TSC-4062-2

Climate Change

Path:

Science and Technology

Applied Science and Technology

Québec

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

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