Éducation, Loisir et Sport Québec

Progression of Learning in Secondary School

Chemistry
Secondary V Optional Program

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Progression of Learning in Secondary School

The progression of learning in secondary school constitutes a complement to each school subject, providing further information on the knowledge that the students must acquire and be able to use in each year of secondary school. This tool is intended to assist teachers in planning both their teaching and the learning that their students are to acquire.

The role of knowledge in learning

The knowledge that young people acquire enables them to better understand the world in which they live. From a very early age, within their families and through contact with the media and with friends, they accumulate and learn to use an increasingly greater body of knowledge. The role of the school should be to progressively broaden, deepen and structure this knowledge.

Knowledge and competencies must mutually reinforce each other. On the one hand, knowledge becomes consolidated when it is used and, on the other hand, the exercise of competencies entails the acquisition of new knowledge. Helping young people acquire knowledge raises the challenging question of how to make this knowledge useful and durable, and thus evokes the notion of competency. For example, we can never be really assured that a grammar rule has been assimilated until it is used appropriately in a variety of texts and contexts that go beyond the confines of a repetitive, targeted exercise.

Intervention by the teacher

The role of the teacher in knowledge acquisition and competency development is essential, and he or she must intervene throughout the learning process. In effect, the *Education Act* confers on the teacher the right to "select methods of instruction corresponding to the requirements and objectives fixed for each group or for each student entrusted to his care." It is therefore the teacher's responsibility to adapt his or her instruction and to base it on a variety of strategies, whether this involves lecture-based teaching for the entire class, individualized instruction for a student or a small group of students, a series of exercises to be done, a team activity or a particular project to be carried out.

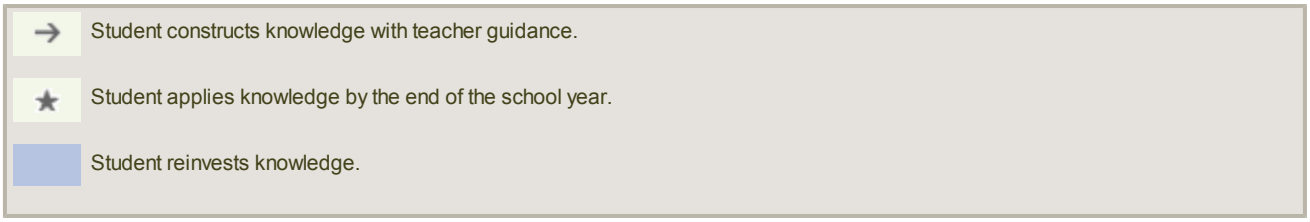
In order to meet the needs of students with learning difficulties, teachers should encourage their participation in the activities designed for the whole class, although support measures should also be provided, when necessary. These might involve more targeted teaching of certain key elements of knowledge, or they might take the form of other specialized interventions.

As for the evaluation of learning, it serves two essential functions. Firstly, it enables us to look at the students' learning in order to guide and support them effectively. Secondly, it enables us to verify the extent to which the students have acquired the expected learning. Whatever its function, in accordance with the *Policy on the Evaluation of Learning*, evaluation should focus on the acquisition of knowledge and the students' ability to use this knowledge effectively in contexts that draw upon their competencies.

Structure

The progression of learning is presented in the form of tables that organize the elements of knowledge similarly to the way they are organized in the subject-specific programs. In mathematics, for example, learning is presented in fields: arithmetic, geometry, etc. For subjects that continue on from elementary school, the *Progression of Learning in Secondary School* has been harmonized with the *Progression of Learning in Elementary School*. Every element of learning indicated is associated with one or more years of secondary school during which it is formally taught.

A uniform legend is used for all subjects. The legend employs three symbols: an arrow, a star and a shaded box. What is expected of the student is described as follows:



An **arrow** indicates that teaching must be planned in a way that enables students to begin acquiring knowledge during the school year and continue or conclude this process in the following year, with ongoing systematic intervention from the teacher.

A **star** indicates that the teacher must plan for the majority of students to have acquired this knowledge by the end of the school year.

A **shaded box** indicates that the teacher must plan to ensure that this knowledge will be applied during the school year.

Chemistry - Secondary V Optional Program

Introduction

This document provides additional information about the learning prescribed in the optional Secondary V Chemistry program. It is intended to help teachers with their lesson planning.

To progress in their learning, students need to do more than merely acquire knowledge. They must also learn to apply their knowledge in a variety of increasingly complex situations. By appropriately using the knowledge, techniques and strategies listed in this document, they will develop the competencies outlined in the Chemistry program. By applying these competencies, they will acquire new knowledge which, in turn, will help them further develop their competencies.

In order to seek answers or solutions to chemistry problems (Competency 1), students must become familiar with strategies and acquire conceptual and technical knowledge that will enable them to define a problem, explore it and then justify their methodological choices and results. Similarly, the appropriate scientific concepts and principles can help them explain phenomena or understand the operation of objects and, consequently, make use of their scientific and technological knowledge (Competency 2). Finally, in order to communicate ideas relating to questions involving chemistry (Competency 3), they must acquire and apply knowledge that will enable them to interpret or produce messages using the languages and types of representations specific to science and technology.

In Secondary Cycle One, students learn about natural phenomena and man-made objects that interest them. In Cycle Two, the concepts are organized around applications connected to seven technological fields, in the Applied Science and Technology General Education Path, or environmental issues in the General Education Path or in the optional programs in Secondary 4.

The four tables in this document outline the knowledge related to the general concepts presented in the chemistry program: gases, energy changes in reactions, reaction rates and chemical equilibrium. Each table is preceded by a text explaining how knowledge of the general concept contributes to the students' learning in chemistry. This is followed by a list of the main concepts studied in Secondary Cycle One and related to this general concept. Lastly, the table itself lists a certain number of statements that refer to subject matter covered during Secondary Cycle Two and that is relevant to the study of concepts in the chemistry program.[1] Two other tables provide information about the appropriate techniques and strategies for students to use.

The concepts are further clarified by a list of statements indicating the degree of complexity of the subject matter targeted and explanations of the progression of learning from one year to the next. In some cases, specifications about the extent of the knowledge to be addressed appear in parentheses.

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1. Only those concepts specific to the Chemistry program are identified by a number.

Chemistry - Secondary V Optional Program

Gases

Studying the behaviour of gases gives students the opportunity to acquire scientific and technical knowledge of phenomena and applications[1] that involve the physical properties of gases.

Over the course of their secondary school education, students have explored increasingly complex phenomena, problems and applications. They have acquired knowledge related to The Material World, The Living World, The Earth and Space and The Technological World. By using the experimental method, modelling and carrying out analysis, they are able to describe, understand and explain the laws and models governing the behaviour of gases. Students learn to apply this new knowledge in a variety of contexts to explain phenomena or make predictions. In this way, they acquire a better understanding of the behaviour of gases in the world around us and of the related applications.

→ Student constructs knowledge with teacher guidance. ★ Student applies knowledge by the end of the school year. Student reinvests knowledge.	Secondary				
	AST	AST – SE	ST	ST – EST	CHE
	3	4	3	4	5
Secondary Cycle One Mass Defines the concept of mass Volume Defines the concept of volume Temperature Describes the effect of heat on the degree of agitation of particles Defines temperature as a measurement of the degree of agitation of particles States of matter Names the different phase changes of matter Characteristic properties Associates a characteristic property of a substance or material with its use (e.g. metal is used to make pots because it is a good conductor of heat) Physical Changes Recognizes different physical changes Molecule Describes a molecule using Dalton's atomic model (combination of atoms linked by chemical bonds)					
Secondary Cycle Two Only those concepts specific to the Chemistry program are identified by a number. Light blue shading indicates that the student acquired this knowledge in Secondary III or IV.					
1. Chemical properties of gases					
a. Reactivity					
i. Associates the use of certain gases in various applications with their chemical reactivity (e.g. argon in light bulbs, nitrogen in bags of chips, acetylene in welding torches)					★
Compressible and incompressible fluids					
Distinguishes between compressible and incompressible fluids	★		★		
2. Physical properties of gases					
a. Kinetic theory					
i. Explains the macroscopic behaviour of a gas (e.g. compressibility, expansion, diffusion) using kinetic theory					★
Pressure					
Defines pressure as the force exerted by particles when they collide with a constricting surface	★		★		
Describes qualitatively the main factors that affect the pressure exerted by a fluid	★		★		

Relationship between pressure and volume					
Describes qualitatively the relationship between the pressure and volume of a gas (e.g. inhaling and exhaling, bicycle pump)	★		★		
Avogadro's number					
Expresses a quantity of particles using Avogadro's number				★	
Concept of the mole					
Defines the mole as the unit of measure of the amount of a substance		★		★	
Expresses an amount of a substance in moles		★		★	
b. General gas law					
i. Determines the relationship between the pressure of a gas and its volume when the temperature and number of moles of gas are kept constant					★
ii. Determines the relationship between the pressure of a gas and its temperature when the number of moles of gas and the volume are kept constant					★
iii. Determines the relationship between the volume of a gas and its temperature when the pressure and the number of moles of gas are kept constant					★
iv. Determines the relationship between the pressure of a gas and the number of moles of that gas when the volume and temperature are kept constant					★
v. Determines the relationship between the volume of a gas and the number of moles of that gas when the temperature and pressure are kept constant					★
vi. Applies the mathematical relationship between the pressure, volume, number of moles and temperature of a gas ($p_1V_1/n_1T_1 = p_2V_2/n_2T_2$)					★
c. Ideal gas law					
i. Explains qualitatively the relationship between the factors affecting the behaviour of gases (pressure, volume, number of moles, temperature) in a given situation (e.g. a balloon exposed to cold, the operation of a bicycle pump)					★
ii. Applies the mathematical relationship between the pressure, volume and number of moles of a gas, the ideal gas constant and the temperature of a gas ($pV = nRT$)					★
d. Dalton's law					
i. Explains qualitatively the law of partial pressures					★
ii. Applies the mathematical relationship between the total pressure of a mixture of gases and the partial pressures of the component gases ($p_{total} = p_{pA} + p_{pB} + p_{pC} + \ldots$)					★
e. Avogadro's hypothesis					
i. Uses Avogadro's hypothesis to predict the number of molecules in equal volumes of gases subjected to the same temperature and pressure					★
f. Molar volume of a gas					
i. Calculates the molar volume of a gas at standard temperature and pressure					★
ii. Calculates the molar volume of a gas at standard ambient temperature and pressure					★
iii. Determines the number of moles of a gas at a given temperature and pressure					★

1. "Application" is understood to mean a technical object, a system, a product or a process.

Chemistry - Secondary V Optional Program

Energy changes in reactions

Studying energy changes in reactions gives students the opportunity to acquire scientific and technical knowledge of phenomena and applications[1] involving endothermic and exothermic reactions.

Over the course of their secondary school education, students have explored increasingly complex phenomena, problems and applications. They have acquired knowledge related to The Material World, The Living World, The Earth and Space and The Technological World. By using the experimental method, modelling and carrying out analysis, they are able to describe, understand and explain the laws and models governing energy changes in reactions. Students learn to apply this new knowledge in a variety of contexts to explain phenomena or make predictions. In this way, they acquire a better understanding of energy changes in the world around us and of the related applications.

→ Student constructs knowledge with teacher guidance. ★ Student applies knowledge by the end of the school year. Student reinvests knowledge.	Secondary				
	AST	AST – SE	ST	ST – EST	CHE
	3	4	3	4	5
Secondary Cycle One Chemical Change Describes the indicators of a chemical change (formation of a precipitate, effervescence, colour change, heat, light) Atom Defines the atom as the basic unit of the molecule Molecule Represents the formation of a molecule using Dalton's atomic model					
Secondary Cycle Two Only those concepts specific to the Chemistry program are identified by a number. Light blue shading indicates that the student acquired this knowledge in Secondary III or IV.					
Forms of energy					
Defines joule as the unit of measurement for energy			★		
Combustion					
Describes the perceivable manifestations of rapid combustion (e.g. heat, light)		★		★	
Endothermic and exothermic reactions					
Distinguishes an endothermic reaction from an exothermic reaction according to perceptible signs (e.g. temperature variations, emission of light)		★		★	
Distinguishes an endothermic reaction from an exothermic reaction according to the position of the energy term in the chemical equation		★		★	
Distinction between heat and temperature					
Describes heat as a manifestation of energy		★		★	
Describes the relationship between heat and temperature		★		★	
Concept of the mole					
Defines the mole as the unit of measure of the amount of a substance		★		★	
Expresses an amount of a substance in moles		★		★	
1. Energy diagram					
a. Produces an energy diagram representing the energy balance for a chemical reaction					★
b. Interprets the energy diagram of a chemical reaction					★

2. Activation energy					
a. Determines the activation energy for a reaction using its energy diagram					★
3. Enthalpy change					
a. Explains qualitatively the enthalpy change of substances during a chemical reaction					★
b. Determines the enthalpy change of a reaction, using its energy diagram					★
Decomposition and synthesis					
Represents a decomposition or synthesis reaction using the particle model			★		
Associates known chemical reactions with decomposition or synthesis reactions (e.g. respiration, photosynthesis, combustion, digestion)		★	★		
Oxidation					
Represents an oxidation reaction using the particle model		★	★		
Associates known chemical reactions with oxidation reactions (e.g. combustion, corrosion)		★	★		
Associates a chemical equation in which oxygen is one of the reactants with one of the possible cases of an oxidation reaction		★		★	
Precipitation					
Describes the visible manifestation of precipitation (formation of a solid deposit after two aqueous solutions are mixed)		★	★		
Represents a precipitation reaction using the particle model		★	★		
Combustion					
Describes the perceivable manifestations of rapid combustion (e.g. heat, light)		★		★	
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 acid-base neutralization (salt and water)				★	
Recognizes an acid-base neutralization from its equation				★	
Relationship between thermal energy, specific heat capacity, mass and temperature variation					
Describes qualitatively the relationship between the change in thermal energy (quantity of heat) of a substance, its mass, its specific heat capacity and the variations in temperature to which it is exposed		★		★	
Applies the mathematical relationship between thermal energy, mass, specific heat capacity and temperature variation ($\Delta E = Q = mc\Delta T$)		★		★	
4. Molar heat of reaction					
a. Determines the molar heat of a reaction using a calorimeter					★
b. Determines the molar heat of a reaction using Hess's Law or bonding enthalpies					★

1. "Application" is understood to mean a technical object, a system, a product or a process.

Chemistry - Secondary V Optional Program

Reaction rate

Studying reaction rates gives students the opportunity to acquire scientific and technical knowledge of phenomena and applications[1] in which these rates are crucial.

Over the course of their secondary school education, students have explored increasingly complex phenomena, problems and applications. They have acquired knowledge related to The Material World, The Living World, The Earth and Space and The Technological World. By using the experimental method, modelling and carrying out analysis, they are able to describe, understand and explain the laws and models governing reaction rates. Students learn to apply this new knowledge in a variety of contexts to explain phenomena or make predictions. In this way, they acquire a better understanding of the importance of reaction rates in the world around us and of the related applications.

→ Student constructs knowledge with teacher guidance. ★ Student applies knowledge by the end of the school year. Student reinvests knowledge.	Secondary				
	AST	AST – SE	ST	ST – EST	CHE
	3	4	3	4	5
Secondary Cycle One Temperature Describes the effect of heat on the degree of agitation of particles Defines temperature as a measurement of the degree of agitation of particles					
Secondary Cycle Two Only those concepts specific to the Chemistry program are identified by a number. Light blue shading indicates that the student acquired this knowledge in Secondary III or IV.					
Concentration					
Describes the effect of variations in the quantity of solute or solvent on a solution's concentration	★		★		
Determines the concentration of an aqueous solution (g/L, percentage, ppm, mol/L)		★		★	
Stoichiometry					
Determines the quantities of reactants or products using stoichiometric calculations (gram or mole)		★		★	
1. Factors that influence the reaction rate					
i. Determines experimentally the factors that influence the reaction rate					★
a. Nature of the reactants					
i. Explains the effect of the nature of the reactants on the reaction rate					★
b. Concentration					
i. Explains the effect of the concentration of the reactants on the reaction rate					★
c. Surface area					
i. Explains the effect of the surface area of reactants on the reaction rate					★
d. Temperature					
i. Explains the effect of the temperature of the reactants on the reaction rate					★
e. Catalysts					
i. Explains the effect of a catalyst on the reaction rate					★

2. Rate law					
a. Describes the relationship between the concentration of the reactants and the reaction rate using algebraic expressions					★
b. Determines the effect of a variation in the concentration of a reactant on the reaction rate, using the related algebraic expression					★

1. “Application” is understood to mean a technical object, a system, a product or a process.

Chemistry - Secondary V Optional Program

Chemical equilibrium

Studying chemical equilibrium gives students the opportunity to acquire scientific and technical knowledge of phenomena and applications[1] in which dynamic equilibrium is established between reactants and products.

Over the course of their secondary school education, students have explored increasingly complex phenomena, problems and applications. They have acquired knowledge related to The Material World, The Living World, The Earth and Space and The Technological World. By using the experimental method, modelling and carrying out analysis, they are able to describe, understand and explain the laws and models governing the state of equilibrium of a chemical system. Students learn to apply this new knowledge in a variety of contexts to explain phenomena or make predictions. In this way, they acquire a better understanding of the dynamics of chemical equilibrium in the world around us and of the related applications.

→ Student constructs knowledge with teacher guidance. ★ Student applies knowledge by the end of the school year. Student reinvests knowledge.	Secondary				
	AST	AST – SE	ST	ST – EST	CHE
	3	4	3	4	5
Secondary Cycle One Temperature Describes the effect of heat on the degree of agitation of particles Defines temperature as a measurement of the degree of agitation of particles					
Secondary Cycle Two Only those concepts specific to the Chemistry program are identified by a number. Light blue shading indicates that the student acquired this knowledge in Secondary III or IV.					
Pressure					
Defines pressure as the force exerted by particles when they collide with a constricting surface	★		★		
Describes qualitatively the main factors that affect the pressure exerted by a fluid	★		★		
Relationship between pressure and volume					
Describes qualitatively the relationship between the pressure and volume of a gas (e.g. inhaling and exhaling, bicycle pump)	★		★		
Concentration					
Describes the effect of variations in the quantity of solute or solvent on a solution's concentration	★		★		
Determines the concentration of an aqueous solution (g/L, percentage, ppm, mol/L)		★		★	
Concept of the mole					
Defines the mole as the unit of measure of the amount of a substance		★		★	
Expresses an amount of a substance in moles		★		★	
1. Factors that influence the state of equilibrium					
i. Explains qualitatively the state of dynamic equilibrium					★
a. Temperature					
i. Explains the effect of a temperature change on a system's state of equilibrium					★
b. Pressure					
i. Explains the effect of a pressure change on a system's state of equilibrium					★

c. Concentration					
i. Explains the effect of a change in the concentration of a reactant or a product on a system's state of equilibrium					★
2. Le Chatelier's Principle					
a. Predicts the direction of the shift in equilibrium of a system following a change in concentration, temperature or pressure					★
b. Predicts the effects of a shift in equilibrium on the concentrations of reactants and products					★
Types of bonds (Ionic)					
Defines an ionic bond as a bond resulting from the gain or loss of electrons		★		★	
Defines Makes a schematic representation of an ionic bond		★		★	
Identifies molecules that feature an ionic bond (e.g. NaCl, NH_4OH)		★		★	
Associates an ionic bond with an electrolytic substance		★		★	
Strength of electrolytes					
Qualitatively speaking, associates the strength of an electrolyte with its degree of dissociation		★		★	
Electrical conductivity					
Describes the mechanism that allows aqueous solutions to conduct electricity (electrolytic dissolution of a solute, formation of mobile ions)		★		★	
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 acid-base neutralization (salt and water)		★		★	
Recognizes an acid-base neutralization from its equation		★		★	
Salts					
Determines the molecular formula of the salt produced by the neutralization of a given acid and a given base		★		★	
pH scale					
Describes the pH scale (acidity, alkalinity, neutrality, increasing and decreasing values)		★		★	
3. Equilibrium constant					
a. Acidity and alkalinity constants					
i. Writes as an algebraic expression the equilibrium constant for the dissociation of an acid or a base					★
ii. Experimentally determines the acidity or alkalinity constant of a system					★
iii. Associates the strength of acids and bases with the value of their acidity or alkalinity constant					★
b. Solubility product constant					
i. Writes as an algebraic expression the equilibrium constant for the dissociation of various substances in water					★
ii. Calculates the solubility product constant of a substance					★
iii. Explains the use of various substances using their solubility product constant (e.g. rapidly dissolving salts have a high constant)					★

c. Water ionization constant					
i. Writes the water ionization constant as an algebraic expression					★
ii. Calculates the molar concentration of hydronium and hydroxide ions, using the water ionization constant at 25°C					★
4. Relationship between the pH and molar concentration of hydronium and hydroxide ions					
a. Describes the relationship between the pH and the molar concentration of hydronium and hydroxide ions					★
b. Applies the relationship between the pH and the molar concentration of hydronium ions ($pH = -\log_{10} [H^+]$)					★

1. “Application” is understood to mean a technical object, a system, a product or a process.

Chemistry - Secondary V Optional Program

Techniques

It can be useful to refer to the techniques related to science and technology that were covered earlier.[1] The techniques listed below are divided into two categories, depending on whether they are related to laboratory work or measurement. Many of them involve using instruments and tools or handling chemicals. Safety in the workshop and laboratory should be a constant concern for users.

→ Student constructs knowledge with teacher guidance. ★ Student applies knowledge by the end of the school year. Student reinvests knowledge.	Secondary				
	AST	AST – SE	ST	ST – EST	CHE
A. Techniques related to laboratory work	**3**	**4**	**3**	**4**	**5**
1. Safely using laboratory or workshop materials and equipment[2]					
a. Uses laboratory materials and equipment safely (e.g. allows hotplate to cool, uses beaker tongs)	→	★	→	★	
b. Handles chemicals safely (e.g. uses a spatula and pipette filler)	→	★	→	★	
2. Using observational instruments					
a. Uses observational instruments appropriately (e.g. magnifying glass, stereomicroscope, microscope)					
3. Preparing solutions					
a. Prepares an aqueous solution of a specific concentration given a solid solute			★		
b. Prepares an aqueous solution of a specific concentration given a concentrated aqueous solution			★		
4. Collecting samples					
a. Collects samples appropriately (e.g. sterilizes the container, uses a spatula, refrigerates the sample)			→	★	
B. Measurement techniques	**3**	**4**	**3**	**4**	**5**
1. Verifying the repeatability, accuracy and sensitivity of measuring instruments					
a. Takes the same measurement several times to check the repeatability of the instrument used				★	
b. Carries out the required operations to ensure the accuracy of a measuring instrument (e.g. cleans and calibrates a balance, dries out a graduated cylinder, rinses and calibrates a pH-meter)				★	
c. Chooses a measuring instrument by taking into account the sensitivity of the instrument (e.g. uses a 25-mL graduated cylinder rather than a 100-mL one to measure 18 mL of water)				★	
2. Interpreting the results of measurement					
a. Determines the 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				★	
b. Estimates the errors associated with the user and the environment when taking a measurement				★	
c. Expresses a result with a significant number of digits that takes into account the errors related to the measure (e.g. a measurement of 10.35 cm taken with a ruler graduated in millimetres should be expressed as 10.4 cm or 104 mm)				★	
d. Expresses the value of a measurement with its absolute or relative uncertainty (e.g. 24.1 ± 0.1 cm^3 or 24.1 cm^3 ± 0.4 %)					★

1. See the *Techniques* section in the *Progression of Learning in Secondary School* (Secondary I to IV) documents.
2. When the teacher introduces a new technique, he or she should explain the related safety rules and repeat them often. After several practice sessions, students should apply the rules without being reminded.

Chemistry - Secondary V Optional Program

Strategies

The strategies listed below are fundamental to the approaches used in science and technology. They can be applied in a variety of increasingly complex contexts and are therefore inclusive. Thus, students build on the strategies they learned in elementary school. New strategies are added, including analytical strategies, which are adapted to students' level of cognitive development.

→ Student constructs knowledge with teacher guidance. ★ Student applies knowledge by the end of the school year. Student reinvests knowledge.	Secondary					
	Cycle One	AST	AST – SE	ST	ST – EST	CHE
A. Exploration strategies		3	4	3	4	5
1. Studying a problem or a phenomenon from different points of view (e.g. social, environmental, historical, economic)						
2. Distinguishing between the different types of information useful for solving the problem						
3. Referring to similar problems that have already been solved						
4. Becoming aware of his or her previous representations						
5. Drawing a diagram for the problem or illustrating it						
6. Formulating questions						
7. Putting forward hypotheses (e.g. individually, in teams, as a class)						
8. Exploring various ways of solving the problem						
9. Anticipating the results of his or her approach						
10. Imagining solutions to a problem in light of his or her explanations						
11. Taking into account the constraints involved in solving a problem or making an object (e.g. specifications, available resources, time allotted)						
12. Examining his or her mistakes in order to identify their source						
13. Using different types of reasoning (e.g. induction, deduction, inference, comparison, classification)						
14. Using empirical approaches (e.g. trial and error, analysis, exploration using one's senses)						
15. Ensuring that the procedure is appropriate and safe, and making the necessary adjustments	★					
16. Collecting as much scientific, technological and contextual information as possible to define a problem or predict patterns		→	★	→	★	
17. Studying a problem or a phenomenon from different points of view (e.g. social, environmental, historical, economic)		→	★	→	★	
18. Distinguishing between the different types of information useful for solving the problem		→	★	→	★	
19. Referring to similar problems that have already been solved		→	★	→	★	

B. Instrumentation strategies		3	4	3	4	5
1. Using different sources of information (e.g. books, newspapers, Web sites, magazines, experts)						
2. Validating sources of information						
3. Using technical design to illustrate a solution (e.g. diagrams, sketches, technical drawings)						
4. Using different tools for recording information (e.g. diagrams, notes, graphs, procedures, logbook)						
5. Using a variety of observational techniques and tools						
6. Selecting suitable techniques or tools for observation	★					
C. Analytical strategies		**3**	**4**	**3**	**4**	**5**
1. Identifying the constraints and important elements related to the problem-solving situation	★					
2. Dividing a complex problem into simpler subproblems	★					
3. Using different types of reasoning (e.g. inductive and deductive reasoning, comparison, classification, prioritization) in order to process information	★					
4. Reasoning by analogy in order to process information and adapt scientific and technological knowledge		→	★	→	★	
5. Selecting relevant criteria to help him or her determine where he or she stands on a scientific or technological issue		→	★	→	★	
D. Communication strategies		**3**	**4**	**3**	**4**	**5**
1. Using different means of communication to propose explanations or solutions (e.g. oral presentation, written presentation, procedure)						
2. Organizing information for a presentation (e.g. tables, diagrams, graphs)						
3. Exchanging information						
4. Comparing different possible explanations for or solutions to a problem in order to assess their relevance (e.g. full-group discussion)						
5. Using tools to display information in various formats (e.g. data tables, graphs, diagrams)	★					