifically on action, helps us interact with the environment. Its fields of application extend to every sphere of human activity.

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,[1] systems,[2] products[3] or processes,[4] 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.

Sometimes, technological advancements precede the scientific theories that explain them. Compasses had been in use for some time before the first modern study of

1. *A technical object* is a simple, practical object that has been manufactured, as opposed to an object found in nature (e.g. hammer, tweezers).
2. *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).
3. *A product* is a substance created by transformations effected by human beings (e.g. food product, beauty care product).
4. *A process* is the means and method used to perform a task or obtain a result (e.g. technical, industrial, manufacturing process).

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.

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 technocratic approach focuses on scientific skills. The democratic approach is more concerned with developing citizenship skills. The humanist perspective aims to help students develop their intellectual potential, while the utilitarian approach is based on the everyday uses of science and technology.

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

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 form opinions about major scientific and technological issues.

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.

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 focuses on the students' ability to conceptualize and apply what they have learned in science and in 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 understanding various problems and analyzing the inner workings of technical objects and technological systems. 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 three competencies are developed and evaluated together and not in isolation or sequentially.

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 in order to understand the issues at stake.

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 Material World, The Living World, The Earth and Space and The Technological World. Each of these is presented in detail under *Program Content* and provides essential resources for the development of competencies.

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

In a variety of ways, the 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).

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.

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.

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 health are a good source for creating 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.

Scientific and technological knowledge is required in a variety of employment sectors. Teachers can help students discover these sectors and determine their level of interest and aptitudes for them. In Secondary Cycle Two, these elements are particularly important, since the students will soon be called upon to make a career choice.

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 nutrition awareness campaign or an environmental retrofit of school premises 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.

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

Intellectual 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.

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 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 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 Competency

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 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 science and technology just as 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 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 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. Science and technology 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 explaining a phenomenon, 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, problem solving, which requires the use of creativity.

In turn, science and technology contribute to a better understanding of the arts. For example, an understanding of how the human body works makes it possible to develop dance techniques and improve one's performance. Similarly, producing and sharing scientific and technological messages is related to the production of media images in the Visual Arts program.

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 production of unwanted embryos for the purposes of *in vitro* fertilization raise a number of issues associated with their use and women's health.

Connections can also be made with physical education and health. By studying the biomechanical forces and principles associated with physical activity, students are able to better understand how they affect performance. Moreover, healthy eating habits, energy management, the body's energy needs, cardiovascular endurance and health and safety are concerns related to both programs.

The 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 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. In the first year of the cycle, competencies are acquired in learning and evaluation situations based on the theme *The Human Organism;* in the second year, situations are based on four environmental topics.

Competencies are acquired in learning and evaluation situations based on the theme The Human Organism *in the first year of the cycle and on environmental topics in the second year of the cycle.*

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,[5] 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.

5. 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, such as climate change.

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.

Learning and evaluation situations should enable students to develop every aspect of the targeted competency. In this program, they involve problems related to specific themes.

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 problems related to specific themes. Students must be encouraged to make decisions, form opinions about scientific or technological issues or use a more hands-on approach, such as the experimental method or the design process.

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,[6] 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. 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 the selected topics. 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. They should be capable of explaining and justifying the steps in their procedure in light of their analysis of the situation.

6. 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.

COMPETENCY 1 Seeks answers or solutions to scientific or technological problems

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 scientific or technological problems involves using different types of reasoning and methodological procedures associated with science and technology, 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 as well as modelling are added. The goal is to eventually combine these methods when seeking answers or solutions to scientific or technological problems.

Usually relatively complex, the initial problems are generally approached in a scientific manner. 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 these two types of problems 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.

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.

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 and 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 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 scientific and technological problems. 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

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.

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

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.

COMPETENCY 2 Makes the most of his/her knowledge of science and technology

Focus of the Competency

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 an issue in context, identify the related scientific and technological principles and form an opinion.

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 continue to do so in more complex situations. They are called upon to examine a variety of issues and to form an opinion that takes into account different perspectives (e.g. aspects, points of view, consequences). Moreover, they are called upon to use previously acquired conceptual resources and to develop new ones.

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

The ability to analyze an issue involves identifying 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, sometimes, predicting new phenomena. The empirical and observation methods and modelling are resources students can use to gain a better understanding of scientific principles.

Making the most of one's scientific and technological knowledge often involves analyzing related objects, systems, products or processes. This analysis begins with an understanding of the overall function of the object, system, product or process. Then it is necessary to understand the operation of each component, its technical characteristics and the underlying scientific principles. Lastly, it involves considering solutions for constructing the object, system, product or process.

Making the most of one's scientific and technical knowledge also involves exercising critical judgment. The systematic analysis of an issue should allow students to gradually form an opinion. Having consulted different resources addressing different aspects and points of view, they can now organize their information and select the items on which their opinion will be based. They will then be able to justify or qualify their opinion on the basis of any new information obtained.

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

Puts scientific or technological issues in context

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

Understands the scientific principles underlying the issue

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

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

Forms an opinion about the issue

Seeks different resources and considers different points of view • Determines the elements that can help form an opinion • Supports his/her opinion with the elements considered • Qualifies his/her opinion, taking others' opinions into account

Understands the technological principles underlying the issue

Identifies the overall function of an object, system, product or process • Identifies the different components and determines their respective functions • Describes the principles underlying the construction and operation of the object, system, product or process • Makes connections between the principles using concepts, laws or models • Makes a schematic representation of the principles underlying the construction and operation of the object, system, product or process

Evaluation Criteria

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

End-of-Cycle Outcomes

By the end of Secondary Cycle Two, students are capable of dealing with situations and questions relating to current events and the major issues of the day and analyzing them from the point of view of science and technology. They define the issue, explore its different aspects (e.g. social, environmental, economic, political) and identify any ethical questions at stake. When necessary, they are able to evaluate the long-term consequences of the issues raised.

When students analyze a problem 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 a problem from a technological point of view, they determine the overall function of the object, technological system or product. 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 technical object or technological system.

After exploring different aspects (e.g. social, environmental, economic, political) or different ethical questions related to the issue, the students seek resources expressing different points of view. They give priority to information they deem important, paying special attention to the reliability of their sources. Thus, they form an opinion based among other things on scientific and technological principles. They are capable of justifying their opinion and reconsidering it in the light of new information.

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 students examine the issue from a limited number of points of view (e.g. of the government, unions, social groups, businesses) and aspects (e.g. social, historical, ethical).	– The problem is not as well defined: students are informed of only some of the steps involved. – The students examine the issue from a greater number of points of view (e.g. of the government, unions, social groups, businesses) and aspects (e.g. social, historical, ethical).
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. – 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. – 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

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 assembly 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

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

Communicates in the languages used in science and technology

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 gives few guidelines for the elements related to the analysis of the message. – The situation gives 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 Applied Science and Technology program, the Secondary Cycle Two Science and Technology program is aimed at consolidating and enriching students' scientific and technological literacy based on the development of the targeted competencies and on the construction and use of different types of resources. This section is divided into two parts:

- methods, strategies, attitudes and techniques
- compulsory concepts

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

The first part addresses the strategies, attitudes and techniques introduced in Cycle One. For Cycle Two, a new section, "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 second part presents the program's compulsory concepts. As in Cycle One, this part is divided into four areas: The Living World, The Material World, The Earth and Space and The Technological World. 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.

In the first year of Cycle Two, the four areas are combined to address the theme *The Human Organism,* because of the importance of encouraging students to take responsibility for their bodies and their health. In the second year, the concepts are combined to address the theme *The Environment,* which is broken down into four topics: climate change, the energy challenge, drinking water and deforestation. The scientific and technological aspects of these topics are conducive to the development of the program's three competencies.

For each of the two years in the cycle, the themes are described at the beginning of the *Compulsory Concepts* section. For the second year, a diagram of the conceptual networks makes it possible to rapidly identify the concepts generally associated with each of the topics. Although they are not compulsory, the four topics are conducive to developing subject-specific competencies and assimilating program content. Teachers may, however, select different environmental issues to help the students apply the same concepts.

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 also 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.

Methods, Strategies, Attitudes and Techniques

This section addresses the methods, strategies, attitudes and techniques recommended in the program. While they are different from the 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, formation of an opinion, the technological design process and technological analysis. 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.

Formation of an opinion

When called upon to form an opinion and develop arguments related to a scientific or technological issue, students must be aware of their level of involvement, beliefs and values. They must therefore realize how the acquisition and application of knowledge (subject-related, epistemological and contextual) and more general skills can contribute to the formation of an informed opinion. Like other methods, this one involves interpreting and comparing information, recognizing biases and assumptions, reasoning by analogy and taking into account seemingly contradictory facts. It allows students to develop solid arguments and justify their conclusions. By the end of the process, the students learn that their beliefs and values can influence their judgment, that it is necessary to consult several sources, that contradictions between sources are common and need to be interpreted, and that the choice of a solution can depend on a number of factors.

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 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. The design process, which requires logic, precision, abstraction and execution, enables students to move from the reasoning stage to the practical stage. Reflective reviews during and at the end of the process enable students to analyze their progress, validate their choices and, if necessary, suggest improvements to the chosen solution.

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.

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 – Sense of initiative – An inclination to take intellectual risks – Interest in comparing different ideas – Receptivity to original solutions – Intellectual rigour – Objectivity – Methodical approach to their work – Concern about using proper and precise language	– Discipline – Independence – Perseverance – Concern for a job well done – Sense of responsibility – Willingness to work hard – Willingness to cooperate effectively with others – Concern for health and safety – 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	**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)

In the first year of Cycle Two, the concepts related to the four areas are combined to address *The Human Organism.* With the physical and psychological changes they are undergoing, students need to gain a better understanding of the human body and of the interdependence of its different systems. A study of the factors that affect the operation and efficiency of the respiratory, circulatory, excretory, digestive, nervous and reproductive systems enables students to become more familiar with their own organism. Knowledge of these systems helps them take responsibility for personal hygiene and make healthy lifestyle choices.

In the first year of Cycle Two, the compulsory concepts are organized around the theme The Human Organism.

Moreover, exploring the human body as a living organism provides an opportunity to integrate concepts from the other three areas that will be useful for analyzing issues related to this theme. For example, studying the influence of external physical factors such as sound and light can help students understand their sensory organs and integrate their learning.

The theme also provides an opportunity for students to learn about the history of life on Earth. They can situate our brief existence in terms of the geological time scale and understand the fragility and complexity of the conditions necessary for life, whether in terms of their own lives, or with respect to planetary evolution.

In their efforts to satisfy their needs and their desire to understand and push back the limits of their knowledge, human beings have demonstrated considerable creative genius, among other things, in the development of concepts related to the world of technology. Objects, systems and products that contribute to our survival and improve our living conditions are a good indication of our ability to adapt.

Knowledge of the human body helps students take responsibility for their health and make healthy lifestyle choices.

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. The seven general concepts presented in this section are associated with life-sustaining processes: cell division and the organization of cells into tissues, organs and systems. The latter are presented according to their function: nutrition (digestive, respiratory and circulatory systems), relationships (nervous and musculoskeletal systems) and reproduction (reproductive system). The survival of an organism requires that the systems integrate harmoniously and efficiently.

The study of the concepts related to the human body does not involve an in-depth view of each system; rather it should be approached with a view to helping students develop a better understanding of their interrelationships. The theme for the first year of the cycle, *The Human Organism,* should be considered an integrative element and used as a basis for the assimilation of concepts related to other areas. For example, a study of the sense of sight can integrate a variety of concepts and knowledge such as the path of light inside the eye, the formation of images on the retina and the function of corrective lenses.

Orientations	Compulsory Concepts
Hierarchical organization of life	
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. From the more specific point of view of human beings, studying the functions of mitosis (reproduction, growth, regeneration) and meiosis helps students understand the specific role of the cell in maintaining and reproducing life. In sexual reproduction, descendants are genetically different from their parents. This type of reproduction can be broken down into two steps: meiosis and fertilization. Meiosis produces the sexual gametes (spermatozoa and ova) needed for sexual reproduction. Reproductive cells are haploid (23 chromosomes), while somatic cells are diploid (46 chromosomes). The fusion of male and female sex cells ensures genetic diversity, since the result is a combination of the mother's and father's genes. These genes (DNA) carry the blueprint of the human organism's heredity. The genetic information inherited by a cell is called the genome. The transmission of hereditary characteristics, which ensures the continuation of life, is based on the replication of the characteristic double helix of the DNA macromolecule. **Note:** The compulsory content includes only the general characteristics of mitosis and meiosis. The main objective is to enable students to differentiate between the two types of cell division (not their respective phases) and to understand the basis of genetic diversity. For this reason, the phases of embryonic development are not compulsory content.	– DNA – Mitosis – Functions of cell division (reproduction, growth, regeneration) – Meiosis and sexual development (meiosis, fertilization) – Genetic diversity

Orientations (cont.)	Compulsory Concepts (cont.)
Hierarchical organization of life (cont.)	
Tissues, organs and systems Microscopic study reveals that tissues, organs and systems are made up of anatomically and physiologically specialized cells. During embryonic development, the cells differentiate and specialize as they multiply and combine to form tissues. Like those of many living organisms, the different human tissues are organized in a precise way and constitute specialized functional centres known as organs. These in turn combine to form systems, which perform bodily functions such as nutrition, circulation and gas transfer, excretion and reproduction. The survival of an organism requires that such systems interrelate harmoniously and efficiently.	– Tissues – Organs – Systems
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 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.	– 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.	– 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.	– 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 in the way in which we move about. Sensory saturation can result from excessive use of new information and communications technologies. 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.	– Central nervous system (brain, spinal cord) – Peripheral nervous system (nerves) • Neuron (synapse, axon, dendrites) • Neural inflow (voluntary act, reflex arc) – 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

Orientations (cont.)	Compulsory Concepts (cont.)
Systems – Reproduction	
Reproductive system In Secondary Cycle One, the study of human reproductive organs familiarized the 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 make it possible to address 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, whether they are 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. 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 dangers they can 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. Many biological phenomena rely on the ability of water and fats to dissolve a number of substances. Concentration is expressed in grams of solute per litre of solution or as a percentage. The solubility of a solid or a gas is expressed in grams of solute per volume of solvent, or as a percentage. Solubility varies according to temperature.	– Characteristic physical properties • Melting point • Boiling point • Density • Solubility – Characteristic chemical properties • Reaction to indicators – Properties of solutions • Concentration • Solute • Solvent

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. Students should be able to master these operations and carry them out precisely. A chemical change alters the molecules involved. The products of the change differ from the reagents; they are characterized by different properties. The mass and the number of atoms of each of the constituent elements remain the same. On this basis, simple chemical equations are balanced (oxidizing, synthesis and decomposition reactions). Certain indicators can help us recognize the formation of a new substance.	– Physical changes • Dissolution • Dilution • Phase changes – Chemical changes • Decomposition and synthesis • Oxidation • Precipitation – Forms of energy (chemical, thermal, mechanical, radiation) – 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 An internal transportation system is responsible for the circulation of substances selected by the organism (water, oxygen, carbon dioxide, certain nutrients, mineral salts and various waste products) 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. 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. In the case of compressible fluids at a given temperature, their volume 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. 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.	– Frequency – Wavelength – Amplitude – Decibel scale – Electromagnetic spectrum – Deviation of light waves – Focal point of a lens

Orientations (cont.)	Compulsory Concepts (cont.)
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 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 Telecommunications systems	Nobel Prize Science fairs

The Earth and Space (First Year of Cycle Two)

The knowledge of the Earth and space addressed in Cycle One enabled students to interpret different terrestrial and astronomical phenomena and to become aware of the dynamic aspect of the Earth. In the first year of Cycle Two, the students learn about the origins of life and the appearance of human beings on Earth. An introduction to the dimensions of space and time enable them to make connections between the processes associated with the development of living beings and the physical characteristics of our planet. It is therefore important to address the geological time scale, the major stages in the development of life on Earth and our place in the universe.

Orientations	Compulsory Concepts
The Earth	
The geological time scale helps students understand the environmental conditions that existed during the major stages in the development of life on Earth. It begins with the creation of the Earth more than 4.55 billion years ago. After the formation of the Earth's crust and the oceans at the beginning of the Precambrian Era, the first forms of life (bacteria, prokaryotes) appear. Living organisms proliferated and diversified during the Paleozoic Era. This era is characterized by the massive extinction of almost all marine life forms and nearly 70 per cent of land species at the end of the Permian Period. The Mesozoic Era is associated with the reign of the large reptiles and dinosaurs. The Cenozoic Era (Tertiary and Quaternary periods) begins with the disappearance of the dinosaurs in another major extinction at the end of the Cretaceous Period. This era is associated with the diversification of mammals and the development of the primate and hominid lines. The Quaternary Period was the age of great glaciations and saw the disappearance of a number of mammal species, including the woolly mammoth. Modern man has been evolving for hundreds of thousands of years, but has been sedentary only for the past ten thousand years. Many traces of these changes are recorded in rock formations and on the ocean floor. Fossils provide traces of organisms that lived in the past. In a stratigraphic column, the older fossils are usually below the younger ones. Their arrangement helps us date the layers of the Earth. **Note:** Given the complexity of the taxonomy of living species and the names of the geological eras, students should be expected to learn only the main divisions of these classification systems. The biochemical evolution of prebiotic molecules into primitive cells is not compulsory learning.	– Geological time scale – Major stages in the history of life on Earth – Extinctions – Fossils – Stratigraphic layers

Orientations (cont.)	Compulsory Concepts (cont.)
Space	
Curious about the universe and its size, human beings have been watching the sky since the beginning of time. The astronomical unit is useful for comparing planetary orbits. The solar system is part of a much larger galaxy of stars, gases and dust: the Milky Way. At this scale, distances are expressed in light years. While the light from the Sun takes eight seconds to reach the Earth, the light from the closest star takes about four years. Beyond the Milky Way, observations indicate that there are billions of galaxies in the universe and that they are millions of light years away. It is generally accepted that life appeared on Earth as a result of chemical changes that took place under certain conditions including the presence of water, energy sources and a gaseous atmosphere. The atmosphere plays a role in the water cycle and protects us from harmful radiation. The absence of an atmosphere around a planet or satellite, like the Moon, results in a sterile world incapable of supporting life. Studying the conditions conducive to supporting life may enable humans to one day discover the existence of other life forms in the universe.	– Scale of the universe – Astronomical unit – Light year – Location of the Earth in the universe – Conditions conducive to the development of life

Cultural References			
History	**Community resources**	**Applications**	**Events**
Galileo Arthur Holmes Copernicus Hubert Reeves Johannes Kepler Edmond Halley Edwin Hubble	Parc national de Miguasha Mont Mégantic Observatory Canadian Space Agency Montréal Planetarium Laval Cosmodôme Geological Survey of Canada	Space exploration missions SETI program Hubble space telescope	Solar eclipse Lunar eclipse Meteoric impacts Ice ages Formation of the Canadian Shield

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 and biotechnology. The first three 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. Aspects related to manufacturing are addressed in the section on techniques. The fourth general concept involves a special dimension: that of technology as it applies to living beings and systems.

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. The technological world proposes several objects, systems and products that relate to *The Human Organism.* 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. 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) – Sections – Dimensioning – 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 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. Many objects and systems designed to meet human needs fall into this category (e.g. stethoscope, inhaler, thermos).	***Mechanics*** – 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) – Function, components and use of motion transformation systems (screw gear system, cams, connecting rods, cranks, slides, rotating slider crank mechanisms, rack-and-pinion drive)
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 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 easy to find and work, nonferrous metals and alloys are used in the manufacture of many consumer goods. Wood is also a very common material. Although its properties differ depending on the species (softwood, hardwood), it has many uses.	– Constraints (tension, compression, torsion) – Mechanical properties – Types and properties • Ferrous alloys • Nonferrous metals and alloys • Wood and modified wood

Orientations (cont.)	Compulsory Concepts (cont.)
Biotechnology The hopes and fears associated with recent spectacular advances in biotechnology make this 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, assisted reproduction, cell cultures and genetic transformation. 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. *In vitro* fertilization and artificial insemination sparked a veritable revolution in the treatment of sterility, while helping to explain the mechanisms of human reproduction. These procedures often raise ethical questions that must be addressed. 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. Many plant and animal species can now be genetically transformed. Genetic engineering now plays an important role in our society. Medical researchers have already experimented with gene therapy, in the treatment of various types of cancer, for example. In agriculture, genetically modified plants such as beets and rapeseed are highly resistant to harmful insects and have a tolerance for certain herbicides. Developments in the food industry are becoming increasingly common (e.g. vitamin A-enriched rice, modification of fatty acids in oils). It is also important to look at the regulations governing this sector of activity. When studying concepts related to GMOs, 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 the food web, which has direct and indirect consequences at various levels of the food pyramid. 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.	– Processes • Pasteurization • Manufacture of vaccines • Assisted reproduction • Cell cultures • Genetic transformation (GMOs)

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 Centre de recherche industrielle du Québec Institut Armand-Frappier	Food preservation Plastics Genetic manipulation	Printing World fairs Human genome project

Examples of objects, systems and products related to The Human Organism

- Equipment and processes for processing, producing and preserving foods: sugar, wheat flour, bread, pasta, processed milk, pasteurized butter, cheese, yogurt, margarine, edible oils, cocoa, chocolate, coffee, fruit juice, energy drinks, canned goods, etc.
- Kitchen equipment (e.g. preparation, cooking)
- Enzymes
- Functional foods (preventive and curative products), vitamins, prescription drugs, vaccines
- Inhaler, gas mask, artificial lung, artificial heart, pacemaker, incubator
- Prostheses (limbs or organs): cristalline, implant, lumbar disc, etc.
- Special equipment: wheelchair, walker, etc.
- Hygiene and beauty care products: soap, shampoo, creams, oils, perfumes, etc.
- Everyday objects: hairdryer, razor, toothbrush, scissors, scale, clock, etc.
- Faucet, filter, condenser, desiccator
- Bathroom plumbing fixtures, sauna, whirlpool
- Exercise equipment
- Thermometer, thermos, refrigerator, air conditioner
- Home heating system (water or air circulation), pressure gauge
- Stethoscope, sphygmomanometer
- Contact lenses, eyeglasses, binoculars, microscope
- Microwave oven
- X-rays, laser, scanner, magnetic resonance imaging, ultrasound
- Television, camera, computer, etc.

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

The Living World

Cell division
– DNA
– Mitosis
– Functions of cell division (reproduction, growth, regeneration)
– Meiosis and sexual development (meiosis, fertilization)
– Genetic diversity

Tissues, organs and systems
– Tissues
– Organs
– Systems

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)

The Material World

Properties of matter
– Characteristic physical properties
  • Melting point
  • Boiling point
  • Density
  • Solubility
– Characteristic chemical properties
  • Reaction to indicators
– Properties of solutions
  • Concentration
  • Solute
  • Solvent

Changes in matter
– Physical changes
  • Dissolution
  • Dilution
  • Phase changes
– Chemical changes
  • Decomposition and synthesis
  • Oxidation
  • Precipitation
– Forms of energy (chemical, thermal, mechanical, radiation)
– Particle model

Organization of matter
– Pure substance (compound, element)
– Homogeneous and heterogeneous mixtures

Fluids
– Compressible and incompressible fluids
– Pressure
– Relationship between pressure and volume

The Earth and Space

The Earth
– Geological time scale
– Major stages in the history of life on Earth
– Extinctions
– Fossils
– Stratigraphic layers

Space
– Scale of the universe
– Astronomical unit
– Light year
– Location of the Earth in the universe
– Conditions conducive to the development of life

The Technological World

Graphical language
– Geometric lines
– Forms of representation (sketch, perspective drawing, oblique projection)
– Basic lines
– Scales
– Orthogonal projections (multiview, isometric)
– Sections
– Dimensioning
– 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)
– Function, components and use of motion transformation systems (screw gear system, cams, connecting rods, cranks, slides, rotating slider crank mechanisms, rack-and-pinion drive)

The Living World	The Material World	The Earth and Space	The Technological World
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, dendrites) • Neural inflow (voluntary act, reflex arc) – Sensory receptors (eye, ear, skin, tongue, nose) – Musculoskeletal system (bones, joints, muscles) • Function of bones, joints and muscles • Types of muscles • Types of joint movements **Reproduction** **Reproductive system** – Puberty (male and female) – Hormone regulation in men • Spermatogenesis • Erection • Ejaculation – Hormone regulation in women • Oogenesis • Ovarian cycle • Menstrual cycle	**Waves** – Frequency – Wavelength – Amplitude – Decibel scale – Electromagnetic spectrum – Deviation of light waves – Focal point of a lens		**Materials** – Constraints (tension, compression, torsion) – Mechanical properties – Types and properties • Ferrous alloys • Nonferrous metals and alloys • Wood and modified wood **Biotechnology** – Processes • Pasteurization • Manufacture of vaccines • Assisted reproduction • Cell cultures • Genetic transformation (GMOs)

Compulsory Concepts (Second Year of Cycle Two)

The compulsory concepts for the second year in the cycle are organized around four environmental topics: climate change, the energy challenge, drinking water and deforestation.

The content for the second year of the Science and Technology program is organized around four environmental topics. Therefore, before presenting the tables of orientations and compulsory content for each area, this section begins with a general description of each of the four topics, followed by a diagram classifying the related content by area.

Climate change

Climate change is one of the major challenges humanity will have to face. The most urgent problem is the rise in the average temperature of the Earth. There are a number of theories as to the causes of this phenomenon, but the greenhouse effect is the most commonly accepted by the scientific community.

The greenhouse effect is first and foremost a natural phenomenon. Sunlight passes through the Earth's atmosphere and heats the surface of the planet, which, in turn, reflects heat into space. This infrared radiation is absorbed in part by certain gases and water vapour in the atmosphere, keeping it close to the Earth. If there were no greenhouse gases (carbon dioxide, methane and nitrous oxide), most of the heat that penetrates the Earth's atmosphere would quickly return to space, and the average temperature of the Earth would be -18°C instead of 15°C.

The concentration of greenhouse gases has varied over the course of the Earth's history. However, it appears that the amount of carbon dioxide and methane in the atmosphere has not been this high in 420 000 years, and that the amount of nitrous oxide is higher than it has been in at least a thousand years. The concentration of these gases has increased rapidly since the beginning of industrialization, a period characterized by an increase in the population and in the demand for energy, and by changes in land use patterns. By burning enormous quantities of fossil fuels (coal, oil and natural gas), which generate a significant amount of CO_2, and by clear-cutting forests, which hampers the natural process of CO_2 transformation, we magnified the natural greenhouse effect and are now experiencing an increase in the Earth's average temperature.

The study of various environmental issues encourages students to take responsibility for their environment.

Global warming, which is probably related to an increase in the greenhouse effect, affects every aspect of climate because it brings about changes in atmospheric and oceanic circulation. This has a number of consequences, some of which have already been observed. They include changes in the rain cycle, more frequent extreme weather phenomena and permafrost thawing. We also anticipate the accelerated thawing of glaciers and ice floes, which will cause a rise in sea level. This will result in floods and coastline erosion, which will force certain populations to move and require changes in the way land is used. These environmental changes will inevitably have a significant impact on socioeconomic activity throughout the world. Forestry, fishing, water management, tourism, and energy production and consumption will be particularly affected.

In Québec, climate change could affect the quality of our water, endangering human health and the balance of ecosystems. It could also cause fluctuations in the level of the Great Lakes and the flow of the St. Lawrence River. These fluctuations would have various consequences for the marine transportation industry, which relies on the St. Lawrence Seaway. They would also disrupt certain ecosystems, through habitat loss or deteriorating living conditions for some species of fish. Variations in precipitation would undoubtedly affect agricultural productivity and biodiversity in Québec. Moreover, coastal erosion and more frequent freezes and thaws would have an impact on the road network. Finally, if the permafrost thaws, soils in the far north could become unstable, affecting the population there.

The Living World

Ecology

- Study of populations (density, biological cycles)
- Dynamics of communities
  - Biodiversity
  - Disturbances
- Dynamics of ecosystems
  - Trophic relationships
  - Primary productivity
  - Material and energy flow
  - Chemical recycling

The Technological World[7]

Examples of objects, systems, products and processes

- Resources (maps and aerial photographs)
- Rain gauge, thermometer, barometer, anemometer, hygrometer
- Probes
- Radar, sonar
- Communications satellites
- Seismograph
- Geiger counter
- Waste collection and processing equipment (e.g. glass, plastic, tires)
- Antipollution systems on motorized vehicles (catalytic converter)

CLIMATE CHANGE

The Earth and Space

Biogeochemical cycle

- Carbon cycle
- Nitrogen cycle

Climate zones

- Factors that influence the distribution of biomes
- Marine biomes
- Terrestrial biomes

Lithosphere

- Permafrost

Hydrosphere

- Catchment area
- Oceanic circulation
- Salinity
- Glacier and ice floe

Atmosphere

- Greenhouse effect
- Atmospheric circulation
- Air mass
- Cyclone and anticyclone

Space

- Solar energy flow

The Material World

Chemical changes

- Combustion
- Photosynthesis and respiration
- Balancing chemical equations

Organization of matter

- Rutherford-Bohr atomic model
- Lewis notation
- Groups and periods of the periodic table

Transformation of energy

- Distinction between heat and temperature

7. Concepts related to The Technological World are relevant to every environmental topic.

The energy challenge of humankind

Controlling energy resources was an important factor in the development of humankind. It enabled us to control the entire planet and to explore space. History shows how we have met various energy-related challenges.

Today, we are using vast quantities of nonrenewable and polluting forms of energy. This has a serious impact on the environment, and especially on our climate, which raises the question of the environment's ability to adapt. Moreover, we may not have sufficient energy resources to meet the demand of a growing population (e.g. daily individual needs, industrial production, transportation). In simple terms, the challenge is to meet our energy needs while reducing the environmental impact, and to ensure careful and responsible management of nonrenewable energy sources.

Faced with this challenge, we must consider a number of answers, such as reducing demand; increasing the energy efficiency of tools, devices and vehicles; diversifying energy sources; investing in research and technological development related to alternative energy sources; and exploring nuclear power.[8]

In Québec, this problem is augmented by local and regional issues related to the development of hydroelectricity, the creation of wind farms, the debate over the use of nuclear energy and the development of alternative forms of energy such as biomass, solar, geothermal and tidal energy.

8. The issue of nuclear energy is addressed in the optional Secondary IV Science and Technology program. It can be mentioned in this course, but should not be studied in detail.

The Living World

Ecology
- Study of populations (density, biological studies)
- Dynamics of communities
  - Biodiversity
  - Disturbances
- Dynamics of ecosystems
  - Trophic relationships
  - Primary productivity
  - Material and energy flow
  - Chemical recycling

The Technological World[9]

Examples of objects, systems, products and processes
- Electricity: thermal power plant, hydraulic power plant, solar power plant
- Wind turbine
- Oil: well, platform, refinery
- Internal combustion engine
- Electric motor
- Turbine
- Batteries

THE ENERGY CHALLENGE OF HUMANKIND

The Earth and Space

Biogeochemical cycle
- Carbon cycle
- Nitrogen cycle

Climate zones
- Factors that influence the distribution of biomes
- Marine biomes
- Terrestrial biomes

Lithosphere
- Minerals
- Energy resources

Hydrosphere
- Catchment area
- Oceanic circulation
- Energy resources

Atmosphere
- Greenhouse effect
- Atmospheric circulation
- Air mass
- Cyclone and anticyclone
- Energy resources

Space
- Solar energy flow
- Earth-Moon system (gravitational effect)

The Material World

Chemical changes
- Combustion
- Photosynthesis and respiration
- Acid-base neutralization reaction
- Balancing chemical equations
- Law of conservation of mass

Organization of matter
- Rutherford-Bohr atomic model
- Lewis notation
- Groups and periods of the periodic table

Electricity and electromagnetism
- Electrical charge
- Static electricity
- Ohm's law
- Electrical circuits
- Relationship between power and electrical energy
- Forces of attraction and repulsion
- Magnetic field of a live wire

Transformation of energy
- Distinction between heat and temperature
- Law of conservation of energy

9. The concepts related to The Technological World are relevant to every environmental topic.

Drinking water

Water is a basic substance and a very precious natural resource with extensive applications in home life, agriculture, industry and recreation. Because of its vital importance, the United Nations has decreed access to drinking water a basic human right.

Although our planet is called the *blue planet* because much of it is covered by water, very little of that water is easily accessible to humans. Salt water is unfit for human consumption and can be toxic in quantity. That leaves natural fresh water, far less bountiful, unequally distributed over the Earth's surface and often difficult to access because it is trapped in continental glaciers or in the water table.

Not only is fresh water a rare resource, but it is also subject to pollution and waste. A slight imbalance in its characteristics makes it unfit for human consumption. A decomposing animal carcass, a slight variation in pH level or contamination by a few parts per million of a heavy metal can render water toxic. Today, despite the laws and regulations in effect, many sources of fresh water are polluted by different toxic chemical releases, which often result in the proliferation of harmful microorganisms.

Combined with contamination, the waste of fresh water is another important issue. The average North American consumes an average of several hundred thousand litres of water a year, more than half of which is wasted. In reality, a human being needs only about ten thousand litres of water a year to live.

Québec has a large water system, which is considered a world drinking water reserve. A government water policy is aimed at protecting and raising awareness of our water heritage.

The Living World

Ecology
- Study of populations (density, biological cycles)
- Dynamics of communities
  - Biodiversity
  - Disturbances
- Dynamics of ecosystems
  - Trophic relationships
  - Primary productivity
  - Material and energy flow
  - Chemical recycling

The Technological World[10]

Examples of objects, systems, products and processes
- Drinking water treatment plant
- Salt water treatment plant
- Wastewater treatment plant
- Water supply (circulation and distribution network)
- Artesian well, watermill
- Water tower, basin
- Tanker
- Hydraulic equipment
- Pump, valve
- Sprinkler
- Meter (water consumption)
- Bottling equipment and processes
- Containers (tank, bottle, can, etc.)
- Soil irrigation systems
- Aqueduct
- Lock, dyke

DRINKING WATER

The Earth and Space

Climate zones
- Marine biomes
- Terrestrial biomes

Hydrosphere
- Catchment area
- Oceanic circulation
- Salinity
- Glacier and ice floe

Atmosphere
- Atmospheric circulation

The Material World

Physical properties of solutions
- Concentration (ppm)
- Electrolytes
- pH scale
- Electrolytic dissociation
- Ions
- Electrical conductivity

Chemical changes
- Acid-base neutralization reaction
- Balancing chemical equations

Organization of matter
- Rutherford-Bohr atomic model
- Lewis notation
- Groups and periods of the periodic table

10. The concepts related to The Technological World are relevant to every environmental topic.

Deforestation

Forests are among the Earth's natural treasures. They have been part of the landscape of the world for thousands of years and they contribute to the environmental and climatic processes on which biodiversity and human life depend.

In recent centuries, large areas of forest have been destroyed on many continents to meet the need for food and because of the growth of the residential and industrial areas of cities. The reduction of forested areas and the permanent use of this land for other purposes is called deforestation.

However, large forested areas still exist in spite of temporary changes resulting from harvesting of the forests or natural disturbances.

Over the years, the world's forest cover has undergone various natural disturbances through fire, leaf-eating insects or freezing rain. Such events are an integral part of the mechanisms of regeneration of forests and, along with forest harvesting, they help to renew forests and ensure their viability.

Deforestation in some countries in South America, Asia and Africa has major consequences for the environment and for society. It has negative effects on biodiversity, because the majority of the world's plants and animals live in forests. It also has a major impact on climate change, because growing trees fix carbon and release oxygen. Trees processed to manufacture things store this carbon (carbon sink), while trees that die and decompose or burn release it (carbon-neutral).

Forests also regulate the flow of rivers and streams by absorbing excess rainwater and then gradually releasing it. They reduce the force of the winds that dry out and erode the soil, causing loss of fertility, and aggravating the damage caused by natural disasters. Thus, in some environments, deforestation is the first step toward desertification.

Deforestation directly affects hundreds of millions of people in the world who live in or near forests. These populations depend on the forest to meet their basic needs by providing them with food and wood for building and heating.

Forests are an important resource in Québec. Various measures have been implemented to protect them. Sustainable forest management and the creation of protected areas make it possible to protect other resources of the forest, such as wildlife, water and scenery.

The Living World

Ecology

- Study of populations (density, biological cycle)
- Dynamics of communities
  - Biodiversity
  - Disturbances
- Dynamics of ecosystems
  - Trophic relationships
  - Primary productivity
  - Material and energy flow
  - Chemical recycling

The Technological World[11]

Examples of objects, systems, products and processes

- Dam
- Road, highway
- Bridge, tunnel
- Road signs
- Street lights

DEFORESTATION

The Earth and Space

Biogeochemical cycle

- Carbon cycle
- Nitrogen cycle

Climate zones

- Factors that influence the distribution of biomes
- Marine biomes
- Terrestrial biomes

Lithosphere

- Minerals
- Energy resources

Hydrosphere

- Catchment area
- Oceanic circulation

Atmosphere

- Greenhouse effect
- Atmospheric circulation

Space

- Solar energy flow

The Material World

Chemical changes

- Combustion
- Photosynthesis and respiration
- Balancing chemical equations

Organization of matter

- Rutherford-Bohr atomic model
- Lewis notation
- Groups and periods of the periodic table

Transformation of energy

- Distinction between heat and temperature
- Law of conservation of energy

11. The concepts related to The Technological World are relevant to every environmental topic.

The Living World (Second Year of Cycle Two)

In Secondary Cycle Two, the compulsory concepts associated with ecology are indispensable for truly understanding the environmental issues addressed.

This study involves three main concepts: populations, dynamics of communities, and dynamics of ecosystems.

Orientations	Compulsory Concepts
Ecology 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 these 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 disturbance in communities. Another factor can also play an important role in the disturbance of community relations: 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.	– Study of populations (density, biological cycles) – Dynamics of communities • Biodiversity • Disturbances – Dynamics of ecosystems • Trophic relationships • Primary productivity • Material and energy flow • Chemical recycling

Orientations (cont.)	Compulsory Concepts (cont.)
Climate change and the energy challenge are particularly useful in understanding energy circulation and recycling in ecosystems. **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 chosen for their contribution to the study of the four environmental topics addressed.

The first general concept provides a more in-depth view of the *physical properties of solutions,* introduced in Cycle One, especially acidic, basic and salt aqueous solutions. This applies in particular to drinking water. Indeed, raw water, a finite and recyclable resource, exists on Earth in the form of solutions. It is never pure, and its quality varies depending on where it flows. Raw water is becoming increasingly contaminated by pollutants created by humans. The appropriate treatment (biological, physical and chemical) can make this water drinkable again. In the long term, however, restoring the sites through which the water flows is often less expensive than purifying the water itself.

The second general concept, *chemical changes,* was also introduced in Cycle One. Whether the topic is treating raw water, understanding the impact of deforestation and climate change or reflecting on the energy challenge, students will learn about a variety of chemical changes.

Exploring chemical changes in the environment enables students to develop new hypotheses with respect to the *organization of matter,* the third general concept. Three aspects of chemical changes are examined: the development of the theory of ionic dissociation, the discovery of the ability of atoms to bond and the formulation of new hypotheses with respect to the organization of matter.

The fourth general concept, *electricity and electromagnetism,* is related to simple electrical phenomena. This is a good opportunity to explain the conductivity of water and to introduce students to electromagnetism and technological activities.

The fifth general concept involves the *transformation of energy* and the principle of energy conservation. Climate change and the energy challenge are particularly useful topics for exploring this concept. The first deals with the urgent need to slow deforestation and reduce the use of fossil fuels, while the second addresses the fact that a viable alternative would be to develop a variety of means of transforming different forms of renewable energy.

The general concepts are therefore approached as resources to be used in the development of the program's themes. 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 for the purposes of the themes, but also because certain concepts are often necessary for the study of the technological world.

Orientations	Compulsory Concepts
Physical properties of solutions In our environment, matter usually occurs in the form of mixtures, many of which are aqueous solutions. The fact that many substances dissolve in water is essential to understanding biological and environmental phenomena. Special attention will be given to the properties of acidic, basic and salt aqueous solutions. These solutions are defined on the basis of their measurable and observable properties. The physical properties of aqueous solutions vary depending on the nature and proportion of their constituents. The solubility of a solid or gas is measured in grams of solute per volume of solvent and varies according to temperature. Concentration is expressed in grams of solute per litre of solution, in parts per million or as a percentage. In the natural water cycle, dissolution, dilution and evaporation cause variations in the concentration of dissolved substances. Some substances dissolved in water conduct electricity. They are called electrolytes and are referred to as strong or weak depending on their ability to conduct electricity when dissolved in water. The physical change that occurs when a substance is dissolved in water and the ability of electrolyte solutions to conduct electricity can be explained in part by the dissociation of electrolyte molecules into ions.	– Concentration (ppm) – Electrolytes – pH scale – Electrolytic dissociation – Ions – Electrical conductivity
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. This makes it possible to balance chemical equations. Several chemical reactions related to each of the topics 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 – Photosynthesis and respiration – Acid-base neutralization reaction – Balancing chemical equations – Law of conservation of mass
Organization of matter Throughout history, different models of the structure of matter have been developed to explain its properties and the changes it undergoes. In studying the Rutherford-Bohr atomic model, students learn that there are two types of particles (protons and electrons), which are organized in a particular fashion. The nucleus is made up of equal numbers of protons and electrons. The electrons travel in orbits around the nucleus. The periodic table contains vast quantities of information explaining the properties of metals, nonmetals and metalloids and enabling us to predict certain behaviour by comparing atomic structure with the properties of the elements.	– Rutherford-Bohr atomic model – Lewis notation – Groups and periods of the periodic table

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 (electrons) and their accumulation on the surface of certain substances. The affinity of different materials for electrons 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 in 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. **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

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 into 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 climate change. **Note:** Only the qualitative aspects of the transformation of energy are addressed.	– Law of conservation of energy – Energy efficiency – Distinction between heat and temperature

Cultural References			
History	**Community resources**	**Applications**	**Events**
Svante Arrhenius Archimedes Thomas Edison Blaise Pascal Isaac Newton Hans Oersted Joseph Henry Michael Faraday James Watt Ernest Rutherford Niels Bohr	Faculties of science and engineering Museums of science and technology Institut de recherche en électricité du Québec	Means of transportation Water purification systems Development of the electrical network	

The Earth and Space (Second Year of Cycle Two)

In the second year of Cycle Two, students study the interactions between life forms and abiotic elements in the biosphere. Within certain limits and setting aside human activity and exceptional climatic phenomena, various biogeochemical cycles, such as the carbon and nitrogen cycles, regulate the biosphere and ensure the survival of ecosystems. More than ever, the means used to support the development of certain socioeconomic models have an impact on certain biomes. In studying the proposed topics, students will learn about different terrestrial systems and come to understand the balance of the geosphere. Space-related concepts are addressed in terms of the future of our energy resources.

Orientations	Compulsory Concepts
The Earth	
Biogeochemical cycles A biogeochemical cycle describes the natural process during which an organic or mineral element circulates in the biosphere. The carbon cycle is regulated by the interaction of continental plates, the atmosphere, the oceans and living organisms. Although plants use photosynthesis to fix carbon in nonvolatile forms, carbonate rock, precipitated or created by living beings, constitutes the largest reserve of CO2. While this gas is released during volcanic eruptions, anthropogenic emissions restore the natural balance. Certain environmental biotechnologies contribute to the chemical recycling of carbon. Although it is abundant, atmospheric nitrogen can be assimilated by plants only in the presence of certain bacteria. The metabolism of biological organisms—alive or dead—produces waste that returns nitrogen to its mineral state and the cycle begins anew. Significant variations in the humidity, temperature or pH of the soil affect the regulation of the nitrogen cycle. Plants are the only source of nitrogen usable by animals, which is a good reason for preserving the world’s plant life.	– Biogeochemical cycles • Carbon cycle • Nitrogen cycle
Climate zone The distribution of biomes is a function of geographic latitude and other factors such as altitude, temperature and soil type. Their composition varies, since habitat conditions influence the distribution of plant and animal species. Marine biomes are at the bottom of an immense food pyramid; their continued health is therefore critical for humans. The types of animals present in a terrestrial biome depend on the types of plants there. Any imbalance caused by habitat destruction or contamination will have an impact on the ecosystems and, eventually, on a wide range of human activity.	– Factors that influence the distribution of biomes – Marine biomes – Terrestrial biomes

Orientations (cont.)	Compulsory Concepts (cont.)
The Earth (cont.)	
Lithosphere The lithosphere contains a wide variety of mineral resources essential to the development of civilization, including metals, industrial minerals and construction materials. The use and transformation of minerals, however, have an impact on the environment. In addition, minerals exist in limited amounts, hence the growing need to take another look at residual materials and recycling in general. The layers we see in a core sample, called horizons, differ in structure and composition. Studying a soil profile helps us understand the circulation of chemical elements in the soil and predict how it will evolve. Humidity, pH and mineral content help regulate the biological activity of soils, which is essential for feeding living organisms. The permafrost is sensitive to climate change because the underground ice it contains is unstable. Warming of the permafrost can cause landslides and damage to infrastructures and alter the landscape and ecosystems. Fossil fuels 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 two major concerns in today's world.	– Minerals – Soil profile (horizons) – Permafrost – Energy resources
Hydrosphere A catchment area is a territory bounded by crest lines (geomorphology) surrounding a waterway, into which flow ground and surface water. Human activity in a catchment area, for example the creation of a reservoir upstream of a hydroelectric power plant, can disturb ecosystems. Because of their ability to absorb heat, the oceans play an essential role in regulating climate by standardizing the temperature of the Earth. There are two types of marine currents, which are interrelated. Surface currents, generated by wind, ensure wide-scale horizontal circulation. Deep currents, caused by differences in temperature or salinity, ensure vertical circulation between the different layers of the ocean. These vertical currents are very sensitive to small local variations in temperature. The rise in sea level, due to the accelerated thawing of glaciers and ice floes, is a major concern for coastal populations. Marine currents and tides create large quantities of energy. Tidal power plants use tides to produce electrical energy.	– Catchment area – Oceanic circulation – Salinity – Glacier and ice floe – Energy resources

Orientations (cont.)	Compulsory Concepts (cont.)
The Earth (cont.)	
Atmosphere The Earth reflects part of the heat generated by solar radiation back into space. Some gases in the atmosphere absorb this heat and cause the temperature to rise: this is the greenhouse effect. Carbon dioxide is the most abundant greenhouse gas. Its proportion has increased over the past century because of the use of fossil fuels and the manufacture of cement. Methane and other gases also contribute to the greenhouse effect. The different types of air masses can be distinguished by their temperature and humidity. These masses circulate around the globe at the whim of wind, convection currents and the Earth's rotational movement. 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 around a low-pressure area. Cyclones form over warm tropical seas and cause abundant precipitation accompanied by strong winds and generally devastating effects. Pressure variations caused by cyclones and anticyclones ensure atmospheric circulation. 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 energy is an abundant source of soft energy.	– Greenhouse effect – Atmospheric circulation – Air mass – Cyclone and anticyclone – Energy resources
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**
Niels Steensen James Hutton Henry Cavendish Sir Charles Lyell Alfred Wegener	Geological Survey of Canada Agence de l'efficacité énergétique Natural Resources Canada Ouranos Consortium Greenpeace	Observation satellites Global positioning systems	Earth summits Kyoto Protocol Meteorological phenomena

The Technological World (Second Year of Cycle Two)

Combining different knowledge related to the use, understanding and creation of technical systems, the general concepts associated with the world of technology in the second year of Cycle Two are again related to 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 plastics, ceramics and composites have been introduced in order to allow for a greater variety of possible solutions to a design or analysis problem.

In the second year of Cycle Two, objects, systems, products and processes are also addressed. All of these are associated with the different environmental topics. They all involve specific knowledge and practices and reflect scientific, technical, social, environmental and ethical possibilities and constraints. The in-depth study of technological concepts and the associated achievements should help students gain a better understanding of objects, machines and systems in general, and those related to the environment in particular. The study of the environment is conducive to the integration of learning and the development of an awareness of the state of the Earth.

Orientations	Compulsory Concepts
Engineering The design or analysis of a technical object or a 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, the most common 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, the compulsory concepts are related to the different electrical 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. Many objects, systems and equipment related to the environment fall into this category (e.g. rain gauge, turbine, pump).	***Mechanics*** – Characteristics of the linking of mechanical parts – 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 – Construction and characteristics of motion transformation system (screw gear system, cams, connecting rods, cranks, slides, rotating slider crank mechanisms, rack-and-pinion drive) ***Electricity*** – Power supply – Conduction, insulation and protection – Control – Transformation of energy (electricity and light, heat, vibration, magnetism)

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. 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 – Types and properties • Plastics (thermoplastics, thermosetting plastics) • Ceramics • Composites – Modification of properties (degradation, protection)

Cultural References			
History	**Cultural Resources**	**Applications**	**Events**
Allessandro 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 Computer Home automation Robotics Remote sensing Street lights Clothing Refrigeration	Industrial revolution Establishment of labour standards Globalization

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

The Living World	The Material World	The Earth and Space	The Technological World
ECOLOGY – Study of populations (density, biological cycles) – Dynamics of communities • Biodiversity • Disturbances – Dynamics of ecosystems • Trophic relationships • Primary productivity • Material and energy flow • Chemical recycling	**PHYSICAL PROPERTIES OF SOLUTIONS** – Concentration (ppm) – Electrolytes – pH scale – Electrolytic dissociation – Ions – Electrical conductivity **CHEMICAL CHANGES** – Combustion – Photosynthesis and respiration – Acid-base neutralization reaction – Balancing chemical equations – Law of conservation of mass **ORGANIZATION OF MATTER** – Rutherford-Bohr atomic model – Lewis notation **ELECTRICITY AND ELECTROMAGNETISM** **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 **TRANSFORMATION OF ENERGY** – Law of conservation of energy – Energy efficiency – Distinction between heat and temperature	**BIOGEOCHEMICAL CYCLES** – Carbon cycle – Nitrogen cycle **CLIMATE ZONES** – Factors that influence the distribution of biomes – Marine biomes – Terrestrial biomes **LITHOSPHERE** – Minerals – Soil profile (horizons) – Permafrost – Energy resources **HYDROSPHERE** – Catchment area – Oceanic circulation – Glacier and ice floe – Salinity – Energy resources **ATMOSPHERE** – Greenhouse effect – Atmospheric circulation – Air mass – Cyclone and anticyclone – Energy resources **SPACE** – Solar energy flow – Earth-Moon system (gravitational effect)	**MECHANICAL ENGINEERING** – Characteristics of linking of mechanical parts – 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 – Construction and characteristics 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 – Control – Transformation of energy (electricity and light, heat, vibration, magnetism) **MATERIALS** – Constraints (deflection, shearing) – Characteristics of mechanical properties – Types and properties • Plastics (thermoplastics, thermosetting plastics) • Ceramics • Composites – Modification of properties (degradation, protection)

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Physical Activity and Lung Capacity

1. Educational aim

This activity is designed to help students develop subject-specific competencies 1 and 3 by designing an experimental prototype to measure lung capacity and submitting a written report.

2. Student groups targeted

Students in the first year of Secondary Cycle Two (science and technology)

3. Broad area of learning and focuses of development

Health and Well-Being

– Self-awareness and awareness of his/her basic needs (through the study of concepts of lung capacity)

– Active lifestyle and safe behaviour (through the study of the effects of physical activity)

4. Description of the task

Introduction

You have recently observed that many students in the school do physical activity in order to stay in shape. These students say that regular physical activity makes them feel better and helps them carry out their daily tasks more effectively.

You would like to know how physical activity affects the human body. You hypothesize that regular physical activity improves lung capacity.

Proposed activity

In pairs, the students construct a device to measure an individual's lung capacity. The teacher provides certain resources (e.g. specifications, material resources, documents) for the development of the prototype.

The students write a report containing the results of their research, a schematic diagram of the prototype used to measure lung capacity, a discussion of how the prototype could be improved and a conclusion describing the consistency of the prototype with specifications.

5. Productions

– Experimental prototype of a device to measure lung capacity

– Written report (including a schematic diagram of the prototype, the students' results, a discussion and a conclusion)

6. Targeted subject-specific competencies

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

– **Defines a problem**
Development of scientific concepts (respiration, pressure, compressible fluid) and technologies associated with the measurement of exhaled gas

– **Develops a plan of action**
Choice of design methods and development of survey

– **Carries out the plan of action**
Design of the measuring device, data collection using a survey

– **Analyzes his/her results**
Interpretation of results and formulation of an adequate conclusion

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

– **Participates in exchanging scientific and technological information**
Sharing of different design methods

– **Interprets scientific and technological messages**
Understanding of the operation and principles of the measuring device

– **Produces and shares scientific and technological messages**
Presentation of research results

7. Cross-curricular competencies

Solves problems – Uses creativity

8. Resources (specified in the program content)*

Compulsory concepts

<table>
<tr><th>The Material World</th><th>The Living World</th></tr>
<tr><td rowspan="3">– Particle model
– Compressible and incompressible fluids
– Pressure</td><td>– Respiratory system
– Musculoskeletal system</td></tr>
<tr><th>The Technological World</th></tr>
<tr><td>– Forms of representation (schematic diagram)</td></tr>
</table>

Method

– Technological design method (design of a functional prototype of a device to measure lung capacity)

9. Approximate duration

Four 75-minute periods

10. Avenues for evaluation

– Joint (teacher-student) evaluation of prototype
– Evaluation of written report (teacher)
– Self-evaluation rubric for each student

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

A Power Plant on Île Beaumont

1. Educational aim

This activity is intended to help students develop subject-specific competencies 2 and 3 by carrying out a technological analysis of the operating principles of three different types of power plants and by presenting a study on the environmental impact of each type of energy production.

2. Student groups targeted

Students in the second year of Secondary Cycle Two (science and technology)

3. Broad area of learning and focuses of development

Environmental Awareness and Consumer Rights and Responsibilities

– Knowledge of the environment (through environmental impact studies)

– Responsible consumption and use of goods and services (through a technological analysis of the power plants)

– Awareness of social, economic and ethical aspects of consumption (through the study of the population's energy needs)

– Construction of a viable environment based on sustainable development (through environmental impact studies)

4. Description of the task

Introduction

The town council of Île Beaumont must replace its coal-fired power plant, which is now obsolete and causes too much pollution. The citizens do not want a nuclear power plant because of health and environmental risks. Île Beaumont, which is accessible only by boat, is recognized for its market garden and fruit production.

Three engineering firms are invited to present proposals. One of them proposes building a wind farm, another suggests a biomass power plant and the third recommends converting the existing plant to run on natural gas.

Proposed activity

Students participate in a role-playing exercise to present the operating principles and consequences of the different proposals submitted following a public call for tenders. First, the engineering firms must produce an information document in the form of a leaflet or written report, which explains in simple terms the operating principles of each type of power plant. Three teams will present the points of view of the three firms. Another team will represent the town council, whose role is to ask questions in order to select the most appropriate type of power plant.

The students must compare the environmental impact of each of the three types of production. The teacher may provide certain resources (e.g. media, IT) for the different types of power plants.

5. Productions

– Information document (leaflet, poster, written report)

– Oral presentation (role-play)

6. Targeted subject-specific competencies

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

– **Puts scientific or technological issues in context**

Consideration of the various aspects of issues when conducting environmental impact studies

– **Understands the scientific principles underlying the issue**

Development of concepts related to energy conservation, energy efficiency and chemical reactions

– **Understands the technological principles underlying the issue**

Development of concepts related to the operation of systems, constraints and innovations

– **Forms an opinion about the issue**

Consideration of the different aspects of the arguments presented

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

– **Participates in exchanging scientific and technological information**
  Sharing of information in order to produce an information document

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

– **Produces and shares scientific and technological messages**
  Production of the information document and oral presentation

7. Cross-curricular competencies

Uses information – Cooperates with others – Communicates appropriately – Exercises critical judgment

8. Resources (specified in the program content)*

Compulsory concepts

The Material World	The Earth and Space
– Combustion – Forms of energy – Energy efficiency – Law of conservation of energy	– Carbon cycle – Energy resources – Marine biomes – Terrestrial biomes – Greenhouse effect – Atmospheric circulation
The Living World	**The Technological World**
– Study of populations – Dynamics of communities – Dynamics of ecosystems	– Transformation of energy (electricity and magnetism) – Motion transmission systems – Orthogonal projections – Standards and representations (schematic diagrams)

Methods

– Technological analysis (operating principle of the power plants)

– Formation of an opinion (consideration of different points of view, selection of criteria, organization and interpretation of documentary resources)

9. Approximate duration

Eight 75-minute periods (excluding research)

10. Avenues for evaluation

– Evaluation of the information document (teacher)

– Joint (teacher-student) evaluation of the oral presentation

– Self-evaluation rubric for each student

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