Science 9
Ecosystem Dynamics

2020

New Nouveau Brunswick

Science 9 *__Ecosystem Dynamics__*

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Website References

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Table of Contents

1. Introduction

1.1 Mission and Vision of Educational System

The New Brunswick Department of Education and Early Childhood Development is dedicated to providing the best public education system possible, wherein all students have a chance to achieve their academic best. The mission statement for New Brunswick schools is:

> *Each student will develop the attributes needed to be a lifelong learner, to achieve personal fulfillment and to contribute to a productive, just and democratic society.*

1.2 New Brunswick Global Competencies

New Brunswick Global Competencies provide a consistent vision for the development of a coherent and relevant curriculum. The statements offer students clear goals and a powerful rationale for school work. They help ensure that provincial education systems' missions are met by design and intention. The New Brunswick Global Competencies statements are supported by curriculum outcomes.

New Brunswick Global Competencies are statements describing the knowledge, skills and attitudes expected of all students who graduate high school. Achievement of the New Brunswick Global Competencies prepares students to continue to learn throughout their lives. These Competencies describe expectations not in terms of individual school subjects but in terms of knowledge, skills and attitudes developed throughout the curriculum. They confirm that students need to make connections and develop abilities across subject boundaries if they are to be ready to meet the shifting and ongoing demands of life, work and study today and in the future.

See Appendix 6.1.

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1.3 Teaching for Scientific Literacy

The emergence of a highly competitive and integrated global economy, rapid technological innovation, and a growing knowledge base will continue to have a profound impact on people's lives. Advancements in science and technology play an increasingly significant role in everyday life. Science education will be a key element in developing scientific literacy and in building a strong future for New Brunswick's young people.

Science education for the future requires that students learn more than just the basic concepts of science. It should equip students with the skills which enable them to use scientific knowledge to identify questions, draw evidence-based conclusions, and understand and make decisions about the natural world. Students come to understand the characteristic features of science (*Nature of Science)* as a form of human knowledge and inquiry and are aware of the many ways science and technology shape the world. Lastly, scientifically literate students possess attitudes and values that enable them to participate in science-related issues as an ethical citizen.

A strong foundation in scientific knowledge and practices will include the development of reasoning and analytical skills, decision and problem-solving skills, flexibility to respond to different contexts and inspire students at all grade levels to develop a critical sense of wonder about scientific and technological endeavours. A foundation in scientific literacy will prepare students to address science-related societal, economic, ethical, and environmental challenges. These are skills and competencies that are aligned to the New Brunswick Global Competencies.

1.4 Education for Sustainable Development (ESD)

Science, Technology, and Innovation (STI) are recognized as the key drivers behind economic growth and prosperity. STI plays a central role for achieving sustainable development. To become sustainability changemakers learners must engage with sustainability issues. Science education therefore is vital for the achievement of sustainable development.

Reorienting science education to support the development of sustainability mindsets require teaching and learning about knowledge, skills, perspectives, and values that will guide and motivate young people to pursue sustainable livelihoods, to participate in a democratic society, and to live in a sustainable manner. By connecting learning and living to the SDGs, teachers present real-world contexts for students to help them become globally competent citizens. The scientific content and concepts outlined in Section 4: Curriculum Outcomes, are situated in the four SDGs identified above by the darkened boxes.

Guiding Principles for Science in the Sustainable Development Goals (SDGs)

The SDGs activate science at multiple levels and across disciplines to gather and create the necessary knowledge to lay the foundations for practices, innovations, and technologies that address local challenges. Teaching and learning for sustainable futures in science is guided by the following principles:

- Strengthen science education to increase science literacy and capacity-building in science at all levels.
- Recognize science as a universal public good that helps in laying the foundation for a sustainable world.

- Enhance diversity in science for sustainable development by realizing gender equity in science and by building on the entire spectrum of society, including under-represented groups and minorities
- Promote an integrated scientific approach that addresses the environmental, social, and economic dimensions of sustainability respecting the diversity of knowledge systems.

In Grade 10 students explore and investigate topics related to goals: SDG 11 - Industry, Innovation Sustainable cities and communities; SDG 13 - Climate Action.; SDG 14 - Life below water; and SDG 15 - Life on land. The goals framing the Grade 9 program of study appear in Section 4: Curriculum Organizers and Outcomes and are hyperlinked to the corresponding Global Goals webpage.

1.5 Science as a Way of Knowing

An inclusive science program recognizes that Eurocentric science is not the only form of knowledge about natural world and aims to broaden student understanding of traditional and local perspectives. The dialogue between scientists and traditional knowledge holders has an extensive history and continues to grow as researchers seek to better understand our complex world. The terms "traditional knowledge", and "Traditional Ecological Knowledge" are used by practitioners worldwide when referencing local knowledge systems which are arise from Indigenous ways of knowing. Education researchers suggest that an enhanced science curriculum is one that supports both Indigenous Knowledge and scientific literacy, represents complementary, not separate realities, and broadens the purpose of science education to become *knowing-nature literacy*.

See Appendix 6.2.

Indigenous Ways of Knowing

Traditional knowledge is a cumulative body of knowledge, know-how, practices and representations maintained and developed by Indigenous Peoples with extended histories of interaction with the natural environment. These sophisticated sets of understandings, interpretations and meanings are part of a cultural complex that encompasses language, naming and classification systems, resource use practices, ritual, spirituality and worldview (International Council for Science, 2002 as cited by Restoule, 2019).

As an oral culture, Indigenous Knowledge is not written down, contained in textbooks, or stored on shelves for future reference. Elders are the cultural experts and keepers of knowledge in the traditional stories, in the ceremonies, and in the practices; teaching is by mentoring and learning is by doing and application.

Scientific Knowledge

Although there are other ways of knowing that may be important in our personal and cultural lives, scientists rely on evidence and testing, rather than belief or speculation. Like Indigenous ways of knowing scientific knowledge is a cumulative body of knowledge, know-how, practices, and representations maintained and developed by scientists with extended histories of interaction with the natural environment.

Knowledge produced by scientists is open to change and is generalizable. Aikenhead (2011) suggests that it is this generalizability that affords scientists the power to predict and control. To study the natural world, scientists use methods that are empirical, which means that they are grounded in observations and experimentation and are not based on opinions or sentiments.

2. Pedagogical Components

2.1 Pedagogical Guidelines

Diverse Cultural Perspectives

It is important for teachers to recognize and honour the variety of cultures and experiences from which students are approaching their education and the world. It is also important for teachers to recognize their own biases and be careful not to assume levels of physical, social or academic competencies based on gender, culture, or socio-economic status.

Each student's culture will be unique, influenced by their community and family values, beliefs, and ways of viewing the world. Traditional aboriginal culture views the world in a much more holistic way than the dominant culture. Disciplines are taught as connected to one another in a practical context, and learning takes place through active participation, oral communication and experiences. Immigrant students may also be a source of alternate world views and cultural understandings. Cultural variation may arise from the differences between urban, rural and isolated communities. It may also arise from the different value that families may place on academics or athletics, books or media, theoretical or practical skills, or on community. Providing a variety of teaching and assessment strategies to build on this diversity will provide an opportunity to enrich learning experiences for all students.

English as an Additional Language Curriculum

Being the only official bilingual province, New Brunswick offers the opportunity for students to be educated in English and/or French through our public education system. The EECD provides leadership from K-12 to assist educators and many stakeholders in supporting newcomers to New Brunswick. English language learners have opportunities to receive a range of instructional support to improve their English language proficiency through an inclusive learning environment. EECD, in partnership with the educational and wider communities offer a solid, quality education to families with school-aged children.

Copyright Matters

Teacher must ensure that they respect the fair dealing provision when accessing and using course resources and materials for instructional purposes. The works of others should not be used without their permission unless the use is permitted by the *Copyright Act*. Teachers are expected to be aware of the copyright status of instructional materials in their possession. The *Copyright Act* permits use of a copyright-protected work without permission from the copyright owner or the payment of copyright royalties under specific conditions.

Consumable materials intended for one-time use in the classroom (i.e. workbooks and exercise sheets) are created with the understanding that each student is to have their own copy. Unless teachers have permission to copy a consumable, copying, scanning, or printing materials intended for one-time use is strictly prohibited. Copying from instructional materials intended for one-time use without permission exposes the teacher, the school, and the school board to liability for copyright infringement

To learn more about the fair dealing guidelines and the *Copyright Act* visit, the Council of Ministers of Education Canada website at <https://www.cmec.ca/140/Copyright_Matters!.html>.

2.2 Assessment Guidelines

Assessment Practices

Assessment is the systematic gathering of information about what students know and are able to do. Student performance is assessed using the information collected during the evaluation process. Teachers use their professional skills, insight, knowledge, and specific criteria that they establish to make judgments about student performance in relation to learning outcomes. Students are also encouraged to monitor their own progress through self-assessment strategies, such as goal setting and rubrics.

Research indicates that students benefit most when assessment is regular and ongoing and is used in the promotion of learning (Stiggins, 2008). This is often referred to as formative assessment. Evaluation is less effective if it is simply used at the end of a period of learning to determine a mark (summative evaluation).

Summative evaluation is usually required in the form of an overall mark for a course of study, and rubrics are recommended for this task. Sample rubrics templates are referenced in this document, acknowledging teachers may have alternative measures they will apply to evaluate student progress.

Some examples of current assessment practices include:

• Questioning	• Projects
• Observation	• Investigations
• Conferences	• Checklists/Rubrics
• Demonstrations	• Responses to texts/activities
• Presentations	• Reflective Journals
• Role plays	• Self and peer assessment
• Technology Applications	• Career Portfolios

Formative Assessment

Research indicates that students benefit most when assessment is ongoing and is used in the promotion of learning (Stiggins, 2008). Formative assessment is a teaching and learning process that is frequent and interactive. A key component of formative assessment is providing ongoing feedback to learners on their understanding and progress. Throughout the process adjustments are made to teaching and learning.

Students should be encouraged to monitor their own progress through goal setting, co-constructing criteria and other self-and peer-assessment strategies. As students become more involved in the assessment process, they are more engaged and motivated in their learning.

Additional details can be found in the Formative Assessment document on the Portal ONE site.

Summative Assessment

Summative evaluation is used to inform the overall achievement for a reporting period for a course of study. Rubrics are recommended to assist in this process. Sample rubrics templates referenced in curriculum documents acknowledge teachers may have alternative measures they will apply to evaluate student progress.

Guidelines for *Assessing, Evaluating and Reporting Grades K–8* and *Assessing, Evaluating and Reporting Grades 9-12* provide additional information about assessment and evaluation. These can be accessed on the Portal ONE site.

3. Subject Specific Guidelines

3.1 Rationale

Science in grade 9 is an important preparatory year that provide students with opportunities to identify scientific and technological areas of personal interest. Students explore the concept of ecosystem dynamics by investigating a system which they are inextricably connected to –Earth's biosphere. Students will design and conduct investigations about Earth's place in the universe, biogeochemical reactions, ecological sustainability, and human impacts on Earth's systems. Students are encouraged to make relevant connections between phenomena they encounter daily and the dynamic relationships which exist within and between these systems (e.g., the universe, Earth, community and self), to sustain life.

Course Description

The focus of science in Grade 9 is to enable students to explore the relationship between matter and energy interactions on a macro scale. Students will deepen their understanding of the origins of matter, diversity of life, heredity and ecology, as well as the main principles of environmental stewardship and conservation. The unifying ideas diversity, equilibrium, matter, models and systems serve as sense-making strategies to consolidate science learning from elementary and middle school.

Through hands-on investigations students learn how energy-releasing and energy-requiring chemical reactions connect living systems to the physical components of the biosphere. They are introduced to **chemical thinking** [1] **skills** and develop a wider scientific world view applying the main theories and general laws to biological inquiries. Students explore concepts related to Sustainable Development Goals: 3 - Good health and well-being, 13 - Climate action, 14 - Life on land, and 15 - Life below water. **See Appendix 6.4.**

An interdisciplinary approach to learning that integrates *Life Science, Physical Sciences and Earth and Space Sciences* assist students to develop their inquiry and problem-finding skills. Skills for solving environmental challenges in their communities and making competent socio-scientific decisions are further developed: framing hypotheses, planning experiments and carrying them out, and analysing, representing and interpreting experimental data. Communication of investigative findings; oral and written exhibitions of research results, involving appropriate multi-modal forms of presentation are encouraged.

[1] Chemical thinking: the development and application of chemical knowledge and practices with the main intent of analyzing, synthesizing, and transforming matter for practical purposes. Chemistry Education Research and Practice. DOI:10.1039/C3RP00111C

3.2 Curriculum Organizers

Organizers

Students at all grade levels and in every domain of science should have the opportunity to use scientific inquiry and technological design skills and develop the ability to think and act in ways associated with inquiry, including asking questions, planning and conducting investigations, using appropriate tools and technologies to gather data, thinking critically and logically about relationships between evidence and explanation, constructing and analyzing alternative explanations, and communicating scientific arguments (NSTA, 2008).

The **Science 9** curriculum has been developed with scientific literacy and the nature of science in mind. Students can be considered scientifically literate when they are familiar with, and able to engage in, the following processes within a science context: inquiry, problem-solving, and decision making. Each strand consists of learning outcomes that share a common focus.

Inquiry

Scientific inquiry involves posing questions and developing explanations for phenomena. While there is general agreement there is no such thing as the scientific method, students require certain skills to participate in the activities of science. Skills such as questioning, observing, inferring, predicting, measuring, hypothesizing, classifying, designing experiments, collecting data, analysing data, and interpreting data are fundamental to engaging in science. These activities provide students with opportunities to practise the process of theory development in science and understand the nature of science.

Problem-Solving

The process of problem-solving involves seeking solutions to human problems. It consists of proposing, creating, and testing prototypes, products, and techniques to determine the best solution to a given problem.

Decision Making

The process of decision making involves determining what we, as citizens, should do in a particular context or in response to a given situation. Decision-making situations are inherently important and provide a relevant context for engaging in scientific inquiry and/or problem-solving.

Instruction in science is inquiry-based with hand-on learning that is situated in authentic contexts enabling student to make connections to their own lives and the communities in which they live. Students will become excited and curious about the concepts and phenomena under study, and they then become motivated to learn. **See Appendix 6.3.**

Unifying Ideas[2]

There are numerous unifying ideas that represent a way of organising and connecting scientific knowledge. The organising ideas are not the exclusive domain of science for they apply as well in mathematics, technology, business, economics and other domains. After accumulating a wealth of learning experiences, students will begin to integrate these unifying ideas into their thinking. The following unifying ideas sense-making and consolidation of prior science know in Science 9:

- **Change:** Changes in systems occur in distinct ways—as steady trends, in a cyclical fashion, irregularly or in any combination of these patterns. Student's ability to recognise these types of change depends on astute observation and critical analysis of the system.
- **Diversity:** The natural and constructed world is composed of a vast array of living and non-living forms of matter. Students refine and extend their understanding and appreciation of diversity by applying procedures used to classify and distinguish these forms based on structure and function.
- **Energy:** All physical phenomena and interactions involve energy. It is the driving force of both movement and change within matter. Students will be able to analyse complex energy transformations and will understand energy transformation at the molecular level.
- **Equilibrium**: When opposing forces or processes are balanced in a static or dynamic way, the system is in a state of equilibrium. A system in which all process of change appear to have stopped displays *constancy or stability*. A system in which the rate of input into the system is balanced by the rate of output; making the system appear static, is in *dynamic equilibrium.* A system in which all processes of change have stopped –until something of enough magnitude is done to disturb and cause a change, is in *static equilibrium*.
- **Matter:** Organisms ae linked to one another and to their physical setting by the transfer and transformation of matter and energy. This basic concept connects the understandings from physical, Earth and biological sciences. The cycling of matter can be found at many levels of biological organisation, from molecules to ecosystems. Students will understand that

[2] Atlantic Provinces Education Foundation. (1998). Science Foundation: Content for learning and teaching. Halifax, Nova Scotia. PP. 34-38.

recycling of matter involves the breakdown and reassembly of invisible units rather than the creation and destruction of matter.

- **Models**: Physical and conceptual models serve as useful tools to support student's learning about abstract ideas. Models, regardless of type, represent a simplification of an idea or process. Physical models use a hands-on approach while conceptual models consist of mathematical representations of essential components and their interactions. As student's understanding of phenomena improves, models become more refined.

- **Systems:** The natural and constructed world is made up of systems and the interactions that take place within and among them. Whether a system is regarded as a system or a subsystem is dependent upon the scale of observation. The ability of students to think about a whole in terms of its parts and alternatively, about the parts in terms of how they relate to one another is demonstrative of higher order thinking.

Essential Questions

Essential Questions can open doors to student understanding when used to frame instruction and guide learning (McTighe & Wiggins, 2013). By framing learning with Essential Questions (also called EQs) teachers can stimulate thought, provoke inquiry, and activate students' prior knowledge and transform instruction. EQs often begin with, "Why," "How" or "To What Extent" but may sometimes begin with other question stems. The EQs listed below will assist in *uncovering* the important ideas, processes and content so that students can make helpful connections and are equipped to transfer their learning in meaningful ways:

1. What are Earth's major systems and how do they interact?
2. How is energy transferred and conserved in an ecosystem?
3. How do organisms obtain and use the matter and energy they need to grow and live?
4. How (and why) do organisms interact with their environment and what are the effects of these interactions; on the environment? on the organisms?
5. What is a complex real-world ecological challenge in your local community? Design a solution to address this challenge.

4. Curriculum Outcomes and Learning Contexts

Curriculum Outcomes for Science

The New Brunswick Curriculum is stated in terms of general curriculum outcomes, specific curriculum outcomes and achievement indicators. The General and Specific Curriculum Outcomes in the 2021 Science curriculum are focused on students doing science.

General Curriculum Outcomes (GCO) are overarching statements about what students are expected to learn in each strand/sub-strand. The general curriculum outcome for each strand/sub-strand is the same throughout the grades.

There are two broad areas of focus: 1**. The Nature of Science** and 2. **Learning and Living Sustainably**. The *Nature of Science* involves students understanding the world through careful, systematic inquiry. Students discover that scientific knowledge produced through this process is both durable and subjected to change. *Learning and Living Sustainably* encompasses the students understanding that science affects and is affected by society. The achievement indicators for this GCO were previously categorized as Science, Technology, Society and the Environment (STSE).

Specific Curriculum Outcomes (SCO) are statements that identify specific concepts and related skills underpinned by the understanding and knowledge attained by students as required for a given grade.

Learning Contexts: Core Ideas and Concepts

The development of science skills is situated in learning contexts – core ideas and concepts; which provide learners opportunities to explore their understandings in multiple disciplines over time. The core ideas and concepts are stated after the outcomes. The goal is for students to develop scientific literacy while accumulating a body of knowledge framed within the boundaries of the human-built and natural environments.

GCO 1.0: Students will use scientific inquiry and technological design skills to solve practical problems, communicate scientific ideas and results, and make informed decisions while working collaboratively.

4.1 The Nature of Science

General and Specific Curriculum Outcomes

GCO 1	**Students will use scientific inquiry and technological design skills to solve practical problems, communicate scientific ideas and results, and make informed decisions while working collaboratively.**
SCO 1.1	**Students will ask questions about relationships between and among observable variables to plan investigations (scientific inquiry and technological problem-solving) to address those questions.**

Achievement indicators:

- Formulate a hypothesis using, if, then, because giving plausible reasons based on understandings and/or research.
- Identify major variable(s) to be controlled.
- Define a design problem that involves the development of a process or a system with interacting components.
- Propose alternative solutions to a given problem, select one, develop a plan.
- Select appropriate methods for collecting data and information.
- Construct models to make testable predictions based on scientific evidence.

SCO 1.2	**Students will collect and represent data using tools and methods appropriate for the task.**

Achievement indicators:

For Mathematics skills applied in Science 9, **see Appendix 6.5.**

Achievement indicators connected to safety concerning oneself, procedures and practices are noted in GCO 2.0 on page 31. Safety is a subset of sustainability.

- Conduct the investigation; fieldwork, laboratory experiment and/or technological design solution to collect reliable data.
- Assess risk associated with investigation method applied.
- Assess ethical issues associated with investigation method used.
- Use instruments accurately for collecting data (precision, reliability and validity)
- Organise data using a form that is an appropriate to the task or investigation.
- Develop classification key for qualification data.

GCO 1.0: Students will use scientific inquiry and technological design skills to solve practical problems, communicate scientific ideas and results, and make informed decisions while working collaboratively.

SCO 1.3	Students will analyse and interpret qualitative and quantitative data to construct explanations.
Achievement indicators: • Analyze patterns and trends in data; including describing relationships between varies and identifying inconsistencies. • Suggest reasonable amount of error in measurement; identifying outliers. • Describe specific ways to improve the quality of data. • Evaluate potential application of findings. • Test the design of a constructed device or system. • Discuss the limitations of a model as the representation of a system, process, or design. • Suggest ways the model can be improved to better fit available evidence or better reflect a design's specifications. • Identify new questions and problems that arise from what was learned.	
SCO 1.4	**Students will work collaboratively on investigations to communicate conclusions supported by data.**
Achievement indicators: • State a logical conclusion that supports, refutes or inclusive the hypothesis. • Compare the findings to and address variation (if applicable). • Defend[3] a given position on an issue or problem based on findings. • Extend what has been learned to suggest new questions to investigate. • Evaluate results in relation to other models, products and knowledge. • Communicate scientific and technological ideas and information for a purpose. • Use appropriate scientific and technological language, conventions and representations.	

[3] Through scientific argumentation – The practice of argumentation –developing, exploring, analyzing, and refining lines of reasoning and explanation in evidence-based ways—is essential to the work of scientists and to scientific thinking and learning. See the Science Argumentation Toolkit http://www.argumentationtoolkit.org/intro.html for details.

GCO 1.0: Students will use scientific inquiry and technological design skills to solve practical problems, communicate scientific ideas and results, and make informed decisions while working collaboratively.

Learning Contexts

Students build an understanding of the nature of science through inquiry activities supported by core ideas and concepts connected to Physical Sciences, and Earth and Space Sciences. They also draw from personal learning experiences, funds of knowledge, cultural worldviews and science capital [4] they already possess.

The Nature of Science: Core ideas and contexts	
Earth and its Place in the Universe	• Earth and the solar system - Perspectives: Scientific (empirical) and technological evidence; cultural interpretations of space phenomena • Earth Systems - The Biosphere: Atmosphere, hydrosphere, cryosphere, and geosphere - The role of water in Earth's surface process - Weather systems and climate
Ecosystems: Energy, Matter and Interactions	• Energy: Definitions and source (Radiant energy, electromagnetic radiation, EMS); Energy in chemical processes and everyday life; Conservation and transfer: radiation, conduction, convection • Ecosystems: Interdependent relationships; Cycling of matter: Water, Carbon and Nitrogen; Energetics: Energy transfer in ecosystems; Ecosystem dynamics: functioning and resilience • Structure and properties of matter: Elements of life and nutrient cycles • Biogeochemical reactions: respiration, photosynthesis and chemosynthesis (oceans)
From Molecules to Organisms	• Structure and function: Cells, cell division, and reproduction • Organisation of matter • Energy flow in organisms

[4] Science capital – A holistic measure of young people's scientific identity, attitudes towards science, behaviours and contacts, culminating in a feeling of science being 'for them'. OECD. 2020. *PISA 2024: Strategic Vision and Direction for Science*. Pg. 14.

GCO 1.0: Students will use scientific inquiry and technological design skills to solve practical problems, communicate scientific ideas and results, and make informed decisions while working collaboratively.

Biological Evolution: Variation and Diversity	• Biodiversity and humans • Inheritance of traits • Adaptations

GCO 2.0: Students will demonstrate an understanding of the nature of science and technology, of the relationships between science and technology, and of the social and environmental contexts of science and technology (STSE).

4.2 Learning and Living Sustainably (STSE)

General and Specific Curriculum Outcomes

GCO 2	**Students will demonstrate an understanding of the nature of science and technology, of the relationships between science and technology, and of the social and environmental contexts of science and technology (STSE).**
SCO 2.1	**Students will consider factors that support responsible application of scientific and technological knowledge and demonstrate an understanding of sustainable practices.**

Achievement indicators:

- Safely use equipment while carrying out an inquiry.
- Identify behaviours that will keep myself and others safe.
- Work with team members to develop and carry out a plan.
- Conduct science experiment/field investigation while following environmentally appropriate practices.
- Demonstrate a knowledge of WHMIS standards by using proper techniques for handling and disposing of materials.
- Apply the concept of systems as a tool for interpreting the structure and interaction of natural and technological systems.
- Explain why practical solution to a scientific or technological problem requires a compromise between competing priorities.
- Identify effects of the chosen solution on people and the environment considering criteria.
- Evaluate the effects, both beneficial and harmful of various technologies developed to improve living conditions.
- Explore science- and technology-based careers in Canada based on my interests.

GCO 2.0: Students will demonstrate an understanding of the nature of science and technology, of the relationships between science and technology, and of the social and environmental contexts of science and technology (STSE).

SCO 2.2	Students will identify a community-based challenge connected to at least two of sustainable development goals; 3, 13, 14 and 15, then apply an iterative process to design a solution
Achievement indicators: • Safely use tools used to build a model/prototype. • Identify behaviours that will keep myself and others safe. • Work with team members to develop and carry out a plan. • Evaluate design or prototypes in terms of function reliability, safety, use of materials and impact on the environment. • Refine a model based on empirical evidence to improve its quality or explanatory power. • Demonstrate a holistic understanding of the interconnections of a person's well-being and health and the natural environment – the community. • Explore different environmental pollutants and ways to reduce the pollution. • Conduct research into real world challenges for the sustainable use of oceans, seas and marine resources. • Analyze results of environmental monitoring to take appropriate actions (e.g., Actions → climate mitigation and adaptation strategies). • Develop an action project or campaign related to biodiversity protection in community or region.	

GCO 2.0: Students will demonstrate an understanding of the nature of science and technology, of the relationships between science and technology, and of the social and environmental contexts of science and technology (STSE).

Learning Contexts

Learning to live sustainably contributes to scientific literacy by supporting young people to solve complex interconnected problems related to socio-environmental systems and sustainability[5] in their communities. It also includes knowledge within the disciplinary subject areas.

Learning and Living Sustainably: Core ideas and contexts	
Safety	• Knowledge and application of safety guidelines - Safe practices for conducting scientific inquiry e.g. field and lab investigations - Safe practices for conducting technological problem-solving
Sustainability 	• Earth and Human Activity - Human impacts on Earth systems - Global climate change - Populations and carrying capacity - Natural resources: geographic distribution, availability, extraction and use • Conservation and Stewardship - Change in environments e.g., biodiversity loss, invasive species - Risks and benefits of a scientific or technological development
Applied Technology	• Design Challenge - Draw on prior science and technological knowledge related to unifying ideas matter, energy, models and systems - Seek inspiration in Earth's operating system where appropriate - Criteria and constraints may include social, technological or environmental considerations specific to problem under investigation

[5] OECD. 2020. *PISA 2024: Strategic Vision and Direction for Science*. Pg. 4.

5. Resources

GCO 1 – The Nature of Science: Core Ideas and Concepts

Resources for GCO 1		
Video	**Website**	**Document**
Bozeman Science | Energy Flows in Ecosystems, Ecosystem Dynamics, Functioning and Resilience & Population Ecology Crash Course | Ecological Succession, Heredity, Human Impacts to the Environment Creating Scientists | Open vs. Closed Questions & What is a Mental Model National Science Foundation. (2012). Earth: The Operators Manual - Program 1 Natural History Museum| Hydrothermal Vents Nautilus Live | Chemosynthesis TEDEd. (2020). Science and Technology	Biomimicry Institute - Ask Nature | Biological Strategies Chemix - Draw Lab Diagrams CK-12 Org | FlexBook 24.0 Ecosystem Dynamics, Biology for High School & CK-12 Interactives | Chemistry & Physics Digital Mik'maq | Backyard Science: Finding Your Way - Observational Science and the Night Sky, Oceans Alive, Weather Wise, Etepne'g Ecology, Forces of the Earth. & Climate Change HHMI Biointeractive | Population Dynamics Let's Talk Science | Educational Resources Minecraft Education | Building a Biome, Extinction! Biodiversity, Science Lab & Scientific Method Perimeter Institute | High School Space Science PhET Simulations | Chemistry, Physics & Natural Selection Waters Centre for Systems Thinking | What is systems thinking, Tools & Strategies & Habits of a Systems Thinker [Teacher Aid] Window to the Universe | Earth, Solar System	American Association for the Advancement of Science. (2019). Matter and Energy for Growth and Activity. ISBN: 978-1-68140-685-5., & (2017). Towards high School Biology: Understanding growth in living things. ISBN: 978-1-68140-560 [Teacher Aids] National Science Teachers Association. (2016). Teaching energy across the sciences, K-12 /edited by Jeffrey Nordine. Arlington, VA. Book. [Teacher Aid]

GCO 2 – Learning and Living Sustainably: Core Ideas and Concepts

Resources for GCO 2		
Video	**Website**	**Document**
Bozeman Science | Ecosystem Dynamics, Functioning and Resilience & Population Ecology Crash Course | Ecological Succession, Heredity, Human Impacts o the Environment Earth Science Literacy Principles | 9 Big Ideas - Media McGill University. (2010). Green Chemistry National Science Foundation. (2012). Earth: The Operators Manual - Program 1	Bencze, J.L. (2019). STSE Education: Learning About Relationships Among Fields of Science & Technology and Societies & Environments Biomimicry Institute - Ask Nature | Biological Strategies CLEAN Network | Climate Literacy and Energy Awareness Digital Mi'kmaq - Backyard Science (Climate Change) Learning for Sustainable Future (LSF) | Resources for Rethinking Let's Talk Science | Career Explorations NASA | Solar System Exploration Teach Engineering - Environmental Engineering The Gaia Project – High School	Best Evidence Science Teaching – Approaches Teaching Energy Essential Principles of Climate Science. (2009). Climate Literacy National Science Teachers Association. Position Statement: Teaching of Climate Science. United Nation Educational Scientific Cultural Organisation. (2017). Education 2030. | SDG Learning Objectives [Teacher Aid] Stier, S. C. (2020). Engineering Education for the Next Generation: A nature-inspired approach. Book [Teacher Aid]

General

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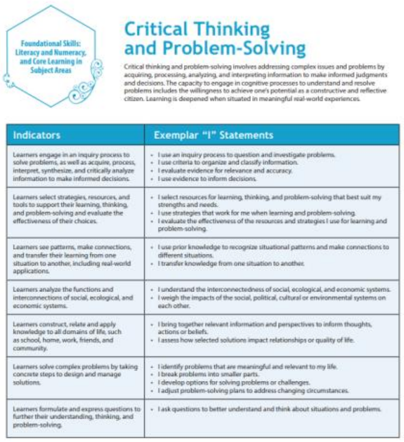
7. Appendices

6.1 New Brunswick Global Competencies

Click on any of the images below to redirected to the web version of the document. Get the poster.

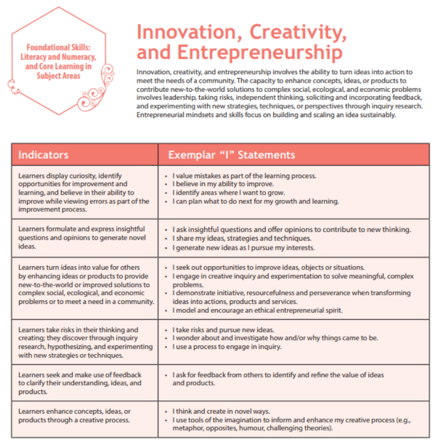


Foundational Skills: Literacy and Numeracy, and Core Learning in Subject Areas

Critical Thinking and Problem-Solving

Critical thinking and problem-solving involves addressing complex issues and problems by acquiring, processing, analyzing, and interpreting information to make informed judgments and decisions. The capacity to engage in cognitive processes to understand and resolve problems includes the willingness to achieve one's potential as a constructive and reflective citizen. Learning is deepened when situated in meaningful real-world experiences.

Indicators	Exemplar "I" Statements
Learners engage in an inquiry process to solve problems, as well as acquire, process, interpret, synthesize, and critically analyze information to make informed decisions.	• I use an inquiry process to question and investigate problems. • I use criteria to organize and classify information. • I evaluate evidence for relevance and accuracy. • I use evidence to inform decisions.
Learners select strategies, resources, and tools to support their learning, thinking, and problem-solving and evaluate the effectiveness of their choices.	• I select resources for learning, thinking, and problem-solving that best suit my strengths and needs. • I use strategies that work for me when learning and problem-solving. • I evaluate the effectiveness of the resources and strategies I use for learning and problem-solving.
Learners see patterns, make connections, and transfer their learning from one situation to another, including real-world applications.	• I use prior knowledge to recognize situational patterns and make connections to different situations. • I transfer knowledge from one situation to another.
Learners analyze the functions and interconnections of social, ecological, and economic systems.	• I understand the interconnectedness of social, ecological, and economic systems. • I weigh the impacts of the social, political, cultural or environmental systems on each other.
Learners construct, relate and apply knowledge to all domains of life, such as school, home, work, friends, and community.	• I bring together relevant information and perspectives to inform thoughts, actions or beliefs. • I assess how selected solutions impact relationships or quality of life.
Learners solve complex problems by taking concrete steps to design and manage solutions.	• I identify problems that are meaningful and relevant to my life. • I break problems into smaller parts. • I develop options for solving problems or challenges. • I adjust problem-solving plans to address changing circumstances.
Learners formulate and express questions to further their understanding, thinking, and problem-solving.	• I ask questions to better understand and think about situations and problems.

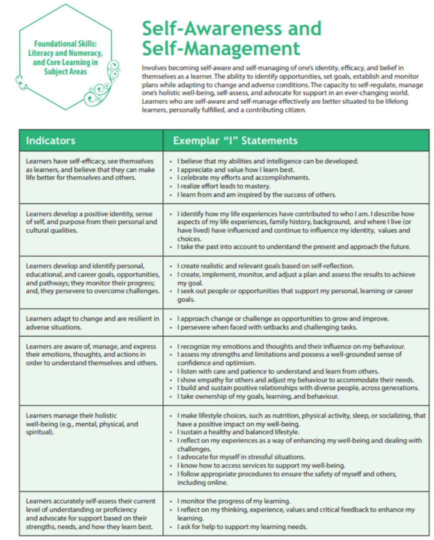


Foundational Skills: Literacy and Numeracy, and Core Learning in Subject Areas

Innovation, Creativity, and Entrepreneurship

Innovation, creativity, and entrepreneurship involves the ability to turn ideas into action to meet the needs of a community. The capacity to enhance concepts, ideas, or products to contribute new-to-the-world solutions to complex social, ecological, and economic problems involves leadership, taking risks, independent thinking, soliciting and incorporating feedback, and experimenting with new strategies, techniques, or perspectives through inquiry research. Entrepreneurial mindsets and skills focus on building and scaling an idea sustainably.

Indicators	Exemplar "I" Statements
Learners display curiosity, identify opportunities for improvement and learning, and believe in their ability to improve while viewing errors as part of the improvement process.	• I value mistakes as part of the learning process. • I believe in my ability to improve. • I identify areas where I want to grow. • I can plan what to do next for my growth and learning.
Learners formulate and express insightful questions and opinions to generate novel ideas.	• I ask insightful questions and offer opinions to contribute to new thinking. • I share my ideas, strategies and techniques. • I generate new ideas as I pursue my interests.
Learners turn ideas into value for others by enhancing ideas or products to provide new-to-the-world or improved solutions to complex social, ecological, and economic problems or to meet a need in a community.	• I seek out opportunities to improve ideas, objects or situations. • I engage in creative inquiry and experimentation to solve meaningful, complex problems. • I demonstrate initiative, resourcefulness and perseverance when transforming ideas into actions, products and services. • I model and encourage an ethical entrepreneurial spirit.
Learners take risks in their thinking and creating; they discover through inquiry research, hypothesizing, and experimenting with new strategies or techniques.	• I take risks and pursue new ideas. • I wonder about and investigate how and/or why things came to be. • I use a process to engage in inquiry.
Learners seek and make use of feedback to clarify their understanding, ideas, and products.	• I ask for feedback from others to identify and refine the value of ideas and products.
Learners enhance concepts, ideas, or products through a creative process.	• I think and create in novel ways. • I use tools of the imagination to inform and enhance my creative process (e.g., metaphor, opposites, humour, challenging theories).

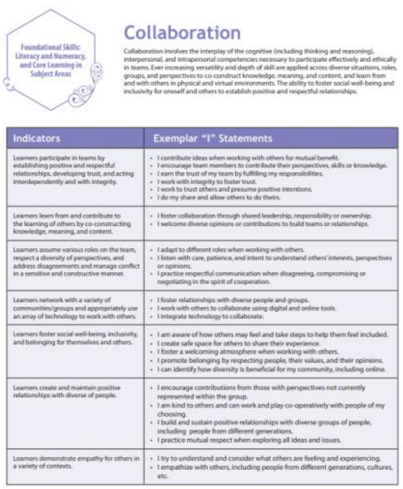


Foundational Skills: Literacy and Numeracy, and Core Learning in Subject Areas

Self-Awareness and Self-Management

Involves becoming self-aware and self-managing of one's identity, efficacy, and belief in themselves as a learner. The ability to identify opportunities, set goals, establish and monitor plans while adapting to change and adverse conditions. The capacity to self-regulate, manage one's holistic well-being, self-assess, and advocate for support in an ever-changing world. Learners who are self-aware and self-manage effectively are better situated to be lifelong learners, personally fulfilled, and a contributing citizen.

Indicators	Exemplar "I" Statements
Learners have self-efficacy, see themselves as learners, and believe that they can make life better for themselves and others.	• I believe that my abilities and intelligence can be developed. • I appreciate and value how I learn best. • I celebrate my efforts and accomplishments. • I realize effort leads to mastery. • I learn from and am inspired by the success of others.
Learners develop a positive identity, sense of self, and purpose from their personal and cultural qualities.	• I identify how my life experiences have contributed to who I am. I describe how aspects of my life experiences, family history, background, and where I live (or have lived) have influenced and continue to influence my identity, values and choices. • I take the past into account to understand the present and approach the future.
Learners develop and identify personal, educational, and career goals, opportunities, and pathways; they monitor their progress; and, they persevere to overcome challenges.	• I create realistic and relevant goals based on self-reflection. • I create, implement, monitor, and adjust a plan and assess the results to achieve my goal. • I seek out people or opportunities that support my personal, learning or career goals.
Learners adapt to change and are resilient in adverse situations.	• I approach change or challenge as opportunities to grow and improve. • I persevere when faced with setbacks and challenging tasks.
Learners are aware of, manage, and express their emotions, thoughts, and actions in order to understand themselves and others.	• I recognize my emotions and thoughts and their influence on my behaviour. • I assess my strengths and limitations and possess a well-grounded sense of confidence and optimism. • I listen with care and patience to understand and learn from others. • I show empathy for others and adjust my behaviour to accommodate their needs. • I build and sustain positive relationships with diverse people, across generations. • I take ownership of my goals, learning, and behaviour.
Learners manage their holistic well-being (e.g., mental, physical, and spiritual).	• I make lifestyle choices, such as nutrition, physical activity, sleep, or socializing, that have a positive impact on my well-being. • I sustain a healthy and balanced lifestyle. • I reflect on my experiences as a way of enhancing my well-being and dealing with challenges. • I advocate for myself in stressful situations. • I know how to access services to support my well-being. • I follow appropriate procedures to ensure the safety of myself and others, including online.
Learners accurately self-assess their current level of understanding or proficiency and advocate for support based on their strengths, needs, and how they learn best.	• I monitor the progress of my learning. • I reflect on my thinking, experience, values and critical feedback to enhance my learning. • I ask for help to support my learning needs.



Foundational Skills: Literacy and Numeracy, and Core Learning in Subject Areas

Collaboration

Collaboration involves the interplay of the cognitive (including thinking and reasoning), interpersonal, and intrapersonal competencies necessary to participate effectively and ethically in teams. Ever increasing versatility and depth of skill are applied across diverse situations, roles, groups, and perspectives to co-construct knowledge, meaning, and content, and learn from and with others in physical and virtual environments. The ability to foster social well-being and inclusivity for oneself and others to establish positive and respectful relationships.

Indicators	Exemplar "I" Statements
Learners participate in teams by establishing positive and respectful relationships, developing trust, and acting interdependently and with integrity.	• I contribute ideas when working with others for mutual benefit. • I encourage team members to contribute their perspectives, skills or knowledge. • I earn the trust of my team by fulfilling my responsibilities. • I work with integrity to foster trust. • I work to trust others and presume positive intentions. • I do my share and allow others to do theirs.
Learners learn from and contribute to the learning of others by co-constructing knowledge, meaning, and content.	• I foster collaboration through shared leadership, responsibility or ownership. • I welcome diverse opinions or contributions to build teams or relationships.
Learners assume various roles on the team, respect a diversity of perspectives, and address disagreements and manage conflict in a sensitive and constructive manner.	• I adapt to different roles when working with others. • I listen with care, patience, and intent to understand others' interests, perspectives or opinions. • I practice respectful communication when disagreeing, compromising or negotiating in the spirit of cooperation.
Learners network with a variety of communities/groups and appropriately use an array of technology to work with others.	• I foster relationships with diverse people and groups. • I work with others to collaborate using digital and online tools. • I integrate technology to collaborate.
Learners foster social well-being, inclusivity, and belonging for themselves and others.	• I am aware of how others may feel and take steps to help them feel included. • I create safe space for others to share their experience. • I foster a welcoming atmosphere when working with others. • I promote belonging by respecting people, their values, and their opinions. • I can identify how diversity is beneficial for my community, including online.
Learners create and maintain positive relationships with diverse of people.	• I encourage contributions from those with perspectives not currently represented within the group. • I am kind to others and can work and play co-operatively with people of my choosing. • I build and sustain positive relationships with diverse groups of people, including people from different generations. • I practice mutual respect when exploring all ideas and issues.
Learners demonstrate empathy for others in a variety of contexts.	• I try to understand and consider what others are feeling and experiencing. • I empathize with others, including people from different generations, cultures, etc.

Foundational Skills: Literacy and Numeracy, and Core Learning in Subject Areas

Communication

Communication involves receiving and expressing meaning in different contexts and with different audiences and purposes. Effective communication increasingly involves understanding both local and global perspectives, societal and cultural contexts, and adapting and changing, using a variety of media, responsibly, safely, and with regard to one's digital identity.

Indicators	Exemplar "I" Statements
Learners express themselves using the appropriate communication tools for the intended audience and create a positive digital identity.	• I select appropriate media according to purpose, context and audience. • I create responsible digital content to establish and maintain a positive digital profile.
Learners communicate effectively in French and/or English and/or Mi'kmaq or Wolastoqey through a variety of media and in a variety of contexts.	• I express my thoughts in two or more languages. • I express my thoughts through alternate modes of expression such as art, music, drama, poetry, etc. • I enhance my communication using mime, gestures and facial expressions. • I articulate my current level of ability in the language(s) I am learning.
Learners gain knowledge about a variety of languages beyond their first and additional languages; they recognize the strong connection between language and ways of knowing the world.	• I consider cultural nuances in my verbal and non-verbal communications. • I engage in learning to communicate in one or more languages, other than my first language. • I switch from one language to another. • I express myself in one language and understand a person speaking another. • I act as an intermediary between two speakers who are unable to understand each other.
Learners ask effective questions to create a shared communication culture, attend to understand all points of view, express their own opinions, and advocate for ideas.	• I ask questions to construct meaning, inform decisions, and justify opinions. • I express opinions that are informed. • I respect different points of view. • I show empathy and take responsibility to communicate in ways that benefit others. • I ask people to elaborate on specific points they made in their initial explanation. • I encourage a shared communication culture by expressing understanding and appreciation of different ideas, feelings and viewpoints, and inviting participants to contribute and react to each others' ideas. • I work collaboratively with people who have different cultural orientations, discussing similarities and differences in viewpoints. • I support communication across cultures by initiating conversation and expressing agreement and understanding.

Foundational Skills: Literacy and Numeracy, and Core Learning in Subject Areas

Sustainability and Global Citizenship

Sustainability and global citizenship involves reflecting on and appreciating diverse worldviews and understanding and addressing social, ecological, and economic issues that are crucial to living in a contemporary, interdependent, and sustainable world. It also includes the acquisition of knowledge, dispositions, and skills required to be an engaged citizen with an appreciation for the diversity of people perspectives.

Indicators	Exemplar "I" Statements
Learners understand the interconnectedness of social, ecological, and economic forces, and how they affect individuals, societies, and countries.	• I examine systems (e.g., local, regional, national, global) to understand their influence. • I analyse how communities address issues to ensure that diverse social and cultural identities and interests are included.
Learners recognize discrimination and promote principles of equity, human rights, and democratic participation.	• I identify when there is a lack of fair treatment (e.g., gender, socio-economic status, culture, religion, age, etc.) • I advocate for others. • I take action to support diversity and human rights. • I engage in open, appropriate and effective interactions across cultures. • I use cultural competence in my interactions.
Learners understand Indigenous worldviews, traditions, values, customs, and knowledge.	• I respect Indigenous culture, rights and experiences. • I acknowledge and understand the implications of the Peace and Friendship treaties. • I appreciate the contributions of Indigenous peoples. • I strive to be a leader in reconciliation by acknowledging the land, language and history of the Mi'kmaq, Wolastoqey and Peskotomuhkati. • I accept and respect the perspectives of Mi'kmaq, Wolastoqey and Peskotomuhkati people.
Learners learn from and with diverse people, develop cross cultural understanding, and understand the forces that affect individuals and societies.	• I value diverse cultures and experiences. • I listen to and understand diverse perspectives and experiences. • I engage in open, appropriate and effective interactions across cultures. • I use cultural competence in my interactions.
Learners take actions and make responsible decisions that support social settings, natural environments, and quality of life for all, now and in the future.	• I bring together relevant information and perspectives to inform thoughts, actions or beliefs. • I assess how selected solutions impact relationships or quality of life.
Learners contribute to society and to the culture of local, national, global, and virtual communities in a responsible, inclusive, accountable, sustainable, and ethical manner.	• I model leadership/stewardship to promote healthy and sustainable communities. • I advocate for equity and sustainability. • I engage in local, national, and global initiatives to make a positive difference. • I create responsible digital content.
Learners participate in networks in a safe and socially responsible manner.	• I am mindful of safety and social responsibility in real-world and virtual domains. • I create a positive digital profile.

6.2 The Nature of Science

"Science know no country, because knowledge belong to humanity, and is the torch which illuminates the world." – Louis Pasteur

The Nature of Science

Empirical	Science is a process which relies heavily, on observation, experimental evidence, rational arguments and skepticism. Science becomes a tool to explain natural phenomena.
Tentative	Scientific understanding can change over time given new evidence or interpretations; however, scientific understanding is dependable.
Creative	Creativity and imagination play significant roles throughout scientific practices. Scientists use creativity and imagination to resolve problems, propose new approaches and consider what the results are telling them.
Socio-cultural	People from all cultures contribute to science. Personal, social and cultural influences shape science and the ways scientists interpret data and arrive at a conclusion.
Theory & Law	Theories and laws are unique representations of scientific understanding because theories explain complex phenomena while laws describe consistent regularities.
Scientific Models	Scientific models are based on data and inferences and are useful for understanding or predicting phenomena. They represent abstract ideas. Multiple models of the same content/context are possible and useful.

6.3 How Science Works (Grades 9-12)

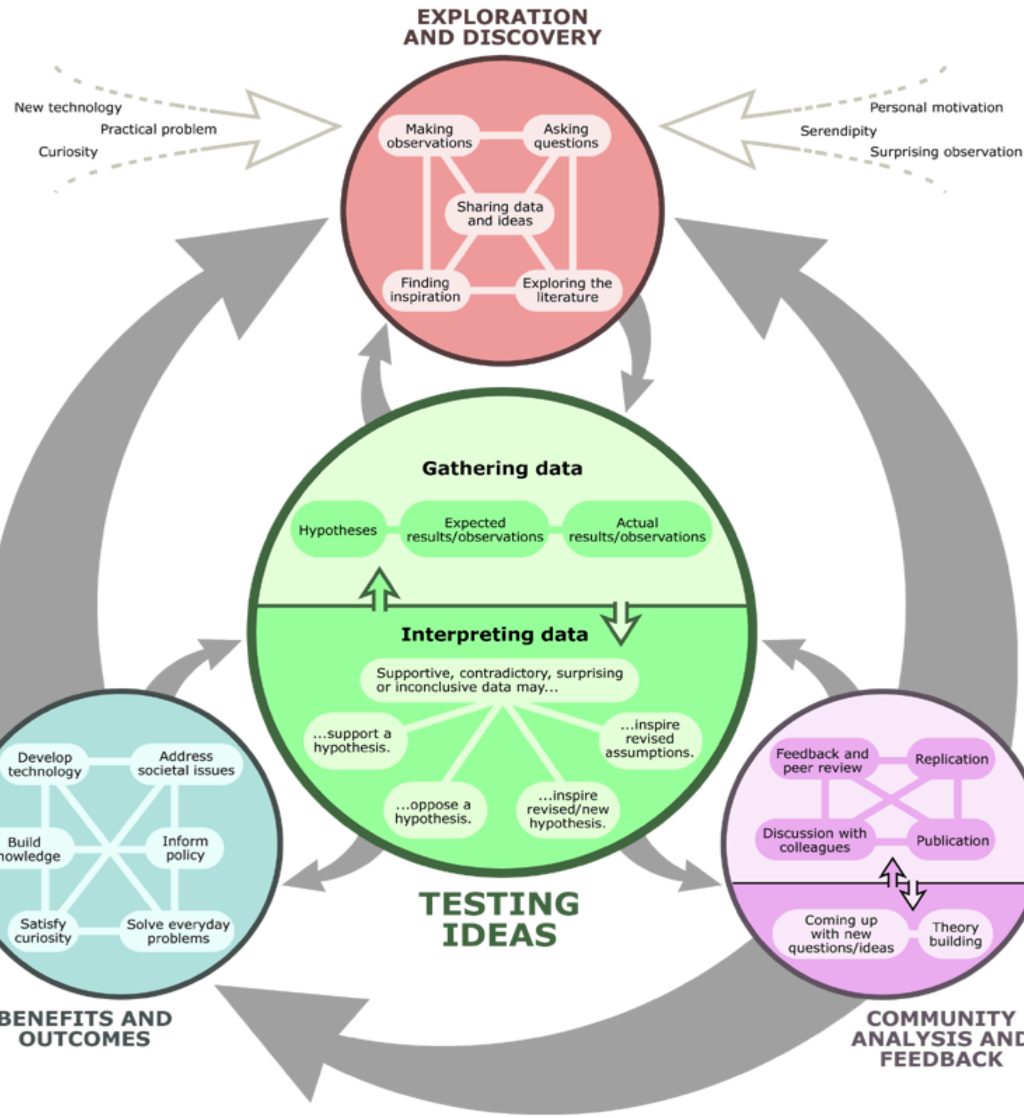


Figure 1-Understanding Science. 2020. University of California Museum of Paleontology. 3 January 2020 <http://www.understandingscience.org>

6.4 Chemical Thinking Learning Progression

Chemical thinking is the development and application of chemical knowledge and practices with the main intent of analyzing, synthesizing, and transforming matter for practical purposes (Seviana & Talanquer, 2014). Chemical Thinking Learning Progression (CTLP) outlined below characterizes various pathways through which students' ideas and ways of thinking about synthesis, analysis, and transformation (i.e., their chemical thinking) develop through formal education, in the context of pedagogical approaches that involve investigation, design, and evaluation.

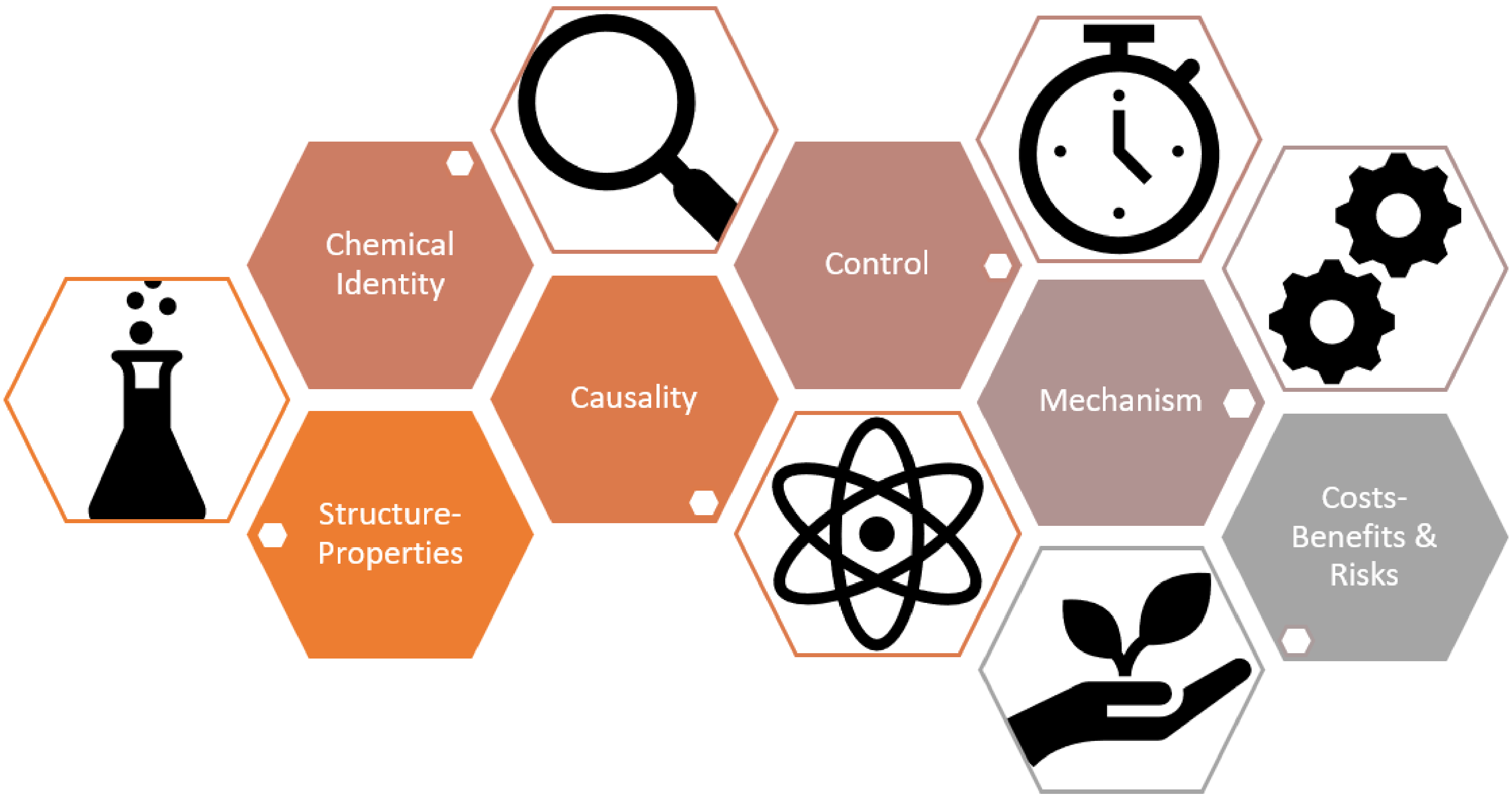


Figure 2 -Chemical Thinking Learning Progression Overview (Click on image to be redirected)

6.5 Mathematical Skills for Science 9

Students will apply the following Mathematics knowledge and skills in science studies:

Numbers and Operations

- Understanding exponents
- Solving problems involving powers to 10
- Dimensional analysis: A strategy for making sure the units of different quantities make sense in any scientific calculation

Patterns and Relations

- Data displays are constructed to communicate information accurately and clearly
- Graph linear relations: Analyse graphs and interpolate and extrapolate to solve problems

Data and Probability

- Probability in society: Statistics is the science of data, and science practices involve data collection, interpretation, and analysis of results.
- Scientific notation: In science it is more efficient to write very large and very small numbers using scientific notation
- Significant figures: Scientists use significant figures communicate the precision of a measurement or calculation