PROGRAM OF STUDY
SCIENCE AND TECHNOLOGY
Subject Area: Mathematics, Science and Technology

Adult General Education

DBE
Diversified Basic Education

Québec

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This document has been adapted from the Science and Technology, Applied Science and Technology, Environmental Science and Technology, and Science and the Environment sections of the *Québec Education Program*, *Secondary Cycle Two*.

Coordination and content
Direction de l'éducation des adultes et de la formation continue
Secteur de l'éducation préscolaire et de l'enseignement primaire et secondaire

Title of original document:
PROGRAMME D'ÉTUDES, Science et Technologie, Formation générale des adultes

English translation
Direction des services à la communauté anglophone – Services langagiers

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An electronic version of this document is available on the Ministère's website at:
www.education.gouv.qc.ca.

ISBN 978-2-550-81889-2 (PDF)
ISBN 978-2-550-81888-5 (French edition)

Legal deposit – Bibliothèque et Archives nationales du Québec, 2018

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Introduction

1.1 Contribution of the Subject to the Education of Adult Learners

Science and technology apply to many different spheres of human activity and have made a key contribution to the transformation of societies. Their applications influence the way in which we live and help broaden our knowledge base.

Curiosity, imagination, listening skills, objectivity, independence and perseverance are just as much a part of scientific and technological activities as is the formal acquisition of knowledge and skills. These activities satisfy adult learners' need to understand and explain. They help learners develop intellectual rigour, a careful and methodological approach to their work, and a concern about using precise language. They also elicit an interest in major issues of the day, such as health and safety as well as respect for life and the environment, while offering ways of dealing with them. Lastly, they promote a critical attitude toward consumer choices and openness to international solidarity.

The Science and Technology program is in keeping with the aims of adult general education: **the construction of identity**, **the construction of a world-view**, and **empowerment.**

1.2 Approach to the Subject

Science is a means of analyzing the world around us. Made up of a set of different types of knowledge, techniques and methods, it is characterized by an investigative process based on objective and verifiable relationships.

The word *technology* encompasses a wide variety of achievements, including techniques and technological processes, as well as tools, machines and materials. Technology focuses on action and intervention, and its fields of application extend to every sphere of human activity.

Science and technology are so interdependent that it is often difficult to draw a clear line between the two. In its attempts to explain the world around us, science often relies on technological developments and achievements. Conversely, when technology seeks to meet a need, it makes use of scientific principles, laws and theories.

Sometimes, technological advances precede the scientific theories that explain them. In such cases, technology can provide opportunities for exploration and questioning that lead to the development of new theories. The complementary nature of science and technology can also be seen in their respective approaches to the physical world, in terms of both design and practice.

1.3 Connections Between the Subject and the Other Elements of the Diversified Basic Education Program

The Science and Technology program is connected to the other components of the Diversified Basic Education Program, such as the broad areas of learning, the cross-curricular competencies and the other subject areas.

1.3.1 Connections With the Broad Areas of Learning

The broad areas of learning are divided into five areas of life: *Health and Well-Being*, *Environmental Awareness and Consumer Rights and Responsibilities*, *Media Literacy*, *Career Planning and Entrepreneurship*, and *Citizenship and Community Life*. The Science and Technology program uses learning situations pertaining to these broad areas to make learning more meaningful. In this way, adult learners are able to see that their learning is related to their various everyday activities.

Health and Well-Being

Science and technology can help answer many questions related to health and well-being. The program for this subject gives adult learners the chance to learn more about the human body and encourages them to adopt healthy lifestyle habits. For example, they can examine biochemical principles as they relate to the energy value of certain foods, study how sound waves affect auditory health and identify the biomechanical principles underlying good posture.

Environmental Awareness and Consumer Rights and Responsibilities

Many advances in science and technology have changed consumer habits and have had various consequences for the environment. The solutions proposed to mitigate this impact are based on scientific concepts and often involve technology. The learning situations related to this field enable adult learners to become aware of these issues and the different ways of dealing with them, and to question their own consumer habits. In short, these learning situations encourage adult learners to adopt responsible behaviour.

Media Literacy

Different media are available to adult learners, who are required to communicate and gather information in learning situations related to current events. Technological objects such as still cameras, video cameras, radios, televisions, computers, telephones and communications satellites are used to transmit information. The design and operating principles of these devices can elicit adult learners' interest and become a focus of learning.

Career Planning and Entrepreneurship

Scientific and technological knowledge is required in a variety of employment sectors. With learning content related to different fields of technology, the Science and Technology program helps adult learners develop an interest in and gauge their aptitude for trades and occupations in these areas.

Some of the activities in this program also provide an opportunity to learn about the work of scientists and technologists and to consider a career in this field.

Citizenship and Community Life

The environmental issues addressed in science and technology, such as climate change, waste management and the energy challenge, raise adult learners' awareness of the interdependence of individuals, generations and peoples, and encourage them to take action to promote respect for the environment and to improve its quality. The competencies developed in science and technology help adult learners become involved in environmental issues in their community. They learn to put issues and applications in context, foresee long-term consequences and consult reliable and accurate sources to form their own opinions and analyze those of others.

1.3.2 Connections With the Cross-Curricular Competencies

The development of scientific and technological literacy involves the acquisition and development of three subject-specific competencies which, in turn, contribute to the acquisition of the more general *cross-curricular competencies*. These are grouped in several categories, reflecting different facets of the ability to act.

Intellectual Competencies

The learning situations proposed in the Science and Technology program requires that adult learners *use information* judiciously and question the reliability of their sources. The search for answers or solutions enables them to acquire *problem-solving skills* that they can then apply in other situations. Furthermore, considering alternative solutions to the design and development of technical objects and developing plans of action are ways of *using creativity*. Lastly, analyzing scientific texts or presentations, or the effects of science and technology, requires that adult learners *exercise critical judgment*.

Methodological Competencies

The attention to precision associated with the methods used in science and technology requires that adult learners *adopt effective work methods*. They *use information and communications technologies* that provide them with access to a wider variety of information sources and means of action.

Personal and Social Competencies

Adult learners who move from the abstract to the concrete or from decision to action and who agree to take risks *achieve their potential*. The development of scientific and technological knowledge is based on the sharing of ideas or points of view, and peer or expert validation. In these contexts, adult learners are required to *cooperate with others*.

Communication-Related Competency

The acquisition and use of scientific and technological language help adult learners develop the ability to *communicate appropriately*.

1.3.3 Connections With the Other Subject Areas

Each subject has its own view of the world. Other subjects can shed light on science and technology which, in turn, enrich the learning acquired in those subjects. When adult learners develop a competency in another subject by applying the learning connected with a subject-specific competency in a Science and Technology program, they are developing their cross-curricular competencies.

Mathematics, Science and Technology

The programs of study in Mathematics, Science and Technology all belong to the same subject area. They target the development of similar subject-specific competencies in terms of problem solving, reasoning and communication. In the Diversified Basic Education Program, this subject area is complemented by the Computer Science program.

Mathematical vocabulary, graphs and notation provide science and technology with a precise and useful language. Conversely, science and technology can help adult learners understand certain mathematical concepts, such as variables and relations. Science and technology also offer a wide variety of contexts for applying the principles of geometry, measurement and statistics.

The computer boom has accelerated the development of scientific and technological knowledge through the use of tools for finding information, processing data, presenting and exchanging results, and designing and manufacturing various objects. Science and technology provide contexts for the application of computer science principles, thereby stimulating the production and development of new tools. Since computers are themselves technological objects, their evolution and improvement is based on scientific and technological research and development.

Languages

The Languages subject area provides adult learners with communication tools essential to the development of their competencies in science and technology. The competencies adult learners develop in language courses are indispensable for interpreting information, describing or explaining phenomena, analyzing technical objects and justifying choices. Conversely, the Science and Technology program presents adult learners with an opportunity to use a precise vocabulary and to understand the importance of rigorously accurate language.

Since English is used worldwide in scientific communication, the adult learner who possesses a command of English, as well as of a second or third language, has access to more numerous and diverse sources of information.

Social Sciences

Scientific and technological developments occur in a social and historical setting. Historical perspective makes it possible to contextualize these developments, enabling adult learners to appreciate the importance of such progress and measure its implications. Similarly, wealth (and its distribution) influences both societal development and scientific and technological advances.

Since societies are dependent on the tools and means at their disposal, the study of science and technology enables students to see their history and development in a different light.

Arts Education

The subjects in Arts Education contribute substantially to the development of creativity. The Science and Technology program draws on this creativity for solving problems. Some of the methods used in science and technology rely on the joint creation dynamic shared by the Arts Education programs. One example of this is design, which is based on the rules of aesthetics.

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 and improve artistic performances. Similarly, the materials, products, tools and instruments used in Arts Education are the result of scientific research and technological development.

Personal Development

The Science and Technology program takes into account issues related to personal development when it addresses questions of an ethical nature, such as biotechnology, health choices, the observance of health and safety rules, and the protection of biodiversity.

The study of science and technology also contributes to personal development by equipping adult learners with knowledge about the human body and its needs, and about how science and technology affect the environment and interact with it. An understanding of the digestive system and nutritional needs, for example, can help adult learners remain healthy and improve their physical performance.

Career Development

The fields of application for technology touch on numerous sectors of activity and can be associated with the trades and occupations in these sectors. The learning situations proposed in the Applied Science and Technology program give adult learners an opportunity to explore different tasks related to these trades and occupations. In turn, the activities associated with the Career Development programs can help adult learners discover aspects of science and technology that interest them.

Chapter 2

Pedagogical Context

2.1 Learning Situations

Learning situations help adult learners construct and mobilize knowledge and develop subject-specific and cross-curricular competencies. Related to a specific context, they present a problem to be solved or an issue to be examined. They involve one or more tasks leading to the production of a specific piece of work.

Through their context, learning situations help achieve the educational aim of the broad area of learning to which they are related. *Meaningful, open* and *complex* learning situations confer more meaning to the learning acquired, and foster the integration of subject-specific content and key features of the competencies. A learning situation is *meaningful* when it focuses on adult learners' interests as they relate to current events, major social issues, or scientific or technological achievements that affect everyday life. It is *open* when it enables adult learners to choose a method and explore several possible solutions. It is *complex* when it gives adult learners an opportunity to develop and apply more than one competency. Learning situations help adult learners make connections between general concepts arising from different subject areas and require them to draw on a greater number of resources.

Although the use of learning situations is compulsory, none of the examples given in the courses is prescribed. The same applies to examples of tasks. Teachers create or choose those that they deem appropriate. However, in order to facilitate course planning, it is recommended that the general concepts be spread out over several learning situations.

2.2 Families of Learning Situations

Learning situations that share a resemblance because of the types of tasks they include constitute a family. Whatever their level of complexity, situations in the same family foster the transfer of learning. The Science and Technology program consists of two families of learning situations: *Research* and *Expertise*.

Research

Learning situations in the *Research* family consist of tasks aimed at solving a scientific or technological problem. Such situations require creativity. Adult learners select the scientific or technological tools they need and use them to solve the problem. They present the results of their work and, if applicable, suggest new hypotheses or solutions. Generally speaking, learning situations in this family involve the use of laboratory equipment and techniques in a scientific context, or materials, manual tools, machine tools, graphical language and manufacturing techniques in a technological context.

Expertise

Learning situations in the *Expertise* family involve tasks in which adult learners study a problem involving an issue or an application in order to identify the scientific or technological concepts at play, determine how they work together, and explain them. They adopt a work method that enables them to make use of all available information. They may also disassemble and closely examine an application in order to make an informed judgment concerning the issues raised by the problem or the quality of the application. When adult learners study scientific phenomena, they sometimes need to use measurement and observation materials and techniques. When they analyze technological applications, they use graphic-representation or dismantling tools and techniques.

The learning situations in the *Research* and *Expertise* families allow for the construction of knowledge, the mobilization of resources, the implementation of investigative processes and the development of the competencies in the Science and Technology courses.

The families of learning situations are compulsory. Every course must include situations drawn from the two families indicated above.

2.3 Educational Resources

In developing their competencies, adults draw on different resources that can be classified as personal, conceptual, informational, material, institutional or human.

Personal resources include knowledge, skills, strategies, attitudes and techniques that adult learners have already acquired. Conceptual resources comprise knowledge acquired in different academic subjects, while informational resources include textbooks, reference documents and any other materials used in searching for information. Material resources comprise instruments, tools, machines and various objects, while institutional resources include public and parapublic organizations, local industries and businesses, and other community resources. Teachers and classmates are the most immediately accessible human resources. Laboratory and workshop technicians are indispensable at a number of levels, especially where laboratory and workshop safety are concerned. As needed, adult learners can also consult teachers in other subjects or different experts.

Chapter 3

Subject-Specific Competencies

3.1 How the Subject-Specific Competencies Work Together

In the Diversified Basic Education Program, a competency is defined as the ability to act effectively by mobilizing a range of resources. It is demonstrated in contexts of a certain complexity, and the degree to which it is mastered may increase throughout a person's education and even lifetime. All of the Science and Technology courses target the development of the same three subject-specific competencies. These competencies are associated with three complementary dimensions of science and technology: methodology, theory and communication.

The first competency, *Seeks answers or solutions to scientific or technological problems,* focuses on methodology. It mainly targets the acquisition and mobilization of scientific and technological concepts and techniques used in the laboratory or workshop.

The second competency, *Makes the most of his/her knowledge of science and technology,* stresses the ability to conceptualize and to transfer learning, especially in everyday situations. It also involves examining the very nature of scientific and technological knowledge, its evolution and its numerous repercussions, in particular its societal, environmental and economic consequences.

The third competency, *Communicates in the languages used in science and technology,* is demonstrated by the knowledge and use of specialized terminology and symbols.

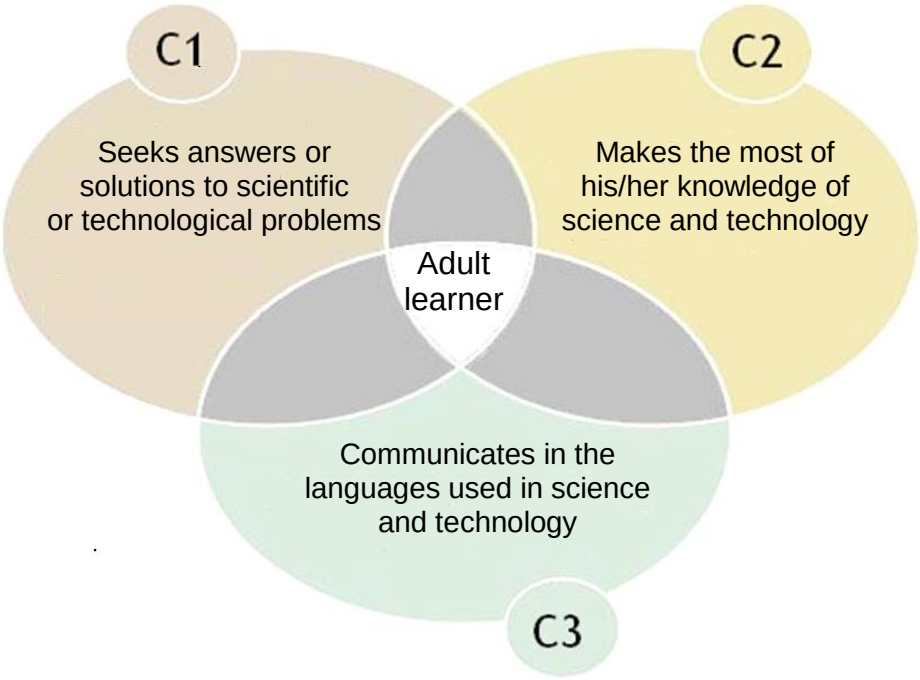

Diagram 1 - How the Subject-Specific Competencies Work Together

The three competencies are interrelated in various ways and are developed in synergy. For example, adult learners cannot seek answers to scientific or technological problems without learning and applying specific knowledge and mastering communication strategies. Similarly, the application of scientific and technological knowledge, which requires the use of the common language shared by members of the scientific or technological community, can help solve future problems.

The Three Aspects of Demonstrating a Competency

A competency is demonstrated through action and is expressed in the satisfactory execution of tasks in a given context. There are three aspects to its demonstration: contextualization, mobilization of resources and reflection.

First of all, applying a competency requires a thoughtful reading of the characteristics of the context, in other words, contextualization. Second, adult learners must take into account any constraints inherent in the context, make a plan and mobilize a set of resources. Lastly, they must be able to explain how they went about mobilizing an appropriate set of resources to act in a given situation. The concept of competency therefore involves the ability to think about the steps taken to carry out tasks and solve problems. This reflection process allows adult learners to better adjust their actions and the teachers to adjust their interventions.

Interactions Between the Different Aspects of Demonstrating a Competency

The three aspects of demonstrating a competency are not simply juxtaposed. They interact in a dynamic way.

- The interaction between contextualization and the mobilization of resources involves re-using and recombining the same knowledge in a number of ways, depending on the contexts.
- The interaction between reflection and contextualization enables adult learners to perceive more clearly the characteristics of the situation and to better understand its constraints.
- The interaction between reflection and the mobilization of resources primarily involves the reorganization of knowledge. It is also related to any type of analysis that enables adult learners to identify the strengths and weaknesses of the course of action taken.

Each of these interactions contributes to the transfer of learning. The following diagram illustrates how the different aspects of demonstrating a competency work together.

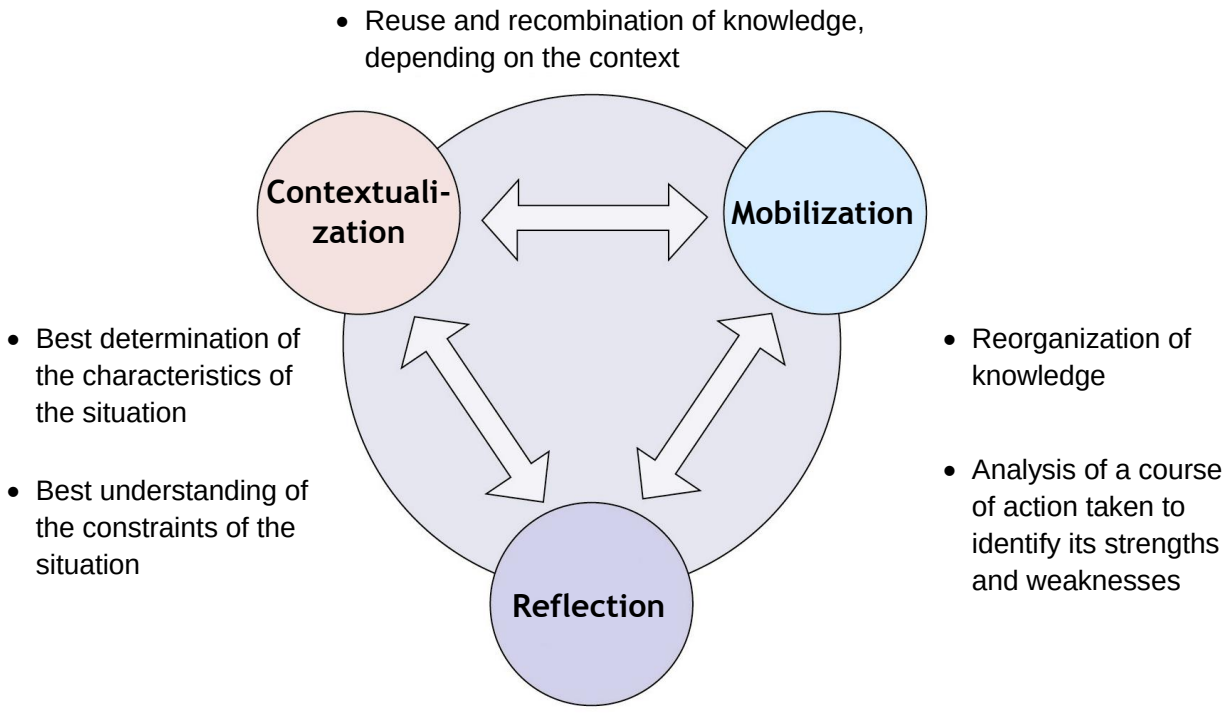

Diagram 2 - Interactions Between the Aspects of Demonstrating a Competency

3.2 Competency 1: Seeks answers or solutions to scientific or technological problems

3.2.1 Focus of the Competency

The field of science and technology is characterized, in particular, by the search for answers or solutions to problems. This type of reasoning is based on investigative processes that require the mobilization of scientific and technological resources (strategies, techniques and concepts). The structuring of these resources implies that adult learners are capable of selecting and adapting them to a particular situation. By exploring different avenues, testing hypotheses, receiving feedback and reformulating the problem, they reach a satisfactory, although not necessarily the only possible, solution. In most cases, this competency involves the experimental method or the design process. These investigative processes require specialized laboratory, workshop or machining equipment.

The first aspect of this competency becomes evident when adult learners develop a way of representing a problem based on meaningful indicators and relevant elements. Their initial, sometimes underdeveloped, representation may require several adjustments over time.

Using their representation of the problem as a starting point, adult learners explore different solutions and select one of them, developing a plan of action that takes into account material constraints and limitations, as well as the resources available.

Adult learners carry out their plan of action, taking care to record all observations that may be useful to them at a later point. They may even, in certain cases, carry out trials. New data may then require them to adapt their initial plan or search for more appropriate solutions.

In the case of a scientific problem, adult learners analyze the information they have collected, identify significant trends and relationships, draw conclusions and develop relevant explanations. This enables them to validate or refute their hypotheses and ensure that their solution is appropriate. In the case of an application, they make sure that their solution meets the need defined or the requirements in the specifications. If applicable, they formulate new hypotheses, suggest improvements to their solution or come up with other solutions.

3.2.2 Key Features and Manifestations of the Competency

- **Defines a problem**
  - Determines the elements that seem relevant
  - Determines the relationships between the different elements
  - Reformulates the problem in terms of scientific and technological concepts
  - Formulates realistic hypotheses or possible solutions

- **Develops a plan of action**
  - Chooses a hypothesis or a solution
  - Determines the necessary resources
  - Plans the steps involved in implementing the plan of action

- **Carries out the plan of action**
  - Handles equipment and substances and carries out planned operations
  - Performs tests, if applicable
  - Gathers data and takes note of observations that may prove useful
  - Adjusts the plan of action or its implementation, if necessary

- **Analyzes his/her results**
  - Processes the data gathered or his/her observations
  - Looks for significant patterns or relationships

- Makes connections between his/her results and scientific and technological concepts
- Judges the appropriateness of the answer or solution found
- Formulates new hypotheses or solutions, if applicable
- Suggests improvements to his/her solution, if applicable

3.2.3 Development of the Competency

In order to foster development of the competency *Seeks answers or solutions to scientific or technological problems,* teachers propose learning situations that are based on an investigative process and that encourage the adult learners' involvement in problem solving.

Science seeks to answer questions about phenomena governed by natural laws. It makes use of an investigative process that generates models or theories that serve as the basis for explaining the phenomena in question. Technology seeks solutions to problems associated with a need. It involves an investigative process aimed at solving technological problems related to the need in question.

In order to carry out the plan of action, it is necessary, in most cases, to perform a certain number of tasks in the laboratory or workshop. Review activities performed throughout the problem-solving process are focused on the procedures chosen and encourage better use of the steps of these procedures and their related techniques and strategies, as well as their adaptation to different contexts.

3.3 Competency 2: Makes the most of his/her knowledge of science and technology

3.3.1 Focus of the Competency

Science and technology are indispensable for understanding and adapting to the world in which we live. Some scientific and technological innovations have a positive impact and significantly improve our quality of life. Others raise ethical issues, and we must decide where we stand in relation to them. Adult learners who are able to make the most of their knowledge in various situations are better equipped to participate in society and understand their role in it more clearly. To acquire this knowledge, adult learners must use methods of reasoning and investigative processes.

The first manifestation of this competency comes to light when adult learners put scientific and technological issues or applications in context. By taking different contextual aspects and points of view into account, they can identify any ethical questions at stake.

Adult learners who analyze an application or an issue from a scientific point of view can also identify the related scientific principles, thereby demonstrating their understanding of the issue or application.

To carry out this analysis, it may be useful to perform a certain number of tasks in the laboratory (e.g. using a microscope) or the workshop (e.g. disassembling and reassembling). To understand a principle, adult learners must be able to represent it qualitatively or quantitatively, explain it using the appropriate laws or models, describe it, grasp the relationships involved and, sometimes, predict new related phenomena.

In some cases, adult learners are required to analyze applications, for example technical objects, systems, products or technological processes. This technological analysis involves understanding the overall function of the object, system, product or process, identifying its different components and their functions, and considering the technical characteristics and scientific principles in question in order to explain the solutions to be applied at the design or manufacturing stage.

Thus, when adult learners form an opinion about an issue or the quality of an application, they can justify or qualify that opinion based on the results of their analysis.

3.3.2 Key Features and Manifestations of the Competency

- **Puts applications or scientific and technological issues in context**
  - Defines the contextual aspects of the issue or application (e.g. social, environmental, historical aspects)
  - Establishes connections between these aspects
  - Identifies any questions related to the issue or application

- **Analyzes an application or an aspect of the issue from a scientific point of view**
  - Recognizes scientific principles related to the aspect of the issue or the application
  - Describes these principles qualitatively or quantitatively
  - Makes connections between the principles using concepts, laws, theories or models

- **Analyzes an application from a technological point of view**
  - Determines the overall function of the application
  - Identifies the different components and determines their respective functions
  - Describes the principles underlying the construction and operation of the application and its components
  - Makes connections between the principles using concepts, laws, theories or models
  - Represents the principles in a schematic fashion
  - Explains the solutions applied in designing or manufacturing the application and its components

- **Forms an opinion about the issue**
  - Consults different resources and considers different points of view
  - Determines the elements that can help him/her form an opinion

- Supports his/her opinion with the elements considered
- Qualifies his/her opinion, taking others' opinions into account

❖ **Forms an opinion about the quality of the application**

- Gathers information about the solutions to be applied in designing or manufacturing an application
- Determines the elements that can help him/her form an opinion
- Supports his/her opinion with the elements considered
- Qualifies his/her opinion, taking others' opinions into account
- Suggests improvements, if applicable

3.3.3 Development of the Competency

To enable adult learners to develop the competency *Makes the most of his/her scientific or technological knowledge,* teachers propose learning situations involving questioning related to one or more scientific or technological concepts.

To understand an issue, describe its context, explain the scientific aspects involved or measure its impact, adult learners must acquire new knowledge which they must connect to what they already know. This knowledge can also be used to explain the operation or defects of an application, judge its quality or suggest improvements.

Review activities performed throughout the process involve assimilating knowledge, using resources and adapting them to the requirements of different contexts.

3.4 Competency 3: Communicates in the languages used in science and technology

3.4.1 Focus of the Competency

Communication plays an essential role in the acquisition of scientific and technological knowledge. This knowledge is constructed based on a set of common meanings, the exchange of ideas and the negotiation of points of view. This calls for a special language, or code, that defines linguistic and graphical symbols in accordance with the way they are used in the scientific and technological community.

This competency cannot be developed in isolation from the other two competencies in the program, to whose development it contributes. The first competency, which focuses on problem solving, involves following certain standards and conventions, whether in developing or reading a research procedure, a scientific or technological article, specifications or a process sheet, or in presenting the results of an experiment. Tables, symbols, formulas, graphs, diagrams, detail or general arrangement drawings,

mathematical and chemical equations and models can all be used to communicate, but it is important to understand and follow the rules governing their use. The second competency, which focuses on the assimilation of scientific and technological concepts, requires that adults learn and use precise and specialized vocabulary, whether in developing arguments or putting together a scientific or technical file. The concepts involved are learned by using an appropriate language and type of discourse.

These activities require that adult learners understand the precise meaning of words, definitions and statements, and explain graphs, diagrams and detail drawings. Their effort to properly use formalism, symbols, graphs, diagrams and drawings helps give clarity, coherence and rigour to their explanations.

3.4.2 Key Features and Manifestations of the Competency

- **Interprets scientific and technological messages**
  - Places the message in context
  - Makes sure the sources are reliable
  - Selects the elements needed to interpret the message
  - Grasps the precise meaning of words or statements
  - Establishes connections between concepts and their various graphic or symbolic representations

- **Produces scientific and technological messages**
  - Structures his/her message
  - Uses scientific and technological vocabulary
  - Uses the symbolic or graphical language associated with science and technology
  - Adheres to established standards and conventions for the different languages
  - Demonstrates rigour and coherence
  - Respects intellectual property rights

3.4.3 Development of the Competency

To enable adult learners to develop the competency *Communicates in the languages used in science and technology*, teachers propose learning situations involving various forms of presentation and the use of precise scientific and technological vocabulary. This helps adult learners make connections between various representations of concepts.

By proposing learning situations involving the first and second competencies, teachers give adult learners an opportunity to develop the third competency. In fact, this competency is needed to analyze technical objects, systems, products or technological processes, present a project or report, carry out a research procedure or create a model. Similarly, situations in which adult learners exchange scientific and technological information to share their findings with their peers or to consult experts for

answers to questions foster the development of their ability to communicate in language suited to science and technology.

Review activities performed throughout the process focus on the resources and techniques that form the basis of communication, on their use and on their adaptation to the requirements of the context.

3.5 Processes

To solve a problem, address an issue, or study a phenomenon or an application in science and technology, adult learners use an investigative process. The following diagram illustrates the similarity of the investigative processes for dealing with scientific and technological topics related to both families of learning situations.

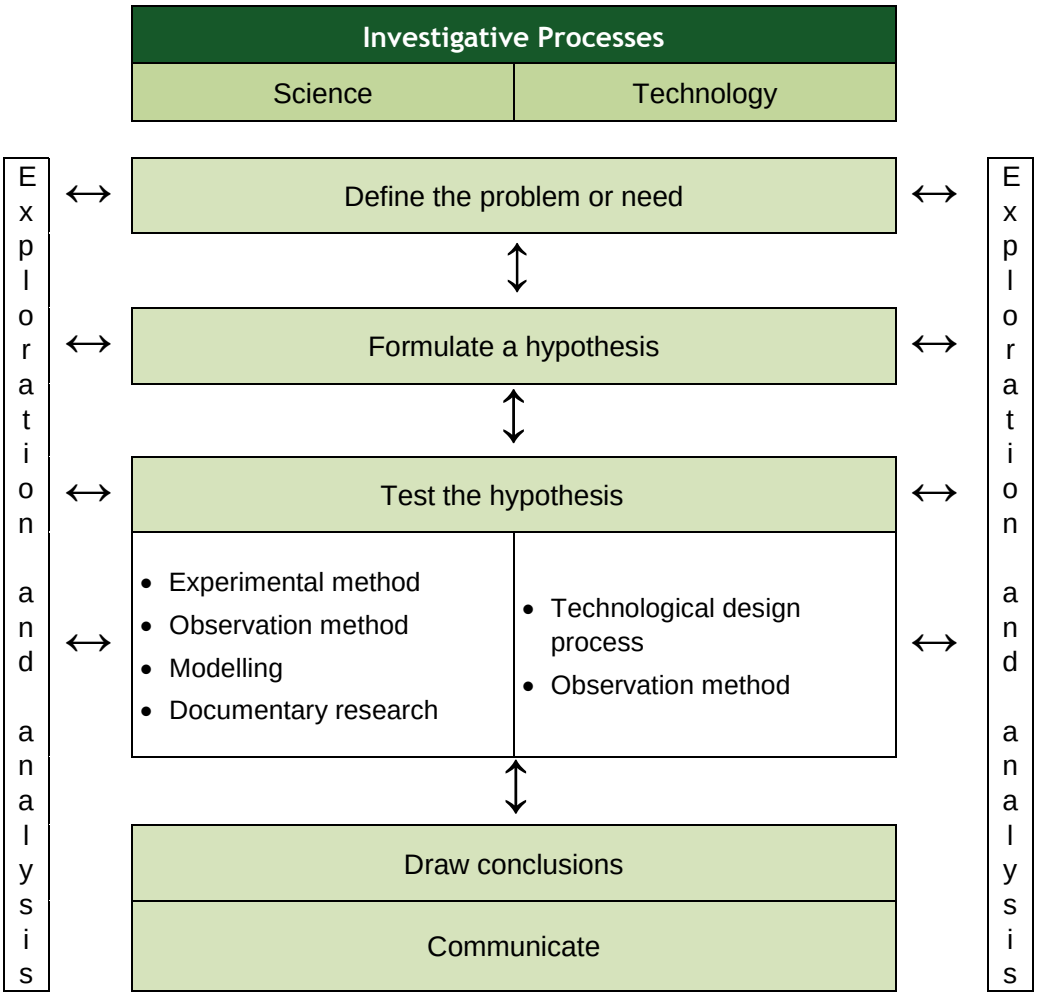

Diagram 3 - Investigative Processes

As suggested by the vertical double-headed arrows, investigative processes are rarely linear. Before adult learners are able to draw conclusions and communicate their solutions, they may return several

times to a previous step. The horizontal double-headed arrows refer to the exploration and analysis strategies used by adult learners to reach a conclusion more effectively. Examples of each of the strategies and each of the steps are given in Appendixes 1 and 2.

The *investigative processes* encompass the different methods mentioned in the Secondary Cycle Two programs, in particular the experimental method, modelling, the observation method and formation of an opinion in science, and technological analysis and the technological design process in technology. As illustrated in the above diagram, these processes diverge only at the hypothesis testing stage; that is why, in this program, they are grouped together under the general heading “Investigative Processes.” The tables in Appendix 3 present in detail each of the methods used to test hypotheses.

Chapter 4

Subject-Specific Content

4.1 Knowledge

The knowledge covered in the courses in the Science and Technology program is taken from the four programs offered in Secondary Cycle Two. The knowledge covered in the general science courses is the same as that covered in the first year of Cycle Two. The knowledge covered in the Science and Technology courses is the same as that covered in the second year of Cycle Two.

This knowledge involves several scientific or technological fields (such as biology, chemistry, geology, physics, engineering, biotechnology). This combination of knowledge from these different fields makes it possible to offer adult learners meaningful learning contexts that deal with contemporary issues in science and technology.

The knowledge covered in the Science and Technology program is intended to consolidate and enrich adult learners' scientific and technological literacy based on the development of the targeted competencies and on the use and mobilization of different types of resources: compulsory concepts, processes, techniques and cultural references.

4.1.1 Compulsory Concepts

The compulsory concepts make up the specific core content of the Science and Technology program and are divided into four areas: *The Living World* (human biology and ecology), *The Material World* (chemistry and physics), *The Earth and Space* (geology and astronomy), and *The Technological World* (biotechnology and engineering).

In general science, related concepts are combined to address the theme *The Human Organism.* In science and technology, the different concepts are combined to address three environmental topics, namely *The Energy Challenge*, *Climate Change* and *Waste Management*, and one technology-related topic, namely *Mechanization of Work.*

The following tables present the program's compulsory concepts. The tables in Section 5.1 list the general concepts by course. A detailed course-by-course list of the compulsory concepts can be found in Chapter 6.

Summary Table of the Compulsory Concepts for General Science		
The Living World	**The Material World**	**The Technological World**
Digestive System • Types of food: water, proteins, carbohydrates, fats, vitamins and minerals • Energy value of different foods • Transformation of food: mechanical, chemical • Digestive tract: mouth, esophagus, stomach, small intestine, large intestine, anus • Digestive glands: salivary glands, gastric glands, pancreas, liver, intestinal glands **Nervous System** • Central nervous system: brain, spinal cord • Peripheral nervous system: nerves • Sensory receptors: – eye – ear – skin – tongue – nose **Musculoskeletal System** • Function of the musculoskeletal system • Types of joint movement	**Properties of Matter** • Characteristic physical properties: – density – solubility • Characteristic chemical properties: reaction to indicators • Properties of solutions: concentration **Changes in Matter** • Particle model • Physical changes: – dissolution – dilution • Chemical changes: – decomposition and synthesis – oxidation **Transformation of Energy** • Forms of energy: electrical, chemical, thermal, mechanical, radiant **Organization of Matter** • Pure substance: compound, element • Homogeneous and heterogeneous mixtures **Waves** • Frequency • Wavelength • Amplitude • dB (decibel) scale • Electromagnetic spectrum • Deviation of light waves • Focal point of a lens	**Graphical Language** • Basic lines • Scales • Oblique projection • Orthogonal projections: – multiview – isometric • Standards and representations: – diagrams – symbols • Dimensioning **Mechanical Engineering** • Typical functions: linking, guiding, sealing, lubricating • Typical mechanical links • Function, components and use of motion transmission systems • Function, components and use of motion transformation systems • Speed changes **Electrical Engineering** • Power supply • Conduction and insulation • Control • Transformation of energy **Materials** • Mechanical properties • Constraints: tension, compression, torsion

Table 1 - Summary Table of the Compulsory Concepts for General Science

Summary Table of the Compulsory Concepts for Science and Technology			
The Living World	**The Material World**	**The Earth and Space**	**The Technological World**
Ecology • Study of populations: density, biological cycles • Dynamics of communities: – communities – biodiversity – disturbances • Dynamics of ecosystems: – ecosystems – trophic relationships – primary productivity – material and energy flow – chemical recycling • Ecological footprint • Ecotoxicology: – contaminants – bioconcentration – bioaccumulation – toxicity threshold	**Physical properties of solutions** • Solubility • Concentration: ppm, g/L, %, mole/L • Electrolytes • Strength of electrolytes • pH scale • Electrolytic dissociation • Ions • Electrical conductivity **Chemical changes** • Precipitation • Combustion • Oxidation • Photosynthesis and respiration • Decomposition and synthesis • Acid-base neutralization reaction • Salts • Balancing simple chemical equations • Law of conservation of mass • Stoichiometry • Types of bonds: – covalent – ionic **Organization of matter** • Rutherford atomic model • Simplified atomic model • Subatomic particles • Lewis notation • Nomenclature and notation rules • Polyatomic ions • Concept of mole • Avogadro's number • Periodic table: – metals, non-metals, metalloids – groups (families) and periods • Relative atomic mass • Atomic number • Periodicity of properties • Isotopes **Nuclear transformations** • Nuclear stability • Radioactivity • Fission and fusion	**Biogeochemical cycles** • Carbon cycle • Nitrogen cycle • Phosphorus cycle **Climate zones** • Factors that influence the distribution of biomes • Marine biomes • Terrestrial biomes **Lithosphere** • Minerals • Permafrost • Energy resources • Soil depletion • Buffering capacity of the soil • Contamination • Soil profile: horizons **Hydrosphere** • Catchment area • Ocean circulation • Salinity • Glacier and pack ice • Energy resources • Contamination • Eutrophication **Atmosphere** • Greenhouse effect • Atmospheric circulation: prevailing winds • Air mass • Cyclone and anticyclone • Energy resources • Contamination **Space** • Solar energy flow • Earth-Moon system: gravitational effect	**Graphical language** • Axonometric projection: exploded view (reading) • Multiview orthogonal projection: assembly drawing • Functional dimensioning • Developments: prism, cylinder, pyramid, cone • Standards and representations: diagrams and symbols **Mechanical engineering** • Typical functions • Mechanical links • Adhesion and friction of parts • Freedom of movement of a part • Guiding controls • Construction and characteristics of motion transmission systems: friction gears, pulleys and belt, gear assembly, sprocket wheels and chain, wheel and worm gear • Construction and characteristics of motion transformation systems: screw gear system, connecting rod, crank and slide, rack and pinion, cam and roller, eccentrics • Resisting torque, engine torque **Electrical engineering** • Power supply • Conduction, insulation and protection: resistance and coding, printed circuit • Control: lever, pushbutton, toggle, unipolar (single-pole), bipolar (double-pole), unidirectional (single-throw), bidirectional (double-throw) • Transformation of energy: electricity and light, heat, vibration, magnetism • Other functions

Table 2 - Summary Table of the Compulsory Concepts for Science and Technology

Summary Table of the Compulsory Concepts for Science and Technology (cont.)			
The Living World	**The Material World**	**The Earth and Space**	**The Technological World**
	Electricity • Electrical charge • Static electricity • Electrical current • Ohm's law • Kirchhoff's laws • Electrical circuits • Relationship between power and electrical energy • Coulomb's law • Electrical field **Electromagnetism** • Forces of attraction and repulsion • Magnetic field of a live wire • Magnetic field of a solenoid • Electromagnetic induction **Transformation of energy** • Law of conservation of energy • Energy efficiency • Distinction between heat and temperature **Fluids** • Archimedes' principle • Pascal's law • Bernoulli's principle **Force and motion** • Force • Types of forces • Equilibrium of two forces • Relationship between constant speed, distance and time • Relationship between mass and weight		**Materials** • Constraints: deflection, shearing • Characteristics of mechanical properties • Heat treatments • Types and properties: – plastics (thermosetting plastics) – ceramics – composites • Modification of properties: degradation, protection **Manufacturing** • Characteristics of laying out • Machining: – characteristics of drilling, tapping, threading, bending • Measurement and inspection: – direct measurement (vernier calipers) – control, shape and position (plane, section, angle) **Biotechnology** • Wastewater treatment • Biodegradation of pollutants

Table 2 (cont.)

4.1.2 Techniques

Techniques involve methodical procedures that provide guidelines for the proper application of theoretical knowledge. They fall into four categories: *Experimentation*, *Graphical Language*, *Manufacturing* and *Measurement*, and appear in the table below under either Scientific Techniques or Technological Techniques.

The techniques listed in the table are part of the compulsory program content. Many of these techniques require the use of instruments and tools or chemicals. Safety and the use of safety equipment in the workshop and laboratory must be a constant concern for all those using such techniques.

Summary of Techniques		
Scientific Techniques (In the laboratory)	**Technological Techniques (In the workshop)**	
Experimentation	**Graphical language**	**Manufacturing**
- Safely using materials and equipment - Using observational instruments - Preparing solutions - Collecting samples	- Using scales - Producing a graphic representation using instruments - Drawing schematic diagrams - Using vector graphic software	- Safely using machines and tools - Measuring and laying out - Machining - Finishing - Performing verification and control tasks - Assembling and disassembling - Making a part
Technological and Scientific Techniques		
Measurement		
- Checking the reliability, accuracy and sensitivity of measuring instruments - Using measuring instruments - Interpreting measurement results (significant figures, measurement errors)		

Table 3 - Summary of Techniques

4.2 Cultural References

Cultural references are particularly meaningful when it comes to scientific and technological literacy. They contribute to the enrichment of learning situations by rooting them in social and cultural reality. They may include technical objects, technological systems, processes, products, scientists of both sexes, community resources, human activities and events related to the learning content of the courses. A list of cultural references is given for each course in Chapter 6.

Cultural references are part of the program content for Science and Technology. Their use is compulsory, but the list of examples provided is neither compulsory nor exhaustive.

Chapter 5

Organization of the Courses in the Program

5.1 Introduction to the Courses

General Science Courses

Courses TSG-4059-2 and TSG-4060-2 are based for the most part on content common to the general education and applied general education paths for the first year of Secondary Cycle Two in general education in the youth sector.

Course TSG-4059-2 takes a scientific approach (from scientific concept to technological application) and enables adult learners to explore the interaction between the nervous system and the environment as well as the human body's needs in terms of matter and energy. This course includes several concepts related to *The Material World* that can be linked to the nervous and digestive systems.

Course TSG-4060-2 takes a technological approach (from technological application to scientific concept) and focuses on applications that can involve mechanical and electrical engineering. The emphasis is on technological applications for the human body and the musculoskeletal system.

The following table provides more information about the content of the general science courses.

General Science Courses		
Title	**Hours/ Credits**	**General Concepts**
TSG-4059-2 *General Science 1*	50 hours 2 credits	Digestive system Nervous system Properties of matter Changes in matter Waves
TSG-4060-2 *General Science 2*	50 hours 2 credits	Musculoskeletal system Organization of matter Transformation of energy Graphical language Mechanical engineering Materials Electrical engineering

Table 4 – General Science Courses

The two general science courses can be taken in any order. However, adult learners who did not pass the first year of Secondary Cycle Two in general education in the youth sector are advised to complete these courses before taking the Science and Technology courses described on the following page.

The Four Science and Technology Courses

Courses TSC-4061-2, TSC-4062-2, TSC-4063-2 and TSC-4064-2 cover concepts studied in the general education and applied general education paths in the second year of Secondary Cycle Two in the youth sector.

Course TSC-4061-2 takes a mainly technological approach (from technological application to scientific concept). It involves the study of energy and scientific applications related to electricity.

Course TSC-4062-2 takes a more scientific approach (from scientific concept to technological application). It allows adult learners to consider the balance of ecosystems in terms of climate change.

Course TSC-4063-2 takes a technological approach and focuses on the design and analysis of technical objects or technological systems involving force and motion.

Course TSC-4064-2, which focuses on the processing of natural resources and the resulting pollution, takes a scientific approach.

The Science and Technology courses can be taken in any order. However, it is preferable that course TSC-4061-2 be taken before course TSC-4063-2, and that course TSC-4062-2 be taken before course TSC-4064-2.

The following table provides more information about the content of the Science and Technology courses.

Science and Technology Courses		
Title	**Hours/ Credits**	**General Concepts**
TSC-4061-2 *The Energy Challenge*	50 hours 2 credits	Graphical language Electrical engineering Organization of matter Electricity Electromagnetism Transformation of energy Lithosphere Hydrosphere Atmosphere Space
TSC-4062-2 *Climate Change*	50 hours 2 credits	Ecology Biogeochemical cycles Climate zones Lithosphere Hydrosphere Atmosphere Physical properties of solutions Chemical changes
TSC-4063-2 *Mechanization of Work*	50 hours 2 credits	Graphical language Mechanical engineering Materials Manufacturing Force and motion Fluids
TSC-4064-2 *Waste Management*	50 hours 2 credits	Ecology Biogeochemical cycles Lithosphere Hydrosphere Atmosphere Organization of matter Physical properties of solutions Chemical changes Nuclear transformations Biotechnology

Table 5 – Science and Technology Courses

5.2 Connections Between the Adult Sector and the Youth Sector

Secondary IV

- Courses TSG-4059-2 and TSG-4060-2 correspond to the common core of the *Science and Technology* and *Applied Science and Technology* programs in the first year of Secondary Cycle Two (youth sector).
- Courses TSC-4061-2 and TSC-4062-2 correspond to the *Science and Technology* path in the second year of Secondary Cycle Two (youth sector).
- Courses TSC-4061-2, TSC-4062-2 and TSC-4063-2 correspond to the *Applied Science and Technology* path in the second year of Secondary Cycle Two (youth sector).
- Courses TSC-4063-2 and TSC-4064-2 correspond to the *Environmental Science and Technology* path in the second year of Secondary Cycle Two (youth sector).
- Course TSC-4064-2 corresponds to the *Science and Environment* path in the second year of Secondary Cycle Two (youth sector).

The following diagram shows how the adult education courses are related to the secondary-level programs and education paths in the youth sector.

<table>
<tr><th colspan="2">General Education Path (Youth Sector)</th><th>Adult General Education Courses</th><th colspan="2">Applied General Education Path (Youth Sector)</th></tr>
<tr><td rowspan="2">1st Year of Cycle Two</td><td rowspan="2">Science and Technology (ST)</td><td>TSG-4059-2</td><td rowspan="2">Applied Science and Technology (AST)</td><td rowspan="2">1st Year of Cycle Two</td></tr>
<tr><td>TSG-4060-2</td></tr>
<tr><td rowspan="3">2nd Year of Cycle Two</td><td rowspan="2">Science and Technology (ST)</td><td>TSC-4061-2</td><td rowspan="3">Applied Science and Technology (AST)</td><td rowspan="3">2nd Year of Cycle Two</td></tr>
<tr><td>TSC-4062-2</td></tr>
<tr><td rowspan="2">Environmental Science and Technology (EST)</td><td>TSC-4063-2</td></tr>
<tr><td>TSC-4064-2</td><td>Science and Environment (SE)</td></tr>
</table>

Diagram 4 – Connections Between the Adult Education Courses and the Secondary-Level Programs and Paths in the Youth Sector

Chapter 6

Courses

Organization of Course Information

This chapter contains a detailed description of each of the courses in the program. Information on each course is presented under the following headings, in the order shown below:

Headings
Introduction
Subject-Specific Competencies
Processes
Cross-Curricular Competencies
Subject-Specific Content
Families of Learning Situations
Broad Areas of Learning
Example of a Learning Situation
End-of-Course Outcomes
Evaluation Criteria for Subject-Specific Competencies

TSG-4059-2

General Science 1

TSG-4059-2 General Science 1

INTRODUCTION

The course entitled *General Science 1* is aimed at enabling adult learners to function effectively in situations from the *Research* and *Expertise* families that focus on the needs of the human body in terms of matter and energy and on the interactions between the nervous system and the external world.

In this course, adult learners will study scientific issues and seek answers or solutions to a variety of problems. They will acquire scientific knowledge about *The Living World*, which will help them understand and explain the factors at play in different situations involving the digestive and nervous systems. By combining knowledge of the digestive system with knowledge of the properties of and changes in matter, which they will acquire in their study of *The Material World*, they will come to better understand how the human body breaks down and transforms food into nutrients it can assimilate. By combining knowledge of the nervous system with knowledge of the waves associated with the auditory and visual receptors, which they will also acquire in their study of *The Material World*, they will come to understand the role of the networks in the human body that exchange information with the external world.

By the end of this course, in situations concerning the human body's needs in terms of matter and energy and the interactions of the nervous system with the external world, adult learners will be able to:

- ✓ model the physical and chemical changes that take place so that the digestive system can transform food, referring to the characteristics and properties of matter
- ✓ model a characteristic of waves involved in the functioning of the nervous system
- ✓ analyze an aspect of the digestive system or the interaction of the nervous system with the external world
- ✓ discuss an issue dealing with the human body's needs in terms of matter and energy
- ✓ discuss an issue dealing with the interactions of sensory receptors with the external world
- ✓ plan, with assistance, a simple experiment that deals with waves and the properties of or changes in matter
- ✓ follow, with assistance, an experimental procedure that deals with waves and the properties of or changes in matter
- ✓ write a report of an experiment that deals with waves and the properties of or changes in matter by following a basic framework

SUBJECT-SPECIFIC COMPETENCIES

The following table lists, for each competency, the key features studied in the course. The manifestations of the key features are presented in Appendix 4.

Competency 1 Seeks answers or solutions to scientific or technological problems	Competency 2 Makes the most of his/her knowledge of science and technology	Competency 3 Communicates in the languages used in science and technology
▪ Defines a problem ▪ Develops a plan of action ▪ Carries out the plan of action ▪ Analyzes his/her results	▪ Puts applications or scientific and technological issues in context ▪ Analyzes an application or an aspect of the issue from a scientific point of view ▪ Forms an opinion about the issue	▪ Interprets scientific and technological messages ▪ Produces scientific and technological messages

PROCESSES

The investigative processes enable adult learners to examine issues, solve problems and study applications. The following are the steps in an investigative process:

- Define the problem
- Formulate a hypothesis
- Test the hypothesis
- Draw conclusions and communicate

The most appropriate methods for this course are the experimental method, modelling, documentary research and the observation method from a scientific point of view. It is during hypothesis testing that these methods become distinguishable. Section 3.5 and Appendices 1 to 3 present these investigative processes with their respective characteristics.

CROSS-CURRICULAR COMPETENCIES

The cross-curricular competencies supplement the subject-specific competencies. The development of one contributes to the development of the others. Course TSG-4059-2 allows for all the cross-curricular competencies to be put into practice. Some of them, indicated in grey shading in the table below, are especially targeted in the sample learning situation that will be presented in the last part of the course.

Cross-Curricular Competencies			
Intellectual	**Communication-Related**	**Personal and Social**	**Methodological**
Uses information	Communicates appropriately	Achieves his/her potential	Adopts effective work methods
Solves problems		Cooperates with others	Uses information and communications technologies
Exercises critical judgment			
Uses creativity			

SUBJECT-SPECIFIC CONTENT

A) KNOWLEDGE

The compulsory concepts and techniques are presented in the tables in the following two sections.

1. Concepts

❖ The Living World	
General concept: Digestive system Human beings rely on a regular intake of food garnered from other organisms. This intake is necessary and makes it possible to build and repair tissues and produce heat and energy in different forms (e.g. mechanical, thermal). The mechanical and chemical transformation of food takes place in the digestive system. Ingestion, digestion, absorption and elimination are the four steps in the processing of food. The digestive glands are responsible for the chemical decomposition of food. The salivary glands produce saliva, which has several functions (e.g. humidification, partial digestion of carbohydrates, antibacterial functions). Gastric secretions (e.g. hydrochloric acid, mucus, pepsin) help digest proteins. The small intestine and its ancillary structures (the pancreas and the liver) secrete a variety of juices to begin the digestion of fats. Bile salts play an important role in the digestion of fats. The small intestine also plays a major role in the digestion of carbohydrates, proteins and fats and in the absorption of nutrients. The absorption of water and electrolytes is one of the essential functions of the large intestine. The final segment of the large intestine, the rectum, stores fecal matter for elimination.	
Compulsory concepts	**KNOWLEDGE TO BE ACQUIRED**
Types of foods: water, proteins, carbohydrates, fats, vitamins, minerals	• Describes the main biological functions of the different types of food (water, proteins, carbohydrates, fats, vitamins, minerals) • Associates types of food with their main sources (e.g. proteins with meat and meat substitutes)
Energy value of different foods	• Determines the energy and nutritional value of different foods
Transformation of food: mechanical, chemical	• Associates the organs in the digestive system with the type of transformation they perform (e.g. mechanical action of teeth, chemical action of glands)
Digestive tract: mouth, esophagus, stomach, small intestine, large intestine, anus	• Names the main parts of the digestive tract • Explains the role of the digestive tract (decomposition of food, absorption of nutrients and water, elimination of waste)
Digestive glands: salivary glands, gastric glands, pancreas, liver, intestinal glands	• Describes the role of the secretions of the main digestive glands (saliva digests starches, bile breaks down fats, gastric juices digest proteins)

❖ The Living World (cont.)

General concept: Nervous system

The nervous system regulates internal bodily functions and human behaviour, enabling human beings to enter into relationships with the external world and adapt to it.

Complex behaviours are made possible by the central nervous system, which coordinates motor control through the peripheral nervous system. The nervous system collects vast amounts of information using different sensory receptors in the sensory organs that ensure vision, hearing, smell, taste and touch. This information is then integrated into the sensory zones located in the central nervous system. Sensory saturation can result from situations in the workplace and hinder the functioning of an organ.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Central nervous system: brain, spinal cord	• Identifies the parts of the central nervous system (brain, spinal cord) • Explains the role of the central nervous system (managing complex behaviours and processing sensory information and related responses)
Peripheral nervous system: nerves	• Explains the role of the peripheral nervous system (transporting nerve impulses from the senses to the brain and from the brain to the muscles and the glands) • Associates nerves with the transmission of nerve impulses
Sensory receptors: – eye	• Identifies the main parts of the eye involved in vision (iris, cornea, crystalline lens, retina) • Describes the function of the main parts of the eye
– ear	• Identifies the main parts of the ear involved in hearing (auditory canal, eardrum, ossicles, cochlea) • Describes the function of the main parts of the ear involved in hearing
– skin	• Describes the function of the skin's sensory receptors (transforming feelings of pressure, temperature and pain into nerve impulses)
– tongue	• Describes the function of the taste buds on the tongue (transforming flavour [sweet, salty, sour, bitter, umami] into nerve impulses)
– nose	• Describes the function of the olfactory bulb

❖ The Material World

General concept: 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, or 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.

Tables listing the characteristic physical and chemical properties of matter can help us identify substances and understand their roles and uses and the risks they pose for the human body.

Substances in the body are mostly mixtures, many of them solutions. Many vital systems depend on the ability of water and fats to dissolve different substances.

Compulsory concepts	**KNOWLEDGE TO BE ACQUIRED**
Characteristic physical properties:	
– density	• Explains the concept of density • Determines the density of different substances
– solubility	• Defines the concept of solubility • Describes the effect of temperature variations on a substance's solubility
Characteristic chemical properties: reaction to indicators	• Recognizes a substance by its characteristic chemical properties (e.g. starch turns blue in the presence of an iodine solution, acidic solutions turn bromothymol blue yellow)
Properties of solutions: concentration	• Describes the effect of variations in the quantity of solute or solvent on a solution's concentration • Defines the concept of the concentration of a solution • Determines the concentration of an aqueous solution (g/L or percentage) • Recognizes the solute in an aqueous solution • Recognizes the solvent in an aqueous solution (e.g. tears, saliva, urine)

❖ The Material World (cont.)

General concept: 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.

Depending on the average agitation energy of its molecules, a substance can take the form of a liquid, a solid or a gas.

Observing the behaviour of matter during these changes is the starting point for building a particle model of matter.

Preparing solutions through dissolution and changing the concentration of solutions by means of dilution are common operations in everyday life. In chemical changes, the molecules are altered. The products of these changes differ from the reagents: they are characterized by different properties. The mass and number of atoms of each element remain the same, which is the underlying principle of simple balanced chemical equations (oxidation, synthesis and decomposition reactions). Certain indicators are used to make it easier to recognize the formation of a new substance.

Compulsory concepts	**KNOWLEDGE TO BE ACQUIRED**
Particle model	• Defines the particle model as a way of representing the behaviour of matter • Compares the arrangement of particles in a substance in its solid, liquid and gaseous states
Physical changes:	
– dissolution	• Explains dissolution using the particle model
– dilution	• Explains dilution in terms of concentration and volume • Applies the mathematical relationship that exists between the volumes and concentrations of an aqueous solution before and after dilution ($C_1V_1 = C_2V_2$)
Chemical changes:	• Names chemical changes that occur in the human body (e.g. respiration, digestion)
– decomposition and synthesis	• Recognizes a decomposition or synthesis reaction represented by means of the particle model • Associates known chemical reactions with decomposition or synthesis reactions (e.g. protein formation, digestion)
– oxidation	• Associates known chemical reactions with oxidation reactions (e.g. cellular respiration, combustion)

❖ The Material World (cont.)

General concept: 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 (mechanical) waves and visible light (electromagnetic) waves.

Sound waves are longitudinal mechanical waves that are produced by a vibrating elastic body and propagate in a medium that is periodically compressed and rarefied. The exploration of transverse mechanical waves in a spring or in water can help adult learners understand wave motion.

Although they are very different, light waves in some respects 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 waves propagate in a vacuum and in transparent media.

Certain objects in our natural and built environments exhibit the properties of light. The reflection and refraction of light are studied qualitatively using plane mirrors and converging and diverging lenses.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Frequency	• Defines the frequency of a wave as the number of cycles per second (Hz) • Associates the frequency of a sound wave with the pitch of the sound (e.g. a low-frequency wave produces a low-pitched sound)
Wavelength	• Defines “wavelength” as the distance between two identical points on a wave at a given time • Describes the relationship between wavelength and energy (e.g. high-energy x-rays have a short wavelength)
Amplitude	• Defines the amplitude of a sound wave as the loudness of the sound
dB (decibel) scale	• Locates on the decibel scale levels dangerous to the human ear based on duration or frequency of exposure
Electromagnetic spectrum	• Locates different areas on the electromagnetic spectrum (e.g. radio waves, infrared, visible light, ultraviolet, x-rays, γ-rays)
Deviation of light waves	• Describes how light waves are deviated by a plane reflective surface • Determines the angle of reflection of a light ray on the surface of a plane mirror • Describes how light waves are deviated when they pass through the surface of a translucent substance
Focal point of a lens	• Determines the focal point of concave and convex lenses • Describes the relationship between the focal point of a lens and the degree to which light rays are deviated in various situations (e.g. accommodation of the crystalline lens, choice of corrective lenses)

2. Techniques

The techniques presented here are grouped in two categories. Many of these techniques require the use of instruments and tools or chemicals. Safety and the use of safety equipment in the laboratory must be a constant concern for all those using such techniques.

In the Laboratory or Workshop	
Techniques	**KNOWLEDGE TO BE ACQUIRED**
Experimentation	
- Safely using materials and equipment	• Uses laboratory materials and equipment safely (e.g. allows hotplate to cool, uses beaker tongs, uses a universal holder attachment) • Handles chemicals safely (e.g. uses a spatula and a pipette filler)
- Using observational instruments	• Uses observational instruments appropriately (e.g. magnifying glass, binoculars, microscope, light ray box, spectroscope)
- Preparing solutions	• Prepares an aqueous solution of a specific concentration given a solid solute • Prepares an aqueous solution of a specific concentration given a concentrated aqueous solution
Measurement - Using measuring instruments	• Uses measuring instruments appropriately (e.g. ruler, thermometer, graduated cylinder, balance, volumetric flask, sound meter)

B) CULTURAL REFERENCES

Cultural references make learning situations more meaningful. The following table presents some of the references related to this course.

Cultural References				
Technical objects, technological systems, processes and products	– Food preparation and conservation – Enzymes – Nutraceuticals (preventive and curative products), vitamins, medication – Fertilizers and insecticides – Microphone, speaker, telephone, television, camera, CD-ROM player, etc. – Musical instrument – Hearing aid – Contact lenses, eyeglasses, binoculars, microscope – Telecommunications satellite – Magnetic resonance imaging – X-rays, ultrasound – Software enabling people with handicaps to communicate using Morse code – Virtual reality headset – Breathalyzer – Energy drink			
Area	**Scientists**	**Community Resources**	**Applications**	**Events**
The Living World	Giovanni Alfonso Borelli Ivan Petrovitch Pavlov Allvar Gullstrand Edgar Douglas Adrian Georg von Békésy Lazzaro Spallanzani René Antoine Ferchault de Réaumur	*Canada Food Guide* Public Health Agency of Canada Ministère de la Santé et des Services sociaux Regional public health departments World Health Organization	Organic food basket Staple foods in different cultures (wheat, rice, manioc, potatoes, corn, fish) Imported foods Meals: different customs Diet for weight loss	Health fairs Gourmet festivals Food recall notices issued by the MAPAQ (Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec)
The Material World	Heinrich Rudolf Hertz Wilhelm Conrad Röntgen Guglielmo Marconi Louis and Antoine Lumière Alexander Graham Bell	Schools and faculties of engineering Food Research and Development Centre	History of efforts to measure the speed of light Public address systems Fibre optics	First telephone call

FAMILIES OF LEARNING SITUATIONS

The learning situations in this course, derived from the *Research* and *Expertise* families, are related to the human body's needs in terms of matter and energy and the interactions between the nervous system and the external world. These situations involve general concepts related to The Living World and The Material World. The following paragraphs contain examples of tasks that could be assigned to adult learners in learning situations involving different combinations of general concepts.

In a situation involving general concepts applicable to the digestive system and certain properties of matter, adult learners could learn about the importance of the role and concentration of certain substances in the body. They could also conduct experiments to identify substances using tables listing the physical and chemical properties of matter. A study of the concept of changes in matter could also encourage adult learners to examine the quantity and quality of the foods they should eat. They could analyze technologies that are comparable to the digestive system or seek to understand the use of certain substances and their risks for the human body.

In a situation involving waves and the nervous system, adult learners could solve a soundproofing problem. They could experiment with the production of waves in a spring or in water to help them understand wave motion. Experimenting with variations in certain parameters of sound waves (frequency, wavelength, dB scale) could help them understand how the brain "hears" through the ear. They could also compare the decibel levels in different places and their impact on ear health.

In a situation involving general concepts related to the digestive system and chemical changes, adult learners could study the role of different foods in building and repairing tissues. They could also model a physical or chemical principle related to nutrition. In the laboratory, certain indicators such as colour change and heat production could pique their curiosity and lead to a qualitative study of chemical changes such as decomposition, synthesis and oxidation. They could then compare these changes with those that occur in food during the digestive process. In a more complex situation, they could analyze their own body's needs in terms of matter and energy, given their eating habits and level of activity.

In the learning situation described below, the main tasks help adult learners develop the second and third competencies. This situation therefore belongs to the *Expertise* family.

BROAD AREAS OF LEARNING

Learning situations will have more meaning for adult learners if they are related to the broad areas of learning. All of the broad areas of learning are readily applicable to the learning situations for course TSG-4059-2. The example below reflects the educational aim of the broad area of learning *Health and Well-Being.*

Broad Areas of Learning
Health and Well-Being
Career Planning and Entrepreneurship
Environmental Awareness and Consumer Rights and Responsibilities
Media Literacy
Citizenship and Community Life

EXAMPLE OF A LEARNING SITUATION

NEARSIGHTEDNESS IS BECOMING AN EPIDEMIC

The World Health Organization has sounded the alarm: more and more young people are suffering from nearsightedness, and this trend is particularly worrisome in North America. The overuse of screens would seem to be the cause. A diagnosis of nearsightedness usually entails a prescription for corrective lenses—unless a person opts for laser eye surgery.

What is nearsightedness? Why are screens thought to cause the condition? How can this problem be corrected with eyeglasses? What does laser eye surgery do?

Your search for information will allow you to:

– draw a diagram of the main parts of the eye and describe their functions
– describe the path of nerve impulses from the eye to the brain
– explain the causes of nearsightedness
– compare nearsightedness with other vision problems
– experimentally reproduce the optical conditions for nearsightedness and other vision problems
– describe how laser surgery can correct nearsightedness

END-OF-COURSE OUTCOMES

Learning situations are administered on the premise that the adult learner will become familiar with investigative processes, particularly the experimental method, modelling and the observation of scientific phenomena. The learning situations also enable adult learners to apply their problem-solving skills and knowledge, and to produce messages.

When adult learners are engaged in the process of solving a well-defined problem related to the needs of the human body in terms of matter and energy or to the interactions between the nervous system and the external world, they develop a representation of the problem after reading and interpreting scientific messages. They are guided in establishing a plan of action based on one of the suggested hypotheses and use what they know about waves and about the properties of and changes in matter. They complete or select an experimental procedure. They have access to help when implementing a plan of action involving laboratory activities in which they prepare an aqueous solution, devise a setup to study a wave-related phenomenon or use a measuring instrument. They carry out the steps as planned, make changes as needed and use the appropriate techniques. Following a basic framework, they write a report in which they suggest an answer that takes their results into account and explain, if necessary, any changes to be made to their plan of action based on the information given in the problem.

When studying an issue that involves satisfying the human body's needs in terms of matter and energy or the interactions of the human body with the external world, adult learners formulate questions related to the contextual elements presented. Using concepts, laws, theories or models, they identify and explain the wave-related phenomena or the properties of or changes in matter involved. They suggest a solution or take a stand on an aspect of the issue as it relates to the digestive system or the nervous system, using their scientific and technological knowledge to explain their position.

EVALUATION CRITERIA FOR SUBJECT-SPECIFIC COMPETENCIES

Evaluation Criteria for Competency 1	Evaluation Criteria for Competency 2	Evaluation Criteria for Competency 3
▪ Appropriate representation of the situation ▪ Development of a suitable plan of action ▪ Appropriate implementation of the plan of action ▪ Development of relevant explanations, solutions or conclusions	▪ Appropriate interpretation of the issue ▪ Relevant use of scientific and technological knowledge ▪ Appropriate formulation of explanations or solutions	▪ Accurate interpretation of scientific and technological messages ▪ Appropriate production or transmission of scientific and technological messages

TSG-4060-2

General Science 2

TSG-4060-2 General Science 2

INTRODUCTION

This course entitled *General Science 2* is aimed at enabling adult learners to function effectively in learning situations from the *Research* and *Expertise* families that involve technological applications related to the functioning of the human body

In this course, adult learners will analyze and design technical objects and seek solutions to technological problems. They will acquire specific knowledge and techniques that will help them gain a better understanding of these types of objects and the factors at play in different technological problems involving graphical language, materials and engineering. They will also be able to evaluate the solutions proposed. This knowledge, combined with the knowledge acquired in their study of *The Material World*—in particular with respect to pure substances and mixtures—will enable them to study the relationships between the composition, uses and properties of different materials. As well, energy transformations will help adult learners better understand the use of various electrical functions. Similarly, they will be able to draw parallels between mechanical and electrical functions and how the musculoskeletal system works by associating their knowledge of mechanics and electricity with the knowledge acquired in their study of *The Living World*.

By the end of this course, in situations involving the study of a technological application in relation to the functioning of the human body, adult learners will be able to:

- ✓ analyze a technological application involving electrical or mechanical engineering
- ✓ justify the decision to use pure substances or different types of mixtures in the composition of the materials used to make a technical object
- ✓ use mechanical engineering to model the functioning of the musculoskeletal system
- ✓ analyze a characteristic of the musculoskeletal system
- ✓ produce a graphical representation of the simple parts of a technical object
- ✓ design a technical object using graphical language
- ✓ plan, with assistance, the steps for producing a working prototype comprising mechanical or electrical components
- ✓ follow, with assistance, a manufacturing process sheet for a prototype comprising mechanical or electrical components
- ✓ write a report on the testing of a prototype by following a basic framework

SUBJECT-SPECIFIC COMPETENCIES

The following table lists, for each competency, the key features studied in the course. The manifestations of the key features are presented in Appendix 4.

Competency 1 Seeks answers or solutions to scientific or technological problems	Competency 2 Makes the most of his/her knowledge of science and technology	Competency 3 Communicates in the languages used in science and technology
▪ Defines a problem ▪ Develops a plan of action ▪ Carries out the plan of action ▪ Analyzes his/her results	▪ Puts applications in context ▪ Analyzes an application from a scientific point of view ▪ Analyzes an application from a technological point of view ▪ Forms an opinion about the quality of an application	▪ Interprets scientific and technological messages ▪ Produces scientific and technological messages

PROCESSES

The investigative processes enable adult learners to solve problems and study applications. The following are the steps in an investigative process:

- Define the problem
- Formulate a hypothesis
- Test the hypothesis
- Draw conclusions and communicate

The most appropriate methods for this course are the design process, the observation method from a technological point of view and modelling. It is during hypothesis testing that these methods become distinguishable. Section 3.5 and Appendices 1 to 3 present these investigative processes with their respective characteristics.

CROSS-CURRICULAR COMPETENCIES

The cross-curricular competencies supplement the subject-specific competencies. The development of one contributes to the development of the others. Course TSG-4060-2 allows for all the cross-curricular competencies to be put into practice. Some of them, indicated in grey shading in the table below, are especially targeted in the sample learning situation that will be presented in the last part of the course.

Cross-Curricular Competencies			
Intellectual	**Communication-Related**	**Personal and Social**	**Methodological**
Uses information	Communicates appropriately	Achieves his/her potential	Adopts effective work methods
Solves problems		Cooperates with others	Uses information and communications technologies
Exercises critical judgment			
Uses creativity			

SUBJECT-SPECIFIC CONTENT

A) KNOWLEDGE

The compulsory concepts and techniques are presented in the tables in the following two sections.

1. Concepts

❖ The Living World	
General concept: Musculoskeletal system The skeleton supports and protects the body. It plays an essential role in movement because of the muscles that act on it by contracting. Some bones are fused, while others are connected by joints, which provide a certain freedom of movement. Technological applications can sometimes help deal with musculoskeletal problems. For example, prostheses for hip or knee problems and wheelchairs, some of which are motorized, provide a better quality of life for people with disabilities or illnesses, or who have trouble getting around.	
Compulsory concepts	**KNOWLEDGE TO BE ACQUIRED**
Function of the musculoskeletal system	• Identifies the main parts of the skeleton (head, thorax, spinal column, upper and lower limbs) • Explains the role of the musculoskeletal system (supports and protects the body, permits movement)
Types of joint movement	• Describes how joints work (linking bone to bone, mobility) • Describes types of joint movement (e.g. flexion, extension, abduction, adduction, rotation)

❖ The Material World

General concept: Organization of matter

Matter cycles between biotic (living) and abiotic (non-living) components of the environment. 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. More often than not, matter in the environment and in the human body is a mixture of several types of molecules of elements and compounds. A pure substance can be identified by its characteristic properties. The properties of a mixture are different from those of its constituent parts, each of which retain their own characteristic properties.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Pure substance: compound, element Homogeneous and heterogeneous mixtures	• Defines a pure substance as a substance made up of a single type of atom or molecule • Distinguishes between elements (e.g. iron, carbon, sodium) and compounds (e.g. water, carbon dioxide, glucose) • Describes homogeneous and heterogeneous mixtures in different materials (e.g. steel, plastic, carbon fibre)

General concept: 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. Using the appropriate methods, it is possible to convert one form of energy into another.

When designing a new technology, it may be necessary to determine the types of energy that will be utilized and the best way of converting an available form of energy into another desired form of energy.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Forms of energy: electrical, chemical, thermal, mechanical, radiant	• Defines joule as the unit of measurement for energy • Describes different forms of energy (electrical, chemical, thermal, mechanical and radiant) • Identifies the forms of energy involved in a transformation of energy (e.g. light bulbs convert electrical energy into radiant and thermal energy, muscles convert chemical energy into mechanical and thermal energy)

❖ The Technological World

General concept: Graphical lines

Based on conventional geometrical representations, and inextricably linked to invention and innovation, technical drafting is a language that enables adult learners to clarify, refine and materialize their ideas.

The information in a technical drawing is usually associated with geometry, scales and different forms of representation. Orthogonal projections make it possible to create detail drawings and isometric representations, among other things. Some drawings also include information relating to industry standards in accordance with established rules of representation. Dimensioning provides the information about the real dimensions and position of each component of the object or system.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Basic lines	• Names basic lines in a drawing (visible contour, hidden contour, centre, extension, dimension lines) • Associates the basic lines in a drawing with the contours and details of a simple part
Scales	• Associates scales with their use (actual-size representation, reduction or enlargement of an object) • Chooses a simple scale for a drawing (e.g. 1:1, 1:2, 5:1)
Oblique projection	• Makes freehand sketches of simple objects using oblique projection
Orthogonal projections:	
– Multiview	• Interprets drawings representing parts in multiview orthogonal projection • Represents simple shapes in multiview orthogonal projection
– Isometric	• Interprets drawings representing parts in isometric projection
Standards and representations:	
– Diagrams	• Interprets technical diagrams and design plans
– Symbols	• Represents different types of motion related to the operation of an object using the appropriate symbols (rectilinear translation, rotation, helical)
Dimensioning	• Interprets technical drawings that include the dimensions

❖ The Technological World (cont.)

General concept: Mechanical engineering

The design or analysis of a technical object or technological system is based on fundamental concepts of mechanics and on processes specific to the field of engineering.

In mechanics, these concepts involve mechanical functions that can be either basic (linking, guiding, sealing, lubricating) or complex (transmission and transformation of motion). Common types of links and guiding controls as well as mechanisms that allow for rotational or translational motion or a speed change are studied.

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.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Typical functions: linking, guiding, sealing and lubricating	• Associates a typical function with certain parts of a technical object
Typical mechanical links	• Describes the advantages and disadvantages of different types of links • Identifies the types of links used in a technical object (e.g. the two levers in a pair of pliers are connected by a pivoting link)
Function, components and use of motion transmission systems	• Identifies motion transmission systems in technical objects (friction gears, pulleys and belt, gear assembly, sprocket wheels and chain, wheel and worm gear)
Function, components and use of motion transformation systems	• Identifies motion transformation systems in technical objects (e.g. screw gear system, cam and roller, connecting rod and crank, rack and pinion)
Speed changes	• Identifies mechanisms that allow for speed changes in technical objects

General concept: Materials

To select an appropriate material, we must be familiar with its mechanical properties so that we have an accurate idea of the material's behaviour when it is used and subjected to constraints.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Mechanical properties	• Describes mechanical properties of different materials (e.g. hardness, ductility, elasticity, malleability, corrosion resistance) • Associates the use of different types of materials (metals, alloys, plastics and wood) with their mechanical properties
Constraints: tension, compression and torsion	• Describes the constraints to which different technical objects are subjected (e.g. the top of a beam is subjected to compression)

❖ The Technological World (cont.)

General concept: Electrical engineering

The design or analysis of a technical object or technological system is based on fundamental concepts of electricity and on processes specific to the field of engineering. The compulsory concepts are related to the different electrical components and their function (power supply, conduction, insulation, control and transformation of energy). Knowledge of their characteristics makes it possible to select and combine them appropriately.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Power supply	• Defines “power supply” as the function performed by any component that can generate electrical current • Identifies the component that ensures the power supply in an electrical circuit (e.g. cell, alternator, battery)
Conduction and insulation	• Defines “conduction” as the function performed by any component that can transmit electric current through a circuit • Distinguishes between electrical conductors and insulators in an electrical circuit
Control	• Defines “control” as the function performed by any component that allows electric current to flow through a circuit • Identifies the component that performs the control function in an electrical circuit (e.g. toggle switch, pushbutton switch)
Transformation of energy	• Defines the transformation of energy as the function performed by any component that can convert electrical energy into another form of energy • Identifies the component that transforms energy in an electrical circuit (e.g. heating element, motor, light bulb)

2. Techniques

The techniques presented here are grouped in three categories. Many of these techniques require the use of instruments and manual tools or machine tools. Safety and the use of safety equipment in the laboratory and workshop must be a constant concern for all those using such techniques.

In the Laboratory or Workshop	
Techniques	**KNOWLEDGE TO BE ACQUIRED**
Graphical language	
- Using scales	• Reduces or increases the dimensions of a technical object based on the scale
- Producing a graphic representation using instruments	• Uses instruments to produce a multiview orthogonal projection
Manufacturing	
- Safely using machines and tools	• Uses manual tools or machine tools safely (e.g. retractable utility knife, hammer, screwdriver, pliers, band saw, drill, sander)
- Assembling and disassembling	• Chooses and places the electrical components in sequence based on the circuit diagram • Connects the components using wires or connectors • Chooses the appropriate tools to assemble or disassemble a technical object
- Measuring and laying out	• Marks the materials to be shaped using a pencil or punch
- Making a part	• Makes a part using the appropriate techniques
Measurement	
- Using measuring instruments	• Uses measuring instruments appropriately (e.g. ruler, protractor, multimeter)

B) CULTURAL REFERENCES

Cultural references make learning situations more meaningful. The following table presents some of the references related to this course.

Cultural References				
Technical objects, technological systems, processes and products	– Orthotic devices, prostheses, wheelchairs, etc. – Bicycle – Hand tools – Machines: agricultural machinery, diggers, machine tools – Systems: mechanical, electrical – Everyday objects: household appliances, locks, faucets, furniture, pumps			
Area	**Scientists**	**Community Resources**	**Applications**	**Events**
The Technological World	Henry Bessemer John Boyd Dunlop Gustave Eiffel	Invention Québec Schools and faculties of Engineering Institut de recherche en électricité du Québec Centre de recherche industrielle du Québec	Plastics Home automation Space research Robotics Artificial limbs	World fairs Science-fiction film festivals
The Living World	Ambroise Paré	War amputees	Grafts and organ transplants	Paralympics Terry Fox's Marathon of Hope across Canada
The Material World	James Prescott Joule John Dalton	Science and technology museums Science clubs Faculties of Science and Engineering	Medical procedures using special materials	Nobel Prize Science fairs

FAMILIES OF LEARNING SITUATIONS

The learning situations in this course, derived from the *Research* and *Expertise* families, involve technological applications, some of which are related to the functioning of the human body. These learning situations take into account general concepts from different areas. The following paragraphs contain examples of tasks that could be assigned to adult learners in learning situations involving different combinations of general concepts.

In a situation involving the musculoskeletal system and mechanical engineering, adult learners could model one or more types of joint movement in order to associate them with mechanical functions and explain or apply mechanical principles in order to design a prosthetic arm.

In a situation involving graphical language or electrical engineering, adult learners could be required to interpret a circuit diagram with a view to selecting the components needed to achieve the desired energy transformations. In the workshop, they could assemble components using the diagram and take readings of electrical parameters in order to ensure that their circuit is consistent with the specifications.

The musculoskeletal system, graphical language, mechanical engineering, electrical engineering, materials and the organization of matter could also be combined in a situation involving a defective or unsatisfactory technical object. Learners could analyze various comparable items with functions similar to that of the item in their project. By analyzing the item from a scientific point of view, they could determine whether the pure substances or mixtures used were an appropriate choice as a component of the materials.

In the learning situation described below, the main tasks help adult learners develop the second and third competencies. This situation therefore belongs to the *Expertise* family.

BROAD AREAS OF LEARNING

Learning situations will have more meaning for adult learners if they are related to the broad areas of learning. All of the broad areas of learning are readily applicable to the learning situations for course TSG-4060-2. The example below reflects the educational aim of the broad area of learning *Health and Well-Being.*

Broad Areas of Learning
Health and Well-Being
Career Planning and Entrepreneurship
Environmental Awareness and Consumer Rights and Responsibilities
Media Literacy
Citizenship and Community Life

EXAMPLE OF A LEARNING SITUATION

ANKLE SUPPORT

An old ankle injury flares up every time you play hockey, so you want to protect your ankle by providing some sort of support. What would be best?

First, you must define the problem, select at least two types of supports, analyze them from a scientific and then a technological point of view and, finally, form an opinion.

Practically speaking, you must produce a design plan and a technical diagram for each type of support you are considering, provide a detailed account of your analyses and explain the scientific principles of the musculoskeletal system as they relate to the ankle. You might also take ergonomic and practical considerations into account.

END-OF-COURSE OUTCOMES

Learning situations are administered on the premise that the adult learner will become familiar with an investigative process involving the technological design process and the observation of technological applications. The learning situations also enable adult learners to apply their problem-solving skills and knowledge, and to produce messages.

Adult learners engaged in the process of solving a well-defined problem involving the design or modification of a technical object, which has electrical or mechanical components and is designed to support the musculoskeletal system, develop a representation of the need in question after reading and interpreting scientific and technological messages, some of which are contained in the specifications. They are guided in establishing a plan of action based on the chosen solution and use what they know about the characteristics of the musculoskeletal system, forms of energy, properties of materials, or the functions of mechanical or electrical components. They produce a sketch, interpret design plans or technical diagrams, and draw multiview orthogonal projections of one or more parts to be manufactured. They have access to help when carrying out their plan of action by producing a prototype in order to validate the feasibility of their solution and gain a better understanding of the constraints involved. Following a basic framework, they write a report on the testing of the prototype in which they suggest changes or provide justifications for their plan of action or solution in light of the need and constraints involved.

Adult learners studying a technological application that involves mechanical engineering or electrical engineering formulate questions related to the contextual elements presented, establish a connection with the musculoskeletal system, or compare the application and this system in terms of how they work. Using diagrams, concepts, laws, theories or models, they justify the use of materials and choice of electrical and mechanical components, or suggest any improvements in light of the problem that the application is designed to solve. Adult learners identify the substances, mixtures and properties associated with the materials and their uses, or emphasize the usefulness of converting electrical energy into other forms of energy.

EVALUATION CRITERIA FOR SUBJECT-SPECIFIC COMPETENCIES

Evaluation Criteria for Competency 1	Evaluation Criteria for Competency 2	Evaluation Criteria for Competency 3
▪ Appropriate representation of the situation ▪ Development of a suitable plan of action ▪ Appropriate implementation of the plan of action ▪ Development of relevant explanations, solutions or conclusions	▪ Appropriate interpretation of the issue ▪ Relevant use of scientific and technological knowledge ▪ Appropriate formulation of explanations or solutions	▪ Accurate interpretation of scientific and technological messages ▪ Appropriate production or transmission of scientific and technological messages

TSC-4061-2

The Energy Challenge

Path:

Science and Technology

Applied Science and Technology

TSC-4061-2 The Energy Challenge

INTRODUCTION

The course entitled *The Energy Challenge* is aimed at enabling adult learners to function effectively in learning situations from the *Research* and *Expertise* families that involve a technological application that consumes electrical energy or transforms a resource into electrical energy.

In this course, adult learners will study environmental issues and seek answers or solutions by analyzing or designing applications that consume electricity or other resources. Thus, they will acquire more knowledge about *The Technological World*, which will help them gain a better understanding of technical objects and the factors at play in different technological problems involving electrical engineering. They will also be able to evaluate the solutions proposed. This knowledge, combined with that of electricity, electromagnetism and the organization of matter that they will acquire in their study of *The Material World*, will help them gain a qualitative and quantitative understanding of how the components of electrical and electronic circuits work. In addition, the knowledge they will acquire about *The Earth and Space* will help them understand the environmental impact of the transformation of energy resources into electricity in the lithosphere, hydrosphere and atmosphere, and of the stream of energy emitted by the Sun.

By the end of this course, in situations involving a technological application that consumes electrical energy or that transforms a resource into electrical energy, adult learners will be able to:

- ✓ design a simple electrical or electronic circuit to produce electricity, or transform electricity into another form of energy
- ✓ model the transformation of resources to produce electricity, or the operation of an electrical circuit
- ✓ determine the values of the parameters of an electrical circuit (resistance, potential difference, electrical current)
- ✓ analyze a technological application containing electrical or electronic components
- ✓ produce a graphic representation of the operation of an electrical or electronic circuit in a technical object
- ✓ follow a manufacturing process sheet for a prototype including electrical or electronic components
- ✓ follow an experimental procedure that deals with electricity or electromagnetism
- ✓ write a report on the production of a prototype or on an experiment involving electricity or electromagnetism
- ✓ take a stand on the use of energy resources

SUBJECT-SPECIFIC COMPETENCIES

The following table lists, for each competency, the key features studied in the course. The manifestations of the key features are presented in Appendix 4.

Competency 1 Seeks answers or solutions to scientific or technological problems	Competency 2 Makes the most of his/her knowledge of science and technology	Competency 3 Communicates in the languages used in science and technology
▪ Defines a problem ▪ Develops a plan of action ▪ Carries out the plan of action ▪ Analyzes his/her results	▪ Puts applications or scientific and technological issues in context ▪ Analyzes an application or an aspect of the issue from a scientific point of view ▪ Analyzes an application from a technological point of view ▪ Forms an opinion about the issue ▪ Forms an opinion about the quality of the application	▪ Interprets scientific and technological messages ▪ Produces scientific and technological messages

PROCESSES

The investigative processes enable adult learners to examine issues, solve problems and study applications. The following are the steps in an investigative process:

- Define the problem
- Formulate a hypothesis
- Test the hypothesis
- Draw conclusions and communicate

The most appropriate methods for this course are the experimental method, modelling, documentary research, the observation method and the technological design process. It is during hypothesis testing that these methods become distinguishable. Section 3.5 and Appendixes 1 to 3 present these investigative processes with their respective characteristics.

CROSS-CURRICULAR COMPETENCIES

The cross-curricular competencies supplement the subject-specific competencies. The development of one contributes to the development of the others. Course TSC-4061-2 allows for all the cross-curricular competencies to be put into practice. Some of them, indicated in grey shading in the table below, are especially targeted in the sample learning situation that will be presented in the last part of the course.

Cross-Curricular Competencies			
Intellectual	**Communication-Related**	**Personal and Social**	**Methodological**
Uses information	Communicates appropriately	Achieves his/her potential	Adopts effective work methods
Solves problems		Cooperates with others	Uses information and communications technologies
Exercises critical judgment			
Uses creativity			

SUBJECT-SPECIFIC CONTENT

A) KNOWLEDGE

The compulsory concepts and techniques are presented in the tables in the following two sections.

1. Concepts

❖ The Technological World	
General concept: Graphical language Based on conventional geometrical representations and inextricably linked to invention and innovation, technical drafting is a language that enables adult learners to develop, refine and give concrete expression to their ideas. Some drawings include information about industry standards in accordance with the rules of representation.	
Compulsory concepts	**KNOWLEDGE TO BE ACQUIRED**
Standards and representations: diagrams and symbols	• Represents the components and connections involved in the operation of an electrical circuit using the appropriate symbols

❖ The Technological World (cont.)

General concept: Electrical engineering

The design or analysis of electrical or electronic circuits in a technical object or technological system is based on fundamental concepts of electricity and electronics and on design and analysis processes specific to the field of engineering. Mastering these concepts enables adult learners to select and combine these components appropriately.

Such technological 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 types of equipment related to the environment have some of the characteristics described below.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Power supply	• Determines the source of current in technical objects with an electrical circuit (e.g. chemical battery, solar cell, alternator)
Conduction, insulation and protection: resistance and colour code, printed circuit	• Analyzes the factors that affect electrical conductivity (cross-sectional area, length, nature and temperature of a conductor) • Uses the colour code to determine the electrical resistance of a resistor • Describes the operation of a printed circuit
Control: lever, pushbutton, toggle, unipolar (single-pole), bipolar (double-pole), unidirectional (single-throw), bidirectional (double-throw)	• Distinguishes between unipolar (single-pole) and bipolar (double-pole) switches • Distinguishes between unidirectional (single-throw) and bidirectional (double-throw) switches
Transformation of energy: electricity and light, heat, vibration, magnetism	• Associates the transformation of energy with different components of a circuit (e.g. light bulbs transform electrical energy into light and heat) • Describes the energy transformations that take place in electrical or electronic appliances (e.g. in a cell phone, electricity is transformed into light for the display and vibrations for the sound)
Other functions	• Describes the function of certain electronic components (capacitor, diode, transistor, relay)

❖ The Material World

General concept: Organization of matter

Throughout history, different models of the structure of matter have been developed to explain its properties and the changes it undergoes. The classification in the periodic table shows how certain elements have similar properties. The properties of metals, non-metals and metalloids will be studied.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Periodic table: - metals, non-metals and metalloids	• Locates the metals, non-metals and metalloids in the periodic table • Describes the common characteristics of metals, non-metals and metalloids
Rutherford atomic model	• Describes the Rutherford atomic model
Subatomic particles	• Describes the position and electrical charge of the subatomic particles in an atom (proton, electron, neutron)

General concept: Electricity

The study of matter in the environment 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. 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. 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 the voltage in the circuit, 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 quantity has its own unit of measurement.

Note: *Students must analyze and design series-parallel circuits, but are not required to do mathematical calculations related to this type of circuit. Coulomb's law is studied both quantitatively and qualitatively.*

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Electrical charge	• Associates subatomic particles with their electrical charge • Describes the behaviour of electrical charges of opposite signs or of the same sign when close together
Static electricity	• Describes static electricity as the transfer of electrons from one body to another
Electrical current	• Defines electrical current as the quantity of electrical charges that flow through a conductor in a given period of time • Distinguishes between alternating and direct current • Applies the formula that expresses the mathematical relationship between current intensity, electrical charge and time (I = Q/t)
Electrical circuits	• Describes the function of different elements of an electrical circuit (e.g. the wires transmit electrons along the circuit; resistors transform electrical energy into another form of energy) • Describes the two types of connections in electrical circuits (series, parallel) • Distinguish between alternating current and direct current • Represents a simple electrical circuit using a diagram

❖ The Material World (cont.)

General concept: Electricity (cont.)

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Ohm's law	• Qualitatively describes the relationship between voltage, resistance and current intensity in an electrical circuit • Applies the mathematical relationship between voltage, resistance and current intensity in an electrical circuit (V = RI)
Kirchhoff's laws	• Describes the distribution of electrical current in the components of an electrical circuit • Determines the value of the current circulating in the different components of an electrical circuit connected in series or in parallel • Describes the distribution of the voltage across the terminals of the components of an electrical circuit • Determines the value of the voltage across the terminals of the different components of an electrical circuit connected in series or in parallel • Determines the equivalent resistance of a series or parallel circuit using Ohm's law and Kirchhoff's laws
Relationship between power and electrical energy	• Applies the mathematical relationship between power, voltage and current intensity in an electrical circuit (P = VI) • Qualitatively describes the relationship between the power of an electrical appliance, the electrical energy it consumes and the amount of time it is in operation • Applies the mathematical relationship between the electrical energy consumed, the power of an electrical appliance and the amount of time it is in operation (E = PΔt)
Coulomb's law	• Applies the mathematical relationship between electrical force, the quantity of the electrical charges and the distance that separates them ($F = kq_1 q_2 / r^2$)
Electrical field	• Describes the electrical field generated by electrical charges (point charges, charged plates)

General concept: Electromagnetism

The study of matter also involves an exploration of its 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, whether the wire is straight or wound. 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 considering the conventional or actual direction in which electrons travel.

Note: *Only the qualitative aspects of electromagnetism are addressed.*

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Forces of attraction and repulsion	• Compares the behaviour of a compass in the magnetic field of a magnet and in the magnetic field created by a live wire
Magnetic field of a live wire	• Describes the magnetic field produced by a live wire (right-hand rule) • Names ways of modifying the intensity of the magnetic field produced by a live wire (type of wire, current intensity)
Electromagnetic induction	• Names ways of inducing electrical current in a wire (e.g. movement of a magnet, changing the intensity of a magnetic field)

❖ The Material Word (cont.)

General concept: Electromagnetism (cont.)

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Magnetic field of a solenoid	• Describes the magnetic field produced by a solenoid (right-hand rule) • Names ways of modifying the intensity of the magnetic field produced by a solenoid (nature of the core, intensity of the current, number of turns) • Explains the use of solenoids in technological applications (e.g. earphone, electric motor, magnetic crane)

General concept: 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.

Note: *Only the qualitative aspects of the transformation of energy are addressed.*

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Law of conservation of energy	• Explains the law of conservation of energy qualitatively • Applies the law of conservation of energy in different contexts
Energy efficiency	• Defines the energy efficiency of a device or system as the proportion of energy consumed that is transformed into effective work (amount of useful energy / amount of energy consumed x 100) • Explains how to improve the energy efficiency of an electrical appliance
Distinction between heat and temperature	• Describes heat as a manifestation of energy • Describes the relationship between heat and temperature

❖ The Earth and Space

General concept: Lithosphere

The lithosphere contains a wide variety of mineral resources essential to the development of societies, including metals, industrial minerals and construction materials.

Combustion engines and thermal power plants burn fossil fuels, which are non-renewable sources of energy, as are the radioactive materials used in nuclear power plants. The search for new energy sources and the use of renewable resources are both major concerns in today's world.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Minerals	• Distinguishes between minerals and ore • Describes some of the environmental impacts of mining and the transformation of minerals

❖ The Earth and Space (cont.)

General concept: Lithosphere (cont.)

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Energy resources	• Describes technologies employed to produce electricity using the energy resources in the lithosphere • Describes the main impacts of the use of energy resources in the lithosphere

General concept: Hydrosphere

Human activity in a catchment area, for example the creation of a reservoir upstream from the dam of a hydroelectric power plant, can disturb ecosystems.

Marine currents and tides can be used to create large quantities of energy. Tidal power plants use tides to produce electrical energy.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Energy resources	• Describes technologies employed to produce electricity using the energy resources in the hydrosphere • Describes the main impacts of the use of energy resources in the hydrosphere

General concept: Atmosphere

Wind is a resource. Whether it be to get around, perform mechanical tasks or produce electrical energy, humans take advantage of wind energy by using sails and blades whose shapes, materials and dimensions vary depending on the application. Wind is an abundant source of soft energy.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Energy resources	• Describes the technologies employed to produce electricity using the energy resources in the atmosphere • Describes the main impacts of the use of energy resources in the atmosphere

General concept: 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 radiant 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.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Solar energy flow	• Describes the main factors that control the quantity of solar energy that reaches the Earth's surface (e.g. reflection and absorption of solar energy by the atmosphere or surfaces)
Earth-Moon system: gravitational effect	• Describes the tides in terms of the gravitational effect of the Earth-Moon system

2. Techniques

The techniques presented here are grouped in four categories. Many of the techniques require the use of instruments and tools. Safety and the use of safety equipment in the workshop must be a constant concern for all those using such techniques.

In the Workshop	
Techniques	**KNOWLEDGE TO BE ACQUIRED**
Experimentation - Safely using materials and equipment	• Uses materials and equipment safely
Graphical language - Drawing schematic diagrams	• Indicates all the information needed to explain the operation or construction of an object
Manufacturing - Safely using machines and tools	• Uses tools safely (e.g. disconnects the power source before making adjustments to an electrical circuit, keeps the work area tidy)
- Assembling and disassembling	• In the case of electrical circuits, identifies and gathers the electrical components • Chooses and places the electrical components in sequence based on the circuit diagram • Connects the components using wire, connectors or solders • In the case of electronic circuits, identifies and gathers the electronic components (e.g. connects the components on a printed circuit board) • Chooses and places the electronic components in sequence based on the circuit diagram • Performs the necessary operations to disassemble an electronic circuit (e.g. uses a desoldering bulb to remove a solder)
Measurement - Using measuring instruments	• Uses measuring instruments appropriately (e.g. ammeter, voltmeter, multimeter)

B) CULTURAL REFERENCES

Cultural references make learning situations more meaningful. The following table presents some of the references related to this course.

Cultural References				
Technical objects, technological systems, processes and products	– Petroleum industry equipment: extraction, refining, distribution, use – Wind turbines – Electric power plants – Dams – Turbines – Steam engines – Electric motors – Electrical household devices: lighting, heating, various appliances (e.g. dryer, stove, microwave oven, vacuum cleaner, iron, television, computer, tools) – Bicycle – Automobile – Hybrid vehicles – Street lights			
Area	**Scientists**	**Community Resources**	**Applications**	**Events**
The Technological World	Alessandro Volta Thomas Edison	Canadian Intellectual Property Office Canadian Patent Database Ordre des ingénieurs du Québec	Robotics Remote sensing Street lights	Industrial Revolution Establishment of labour standards Globalization
The Material World	Blaise Pascal Hans Christian Œrsted Joseph Henry Michael Faraday Albert Einstein James Watt Ernest Rutherford Niels Bohr James Chadwick	Faculties of Science and Engineering Museums of science and technology	Automobile industry Development of electrical grids Means of transportation	Construction of dams Construction wind farms
The Earth and Space	Joseph Henry Nicolas Sténon Henry Cavendish	Geological Survey of Canada Transition énergétique Québec Natural Resources Canada Greenpeace	Observation satellites Global positioning systems (GPS)	Meteorological phenomena Earth Summits

FAMILIES OF LEARNING SITUATIONS

The learning situations in this course, derived from the *Research* and *Expertise* families, involve the use of energy resources or electricity. The learning situations contain general concepts related to more than one area. The following paragraphs contain examples of tasks that could be assigned to adult learners in learning situations involving different combinations of general concepts.

In a situation involving electricity, electromagnetism and the hydrosphere, adults could learn how water falling from a certain height at a dam produces electricity by transforming the kinetic energy of the water into the mechanical energy of a turbine, then into electricity through electromagnetic induction between the rotor and stator of an alternator.

In a situation involving electricity, electrical engineering and graphical language, adult learners could model the direction of the current circulating in the components of an electrical circuit and represent it in a diagram. They could also observe the effect of electricity or electromagnetism on the operation of electrical components or, in the workshop, analyze the electrical engineering concepts involved in building a certain technical object, draw its circuit diagram and assess its energy efficiency.

In a situation involving the hydrosphere, the atmosphere, the lithosphere, space and electricity, adult learners could analyze different ways of transforming energy and form an opinion about the consequences of using one type of energy rather than another to produce electricity at a given location, taking political, economic, environmental and social constraints into consideration.

In the learning situation described below, the main tasks help adult learners develop the second and third competencies. This situation therefore belongs to the *Expertise* family.

BROAD AREAS OF LEARNING

Learning situations will have more meaning for adult learners if they are related to the broad areas of learning. All of the broad areas of learning are readily applicable to the learning situations for course TSC-4061-2. The example below reflects the educational aim of the broad area of learning *Environmental Awareness and Consumer Rights and Responsibilities*.

Broad Areas of Learning
Health and Well-Being
Career Planning and Entrepreneurship
Environmental Awareness and Consumer Rights and Responsibilities
Media Literacy
Citizenship and Community Life

EXAMPLE OF A LEARNING SITUATION

ELECTRIC MOTOR

A friend wants to build an electric motor and asks for your advice concerning the operation and construction of this technological system. You want to give your friend clear, precise and accurate information.

To that end, you identify technical objects around you that use electric motors. You take one of these objects and disassemble it to remove the motor. Motor in hand, you do research to understand the scientific and technological principles underlying its operation. You then reassemble the object and ensure that it is in good working order. Your information must include the details of your technological analysis of the electric motor, including a circuit diagram and an explanation of the scientific principles related to electricity and the transformation of energy.

END-OF-COURSE OUTCOMES

Learning situations are administered on the premise that the adult learner will become familiar with an investigative process involving the observation method, the design process, the experimental method, modelling or documentary research. The learning situations also enable adult learners to apply their problem-solving skills and knowledge, and to produce messages.

Adult learners engaged in the process of solving an open problem related to the production or consumption of electrical energy develop a representation of the problem in question after reading and interpreting scientific and technological messages. They establish a plan of action adapted to the chosen solution or hypothesis, relying on their knowledge of electricity or electromagnetism, and placing electrical or electronic components in sequence. They subsequently design a simple electrical circuit or choose a manufacturing process sheet. They implement their plan of action, constructing a prototype electrical or electronic circuit in order to validate their solution. They change or justify their plan of action, solution or answer based on the need to be met or the information given in the problem.

Adult learners studying an environmental issue or technological application involving the use of energy resources or electricity formulate questions related to the contextual elements presented. They identify the characteristics of the issue or the principles underlying the application as they relate to the resources found on Earth and in space. Using diagrams, concepts, laws, theories or models, they explain the operation or construction of the application and evaluate its energy efficiency. They calculate the parameters of an electrical circuit in the application and explain the transformations of energy that take place. In the case of an environmental issue, they explain the issue and take a stand on the environmental impact of using the energy resources on Earth and in space based on their scientific and technological knowledge.

EVALUATION CRITERIA FOR SUBJECT-SPECIFIC COMPETENCIES

Evaluation Criteria for Competency 1	Evaluation Criteria for Competency 2	Evaluation Criteria for Competency 3
▪ Appropriate representation of the situation ▪ Development of a suitable plan of action ▪ Appropriate implementation of the plan of action ▪ Development of relevant explanations, solutions or conclusions	▪ Appropriate interpretation of the issue ▪ Relevant use of scientific and technological knowledge ▪ Appropriate formulation of explanations or solutions	▪ Accurate interpretation of scientific and technological messages ▪ Appropriate production or transmission of scientific and technological messages

TSC-4062-2

Climate Change

Path:

Science and Technology

Applied Science and Technology

TSC-4062-2 Climate Change

INTRODUCTION

The course entitled *Climate Change* is aimed at enabling adult learners to function effectively in learning situations from the *Research* and *Expertise* families that involve the balance of an ecosystem.

In this course, adult learners will study environmental issues and seek answers or solutions. They will acquire knowledge related to *The Earth and Space*, which will help them explain the factors at play in different scientific problems involving the characteristics of climate zones, biogeochemical cycles and the relationships between the lithosphere, hydrosphere and atmosphere. This knowledge, combined with the knowledge of ecology they will acquire in their study of *The Living World*, will help them understand the delicate balance between ecosystems and climate conditions. In addition, by developing their knowledge of *The Material World*—in particular with regard to chemical changes and the physical properties of solutions—they will be able to understand biogeochemical cycles and the impact of certain natural phenomena and human activity on the biosphere.

By the end of this course, in situations involving the balance of an ecosystem, adult learners will be able to:

- ✓ explain the biogeochemical cycles using chemical equations
- ✓ model the dynamics of an ecosystem or the biological cycle of a population
- ✓ analyze a technological application related to the balance of an ecosystem
- ✓ discuss factors at play in the balance or imbalance of an ecosystem
- ✓ discuss a plant or animal population in an environment or the dynamics of a community
- ✓ discuss the impact of climate change on the biosphere
- ✓ plan a simple experiment that deals with the physical properties of solutions or chemical changes
- ✓ follow an experimental procedure that deals with the physical properties of solutions or chemical changes
- ✓ write a report on an experiment concerning the physical properties of solutions or chemical changes
- ✓ take a stand and defend their opinion regarding the contribution of a natural phenomenon or human activity to climate change and its impact on the biosphere

SUBJECT-SPECIFIC COMPETENCIES

The following table lists, for each competency, the key features studied in the course. The manifestations of the key features are presented in Appendix 4.

Competency 1 Seeks answers or solutions to scientific or technological problems	Competency 2 Makes the most of his/her knowledge of science and technology	Competency 3 Communicates in the languages used in science and technology
▪ Defines a problem ▪ Develops a plan of action ▪ Carries out the plan of action ▪ Analyzes his/her results	▪ Puts applications or scientific and technological issues in context ▪ Analyzes an application or an aspect of the issue from a scientific point of view ▪ Forms an opinion about the issue	▪ Interprets scientific and technological messages ▪ Produces scientific and technological messages

PROCESSES

The investigative processes enable adult learners to examine issues, solve problems and study applications. The following are the steps in an investigative process:

- Define the problem
- Formulate a hypothesis
- Test the hypothesis
- Draw conclusions and communicate

The most appropriate methods for this course are the experimental method, modelling, documentary research and the observation method. It is during the hypothesis testing that these methods become distinguishable. Section 3.5 and Appendixes 1 to 3 present these investigative processes with their respective characteristics.

CROSS-CURRICULAR COMPETENCIES

The cross-curricular competencies supplement the subject-specific competencies. The development of one contributes to the development of the others. Course TSC-4062-2 allows for all the cross-curricular competencies to be put into practice. Some of them, indicated in grey shading in the table below, are especially targeted in the sample learning situation that will be presented in the last part of the course.

Cross-Curricular Competencies			
Intellectual	**Communication-Related**	**Personal and Social**	**Methodological**
Uses information	Communicates appropriately	Achieves his/her potential	Adopts effective work methods
Solves problems		Cooperates with others	Uses information and communications technologies
Exercises critical judgment			
Uses creativity			

SUBJECT-SPECIFIC CONTENT

A) KNOWLEDGE

The compulsory concepts and techniques are presented in the tables in the following two sections.

1. Concepts

❖ The Living World

General concept: 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.

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. In addition to human activity and natural disasters, the presence of pathogenic microorganisms in the environment (bacteria, viruses, fungi, parasites) can play an important role in the disturbance of relationships within communities. Some of these agents can be allergenic, toxic or even deadly in some cases.

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 re-enter circulation.

The study of climate change is 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.*

Compulsory concepts	**KNOWLEDGE TO BE ACQUIRED**
Study of populations: density and biological cycles	• Describes a given population (density, distribution, biological cycles) • Describes the influence of biotic or abiotic factors on the biological cycles of a population (natality, mortality, immigration, emigration) • Explains how the availability of resources in the environment affects reproduction and survival

❖ The Living World (cont.)

General concept: Ecology (cont.)

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Dynamics of communities:	
- communities	• Defines a community as a group of populations that interact
- biodiversity	• Defines the biodiversity of a community as the relative abundance of the species it comprises • Explains factors that affect the biodiversity of a given community
- disturbances	• Defines a disturbance in a community • Explains the effects of certain factors that disturb the ecological balance (e.g. human activity, natural disasters)
Dynamics of ecosystems:	
- ecosystems	• Defines an ecosystem as the relationships between the individuals in a community and abiotic factors in the environment
- trophic relationships	• Describes the trophic levels (producers, consumers, decomposers) • Explains the relationships between the trophic levels of a food web
- primary productivity	• Defines “primary productivity” as the quantity of organic matter produced by plants in a given territory • Explains the effects of certain factors on primary productivity (e.g. bees help pollinate fruit trees, pathogenic microorganisms hinder plant growth)
- material and energy flow	• Describes material and energy flow in an ecosystem
- chemical recycling	• Describes certain processes underlying chemical recycling (e.g. action of microorganisms and decomposers, erosion)

❖ The Earth and Space

General concept: 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. Significant variations in the humidity, temperature or pH of the soil affect the regulation of the nitrogen cycle. Plants are the main source of nitrogen that can be assimilated by animals.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Carbon cycle	• Describes transformations related to the circulation of carbon (e.g. photosynthesis, plant decomposition, dissolution in water, combustion of fossil fuels)
Nitrogen cycle	• Describes transformations related to the circulation of nitrogen (e.g. nitrogen fixation, nitrification, denitrification)

❖ The Earth and Space (cont.)

General concept: Climate zones

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.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Factors that influence the distribution of biomes	• Describes the geographical and climatic factors that influence the distribution of biomes (e.g. latitude, humidity, temperature, salinity)
Marine biomes	• Describes different marine biomes (e.g. fauna, flora, temperature, salinity)
Terrestrial biomes	• Describes different terrestrial biomes (e.g. fauna, flora, climate, type of soil)

General concept: Lithosphere

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.

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, alter the landscape and ecosystems, and produce methane emissions.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Soil profile: horizons	• Describes the structure of a soil (superimposition of layers of different compositions and thicknesses) • Explains the chemical and biological reactivity of a soil based on its composition (e.g. oxidation, acid-base neutralization, decomposition)
Permafrost	• Defines the permafrost as a layer of permanently frozen soil • Explains some of the consequences of a rise in temperature in the permafrost (e.g. landslides, methane emissions)

General concept: Hydrosphere

Because of their ability to absorb heat, the oceans play an essential role in regulating climate by stabilizing the temperature of the Earth.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Ocean circulation	• Describes factors that affect the circulation of surface currents and deep currents (e.g. wind, the Earth's rotation, temperature, salinity, density) • Describes the role of thermohaline circulation in global climate regulation (e.g. effect of the Gulf Stream on the climate of the east coast of North America)
Salinity	• Defines "salinity" as a measure of the quantity of salt dissolved in a given volume of liquid • Describes the influence of salinity on the density of a solution

❖ The Earth and Space (cont.)

General concept: Hydrosphere (cont.)

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Glacier and pack ice	• Distinguishes between glaciers and pack ice • Describes some of the impacts of the melting of glaciers and pack ice (e.g. increase in sea level, disturbance of thermohaline circulation)

General concept: Atmosphere

The different substances emitted during the combustion of fossil fuels have harmful effects at the local, regional and planetary levels. Oxides of sulphur, carbon and nitrogen are acid precursors: they contribute to the acidification of precipitation. The air can also be contaminated by solid and liquid suspended particles (e.g. dust, pollen, soot, smoke, droplets) that affect the respiratory system. A biome located far away from a gas emission site can become contaminated, since prevailing winds cause contaminants to circulate in the atmosphere.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Atmospheric circulation	• Describes the main factors responsible for atmospheric circulation (e.g. pressure variations, uneven heating of the Earth's surface)
Air mass	• Describes the properties of an air mass (temperature, humidity, pressure) • Explains the formation of clouds when two different air masses meet
Cyclone and anticyclone	• Explains the formation of cyclones (low-pressure areas) and anticyclones (high-pressure areas)
Greenhouse effect	• Describes the greenhouse effect • Explains some of the consequences of a higher concentration of greenhouse gases (e.g. global warming that could result in higher sea levels, disturbances in ecosystems or the melting of glaciers)

❖ The Material World

General concept: 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 many biological and environmental phenomena. Special attention will be given to the properties of aqueous solutions of acids, bases and salts. 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. In the natural water cycle, dissolution, dilution and evaporation cause variations in the concentration (g/L, percentage or ppm) of dissolved substances. Some substances in water-based solutions 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 electrolytic solutions to conduct electricity can be explained in part by the dissociation of electrolyte molecules into ions.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Concentration: g/L, %, ppm	• Determines the concentration of an aqueous solution (g/L, percentage or ppm)
Electrolytes	• Defines the concept of electrolyte

❖ The Material World (cont.)	
General concept: Physical properties of solutions (cont.)	
Compulsory concepts	**KNOWLEDGE TO BE ACQUIRED**
Strength of electrolytes	• Associates the strength of an electrolyte with its electrical conductivity
pH scale	• Describes the pH scale (acidity, alkalinity, neutrality, increasing and decreasing values) • Determines the pH of a few common substances (e.g. distilled water, rainwater, saliva, lemon juice, household cleaner)
Electrical conductivity	• Describes the mechanism that allows aqueous solutions to conduct electricity (electrolytic dissolution of a solute, formation of mobile ions)
Electrolytic dissociation	• Describes electrolytic dissociation
Ions	• Defines the concept of ion
General concept: Chemical changes The chemical properties of a substance or group of substances are based on the chemical changes that occur when they come into contact with each other. Since the products are different from the reagents, they are characterized by different properties. The number of atoms of each element and their mass, however, remain the same. Several chemical reactions related to each of the topics will be studied.	
Compulsory concepts	**KNOWLEDGE TO BE ACQUIRED**
Oxidation	• Represents an oxidation reaction using the particle model • Associates known chemical reactions with oxidation reactions (e.g. combustion, corrosion, respiration)
Combustion	• Describes the perceivable manifestations of rapid combustion (e.g. heat, light) • Explains a combustion reaction using the fire triangle
Photosynthesis and respiration	• Represents the photosynthesis reaction as a balanced equation • Represents the respiration reaction as a balanced equation
Acid-base neutralization reaction	• Gives examples of acid-base neutralization reactions (e.g. adding lime to neutralize the acidity of a lake) • Names the products formed during an acid-base neutralization reaction (salt and water)
Law of conservation of mass	• Explains the law of conservation of mass during a chemical reaction • Represents the conservation of mass using the particle model
Balancing simple chemical equations	• Balances chemical equations

2. Techniques

The techniques presented here are grouped in two categories. Many of these techniques require the use of instruments and tools or chemicals. Safety and the use of safety equipment in the workshop and laboratory must be a constant concern for all those using such techniques.

In the Laboratory or Workshop	
Techniques	**KNOWLEDGE TO BE ACQUIRED**
Experimentation	
- Safely using materials and equipment	• Uses laboratory materials and equipment safely (e.g. allows hotplate to cool, uses beaker tongs) • Handles chemicals safely (e.g. uses a spatula and a pipette filler)
- Preparing solutions	• Prepares an aqueous solution of a specific concentration given a solid solute • Prepares an aqueous solution of a specific concentration given a concentrated aqueous solution
- Collecting samples	• Collects samples appropriately (e.g. sterilizes the container, uses a spatula, refrigerates the sample)
Measurement	
- Using measuring instruments	• Uses measuring instruments appropriately (e.g. pH meter, electric conductivity detector, volumetric flask)

B) CULTURAL REFERENCES

Cultural references make learning situations more meaningful. The following table presents some of the references related to this course.

Cultural References	
Technical objects, technological systems, processes and products	– Maps and aerial photographs – Satellite photos – Rain gauge, thermometer, barometer, anemometer, hygrometer – Atmospheric probe – Radar, sonar – Communications satellites – Seismograph – Geiger counter – Waste collection and processing equipment (e.g. glass, plastic, tires) – Automobile exhaust systems – Equipment for measuring the pH of water in a swimming pool

Cultural References				
Area	**Scientists**	**Community Resources**	**Applications**	**Events**
The Living World	Leonardo da Vinci Pierre Dansereau	Environment Canada Montréal Biodôme Zoos UNESCO world reserves Environmental groups Conservation societies	Reforestation Carbon exchange	
The Earth and Space		Ouranos Consortium BGS (Brundtland Green Schools)	Carbon exchange	Ratification of the Kyoto Protocol Climatic phenomena El Niño and La Niña
The Material World	Antoine Laurent de Lavoisier Søren Sørensen Svante Arrhenius		Means of transportation	Major scientific expeditions

FAMILIES OF LEARNING SITUATIONS

The learning situations in this course, derived from the *Research* and *Expertise* families, involve the balance of an ecosystem. The learning situations contain general concepts related to more than one area. The following paragraphs contain examples of tasks that could be assigned to adult learners in learning situations involving different combinations of general concepts.

In a situation involving the hydrosphere, the atmosphere and physical properties of solutions, adult learners could make a connection between the accelerated thawing of glaciers and changes in oceanic circulation. After examining the concepts of concentration and salinity in the laboratory, they could model the effects of the melting of the Arctic ice pack on Atlantic marine currents.

Another situation could involve analyzing disturbances in the biodiversity of a particular area that are caused by global warming. Adult learners could apply the general concepts they learned about ecology and the atmosphere as well as their knowledge of the consequences of climate change to the balance of communities and ecosystems.

In a situation involving ecology, biogeochemical cycles, the atmosphere and chemical changes, adult learners could identify human activities that cause global warming, study the connections between human activity and changes in atmospheric and oceanic circulation, or explain the impact of socioeconomic activities on climate change.

In the learning situation described below, the main tasks help adult learners develop the second and third competencies. This situation therefore belongs to the *Expertise* family.

BROAD AREAS OF LEARNING

Learning situations will have more meaning for adult learners if they are related to the broad areas of learning. All of the broad areas of learning are readily applicable to the learning situations for course TSC-4062-2. The example below reflects the educational aim of the broad area of learning *Environmental Awareness and Consumer Rights and Responsibilities*.

Broad Areas of Learning
Health and Well-Being
Career Planning and Entrepreneurship
Environmental Awareness and Consumer Rights and Responsibilities
Media Literacy
Citizenship and Community Life

EXAMPLE OF A LEARNING SITUATION

SPRUCE BUDWORM

During a walk in the forest, you notice that the needles of many of the spruce trees are dry and that the trees appear to be dying. You are told that an insect, the spruce budworm, is responsible. A campaign is under way to spray the forest with a chemical insecticide to destroy the budworm, but a number of people are against the idea. They ask you to sign a petition to prevent the spraying from going ahead.

You have heard that global warming might affect the proliferation of certain insects and you want to learn more. You learn about the biological cycle of forest insects, ecological succession and the dynamics of populations and ecosystems. You are asked to explain the regulating role of the spruce budworm in the forest ecosystem and the influence of certain forestry practices on that same ecosystem. As a conclusion to your research, you must form an opinion about the advantages and disadvantages of spraying chemical insecticides.

END-OF-COURSE OUTCOMES

Learning situations are administered on the premise that the adult learner will become familiar with an investigative process involving the experimental method, modelling, documentary research or the observation method. The learning situations also enable adult learners to apply their problem-solving skills and knowledge, and to produce messages.

Adult learners engaged in the process of solving an open problem related to a population, the dynamics of an ecosystem or a natural phenomenon in the lithosphere, hydrosphere and/or atmosphere develop a representation of the problem in question after reading and interpreting scientific and technological messages. They establish a plan of action adapted to the chosen hypothesis, relying on their knowledge of ecology, the physical properties of solutions or chemical changes. They prepare a simple experimental procedure or a modelling technique. They implement their plan of action, carrying out activities in the laboratory, in the workshop or outdoors. They collect samples, prepare solutions or construct a model, adjusting the steps in the plan as needed and using the appropriate techniques. In a report, they propose an answer that takes their results into account and determine whether the analysis of the results supports their hypothesis.

Adult learners studying an environmental issue or technological application involving the balance of an ecosystem formulate questions pertaining to the contextual elements presented. They identify the characteristics of the issue or application as they relate to a population, the dynamics of an ecosystem or a natural phenomenon in the lithosphere, hydrosphere and/or atmosphere. Using concepts, laws, theories or models, they explain the related issues, illustrate physical properties of the solutions in question and identify the chemical changes at play. They defend their opinion on the contribution of a natural phenomenon or human activity to climate change and its impact on the biosphere.

EVALUATION CRITERIA FOR SUBJECT-SPECIFIC COMPETENCIES

Evaluation Criteria for Competency 1	Evaluation Criteria for Competency 2	Evaluation Criteria for Competency 3
▪ Appropriate representation of the situation ▪ Development of a suitable plan of action ▪ Appropriate implementation of the plan of action ▪ Development of relevant explanations, solutions or conclusions	▪ Appropriate interpretation of the issue ▪ Relevant use of scientific and technological knowledge ▪ Appropriate formulation of explanations or solutions	▪ Accurate interpretation of scientific and technological messages ▪ Appropriate production or transmission of scientific and technological messages

TSC-4063-2

Mechanization of Work

Path:

Applied Science and Technology

Environmental Science and Technology

INTRODUCTION

The course entitled *Mechanization of Work* is aimed at enabling adult learners to function effectively in learning situations from the *Research* and *Expertise* families that involve a technological application in which a mechanism reflects a physical principle.

In this course, adult learners will analyze and design technical objects and seek solutions to technological problems. They will acquire more in-depth technological and technical knowledge, which will help them gain a better understanding of technical objects and the factors at play in different technological problems involving graphical language, materials, engineering and manufacturing. They will also be able to evaluate the solutions proposed. This knowledge, combined with the knowledge they will acquire in their study of *The Material World*, in particular with respect to force and motion, will help them understand the forces at play in the movement of two parts or when a speed change occurs in a motion transmission or transformation system. Similarly, they will learn about the forces exerted by fluids in the movement of a technical object.

By the end of this course, in situations involving a technological application in which a mechanism reflects a physical principle, adult learners will be able to:

- ✓ design a technical object or a technological system in which a mechanism reflects a physical principle
- ✓ analyze a technological application in which a mechanism reflects a physical principle
- ✓ discuss the choice of materials in a technological application
- ✓ draw the development of a simple shape in a technical object
- ✓ plan the steps involved in the production of a prototype containing mechanical parts requiring the use of manual tools or machine tools
- ✓ follow a manufacturing process sheet for a prototype including mechanical parts and requiring the use of manual tools or machine tools
- ✓ control the quality of the machined parts and the types of motion allowed by the links, using information contained in the detail drawings and an assembly drawing
- ✓ write a report on the production of a prototype including mechanical parts

SUBJECT-SPECIFIC COMPETENCIES

The following table lists, for each competency, the key features studied in the course. The manifestations of the key features are presented in Appendix 4.

Competency 1 Seeks answers or solutions to scientific or technological problems	Competency 2 Makes the most of his/her knowledge of science and technology	Competency 3 Communicates in the languages used in science and technology
▪ Defines a problem ▪ Develops a plan of action ▪ Carries out the plan of action ▪ Analyzes his/her results	▪ Puts applications in context ▪ Analyzes an application from a scientific point of view ▪ Analyzes an application from a technological point of view ▪ Forms an opinion about the quality of the application	▪ Interprets scientific and technological messages ▪ Produces scientific and technological messages

PROCESSES

The investigative processes enable adult learners to examine and solve problems and to study applications. The following are the steps in the investigative process:

- Define the problem
- Formulate a hypothesis
- Test the hypothesis
- Draw conclusions and communicate

The most appropriate methods for this course are the technological design process, the observation method, documentary research, the experimental method and modelling. It is during hypothesis testing that these methods become distinguishable. Section 3.5 and Appendixes 1 to 3 present these investigative processes with their respective characteristics.

CROSS-CURRICULAR COMPETENCIES

The cross-curricular competencies supplement the subject-specific competencies. The development of one contributes to the development of the others. Course TSC-4063-2 allows for all the cross-curricular competencies to be put into practice. Some of them, indicated in grey shading in the table below, are especially targeted in the sample learning situation that will be presented in the last part of the course.

Cross-Curricular Competencies			
Intellectual	**Communication-Related**	**Personal and Social**	**Methodological**
Uses information	Communicates appropriately	Achieves his/her potential	Adopts effective work methods
Solves problems		Cooperates with others	Uses information and communications technologies
Exercises critical judgment			
Uses creativity			

SUBJECT-SPECIFIC CONTENT

A) KNOWLEDGE

The compulsory concepts and techniques are presented in the tables in the following two sections.

1. Concepts

❖ The Technological World	
General concept: Graphical language Based on conventional geometrical representations and inextricably linked to invention and innovation, technical drafting is a language that enables adult learners to develop, refine and materialize their ideas. Some drawings include information about industry standards in accordance with the rules of representation.	
Compulsory concepts	**KNOWLEDGE TO BE ACQUIRED**
Axonometric projection: exploded view (reading)	• Interprets exploded-view drawings
Multiview orthogonal projection: assembly drawing	• Interprets assembly drawings of simple technical objects
Functional dimensioning	• Defines “functional dimensioning” as the set of specific tolerances related to certain parts responsible for the smooth operation of an object (e.g. the distance between two axes is a determining factor in the operation of sprocket wheels in a gear assembly)

❖ The Technological World (cont.)

General concept: Graphical language (cont.)

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Developments: prism, cylinder, pyramid, cone	• Associates the development of three-dimensional shapes with the construction of objects from sheet stock (e.g. cardboard boxes, metal air ducts) • Draws developments of simple solids (e.g. pyramid, cylinder, cube)
Standards and representations: diagrams and symbols	• Chooses the appropriate type of diagram for a given representation (e.g. uses a technical diagram to represent assembly solutions, a design plan to represent the operation of an object) • Represents different types of motion related to the operation of an object using the appropriate symbols (rectilinear translation, rotation, helical)

General concept: Mechanical engineering

The design or analysis of a technical object or technological system is based on fundamental concepts of mechanics and on processes specific to the field of engineering.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Typical functions	• Explains the choice of a type of link in a technical object (e.g. using a screw makes it possible to attach and remove a battery case)
Guiding controls	• Explains the choice of a type of guiding control in a technical object (e.g. the slide guides a drawer and reduces friction)
Mechanical links	• Describes the characteristics of the links in a technical object (direct or indirect, rigid or flexible, removable or non-removable, partial or complete) • Determines the desirable characteristics of links in the design of a technical object • Judges the choice of assembly solutions in a technical object
Freedom of movement of a part	• Explains the purpose of limiting motion (degree of freedom) in a technical object (e.g. some hinges limit how far a cupboard door can open, preventing it from hitting the wall)
Adhesion and friction of parts	• Describes the advantages and disadvantages of the adhesion and friction of parts in a technical object
Construction and characteristics of motion transmission systems: friction gears, pulleys and belt, gear assembly, sprocket wheels and chain, wheel and worm gear	• Explains the choice of motion transmission system in a technical object (e.g. using a gear assembly rather than friction gears to get better engine torque and avoid slipping)
Construction and characteristics of motion transformation systems: screw gear system, connecting rod, crank and slide, rack and pinion, cam and roller, eccentrics	• Explains the choice of motion transformation system in a technical object (e.g. most car jacks use a screw gear system rather than a rack-and-pinion system, because the force of the arm on the small crank provides more thrust and because, given that it is non-reversible, the system is safer) • Distinguishes between cams and eccentrics
Resisting torque, engine torque	• Explains speed changes in a technical object using the concepts of resisting torque and engine torque

❖ The Technological World (cont.)

General concept: Materials

The fact that it is possible to change the properties of matter is 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.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Characteristics of mechanical properties	• Explains the choice of a material based on its properties (e.g. the malleability of aluminum makes it useful for making thin-walled containers)
Constraints: deflection, shearing	• Describes the constraints to which different technical objects are subject: deflection, shearing (e.g. a diving board is subject to deflection)
Types and properties:	
- plastics (thermosetting)	• Associates the use of plastics with their respective properties (e.g. Bakelite is used to mould electrical parts because it is a good electrical insulator)
- ceramics	• Associates the use of ceramics with their respective properties (e.g. ceramics are used in ovens because they are very hard, and heat and wear resistant)
- composites	• Associates the use of composites with their respective properties (e.g. carbon fibre is used for hockey sticks because of its hardness, resilience and lightness)
Heat treatments	• Defines heat treatments as a way of changing the properties of materials (e.g. quenching increases hardness but fragility as well)
Modification of properties: degradation, protection	• Describes different treatments to prevent the degradation of materials (e.g. metal plating, antirust treatments, painting)

General concept: Manufacturing

The concepts associated with manufacturing are important prerequisites. They serve as references for the use of different techniques.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Characteristics of laying out	• Associates laying out with saving materials, shaping techniques and the types of materials used
Machining:	
- characteristics of drilling, tapping, threading and bending	• Describes the characteristics of the tools needed to shape a material (e.g. the tip of a metal drill is conical, while that of a wood drill is double fluted)
Measurement and inspection:	
- direct measurement (vernier calipers)	• Explains the choice of the direct measuring instrument used (a vernier caliper is more precise than a ruler)

❖ The Technological World (cont.)

General concept: Manufacturing (cont.)

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Measurement and inspection (cont.): - control, shape and position (plane, section, angle)	• Associates quality control techniques (indirect measurement) for materials and technical objects with the desired degree of precision (e.g. the shape of a musical instrument is validated using a three-dimensional digitizer to ensure the proper sound)

❖ The Material World

General concept: Force and motion

Matter in our environment is subject to different forces. Whether they are gravitational, electrical, magnetic or frictional, when these forces act on a body, they cause deformation and modify its state of motion.

Practically speaking, no mechanical system is subject to only one force. In general, several forces act simultaneously on a body. The result of these forces is a virtual force that produces the same dynamic effect as the forces acting simultaneously. When the resultant of the forces is nil, the body is in equilibrium. Everything is as if there were no forces acting on it. The state of movement of the body does not change: its speed remains constant (sometimes nil).

Adult learners will examine the effect of the force of gravity on a mass and learn to distinguish between mass and weight.

Note: *Cases in which the action of a force causes a change in direction of velocity will not be considered, nor will cases of uniform acceleration.*

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Force	• Describes the effects produced by a force (change in the state of motion of a body, distortion of a body)
Types of forces	• Recognizes different types of forces in technical objects or technological systems (e.g. gravitational force in a chute, magnetic force exerted by an electromagnet)
Equilibrium of two forces	• Describes the conditions under which a body subjected to two forces can be in equilibrium
Relationship between constant speed, distance and time	• Qualitatively describes the relationship between speed, distance and time • Applies the mathematical relationship between constant speed, distance and time
Relationship between mass and weight	• Qualitatively describes the relationship between mass and weight • Applies the mathematical relationship between mass and weight

❖ The Material World (cont.)	
General concept: Fluids Human beings have demonstrated boundless ingenuity in the construction of floating and flying devices. Through research and experiments on prototypes, adult learners must learn to recognize the forces at work and examine their impact. They consider adjustments that might help control movement and ensure lift. **Note:** *These following principles will be studied qualitatively.*	
Compulsory concepts	**KNOWLEDGE TO BE ACQUIRED**
Archimedes' principle	• Describes the relationship between the weight of the water displaced by an immersed body and the upward acting force • Explains the buoyancy of a body in terms of Archimedes' principle
Pascal's law	• Recognizes technical objects or technological systems whose operation is based on Pascal's law (e.g. hydraulic and pneumatic systems)
Bernoulli's principle	• Describes the relationship between the velocity of a fluid and its pressure • Explains the concept of lift in terms of Bernoulli's principle

2. Techniques

The techniques presented here are grouped in three categories. Many of these techniques require the use of instruments and tools. Safety and the use of safety equipment in the workshop must be a constant concern for all those using such techniques.

In the Workshop	
Techniques	**KNOWLEDGE TO BE ACQUIRED**
Graphical language	
- Producing a graphic representation using instruments (development)	• Uses instruments to draw a development
- Drawing schematic diagrams	• Chooses the best view to describe a technical object • Indicates all the information needed to explain the operation or construction of an object
- Using vector graphic software	• Uses vector graphic software to draw different diagrams in two or three dimensions (e.g. drawing toolbar in Word)
Manufacturing	
- Safely using machines and tools	• Uses tools safely (e.g. retractable utility knife, hammer, screwdriver, pliers) • Uses machine tools safely (e.g. band saw, drill, sander)
- Machining	• Forms the part in accordance with the steps in the machining processes (e.g. stripping, splicing, soldering)
- Finishing	• Performs the necessary operations to finish a part (e.g. grinds, polishes, hammers or chisels metal parts)

In the Laboratory or Workshop	
Techniques	**KNOWLEDGE TO BE ACQUIRED**
Manufacturing (cont.)	
- Performing verification and control tasks	• Evaluates the dimensions of a part during and after construction using a ruler • Compares the real dimensions of a part with the specifications (e.g. draft, drawing, technical sheet) • Uses a template to verify the conformity of a part • Evaluates the dimensions of a part during and after construction using vernier calipers
- Making a part	• Makes a part using the appropriate techniques
Measurement	
- Using measuring instruments	• Uses measuring instruments appropriately (e.g. vernier caliper)
- Checking the reliability, accuracy and sensitivity of measuring instruments	• Takes the same measurement several times in order to verify the reliability of the instrument used • Carries out the necessary operations to ensure the accuracy of a measuring instrument (e.g. cleans and calibrates a balance, dries a graduated cylinder, conditions a pH meter) • Takes the sensitivity of a measuring instrument into account (e.g. uses a 25-mL graduated cylinder rather than a 100-mL cylinder to measure 18 mL of water)
- Interpreting measurement results (significant digits, measurement errors)	• Determines the margin of error attributable to a measuring instrument (e.g. the error in a measurement made using a graduated cylinder is provided by the manufacturer or corresponds to half of the smallest division on the scale) • Expresses a result with a number of significant figures that takes into account the errors related to the measure (e.g. a measurement between 10.3 and 10.4 cm, taken with a ruler graduated in millimetres, should be expressed as 10.35 cm or 103.5 mm)

B) CULTURAL REFERENCES

Cultural references make learning situations more meaningful. The following table presents some of the references related to this course.

<table>
<tr><th colspan="5">Cultural References</th></tr>
<tr><td>Technical objects, technological systems, processes and products</td><td colspan="4">– Agricultural machinery
– Petroleum industry equipment: extraction, refining, distribution, use
– Turbines
– Electric power plants, wind turbines
– Printing equipment
– Automobile, hybrid vehicles, bicycle
– Hot air balloons, zeppelins
– Vessels: boat, submarine, air-cushion vehicle
– Airplane
– Manufactured goods in general
– Instruments and devices: scale, clock
– Tools: hand, electric, air, hydraulic
– Machines: agricultural machinery, diggers, machine tools
– Systems: mechanical, electrical, hydraulic, pneumatic, electronic
– Everyday objects: household appliances, locks, faucets, furniture, pumps, skis, musical instruments, toys
– Loom and sewing machine
– Aerial tramway
– Elevator
– Escalator</td></tr>
<tr><th>Area</th><th>Scientists</th><th>Community Resources</th><th>Applications</th><th>Events</th></tr>
<tr><td>The Technological World</td><td>Leonardo da Vinci
Joseph Brown and Lucian Sharp
Le Corbusier
Rudolph Diesel
Henry Ford
Frederick Winslow Taylor</td><td>Canadian Intellectual Property Office
Canadian Patent Database
Ordre des ingénieurs du Québec</td><td>Production line
Interchangeability of parts
Robotics
Remote sensing
Street lights
Clothing
Road network</td><td>Industrial Revolution
Establishment of labour standards
Globalization</td></tr>
<tr><td>The Material World</td><td>Archimedes
Thomas Edison
Blaise Pascal
Orville and Wilbur Wright
Sir Isaac Newton
Albert Einstein</td><td>Faculties of Science and Engineering
Museums of science and technology</td><td>Automobile industry
Means of transportation
Water purification systems</td><td>Breaking of the sound barrier
Construction of dams
Construction of wind farms</td></tr>
</table>

FAMILIES OF LEARNING SITUATIONS

The learning situations in this course, derived from the *Research* and *Expertise* families, involve technological applications aimed at enhancing human strength and general concepts related to *The Material World* and *The Technological World*. The following paragraphs contain examples of tasks that could be assigned to adult learners in learning situations involving different combinations of general concepts.

In a situation involving force, motion, fluids, materials, mechanical engineering and graphical language, adult learners could design an object taking into account the effects of corrosion, oxidation and wear on chosen materials. They could also point out forces in accordance with Pascal's law, verify the application of Archimedes' principle on a body, or analyze the mechanical engineering of a technological system in the workshop and produce the related technical drawing.

In a situation involving graphical language, force, motion and manufacturing, adult learners could try to solve a technological problem. In a technological design process, they could decide on the complex mechanical function to be used to transform lateral motion into rotational motion, then measure, lay out, shape, machine and inspect the necessary parts.

In the learning situation described below, the main tasks help adult learners develop the first and third competencies. This situation therefore belongs to the *Research* family.

BROAD AREAS OF LEARNING

Learning situations will have more meaning for adult learners if they are related to the broad areas of learning. All of the broad areas of learning are readily applicable to the learning situations for course TSC-4063-2. The example below reflects the educational aim of the broad area of learning *Career Planning and Entrepreneurship*.

Broad Areas of Learning
Health and Well-Being
Career Planning and Entrepreneurship
Environmental Awareness and Consumer Rights and Responsibilities
Media Literacy
Citizenship and Community Life

EXAMPLE OF A LEARNING SITUATION

FLYING MACHINE

You decide to participate in a contest to make a flying machine powered only by human force. To do so, you must design and build a machine that will be launched from a ramp eight metres above the surface of a lake. The rules are clear: no catapults, rubber bands or batteries. The airplane motor you bought at a yard sale would have been fantastic! But you must push, pull or pedal your machine to win. You are now designing your flying machine.

Follow the steps in a technological design process. Your flying machine must include technical drawings, technical diagrams and design plans, as well as a history of flying machines. You will build a prototype with the materials made available to you, then test and validate your solution. By explaining the relevant scientific principles, you must demonstrate how you will make sure your machine stays in the air long enough to win the contest.

END-OF-COURSE OUTCOMES

Learning situations are administered on the premise that the adult learner will become familiar with an investigative process involving the technological design process, the observation of technological applications, the experimental method, modelling or documentary research. The learning situations also enable adult learners to apply their problem-solving skills and knowledge, and to produce messages.

Adult learners engaged in the process of solving an open problem related to the design of a technical object or technological system develop a representation of the problem or need in question after reading and interpreting technical drawings, specifications or a manufacturing process sheet. They establish a plan of action based on the chosen solution, relying on their knowledge of force and motion or fluids, and combine materials or mechanical components. They produce design plans or technical diagrams and a development drawing of a simple shape, or determine the operations, manual tools or machine tools and the manufacturing techniques to be used as well as the machining characteristics to be taken into account. In the workshop or the machine shop, they develop a plan of action to construct a prototype, control the quality of the parts and their motion, and make the necessary adjustments. They present a complete and functional prototype in accordance with the need expressed and the constraints established. They explain the changes made to the plan of action or prototype.

Adult learners studying a technological application formulate questions pertaining to the contextual elements presented and identify the principles related to fluids of the types of motion or speed changes needed for the application to work properly. Using diagrams, concepts, laws or models, they explain the related issues and determine the forces involved or the degree of freedom of the parts and their effect. Using their scientific and technological knowledge, they assess the mechanical functions or materials used to make the movable parts of the application and, if applicable, suggest improvements.

EVALUATION CRITERIA FOR SUBJECT-SPECIFIC COMPETENCIES

Evaluation Criteria for Competency 1	Evaluation Criteria for Competency 2	Evaluation Criteria for Competency 3
▪ Appropriate representation of the situation ▪ Development of a suitable plan of action ▪ Appropriate implementation of the plan of action ▪ Development of relevant explanations, solutions or conclusions	▪ Appropriate interpretation of the issue ▪ Relevant use of scientific and technological knowledge ▪ Appropriate formulation of explanations or solutions	▪ Accurate interpretation of scientific and technological messages ▪ Appropriate production or transmission of scientific and technological messages

TSC-4064-2

Waste Management

Path:

Environmental Science and Technology

Science and the Environment

INTRODUCTION

The course entitled *Waste Management* is aimed at enabling adult learners to function effectively in learning situations from the *Research* and *Expertise* families that involve the production and elimination of waste generated by the transformation of natural resources and their impact on the environment.

In this course, adult learners will study environmental issues or technological applications involving waste and seek answers or solutions to related problems. They will acquire knowledge about chemical changes, nuclear transformations, the physical properties of solutions and the organization of matter. This knowledge, combined with the knowledge they will acquire in their study of *The Technological World* and *The Earth and Space*, will help them understand the technological processes that can limit the contamination of the lithosphere, hydrosphere and atmosphere. In addition, by acquiring knowledge related to *The Living World* (e.g. ecotoxicology and the concept of ecological footprint), they will become more aware of the impact of pollution generated by waste resulting from the transformation of natural resources.

By the end of this course, in situations involving the production and elimination of waste generated by the transformation of natural resources and their impact on the environment, adult learners will be able to:

- ✓ analyze the impact of domestic and industrial waste on the environment
- ✓ analyze a technological application related to the production or elimination of waste generated by the transformation of natural resources
- ✓ discuss the effects of certain chemical compounds or nuclear waste on the environment
- ✓ explain the formation of chemical compounds using the periodic properties of the elements
- ✓ plan a simple experiment dealing with the physical properties of solutions or chemical changes
- ✓ follow an experimental procedure that deals with the physical properties of solutions or chemical changes
- ✓ write a report on an experiment related to the physical properties of solutions or chemical changes
- ✓ take a stand on the effects of human activity on the biosphere or on the ways used to limit them

SUBJECT-SPECIFIC COMPETENCIES

The following table lists, for each competency, the key features studied in the course. The manifestations of the key features are presented in Appendix 4.

Competency 1 Seeks answers or solutions to scientific or technological problems	Competency 2 Makes the most of his/her knowledge of science and technology	Competency 3 Communicates in the languages used in science and technology
▪ Defines a problem ▪ Develops a plan of action ▪ Carries out the plan of action ▪ Analyzes his/her results	▪ Puts applications or scientific and technological issues in context ▪ Analyzes an application or an aspect of the issue from a scientific point of view ▪ Forms an opinion about the issue	▪ Interprets scientific and technological messages ▪ Produces scientific and technological messages

PROCESSES

The investigative processes enable adult learners to examine issues, solve scientific problems and study applications. The following are the steps in an investigative process:

- Define the problem
- Formulate a hypothesis
- Test the hypothesis
- Draw conclusions and communicate

The most appropriate methods for this course are the experimental method, modelling, documentary research and the observation method. It is during hypothesis testing that these methods become distinguishable. Section 3.5 and Appendixes 1 to 3 present these investigative processes with their respective characteristics.

CROSS-CURRICULAR COMPETENCIES

The cross-curricular competencies supplement the subject-specific competencies. The development of one contributes to the development of the others. Course TSC-4064-2 allows for all the cross-curricular competencies to be put into practice. Some of them, indicated in grey shading in the table below, are especially targeted in the sample learning situation that will be presented in the last part of the course.

Cross-Curricular Competencies			
Intellectual	**Communication-Related**	**Personal and Social**	**Methodological**
Uses information	Communicates appropriately	Achieves his/her potential	Adopts effective work methods
Solves problems		Cooperates with others	Uses information and communications technologies
Exercises critical judgment			
Uses creativity			

SUBJECT-SPECIFIC COMPETENCIES

A) KNOWLEDGE

The compulsory concepts and techniques are presented in the tables in the following two sections.

1. Concepts

❖ The Living World	
General concept: Ecology The ecological footprint is a tool for evaluating the practical impact of human activity on ecosystems in order to provide for the balanced management of resources. It corresponds to the biologically productive surface of the Earth necessary to ensure the standard of living of an individual or a population. Ecotoxicology is the study of the long-term effects of certain chronic pollutants on ecosystems. While a good many contaminants may degrade naturally, others (e.g. phosphates and mercury) accumulate in ecosystems, living organisms, waterways, lakes and ponds. The toxicity of a contaminant depends on its concentration, the characteristics of the environment in which it is released, the nature of the organisms with which it comes into contact, and the duration of exposure. The toxicity threshold is the minimum quantity of contaminant (in milligrams per kilogram of the organism's mass) that will produce a harmful effect on an organism. **Note:** *Adult learners are only required to perform a qualitative analysis of the toxicity of the environment being studied, based on data made available to them.*	
Compulsory concepts	**KNOWLEDGE TO BE ACQUIRED**
Ecological footprint	• Describes the concept of ecological footprint • Explains the usefulness of the concept of ecological footprint
Ecotoxicology: - contaminants	• Defines a contaminant as an agent that causes changes in the physical, chemical or biological properties of an environment or an organism
- bioaccumulation	• Describes bioaccumulation as being the accumulation, in an organism, of a contaminant originating in its environment or food • Explains bioaccumulation in trophic levels (bioamplification)
- bioconcentration	• Defines "bioconcentration" as a special case of bioaccumulation where an organism accumulates a contaminant while in direct contact with its habitat (sources other than its food)
- toxicity threshold	• Defines the toxicity threshold of a substance as the minimum quantity of a substance that can produce a considerable harmful effect on an organism • Describes factors that influence the toxicity of a contaminant (e.g. concentration, characteristics of the environment in which it is released, nature of the organisms with which it comes into contact, duration of exposure)

❖ The Earth and Space

General concept: Biogeochemical cycles

Phosphorus occurs mainly in rocks and is introduced into biological systems through natural erosion processes. Decomposed biological waste can accumulate in large quantities in soil and sediment. The phosphorus cycle is affected by the use of fertilizers, as well as by household and industrial wastewater containing detergents and phosphates.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Phosphorus cycle	• Describes the changes related to the circulation of phosphorus (e.g. erosion of rocks, degradation of fertilizers)

General concept: Lithosphere

The lithosphere contains a wide variety of mineral resources essential to the development of societies, including metals, industrial minerals and construction materials. The use and transformation of minerals, however, have an impact on the environment. Contamination by persistent organic compounds or heavy metals can modify the physical, chemical and biological properties of the soil and affect its fertility. Soil pollution also varies according to the atmospheric deposits resulting from industrial and agricultural activity. In addition, these resources exist in limited amounts, hence the growing need to take another look at residual materials and recycling in general.

Some agricultural and forestry practices reduce the soil's ability to promote the growth of healthy vegetation. Overcutting exposes more soil to erosion and strips the topsoil of essential minerals and microorganisms. The buffering capacity of the soil is its ability to limit pH variations, which enables it to postpone the consequences of contamination. Its measurement is an indicator of the soil's fertility. For example, the gradual acidification of the soil resulting from acid rain gradually reduces its buffering capacity and leads to the introduction of nutrients or heavy metals into the system.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Contamination	• Names contaminants found in the soil
Soil depletion	• Defines the concept of soil depletion • Explains how human activity contributes to soil depletion
Buffering capacity of the soil	• Defines the buffering capacity of the soil as its ability to limit pH variations • Explains the advantages of a soil with good buffering capacity

❖ The Earth and Space (cont.)

General concept: Hydrosphere

An aquatic environment becomes polluted once its balance has been permanently modified either by the introduction of vast quantities of toxic substances or by an increase in water temperature. When pollutants accumulate, they can cause a decline in populations of more fragile species, alter their physiological abilities or degrade the quality of the water to such an extent that it becomes unsafe for drinking. Other pollutants, such as plastics, metals and some pesticides, are not biodegradable, or barely so; these substances harm the organisms that ingest them. The effects of the different pollutants on aquatic environments depend on the nature and concentration of the pollutant, as well as on the characteristics of the ecosystem. An excessive concentration of phosphates or nitrates, for example, may cause the proliferation of cyanobacteria. In some cases, this can result in the production of neurotoxins harmful to living organisms.

Eutrophication is a stage in the natural evolution of a stagnant body of water. The process intensifies in the presence of excessive amounts of nutrients, particularly nitrogen and phosphorus compounds, which accelerate the growth of algae and other plant forms. This increase in biomass, combined with high water temperatures, causes a decrease in the amount of dissolved oxygen and limits the self-cleaning ability of the body of water. This form of degradation is related to agricultural, household and industrial activities (e.g. animal waste, agricultural runoff, wastewater).

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Contamination	• Names contaminants found in water
Catchment area	• Defines a catchment area as a territory surrounding a water system • Describes some of the impacts of human activity on the waterways in a catchment area
Eutrophication	• Explains the natural process of the eutrophication of a body of water • Explains how human activities accelerate the eutrophication of a body of water

General concept: Atmosphere

The different substances emitted during the combustion of fossil fuels have harmful effects at the local, regional and planetary level. Oxides of sulphur, carbon and nitrogen are acid precursors; they contribute to the acidification of precipitation. The air can also be contaminated by solid and liquid suspended particles (e.g. dust, pollen, soot, smoke, droplets) that affect the respiratory system. A biome located far away from the emission of gases can become contaminated. Prevailing winds foster the circulation of contaminants in the atmosphere.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Contamination	• Names contaminants found in the air
Atmospheric circulation: prevailing winds	• Describes the effect of prevailing winds on the dispersion of pollutants in a given region

❖ The Material World

General concept: Organization of matter

This section examines the properties of the main families in the periodic table and of metals, non-metals and metalloids. This type of classification makes it possible to predict the behaviour of matter. In the periodic table, the elements are classified in increasing order by atomic number. This number designates the number of protons in the nucleus and makes it possible to differentiate among the elements. This classification (with a few irregularities) is based on increasing atomic mass, the relationships between elements with similar chemical properties and the periodicity of certain physical and chemical properties of the elements.

Some atoms of a given element, called isotopes, differ from the others in the number of neutrons they have and, therefore, in their atomic mass. They occupy the same place in the periodic table because they have the same atomic number and the same chemical properties. Isotopes are naturally occurring, but they can also be produced in the laboratory or in industrial settings.

The number of the family in the periodic table indicates the number of valence electrons the element has. Lewis notation represents the valence electrons in an element. It makes it easier to understand the combination of atoms in a molecule. This information enables us to predict certain behaviour by comparing atomic structure with the properties of the elements. The concept of mole and Avogadro's number are addressed to enable adult learners to calculate the quantitative relationships between reagents and products in chemical reactions.

Compulsory concepts	**KNOWLEDGE TO BE ACQUIRED**
Periodic table:	
- groups (families) and periods	• Locates the groups and periods in the periodic table • Describes the common characteristics of a family (e.g. number of valence electrons, chemical reactivity) • Associates the number of electronic shells in an element with the number of its period
Simplified atomic model	• Represents an atom of an element using the simplified atomic model
Atomic number	• Associates the atomic number of an element with the number of protons it has
Relative atomic mass	• Describes the concept of relative atomic mass
Periodicity of properties	• Describes the periodicity of certain properties of the elements (e.g. chemical reactivity, atomic radius, electronegativity)
Isotopes	• Defines an isotope as the atom of an element where the nucleus contains a different number of neutrons giving the atom a different atomic mass • Defines a radioactive isotope as an isotope that has an unstable nucleus
Lewis notation	• Determines the number of valence electrons in an element • Represents atoms using Lewis notation
Polyatomic ions	• Recognizes common polyatomic ions (e.g. NH_4^+, OH^-, NO_3^-, CO_3^{2-}, SO_4^{2-}, PO_4^{3-}) by their name, their formula or their composition
Nomenclature and notation rules	• Applies nomenclature and notation rules to name a molecule or write the molecular formula for binary compounds
Concept of mole	• Defines the concept of mole • Expresses a quantity of matter in moles
Avogadro's number	• Expresses a number of particles using Avogadro's number

❖ The Material World (cont.)

General concept: Physical properties of solutions

The fact that many substances dissolve in water is essential to understanding biological and environmental phenomena. Aqueous solutions are common in the environment, and their properties are measurable and observable. 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. In the *Climate Change* course, adults learned to measure concentration in parts per million (ppm), as a percentage (%) and in grams per litre (g/L). In this course, they learn to measure concentration in moles of solute per litre of solution (mol/L).

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Solubility	• Defines the concept of solubility
Strength of electrolytes	• Qualitatively speaking, associates the strength of an electrolyte with its degree of dissociation
Concentration in mol/L	• Determines the concentration of an aqueous solution (mol/L) • Converts a concentration (g/L, percentage or ppm) into mol/L

General concept: Chemical changes

After studying the concepts of oxidation, acid-base neutralization, combustion, photosynthesis and respiration in the *Climate Change* course, adult learners examine precipitation, decomposition and synthesis in this course. These chemical reactions show that the atoms of different elements and ions have the ability to bond with other atoms depending on their atomic structure.

Stoichiometry is the calculation of quantities of matter (in moles and grams) involved in a chemical reaction.

In a chemical reaction, atoms tend to acquire the peripheral electronic structure of the closest inert gas. This ability to gain, lose or share electrons is determined by the number and arrangement of the electrons in the atoms.

Note: *Stoichiometric calculations are based on the assumption that the chemical reactions are complete. Transition elements are not considered in the study of the different types of bonds.*

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Precipitation	• Represents a precipitation reaction using the particle model
Oxidation	• Associates oxidation reactions with chemical equations in which oxygen gas is one of the reagents
Decomposition and synthesis	• Associates known chemical reactions with decomposition or synthesis reactions (e.g. respiration, photosynthesis, combustion, digestion)
Acid-base neutralization reaction	• Recognizes an acid-base neutralization reaction based on its equation
Salts	• Determines the molecular formula of the salt formed during an acid-base neutralization reaction

❖ The Material World (cont.)

General concept: Chemical changes (cont.)

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Stoichiometry	• Determines the quantity of reagents or products using stoichiometric calculations
Types of bonds: - covalent	• Defines a covalent bond as a bond involving the sharing of electrons • Represents a covalent bond schematically • Identifies molecules containing covalent bonds (e.g. N_2, CO_2)
- ionic	• Defines an ionic bond as a bond involving the gain or loss of an electron • Represents an ionic bond schematically • Identifies molecules containing ionic bonds (e.g. NaCl, NH_4OH) • Associates the presence of an ionic bond with an electrolytic substance

General concept: Nuclear transformations

Changes in matter are considered “nuclear” when they occur in the nucleus of the atom (review the simplified atomic model studied in course TSC-4061-2). During these transformations, the cohesive strength of the nucleons is insufficient to maintain the stability of the nucleus. New nuclei are created (heavier in the case of fusion and lighter in the case of fission or disintegration), particles travel at great speed (kinetic energy) and vast quantities of energy are emitted in the form of radiation. Nuclear energy has enormous potential. However, while radioactive substances have undeniable advantages, their radiation has a definite impact on health.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Nuclear stability	• Defines “nuclear stability” as the cohesion of the nucleus resulting from the fact that an atom has an optimal number of neutrons
Fission and fusion	• Distinguishes between nuclear fusion and nuclear fission
Radioactivity	• Defines “radioactivity” as the emission of particles or energy by the nuclei of atoms following nuclear transformations • Associates the use of radioactivity with technological applications (e.g. radiation therapy, carbon dating)

❖ The Technological World

General concept: Biotechnology

Decontamination processes involve a series of steps consisting of physical, physicochemical and biological treatments. In certain cases, other treatments are necessary (e.g. addition of a disinfecting reagent, use of ultraviolet radiation, ozonation) when the water ends up in a particularly sensitive area. Biological soil decontamination, wastewater and air purification treatments use plants or microorganisms to degrade various pollutants. The main characteristics of an effective decontaminant include the ability to transform a wide range of chemical compounds, to absorb pollutants and to tolerate toxic substances.

No treatment can fully decontaminate soils.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Wastewater treatment	• Describes the treatments used to decontaminate wastewater
Biodegradation of pollutants	• Describes methods of biodegrading pollutants (e.g. phytoremediation)

2. Techniques

The techniques presented here are grouped in two categories. Many of these techniques require the use of instruments and tools or chemicals. Safety and the use of safety equipment in the workshop and laboratory must be a constant concern for all those using such techniques.

In the Laboratory or Workshop	
Techniques	**KNOWLEDGE TO BE ACQUIRED**
Experimentation	
- Safely using materials and equipment	• Uses laboratory materials and equipment safely (e.g. allows hotplate to cool, uses beaker tongs) • Handles chemicals safely (e.g. uses a spatula and a pipette filler)
- Preparing solutions	• Prepares an aqueous solution of a specific concentration given a solid solute • Prepares an aqueous solution of a specific concentration given a concentrated aqueous solution
- Collecting samples	• Collects samples appropriately (e.g. sterilizes the container, uses a spatula, refrigerates the sample)
Measurement	
- Using measuring instruments	• Chooses the appropriate measuring instrument • Uses measuring instruments appropriately (e.g. volumetric flask, pipette, pH meter)
- Checking the reliability, accuracy and sensitivity of measuring instruments	• Takes the same measurement several times in order to verify the reliability of the instrument used • Carries out the necessary operations to ensure the accuracy of a measuring instrument (e.g. cleans and calibrates a balance, dries a graduated cylinder, conditions a pH meter) • Takes the sensitivity of a measuring instrument into account (e.g. uses a 25-mL graduated cylinder rather than a 100-mL graduated cylinder to measure 18 mL of water)
- Interpreting measurement results (significant digits, measurement errors)	• Determines the margin of error attributable to a measuring instrument (e.g. the error in a measurement made using a graduated cylinder is provided by the manufacturer or corresponds to half of the smallest division on the scale) • Expresses a result with a number of significant figures that takes into account the errors related to the measure (e.g. a measurement between 10.3 and 10.4 cm, taken with a ruler graduated in millimetres, should be expressed as 10.35 cm or 103.5 mm)

B) CULTURAL REFERENCES

Cultural references make learning situations more meaningful. The following table presents some of the references related to this course.

Cultural References				
Technical objects, technological systems, processes and products	– Radiation therapy equipment, magnetic resonance imaging, etc. – Petroleum: well, platform, refining processes – Pollutant analyzers: passive diffusion tube, quartz microbalance, beta radiation detector – UV photometric measurement through infrared correlation – Chromatographs, gravimeter, barometer, hygrometer, anemometer – Air exchanger, water softener – Processes for obtaining biofuels (oleaginous, ethyl, gaseous, solid) – Particle filters, antipollution systems on motor vehicles – Smokestack scrubber – Wastewater treatment plant, wastewater purification processes (lagooning or natural filtration using microorganisms) – Drinking water treatment plant, drinking water purification processes (e.g. filtration, ozonation, boiling, distillation, photo-oxidation) – Sorbent barriers, circular brush skimmer, oleophilic rollers (beach), screen (sand) – Physicochemical depollution (dissolution of pollutants): vacuum extraction, injection, flotation treatment, etc. – Biological decontamination: processes using bacteria – Phytorestoration (plant bioremediation)			
Area	**Scientists**	**Community Resources**	**Applications**	**Events**
The Living World	Rachel Louise Carson	Health Canada (Environmental and Workplace Health) Montréal Biodôme Wastewater treatment plants	Environmental protection	
The Earth and Space		Geological Survey of Canada Mining Natural Resources Canada Greenpeace BGS (Brundtland Green Schools) Recyc-Québec	Decontamination activities Observation satellites Global positioning systems (GPS) Regulatory Framework for Air Emissions	Meteorological phenomena Earth Summits
The Material World	Henry Cavendish Svante Arrhenius Sir Isaac Newton Dmitri Mendeleev	Museums of natural science International Union of Pure and Applied Chemistry (IUPAC)	Means of transportation	

FAMILIES OF LEARNING SITUATIONS

The learning situations in this course, derived from the *Research* and *Expertise* families, deal with the waste produced by processing natural resources and with the resulting contamination, as well as with general concepts related to different areas. The following paragraphs contain examples of tasks that could be assigned to adult learners in learning situations involving different combinations of general concepts.

In a learning situation involving the atmosphere and chemical changes, adult learners could determine the impact of different gases on the ozone layer in relation to carbon dioxide (CO_2). They could also illustrate relationships between the composition of air and certain chemical reactions that take place there.

A learning situation could involve the chemical transformation of matter and the contamination of the lithosphere, atmosphere and hydrosphere. In the laboratory, adult learners could analyze the effects of different chemicals on different terrestrial systems or find information about the methods used to deal with problems such as smog, acid rain, the contamination of soil and drinking water, and the bioaccumulation of contaminants.

In a learning situation involving nuclear transformations, the lithosphere, the hydrosphere and the atmosphere, adult learners could analyze the circulation of nuclear contaminants between these different systems or model the circulation of prevailing winds to explain why the contaminants can be found far from their source.

Once they have learned about the biodegradation of pollutants and nuclear transformations, adults could, in a learning situation, take a position on the conceptual, ethical and practical aspects of technological processes that produce nuclear waste, analyze possible solutions to the problem of environmental pollutants or compare and evaluate the quality of decontamination processes.

In the learning situation described below, the main tasks help adult learners develop the first and third competencies. This situation therefore belongs to the *Research* family.

BROAD AREAS OF LEARNING

Learning situations will have more meaning for adult learners if they are related to the broad areas of learning. All of the broad areas of learning are readily applicable to the learning situations for course TSC-4064-2. The example below reflects the educational aim of the broad area of learning *Environmental Awareness and Consumer Rights and Responsibilities.*

Broad Areas of Learning
Health and Well-Being
Career Planning and Entrepreneurship
Environmental Awareness and Consumer Rights and Responsibilities
Media Literacy
Citizenship and Community Life

EXAMPLE OF A LEARNING SITUATION

RECLAIMING TERRITORY

Your municipality is in the news. A group of citizens wants to have a vacant lot decontaminated. Fifty years ago, it was the site of sustained industrial activity. Today, it still contains waste from times past and traces of suspicious chemicals sometimes leach from the soil after a heavy rainfall. The public is concerned. The aim is to have the municipality pay to decontaminate the soil and transform the lot into a soccer field.

To determine the feasibility of the project, the citizens' group asks you to help it identify the contaminants present in the soil.

Your job is to:

- make a list of the substances used or dumped on the site when it was an industrial area
- identify those that are hazardous or toxic
- collect soil samples at different locations and at different depths
- find the best way, given the equipment available, of identifying hazardous or toxic substances in the samples collected
- analyze the samples
- report to the citizens' group on the results of your analyses and your conclusions concerning the nature of the contaminants found and the hazard they represent

END-OF-COURSE OUTCOMES

Learning situations are administered on the premise that the adult learner will become familiar with an investigative process involving the experimental method, modelling, documentary research or the observation method. The learning situations also enable adult learners to apply their problem-solving skills and knowledge, and to produce messages.

Adult learners engaged in the process of solving an open problem related to the production or elimination of waste resulting from the transformation of natural resources develop a representation of the problem in question after reading and interpreting scientific and technical messages. They establish a simple experimental procedure or a modelling technique based on the chosen hypothesis, relying on their knowledge of ecology, the physical properties of solutions or chemical changes. They carry out the steps in their plan of action. During these activities, they handle solutions of different concentrations, or adjust the steps in their plan, using the appropriate techniques. In a report, they give an answer that takes their results into account and verify whether their analysis of the results corresponds to their initial hypothesis.

Adult learners studying an environmental issue or technological application related to the production or elimination of waste formulate questions related to the contextual elements presented. They identify the characteristics of the issue or application as they relate to the physical properties of the solutions in question or chemical changes. Using concepts, laws, theories or models, they explain a related issue, illustrate the chemical reactions involved, describe the chemical elements at play and determine the quantity of products and reagents involved. Using their scientific and technological knowledge, they take a stand on different ways of limiting the impact of household or industrial waste on the environment.

EVALUATION CRITERIA FOR SUBJECT-SPECIFIC COMPETENCIES

Evaluation Criteria for Competency 1	Evaluation Criteria for Competency 2	Evaluation Criteria for Competency 3
▪ Appropriate representation of the situation ▪ Development of a suitable plan of action ▪ Appropriate implementation of the plan of action ▪ Development of relevant explanations, solutions or conclusions	▪ Appropriate interpretation of the issue ▪ Relevant use of scientific and technological knowledge ▪ Appropriate formulation of explanations or solutions	▪ Accurate interpretation of scientific and technological messages ▪ Appropriate production or transmission of scientific and technological messages

Appendixes

Appendix 1

Exploration and analytical strategies enable the adult learner to progress more effectively toward an answer or solution when using an investigative process.

Exploration 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 • Anticipating the results of a process • Developing various scenarios • Exploring various possible solutions • Considering various points of view on scientific or technological issues

Analytical Strategies
• Determining the constraints and important elements involved in solving a problem • Dividing a complex problem into simpler subproblems • Using different types of reasoning (e.g. inference, 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 • Generalizing from particular cases that are structurally similar • Selecting relevant criteria that help determine where one stands on a scientific or technological issue

Appendix 2

The following table illustrates the similarity of the tasks at each step of the investigative process, depending on whether the problems related to either family of situations are scientific or technological.

Investigative Process		
	Science	**Technology**
Steps	**Examples**	
Define the problem or need	Identify the relevant information. Find the related concepts. Use personal theoretical knowledge, theoretical knowledge drawn from documents, previous experiments, past experience or logic.	
Formulate a hypothesis	Develop questions based on different facts. Make analogies or try to predict results. Establish causal relationships. Propose a model.	Identify design or operating solutions. Draw sketches.
Test the hypothesis	Prepare and make observations, conduct an experiment, build a model or do documentary research to prove or disprove the initial hypothesis.	Make design plans or technical diagrams. Prepare the manufacturing and evaluation process for the prototype. Conduct a technological analysis.
Draw conclusions	Express understanding of the facts. Develop an explanation or a new model or theory.	Report on the quality of the design, operation and manufacturing solutions selected.
Communicate	Formulate an answer, solution, explanation, model or opinion.	Formulate a solution, explanation or opinion, or produce a technical information package.

Appendix 3

Scientific methods for testing a hypothesis

Modelling	
Modelling consists in constructing a concrete representation of an abstract situation that is difficult to observe or impossible to see. A model must help people understand a given reality, explain certain properties of what it attempts to represent and help people predict new phenomena. The model can take different forms: a text, a drawing, a mathematical or chemical formula or equation, a software program or a scale model.	
Steps	**Examples**
1. Develop a model	- Identify the components and the relationships between them - Choose the method of representation
2. Build the model	- Make a scale model or a diagram - Derive a mathematical relation
3. Validate the model	- Identify possible contradictions and inconsistencies - Verify the model's validity - Make changes or go back to the preceding steps, if necessary

Observation Method	
The scientific observation method helps the observer to interpret facts on the basis of predetermined criteria and generally accepted elements within a given field. In light of the information collected, the observer gains a new understanding of the facts, which is inextricably linked to the context in which the observations were made. Based on the way he/she interprets and organizes information, the observer reinterprets the world, taking into consideration his/her prior knowledge and the conceptual schemes that he/she applies to the facts observed.	
Steps	**Examples**
1. Plan the observation	- Determine the observation criteria - Prepare an observation checklist
2. Gather information	- Gather information, referring to the observation criteria
3. Interpret the information	- Organize the information in order to explain the phenomenon or the situation - Make connections between the items of information gathered

Experimental Method	
The experimental method involves the development of an experimental procedure that includes the identification of a certain number of variables. 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 allows adults learners to raise new questions, to formulate other hypotheses, to adjust the experimental procedure and to take the limitations of the experiment into account.	
Steps	**Examples**
1. Plan an experiment	- Determine the possible variables - Determine the variable to be measured - Break the experiment down into steps
2. Conduct the experiment	- Prepare an apparatus for the experiment - Perform a set of tasks - Make observations or take measurements
3. Interpret the results	- Process the data collected - Establish relationships - Discuss possible errors

Documentary Research	
Documentary research is a methodical procedure for collecting and interpreting information. The researcher must define his or her goal and know what type of documents he or she is looking for, where to find them and how to choose the appropriate ones. The aim is to construct a solid argument based on facts from reliable sources.	
Steps	**Examples**
1. Plan the research	- Choose the sources to consult - Decide on the type of document to look for, key words and search tools - Make a list of words and related terms characterizing your search
2. Consult the literature	- Find the literature - Evaluate its relevance, given the goal of the research - Gather specific information - Establish a preliminary plan for your report
3. Establish a definitive plan for your report	- Flesh out the preliminary plan in light of additional information - Develop your theme, hypothesis, main ideas and secondary ideas

Technological methods for testing a hypothesis

Technological Design Process	
The technological design of a prototype involves finding solutions to operational and construction problems as well as choosing the necessary materials. By carefully examining and testing the prototype, adult learners can evaluate their solution and check it against the requirements in the specifications.	
Steps	**Examples**
1. Study the underlying principles	- Identify concepts and ideas - Find design solutions - Make sketches and produce design plans and drawings
2. Study the prototype's construction	- Determine the appropriate shapes and dimensions - Choose the materials and fasteners - Draw the technical diagram - Develop the manufacturing process for the prototype
3. Build the prototype	- Organize the steps in the manufacturing or assembly process - Assemble the parts - Verify the overall operation of the prototype

Observation Method	
The technological observation method makes it possible to analyze technical objects or technological systems. Technological analysis involves determining the overall function of an object, identifying the different components and their functions, and taking into account its technical characteristics and the applicable scientific principles in order to explain the design or manufacturing solutions adopted.	
Steps	**Examples**
1. Plan the observation	- Prepare what you need to take notes and make drawings - Prepare the tools necessary for assembly and disassembly
2. Gather information	- Determine the overall function of the object - Identify the operating principles - Sketch out a design plan - Draw a technical diagram
3. Interpret the observations	- Comment on the design and manufacturing solutions adopted - Suggest improvements to the application

Appendix 4

Competency 1 Seeks answers or solutions to scientific or technological problems	Competency 2 Makes the most of his/her knowledge of science and technology	Competency 3 Communicates in the languages used in science and technology
Defines a problem • Determines the elements that seem relevant • Determines the relationships between the different elements • Reformulates the problem in terms of scientific and technological concepts • Formulates realistic hypotheses or possible solutions **Develops a plan of action** • Chooses a hypothesis or a solution • Determines the necessary resources • Plans the steps involved in implementing the plan of action **Carries out the plan of action** • Handles equipment and substances and carries out planned operations • Performs tests, if applicable • Gathers data and takes note of observations that may prove useful • Adjusts the plan of action or its implementation, if necessary **Analyzes his/her results** • Processes the data gathered or his/her observations • Looks for significant patterns or relationships • Makes connections between his/her results and scientific and technological concepts • Judges the appropriateness of the answer or solution found • Formulates new hypotheses or solutions, if applicable • Suggests improvements to his/her solution, if applicable	**Puts applications or scientific and technological issues in context** • Defines the contextual aspects of the issue or application (e.g. social, environmental, historical aspects) • Establishes connections between these aspects • Identifies any questions related to the issue or application **Analyzes an application or an aspect of the issue from a scientific point of view** • Recognizes scientific principles related to the aspect of the issue or the application • Describes these principles qualitatively or quantitatively • Makes connections between the principles using concepts, laws, theories or models **Analyzes an application from a technological point of view** • Determines the overall function of the application • Identifies the different components and determines their respective functions • Describes the principles underlying the construction and operation of the application and its components • Makes connections between the principles using concepts, laws, theories or models • Represents the principles in a schematic fashion • Explains the solutions applied in designing or manufacturing the application and its components **Forms an opinion about the issue** • Consults different resources and considers different points of view • Determines the elements that can help him/her form an opinion • Supports his/her opinion with the elements considered • Qualifies his/her opinion, taking others' opinions into account	**Interprets scientific and technological messages** • Places the message in context • Makes sure the sources are reliable • Selects the elements needed to interpret the message • Grasps the precise meaning of words and statements • Establishes connections between concepts and their various graphic or symbolic representations **Produces scientific and technological messages** • Structures his/her message • Uses scientific and technological vocabulary • Uses the symbolic or graphical language associated with science and technology • Adheres to established standards and conventions for the different languages • Demonstrates rigour and coherence • Respects intellectual property rights

Competency 1 Seeks answers or solutions to scientific or technological problems	Competency 2 Makes the most of his/her knowledge of science and technology	Competency 3 Communicates in the languages used in science and technology
	Forms an opinion about the quality of the application • Gathers information about the solutions to be applied in designing or manufacturing an application • Determines the elements that can help him/her form an opinion • Supports his/her opinion with the elements considered • Qualifies his/her opinion, taking others' opinions into account • Suggests improvements, if applicable	

Glossary

A	Answer	Explanation that takes into account the results obtained in the process of solving a scientific problem
B	Biotechnology	Grouping of methods that are characteristic of both the life sciences and technology
C	Concept	Knowledge essential to the development of competencies in science and technology
	Construction principle	Technological concept used to describe the construction characteristics of an application
D	Design	Process for solving technological problems in order to satisfy a need
E	Experimental procedure	Material resources and steps involved in testing a hypothesis
I	Issue	A set of questions that science examines with regard to a particular situation
L	Laboratory	Place where instruments are used to conduct an experiment
M	Machine tool	Machine capable of holding a tool and programming it to trim, cut, drill or reshape a material (band saw, drill press, belt sander) Usually includes a rigid housing, a sliding table, a tool holder, a motor and controls
	Manual tool	Small technical object used alone or in conjunction with a machine in a workshop in order to carry out technological techniques (e.g. set square, compass, screwdriver, hammer, soldering iron, drill)
	Manufacturing process sheet	Series of steps to be carried out (material resources and operations) in order to machine the parts of a technical object
O	Operating principle	Technological concept used to describe the functions of an application and its components
	Operation	Specific use of a manual tool or machine tool to carry out the steps in a manufacturing process sheet
	Overall function	Purpose of a technological application
P	Plan of action	Series of steps or operations requiring resources, used to test a hypothesis or find a possible solution
	Problem	Difficulty to be solved using creativity in order to find an answer or solution In an open problem, the tasks are not all indicated In a well-defined problem, most of the tasks are indicated

	Prototype	Any object or device that is the first example of something that could be mass produced; it can be a design, manufacturing, production, experimental or test prototype

S	Scientific	Having to do with biology, chemistry, physics, geology or astronomy
	Scientific approach	Method by which an application is studied using scientific concepts
	Scientific phenomenon	Observable fact, the understanding of which requires analysis using scientific concepts
	Scientific principle	Basic scientific idea used to describe a phenomenon
	Solution	Technological application designed to meet a need
	Specifications	Description of the overall function of an application and the constraints involved in its design

T	Technique	Specific and precise skills needed to perform a given task
	Technological	Having to do with engineering, materials and technical drawings
	Technological analysis	Technological observation of an application with the intention of identifying the characteristics of its operation and construction
	Technological application	Practical achievement—object, system, product or process—characterized by its construction and operation, its constituent materials and its underlying scientific and technological principles
	Technological approach	Method by which scientific concepts are studied in relation to an application
	Technological field	Technological applications grouped together according to their use (medical, agricultural and agri-food, energy, information and communications, transportation, manufacturing or construction)

W	Workshop	Place where tools are used to observe or construct a technical object

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