Ministry of
Education

Computer Science 30

January, 2018

nouvelle orthographe

Computer Science 30
1. Study and teaching (Secondary school) - Saskatchewan - Curricula. 2. Competency-based education
- Saskatchewan.
Saskatchewan. Ministry of Education.

Acknowledgements

The Ministry of Education wishes to acknowledge the professional contributions and advice of the provincial Secondary Science Curriculum Reference Committee members:

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In addition, the Ministry of Education wishes to acknowledge the guidance of the *Computer Science 20/30* working group members:

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Rick Heise
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Good Spirit School Division

Miles Muri
Conseil des Écoles Fransaskoises

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The Ministry of Education also wishes to thank many others who contributed to the development of this curriculum:

- former Science Reference Committee members;
- First Nations Elders and teachers;
- university faculty members; and
- other educators and reviewers.

Computer Science 30

Introduction

Science is a required area of study in Saskatchewan's Core Curriculum. The purpose of this curriculum is to outline the provincial requirements for *Computer Science 30*.

This curriculum provides the intended learning outcomes that *Computer Science 30* students are expected to achieve by the end of the course. Indicators are included to provide the breadth and depth of what students should know and be able to do in order to achieve the learning outcomes.

This renewed curriculum reflects current computer science education research and updated technology and is responsive to changing demographics within the province.

This curriculum includes the following information to support science instruction in Saskatchewan schools:

- connections to Core Curriculum, including the Broad Areas of Learning and Cross-curricular Competencies;
- the K-12 aim and goals for science education;
- characteristics of an effective computer science program;
- *Computer Science 30* outcomes and indicators;
- assessment and evaluation; and
- a glossary.

Inquiry into authentic student questions generated from student experiences is the central strategy for teaching science.

(National Research Council [NRC], 1996, p. 31)

Using this Curriculum

Outcomes describe the knowledge, skills and understandings that students are expected to attain by the end of a particular course.

Outcomes are statements of what students are expected to know and be able to do by the end of a grade or secondary level course in a particular area of study. Therefore, all outcomes are required. The outcomes provide direction for assessment and evaluation, and for program, unit and lesson planning.

Critical characteristics of an outcome include the following:

- focus on what students will learn rather than what teachers will teach;
- specify the skills and abilities, understandings, knowledge and/or attitudes students are expected to demonstrate;
- are observable, assessable and attainable;
- are written using action-based verbs and clear professional language (educational and subject-related);
- are developed to be achieved in context so that learning is purposeful and interconnected;
- are grade and subject specific;
- are supported by indicators which provide the breadth and depth of expectations; and,
- have a developmental flow and connection to other grades where applicable.

Indicators are a representative list of what students should know or be able to do if they have attained the outcome.

Indicators are representative of what students need to know and/or be able to do in order to achieve an outcome. When teachers are planning for instruction, they must comprehend the set of indicators to understand fully the breadth and the depth of learning related to a particular outcome. Based on this understanding of the outcome, teachers may develop their own indicators that are responsive of students' interests, lives and prior learning. These teacher-developed indicators must maintain the intent of the outcome.

Within the outcomes and indicators in this curriculum the terms "including", "such as" and "e.g.," commonly occur. Each term serves a specific purpose:

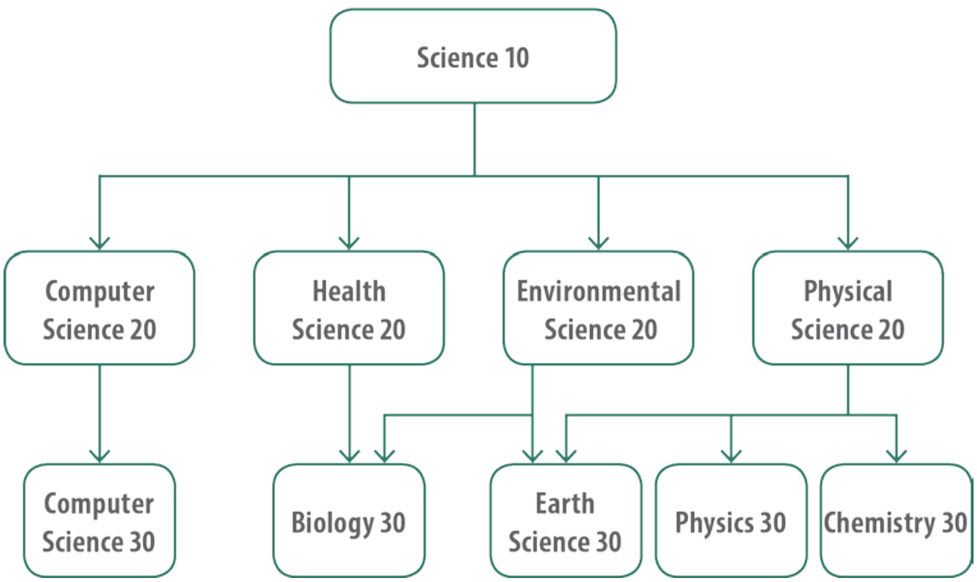
- The term "including" prescribes content, contexts or strategies that students must experience in their learning, without excluding other possibilities.
- The term "such as" provides examples of possible broad categories of content, contexts or strategies that teachers or students may choose, without excluding other possibilities.
- Finally, the term "e.g.," offers specific examples of what a term, concept or strategy might look like.

Grades 10-12 Science Framework

Saskatchewan's grades 10 to 12 science courses incorporate core ideas from the Pan-Canadian Protocol for Collaboration on School Curriculum *Common Framework of Science Learning Outcomes K to 12* (CMEC, 1997). Saskatchewan has developed science courses at Grade 11 that provide students with opportunities to learn core biology, chemistry and physics disciplinary ideas within interdisciplinary contexts. Students should select courses based on their interests and what they believe will best fit their needs after high school.

The chart below visually illustrates the courses in each pathway and their relationship to each other.

Science Pathways Framework



Each course in each pathway is to be taught and learned to the same level of rigour. No pathway or course is considered "easy science"; rather, all pathways and courses present "different sciences" for different purposes.

Students may take courses from more than one pathway for credit. The current credit requirements for graduation from Grade 12 are one 10-level credit and one 20-level credit in science.

Core Curriculum

Core Curriculum is intended to provide all Saskatchewan students with an education that will serve them well regardless of their choices after leaving school. Through its various components and initiatives, Core Curriculum supports the achievement of the Goals of Education for Saskatchewan. For current information regarding Core Curriculum, please refer to the *Registrar's Handbook for School Administrators* found on the Government of Saskatchewan website. For additional information related to the various components and initiatives of Core Curriculum, please refer to the Government of Saskatchewan website for curriculum policy and foundation documents.

The Broad Areas of Learning and Cross-curricular Competencies connect the specificity of the areas of study and the day-to-day work of teachers with the broader philosophy of Core Curriculum and the Goals of Education for Saskatchewan.

Broad Areas of Learning

There are three Broad Areas of Learning that reflect Saskatchewan's Goals of Education. Science education contributes to student achievement of the Goals of Education through helping students achieve knowledge, skills and attitudes related to these Broad Areas of Learning.

Lifelong Learners

Related to the following Goals of Education:

- *Basic Skills*
- *Lifelong Learning*
- *Self Concept Development*
- *Positive Lifestyle.*

Students who are engaged in constructing and applying science knowledge naturally build a positive disposition towards learning. Throughout their study of science, students bring their curiosity about the natural and constructed world, which provides the motivation to discover and explore their personal interests more deeply. By sharing their learning experiences with others, in a variety of contexts, students develop skills that support them as lifelong learners.

Sense of Self, Community, and Place

Related to the following Goals of Education:

- *Understanding & Relating to Others*
- *Self Concept Development*
- *Positive Lifestyle*
- *Spiritual Development.*

Students develop and strengthen their personal identity as they explore connections between their own understanding of the natural and constructed world and perspectives of others, including scientific and Indigenous perspectives. Students develop and strengthen their understanding of community as they explore ways in which science can inform individual and community decision making on issues related to the natural and constructed world. Students interact experientially with place-based local knowledge to deepen their connection to and relationship with nature.

Engaged Citizens

As students explore connections between science, technology, society and the environment, they experience opportunities to contribute positively to the environmental, economic and social sustainability of local and global communities. Students reflect and act on their personal responsibility to understand and respect their place in the natural and constructed world, and make personal decisions that contribute to living in harmony with others and the natural world.

Related to the following Goals of Education:

- *Understanding & Relating to Others*
- *Positive Lifestyle*
- *Career and Consumer Decisions*
- *Membership in Society*
- *Growing with Change.*

Cross-curricular Competencies

The Cross-curricular Competencies are four interrelated areas containing understandings, values, skills and processes which are considered important for learning in all areas of study. These competencies reflect the Common Essential Learnings and are intended to be addressed in each area of study at each grade.

Developing Thinking

Learners construct knowledge to make sense of the world around them. In science, students develop understanding by building and reflecting on their observations and what is already known by themselves and others. By thinking contextually, creatively and critically, students develop deeper understanding of various phenomena in the natural and constructed world.

K-12 Goals for Developing Thinking:

- *thinking and learning contextually*
- *thinking and learning creatively*
- *thinking and learning critically.*

Developing Identity and Interdependence

This competency addresses the ability to act autonomously in an interdependent world. It requires the learner to be aware of the natural environment, of social and cultural expectations and of the possibilities for individual and group accomplishments. Interdependence assumes the possession of a positive self-concept and the ability to live in harmony with others and with the natural and constructed world. In science, students examine the interdependence among living things within local, national and global environments and consider the impact of individual decisions on those environments.

K-12 Goals for Developing Identity and Interdependence:

- *understanding, valuing and caring for oneself*
- *understanding, valuing and caring for others*
- *understanding and valuing social, economic and environmental interdependence and sustainability.*

Developing Literacies

Literacies are multi-faceted and provide a variety of ways, including the use of various language systems and media, to interpret the world and express understanding of it. Literacies involve the evolution of interrelated knowledge, skills and strategies that facilitate an individual's ability to participate fully and equitably in a variety of roles and contexts – school, home, and local and global communities. In science, students collect, analyze and represent their ideas and understanding

K-12 Goals for Developing Literacies:

- *developing knowledge related to various literacies*
- *exploring and interpreting the world through various literacies*
- *expressing understanding and*

communicating meaning using various literacies.

K-12 Goals for Developing Social Responsibility:

- *using moral reasoning processes*
- *engaging in communitarian thinking and dialogue*
- *taking social action.*

of the natural and constructed world in multiple forms.

Developing Social Responsibility

Social responsibility is how people positively contribute to their physical, social, cultural and educational environments. It requires the ability to participate with others in accomplishing shared or common goals. This competency is achieved by using moral reasoning processes, engaging in communitarian thinking and dialogue and taking social action. Students in science examine the impact of scientific understanding and technological innovations on society.

Aim and Goals

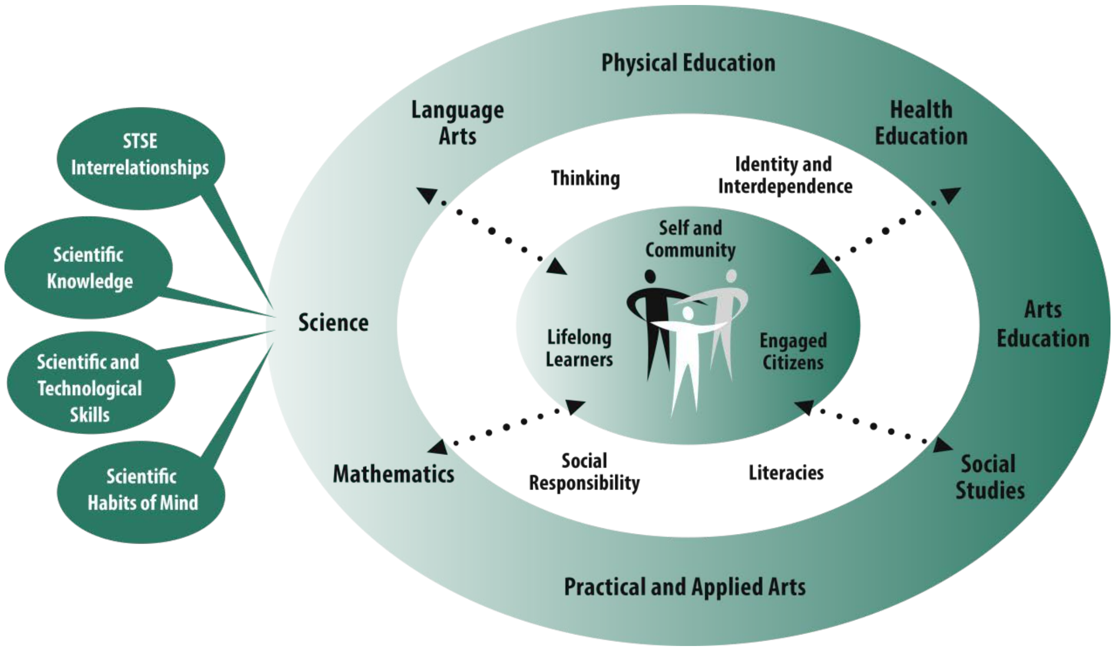
The aim of K-12 science education is to enable all Saskatchewan students to develop scientific literacy. Scientific literacy today embraces Euro-Canadian and Indigenous heritages, both of which have developed an empirical and rational knowledge of nature. A Euro-Canadian way of knowing about the natural and constructed world is called science, while First Nations and Métis ways of knowing nature are found within the broader category of Indigenous knowledge.

Diverse learning experiences based on the outcomes in this curriculum provide students with many opportunities to explore, analyze, evaluate, synthesize, appreciate and understand the interrelationships among science, technology, society and the environment (STSE) that will affect their personal lives, their careers and their future.

Goals are broad statements identifying what students are expected to know and be able to do upon completion of the learning in a particular area of study by the end of Grade 12. The four goals of K-12 science education are to:

- **Understand the Nature of Science and STSE Interrelationships** – Students will develop an understanding of the nature of science and technology, their interrelationships and their social and environmental contexts, including interrelationships between the natural and constructed world.
- **Construct Scientific Knowledge** – Students will construct an understanding of concepts, principles, laws and theories in life science, in physical science, in earth and space science and in Indigenous knowledge of nature and then apply these understandings to interpret, integrate and extend their knowledge.
- **Develop Scientific and Technological Skills** – Students will develop the skills required for scientific and technological inquiry, problem solving and communicating, for working collaboratively, and for making informed decisions.
- **Develop Attitudes that Support Scientific Habits of Mind** – Students will develop attitudes that support the

responsible acquisition and application of scientific, technological and Indigenous knowledge to the mutual benefit of self, society and the environment.



Inquiry

Inquiry learning provides students with opportunities to build knowledge, abilities and inquiring habits of mind that lead to deeper understanding of their world and human experience. Inquiry is more than a simple instructional method. It is a philosophical approach to teaching and learning, grounded in constructivist research and methods, which engages students in investigations that lead to disciplinary and interdisciplinary understanding.

Inquiry is intimately connected to scientific questions – students must inquire using what they already know and the inquiry process must add to their knowledge.

(NRC, 2000, p. 13)

Inquiry builds on students' inherent sense of curiosity and wonder, drawing on their diverse backgrounds, interests and experiences. The process provides opportunities for students to become active participants in a collaborative search for meaning and understanding.

Secondary students who are engaged in inquiry in science should be able to:

- identify questions and concepts that guide scientific investigations.
- design and conduct scientific investigations.
- use technology and mathematics to improve investigations and communications.
- formulate and revise scientific explanations and models using logic and evidence.
- recognize and analyze alternative explanations and models.
- communicate and defend a scientific argument.

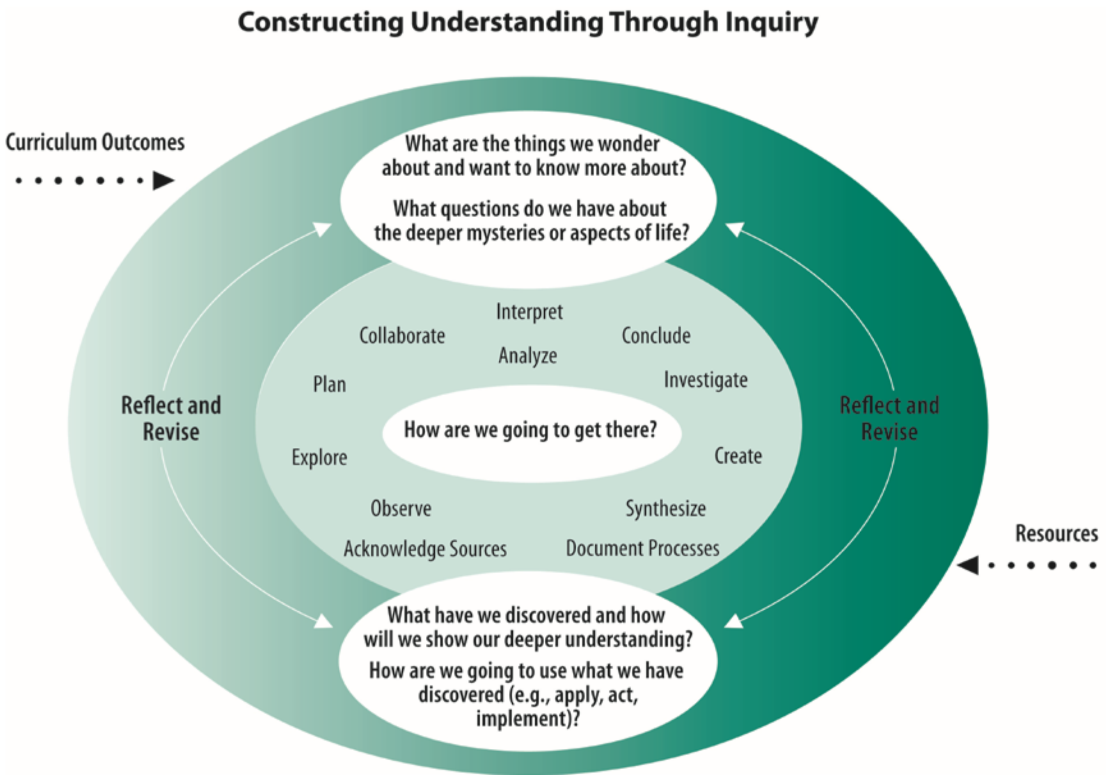
(NRC, 1996, pp. 175, 176)

Students do not come to understand inquiry simply by learning words such as "hypothesis" and "inference" or by memorizing procedures such as "the steps of the scientific method".

(NRC, 2000, p. 14)

An important part of any inquiry process is student reflection on their learning and the documentation needed to assess the learning and make it visible. Student documentation of the inquiry process in science may take the form of works-in-progress, reflective writing, journals, reports, notes, models, arts expressions, photographs, video footage or action plans.

Inquiry learning is not a step-by-step process, but rather a cyclical process, with various phases of the process being revisited and rethought as a result of students' discoveries, insights and construction of new knowledge. Experienced inquirers will move back and forth among various phases as new questions arise and as students become more comfortable with the process. The following graphic shows various phases of the cyclical inquiry process.



Creating Questions for Inquiry in Science

Inquiry focuses on the development of questions to initiate and guide the learning process. Students and teachers formulate questions to motivate inquiries into topics, problems and issues related to curriculum content and outcomes.

Good science inquiry provides many entry points – ways in which students can approach a new topic – and a wide variety of activities during student work.

(Kluger-Bell, 2000, p.48)

Well-formulated inquiry questions are broad in scope and rich in possibilities. Such questions encourage students to explore, observe, gather information, plan, analyze, interpret, synthesize, problem solve, take risks, create, conclude, document, reflect on learning and develop new questions for further inquiry.

In science, teachers and students can use the four learning contexts of Scientific Inquiry, Technological Problem Solving, STSE Decision Making, and Cultural Perspectives (see Learning Contexts section of this document for further information) as curriculum entry points to begin their inquiry. The process may evolve into interdisciplinary learning opportunities reflective of the holistic nature of our lives and an interdependent global environment.

Developing questions evoked by student interests has the potential for rich and deep learning. These questions are used to initiate and guide the inquiry and give students direction for investigating topics, problems, ideas, challenges or issues under study.

Essential questions that lead to deeper understanding in science should:

- *center on objects, organisms and events in the natural world;*
- *connect to science concepts outlined in the curricular outcomes;*
- *lend themselves to empirical investigation; and,*
- *lead to gathering and using data to develop explanations for natural phenomena.*

(NRC, 2000, p. 24)

The process of constructing questions for deep understanding can help students grasp the important disciplinary or interdisciplinary ideas that are situated at the core of a particular curricular focus or context. These broad questions lead to more specific questions that can provide a framework, purpose and direction for the learning activities in a lesson, or series of lessons, and help students connect what they are learning to their experiences and life beyond school.

Questions give students some initial direction for uncovering the understandings associated with a unit of study. Questions can help students grasp the big disciplinary ideas surrounding a focus or context and related themes or topics. They provide a framework, purpose and direction for the learning activities in each unit and help students connect what they are learning to their experiences and life beyond the classroom. Questions also invite and encourage students to pose their own questions in computer science for deeper understanding.

Science Challenges

Science challenges, which may include science festivals, science fairs, science leagues, science Olympics, science Olympiads or talent searches, are instructional methods suitable for students to undertake to achieve curricular outcomes. Teachers may incorporate science challenge activities as an integral component of the science program or treat them similar to other extracurricular activities such as school sports and clubs. Teachers undertaking science challenges as a classroom activity should consider these guidelines, adapted from the National Science Teachers Association (NSTA) position statement *Science Competitions* (1999):

- Student and staff participation should be voluntary and open to all students.
- Emphasis should be placed on the learning experience rather than the competition.
- Science competitions should supplement and enhance other learning and support student achievement of curriculum outcomes.
- Projects and presentations should be the work of the student, with proper credit given to others for their contributions.
- Science competitions should foster partnerships among students, the school and the science community.

Science challenge activities may be conducted solely at the school level, or with the intent of preparing students for competition in one of the regional science fairs, perhaps as a step towards the Canada-Wide Science Festival. Although students may be motivated by prizes, awards and the possibility of scholarships, teachers should emphasize that the importance of doing a science fair project includes attaining new experiences and skills that go beyond science, technology or engineering. Students learn to present their ideas to an authentic public that may consist of parents, teachers and the top scientists in a given field.

Science fair projects typically consist of:

- an experiment, which is an original scientific experiment with a specific, original hypothesis. Students should control all important variables and demonstrate appropriate data collection and analysis techniques;
- a study, which involves the collection of data to reveal a pattern or correlation. Studies can include cause and effect relationships and theoretical investigations of the data. Studies are often carried out using surveys given to human subjects; or,
- an innovation, which deals with the creation and development of a new device, model, or technique in a technological field. These innovations may have commercial applications or be of benefit to humans.

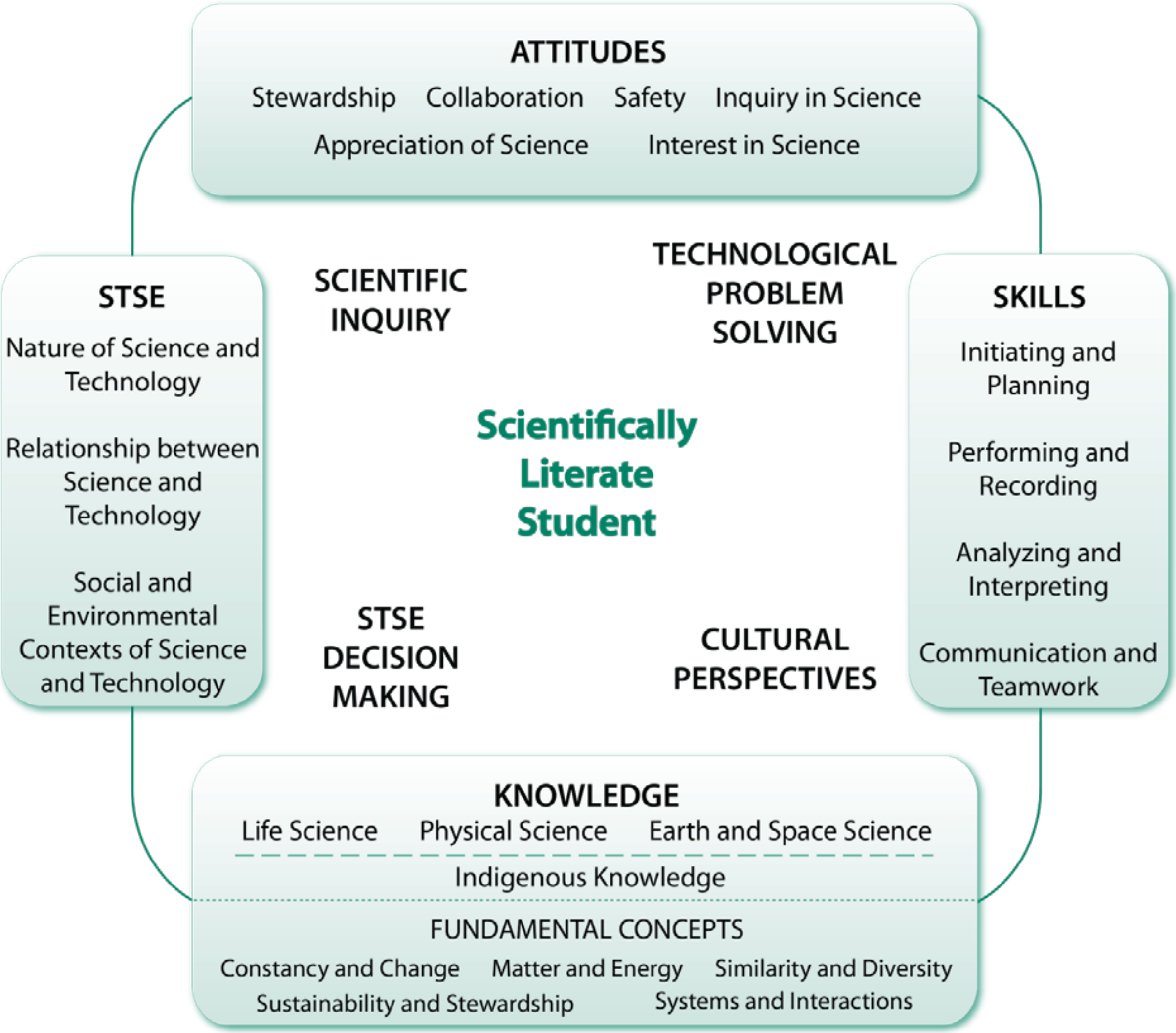
Youth Science Canada provides further information regarding science fairs and festivals in Canada.

An Effective Computer Science Education Program

An effective computer science education program supports student achievement of learning outcomes through:

- incorporating all foundations of scientific literacy;
- using the learning contexts as entry points into student inquiry;
- understanding and effectively using the language of science;
- incorporating computational thinking;
- choosing appropriate programming languages and technologies;
- recognizing health, safety and ethical issues; and,
- adopting programming practices that engage all students.

To achieve the vision of scientific literacy outlined in this curriculum, students must increasingly become engaged in the planning, development and evaluation of their own learning activities. In the process, students should have the opportunity to work collaboratively with others, to initiate investigations, to communicate findings and to complete projects that demonstrate learning.



- All science outcomes and indicators emphasize one or more of the foundations of scientific literacy (STSE, Knowledge, Skills and Attitudes); these represent the “what” of the curriculum. All outcomes are mandatory.
- The four learning contexts (Scientific Inquiry, Technological Problem Solving, Cultural Perspectives and STSE Decision Making) represent different processes for engaging students in achieving curricular outcomes; they represent the “how” of the curriculum.

Foundations of Scientific Literacy

The K-12 goals of science education parallel the foundation statements for scientific literacy described in the *Common Framework of Science Learning Outcomes K to 12* (CMEC, 1997). These four foundation statements delineate the critical aspects of students' scientific literacy. They reflect the wholeness and interconnectedness of learning and should be considered interrelated and mutually supportive.

Foundation 1: Science, Technology, Society and the Environment (STSE) Interrelationships

This foundation is concerned with understanding the scope and character of science, its connections to technology and the social and environmental contexts in which it is developed. This foundation is the driving force of scientific literacy. Three major dimensions address this foundation.

Nature of Science and Technology

Science is a social and cultural activity anchored in a particular intellectual tradition. It is one way of knowing nature, based on curiosity, imagination, intuition, exploration, observation, replication, interpretation of evidence and consensus making over this evidence and its interpretation. More than most other ways of knowing nature, science excels at predicting what will happen next, based on its descriptions and explanations of natural and technological phenomena.

Science-based ideas are continually being tested, modified and improved as new ideas supersede existing ones. Technology, like science, is a creative human activity, but is concerned with solving practical problems that arise from human/social needs, particularly the need to adapt to the environment and to fuel a nation's economy. New products and processes are produced by research and development through inquiry and design.

Relationships between Science and Technology

Historically, the development of technology has been strongly linked to the development of science, with each making contributions to the other. While there are important relationships and interdependencies, there are also important differences. Where the focus of science is on the development and verification of knowledge, in technology, the focus is on the development of solutions, involving devices and systems that meet a given need within the constraints of the problem. The test of science knowledge is that it helps us explain, interpret and predict; the test of technology is that it works – it enables us to achieve a given purpose.

Social and Environmental Contexts of Science and Technology

The history of science shows that scientific development takes place within a social context that includes economic, political, social and cultural forces along with personal biases and the need for peer acceptance and recognition. Many examples show that cultural and intellectual traditions have influenced the focus and methodologies of science, and that science, in turn, has influenced the wider world of ideas. Today, societal and environmental needs and issues often drive research agendas. As technological solutions have emerged from previous research, many of the new technologies have given rise to complex social and environmental issues which are increasingly becoming part of the political agenda. The potential of science, technology and Indigenous knowledge to inform and empower decision making by individuals, communities and society is central to scientific literacy in a democratic society.

Foundation 2: Scientific Knowledge

This foundation focuses on the subject matter of science including the theories, models, concepts and principles that are essential to an understanding of the natural and constructed world. For organizational purposes, this foundation is framed using widely accepted science disciplines.

Life Science

Life science deals with the growth and interactions of life forms within their environments in ways that reflect the uniqueness, diversity, genetic continuity and changing nature of these life forms. Life science includes the study of topics such as ecosystems, biological diversity, organisms, cell biology, biochemistry, diseases, genetic engineering and biotechnology.

Physical Science

Physical science, which encompasses chemistry and physics, deals with matter, energy and forces. Matter has structure, and its components interact. Energy links matter to gravitational, electromagnetic and nuclear forces in the universe. The conservation laws of mass and energy, momentum and charge are addressed in physical science.

Earth and Space Science

Earth and space science brings local, global and universal perspectives to student knowledge. Earth, our home planet, exhibits form, structure and patterns of change, as do our surrounding solar system and the physical universe beyond. Earth and space science includes such fields of study as geology, hydrology, meteorology and astronomy.

Sources of Knowledge about Nature

A strong science program recognizes that modern science is not the only form of empirical knowledge about nature and aims to broaden student understanding of traditional and local knowledge systems. The dialogue between scientists and traditional knowledge holders has an extensive history and continues to grow as researchers and practitioners seek to better understand our complex world. The terms "traditional knowledge", "Indigenous knowledge" and "Traditional Ecological Knowledge" are used by practitioners worldwide when referencing local knowledge systems which are embedded within particular worldviews. This curriculum uses the term "Indigenous knowledge" and provides the following definitions to show parallels and distinctions between Indigenous knowledge and scientific knowledge.

Indigenous Knowledge	Scientific Knowledge
"Traditional [Indigenous] knowledge is a cumulative body of knowledge, know-how, practices and representations maintained and developed by peoples with extended histories of interaction with the natural environment. These sophisticated sets of understandings, interpretations and meanings are part and parcel of a cultural complex that encompasses language, naming and classification systems, resource use practices, ritual, spirituality and worldview" (International Council for Science, 2002, p. 3).	Similar to Indigenous knowledge, scientific knowledge is a cumulative body of knowledge, know-how, practices and representations maintained and developed by people (scientists) with extended histories of interaction with the natural environment. These sophisticated sets of understandings, interpretations and meanings are part and parcel of cultural complexes that encompass language, naming and classification systems, resource use practices, ritual and worldview.

Fundamental Concepts – Linking Scientific Disciplines
A useful way to create linkages among science disciplines is through fundamental concepts that underlie and integrate different scientific disciplines. Fundamental concepts provide a context for explaining, organizing and connecting knowledge. Students deepen their understanding of these fundamental concepts and apply their understanding with increasing sophistication as they progress through the curriculum from Kindergarten to Grade 12. These fundamental concepts are identified in the following chart.

Constancy and Change	The ideas of constancy and change underlie understanding of the natural and constructed world. Through observations, students learn that some characteristics of materials and systems remain constant over time whereas other characteristics change. These changes vary in rate, scale and pattern, including trends and cycles, and may be quantified using mathematics, particularly measurement.
Matter and Energy	Objects in the physical world are comprised of matter. Students examine materials to understand their properties and structures. The idea of energy provides a conceptual tool that brings together many understandings about natural phenomena, materials and the process of change. Energy, whether transmitted or transformed, is the driving force of both movement and change.
Similarity and Diversity	The ideas of similarity and diversity provide tools for organizing our experiences with the natural and constructed world. Beginning with informal experiences, students learn to recognize attributes of materials that help to make useful distinctions between one type of material and another, and between one event and another. Over time, students adopt accepted procedures and protocols for describing and classifying objects encountered, thus enabling students to share ideas with others and to reflect on their own experiences.
Systems and Interactions	An important way to understand and interpret the world is to think about the whole in terms of its parts and alternately about its parts in terms of how they relate to one another and to the whole. A system is an organized group of related objects or components that interact with one another so that the overall effect is much greater than that of the individual parts, even when these are considered together.
Sustainability and Stewardship	Sustainability refers to the ability to meet our present needs without compromising the ability of future generations to meet their needs. Stewardship refers to the personal responsibility to take action in order to participate in the responsible management of natural resources. By developing their understanding of ideas related to sustainability, students are able to take increasing responsibility for making choices that reflect those ideas.

Foundation 3: Scientific and Technological Skills and Processes

This foundation identifies the skills and processes students develop in answering questions, solving problems and making decisions. While these skills and processes are not unique to science, they play an important role in the development of scientific and technological understanding and in the application of acquired knowledge to new situations. Four broad skill areas are outlined in this foundation. Each area is developed further at each grade level with increasing scope and complexity of application.

Initiating and Planning

These are the processes of questioning, identifying problems and developing preliminary ideas and plans.

Performing and Recording

These are the skills and processes of carrying out a plan of action, which involves gathering evidence by observation and, in most cases, manipulating materials and equipment. Gathered evidence can be documented and recorded in a variety of formats.

Analyzing and Interpreting

These are the skills and processes of examining information and evidence, organizing and presenting data so that they can be interpreted, interpreting those data, evaluating the evidence and applying the results of that evaluation.

Communication and Teamwork

In science and technology, as in other areas, communication skills are essential whenever ideas are being developed, tested, interpreted, debated and accepted or rejected. Teamwork skills are also important because the development and application of ideas rely on collaborative processes both in science-related occupations and in learning.

Foundation 4: Attitudes

This foundation focuses on encouraging students to develop attitudes, values and ethics that inform a responsible use of science and technology for the mutual benefit of self, society and the environment. This foundation identifies six categories in which science education can contribute to the development of scientific literacy.

Both scientific and Indigenous knowledge systems place value on attitudes, values and ethics. These are more likely to be presented in a holistic manner in Indigenous knowledge systems.

Appreciation of Science

Students will be encouraged to critically and contextually appreciate the role and contributions of science and technology in their lives and to their community's culture; and to be aware of the limits of science and technology as well as their impact on economic, political, environmental, cultural and ethical events.

Interest in Science

Students will be encouraged to develop curiosity and continuing interest in the study of science at home, in school and in the community.

Inquiry in Science

Students will be encouraged to develop critical beliefs concerning the need for evidence and reasoned argument in the development of scientific knowledge.

Collaboration

Students will be encouraged to nurture competence in collaborative activity with classmates and others, inside and outside of the school.

Stewardship

Students will be encouraged to develop responsibility in the application of science and technology in relation to society and the natural environment.

Safety

Students engaged in science and technology activities will be expected to demonstrate a concern for safety and doing no harm to themselves or others, including plants and animals.

Learning Contexts

Learning contexts provide entry points into the curriculum that engage students in inquiry-based learning to achieve scientific literacy. Each learning context reflects a different, but overlapping, philosophical rationale for including science as a required area of study:

- The **scientific inquiry** learning context reflects an emphasis on understanding the natural and constructed world using systematic empirical processes that lead to the formation of theories that explain observed events and that facilitate prediction.
- The **technological problem solving** learning context reflects an emphasis on designing and building to solve practical human problems similar to the way an engineer would.
- The **STSE decision making** learning context reflects the need to engage citizens in thinking about human and world issues through a scientific lens in order to inform and empower decision making by individuals, communities and society.
- The **cultural perspectives** learning context reflects a humanistic perspective that views teaching and learning as cultural transmission and acquisition (Aikenhead, 2006).

These learning contexts are not mutually exclusive; thus, well-designed instruction may incorporate more than one learning context. Students should experience learning through each learning context at each grade; it is not necessary, nor advisable, for each student to attempt to engage in learning through each learning context in each unit of study. Learning within a classroom may be structured to enable individuals or groups of students to achieve the same curricular outcomes through different learning contexts.

A choice of learning approaches can also be informed by recent well-established ideas on how and why students learn:

- Learning occurs when students are treated as a community of practitioners of scientific literacy.
- Learning is both a social and an individual event for constructing and refining ideas and competences.

- Learning involves the development of new self-identities for many students.
- Learning is inhibited when students feel a culture clash between their home culture and the culture of school science.

Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work.

(NRC,1996, p. 23)

Scientific Inquiry [SI]

Inquiry is a defining feature of the scientific way of knowing nature. Scientific inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations. Scientific inquiry is a multifaceted activity that involves:

- making observations, including watching or listening to knowledgeable sources;
- posing questions or becoming curious about the questions of others;
- examining books and other sources of information to see what is already known;
- reviewing what is already known in light of experimental evidence and rational arguments;
- planning investigations, including field studies and experiments;
- acquiring the resources (financial or material) to carry out investigations;
- using tools to gather, analyze, and interpret data;
- proposing critical answers, explanations, and predictions; and,
- communicating the results to various audiences.

By participating in a variety of inquiry experiences that vary in the amount of student self-direction, students develop competencies necessary to conduct inquiries of their own – a key element to scientific literacy.

Technological Problem Solving [TPS]

Technological design is a distinctive process with a number of defined characteristics; it is purposeful; it is based on certain requirements; it is systematic; it is iterative; it is creative; and there are many possible solutions.

(International Technology Education Association, 2000, p. 91)

The essence of the technological problem solving learning context is that students seek answers to practical problems. This process is based on addressing human and social needs and is typically addressed through an iterative design-action process that involves steps such as:

- identifying a problem;
- identifying constraints and sources of support;
- identifying alternative possible solutions and selecting one on which to work;
- planning and building a prototype or a plan of action to resolve the problem; and,
- testing, evaluating and refining the prototype or plan.

By participating in a variety of technological and environmental problem-solving activities, students develop capacities to analyze and resolve authentic problems in the natural and constructed world.

STSE Decision Making [DM]

Scientific knowledge can be related to understanding the relationships among science, technology, society and the environment. Students must also consider values or ethics, however, when addressing a question or issue. STSE decision making involves steps such as:

- clarifying an issue;
- evaluating available research and different viewpoints on the issue;
- generating possible courses of action or solutions;
- evaluating the pros and cons for each action or solution;
- identifying a fundamental value associated with each action or solution;
- making a thoughtful decision;
- examining the impact of the decision; and,
- reflecting back on the process of decision making.

To engage with science and technology toward practical ends, people must be able to critically assess the information they come across and critically evaluate the trustworthiness of the information source.

(Aikenhead, 2006 p. 2)

Students may engage with STSE issues through research projects, student-designed laboratory investigations, case studies, role playing, debates, deliberative dialogues and action projects.

Cultural Perspectives [CP]

Students should recognize and respect that all cultures develop knowledge systems to describe and explain nature. Two knowledge systems which are emphasized in this curriculum are First Nations and Métis cultures (Indigenous knowledge) and Euro-Canadian cultures (science). In their own way, both of these knowledge systems convey an understanding of the natural and constructed worlds, and they create or borrow from other cultures' technologies to resolve practical problems. Both knowledge systems are systematic, rational, empirical, dynamically changeable and culturally specific.

For First Nations people, the purpose of learning is to develop the skills, knowledge, values and wisdom needed to honour and protect the natural world and ensure the long-term sustainability of life.

(Canadian Council on Learning, 2007, p. 18)

Cultural features of science are, in part, conveyed through the other three learning contexts and when addressing the nature of science. Cultural perspectives on science can also be taught in activities that explicitly explore Indigenous knowledge or knowledge from other cultures.

For the Métis people, learning is understood as a process of discovering the skills, knowledge and wisdom needed to live in harmony with the Creator and creation, a way of being that is expressed as the Sacred Act of Living a Good Life.

(Canadian Council on Learning, 2007, p. 22)

Addressing cultural perspectives in science involves:

- recognizing and respecting knowledge systems that various cultures have developed to understand the natural world and technologies they have created to solve human problems;
- recognizing that science, as one of those knowledge systems, evolved within Euro-Canadian cultures;
- valuing place-based knowledge to solve practical problems; and,
- honouring protocols for obtaining knowledge from a knowledge keeper, and taking responsibility for knowing it.

By engaging in explorations of cultural perspectives, scientifically literate students begin to appreciate the worldviews and belief systems fundamental to science and to Indigenous knowledge.

The Language of Science

Science is a way of understanding the natural world using internally consistent methods and principles that are well-described and understood by the scientific community. The principles and theories of science have been established through repeated experimentation and observation and have been refereed through peer review before general acceptance by the scientific community. Acceptance of a theory does not imply unchanging belief in a theory, or denote dogma. Instead, as new data become available, previous scientific explanations are revised and improved, or rejected and replaced. There is a progression from a hypothesis to a theory using testable, scientific laws. Many hypotheses are tested to generate a theory. Only a few scientific facts are considered laws (e.g., the law of conservation of mass and Newton's laws of motion).

Scientific models are constructed to represent and explain certain aspects of physical phenomenon. Models are never exact replicas of real phenomena; rather, models are simplified versions of reality, constructed in order to facilitate study of complex systems such as the atom, climate change and biogeochemical cycles. Models may be physical, mental, mathematical or contain a combination of these elements. Models are complex constructions that consist of conceptual objects and processes in which the objects participate or interact. Scientists spend considerable time and effort building and testing models to further understanding of the natural world.

When engaging in the processes of science, students are constantly building and testing their own models of understanding of the natural world. Students may need help in learning how to identify and articulate their own models of natural phenomena. Activities that involve reflection and natural phenomena. Activities that involve reflection and metacognition are particularly useful in this regard. Students should be able to identify the features of the natural phenomena their models represent or explain. Just as importantly, students should identify which features are not represented or explained by their models. Students should determine the usefulness of their model by judging whether the model helps in understanding the underlying concepts or processes. Ultimately, students realize that different models of the same phenomena may be needed in order to investigate or understand different aspects of the phenomena.

Programming Languages

The choice of programming language for *Computer Science 20* and *Computer Science 30* is left to individual teachers who are best situated to make the decision based on their experience, language suitability to support curricular outcomes and available technology and technical support. Languages that are platform independent allow flexibility for students to work at home.

In order to facilitate student learning with a focus on problem solving and computational thinking as opposed to a focus on language syntax, the choice of programming language should take into consideration the learning curve associated with a specific language. Some environments may breed student frustration due to language design choices that solve problems that the student will never encounter.

Teachers may choose to change the programming language from *Computer Science 20* to *Computer Science 30*, although the change is not required. When choosing a language that will serve for both courses, it is important that the language not be a constraint for the content in *Computer Science 30*, specifically the need to explore the concepts and principles of object oriented programming (OOP).

Suggested Languages for Computer Science 20	**Suggested Languages for Computer Science 30**
• Python • Java • PHP • JavaScript • Visual Basic	• Python • Processing • Java • PHP • JavaScript

One of the key objectives of *Computer Science 20* is to promote interest in this field. To that end, students should start coding as soon as possible in the course. For that purpose, a visual programming environment can be very useful to simplify the syntax of programming in order to focus on algorithm design and problem solving. While a visual programming environment is useful as an introduction, it should not be used as the core language in *Computer Science 20*.

Suggested Visual Programming Environment for Computer Science 20
• Blockly • Scratch

A useful transition between a visual programming environment and a traditional language can be a constrained language, such as a modern adaptation of Karel the Robot built using the language you will be using for the rest of the course.

Computational Thinking

Computational thinking is a broad set of problem-solving processes which represent an entry point for new ways of thinking that are applicable in computer science and non-computer science contexts. The following are the essential dimensions of computational thinking:

- Decomposition, where a problem is broken into a set of simpler independent sub-problems.
- Pattern recognition, where similarities in related problems are identified.
- Abstraction, where specific differences in problems are viewed more generally, to allow for a single common solution.
- Algorithm design, where a sequence of steps are developed which can be followed to solve a problem.

Teachers should highlight connections to these aspects of computational thinking while addressing the outcomes in this document. As they describe thought processes that allow for description of problems in terms that lead to effective solutions, this should be an underlying theme throughout the entire course.

Technology in the Classroom

While it might seem self-evident that studying computer science requires computer technology, many aspects of programming and computational thinking can and should be addressed before students begin to code potential solutions to problems. No particular hardware is required or expected for *Computer Science 20*. Students may gain experience coding using a wide range of computing devices, such as computers, smartphones, robotics and microcontrollers.

Health, Safety and Ethics

Teachers should be cognizant of the major health and safety concerns associated with computer use, particularly musculoskeletal injuries such as repetitive strain injuries and eye strain. Student workstations should be arranged to support ergonomics and students should be encouraged to take regular breaks to stand and stretch.

Issues of personal safety and privacy are paramount in a computer science class. Students may not have a realistic understanding of the potential concerns that can arise when they share personal information electronically. These concerns might include identity theft, permanence of information on the Internet, cyberbullying and the promotion of hatred

Teachers should model ethical behaviours in the acquisition and use of software. It is also important to develop a classroom climate that respects the intellectual property rights of classmates and others. Students should carefully consider their responsibility when accessing and using confidential information and when accessing computer networks and the Internet. Teachers should ensure students are aware of all relevant school and school divisions' policies.

Gender Equity

Historically, male students have participated in computer science courses at a higher rate than female students. One explanation for this discrepancy is that girls feel that they do not belong in computer science courses (Master, Cheryan & Metzloff, 2016). Suggestions for increasing the female participation rate include connecting girls with female role models, illustrating how computer careers can make a difference in the world, making it fun and exploring problems that have socially meaningful applications.

Collaborative Programming

The nature of work in the programming industry is such that a programmer will seldom work alone on a project. *Computer Science 20* and *Computer Science 30* attempt to address this through the introduction of pair programming in *Computer Science 20* and team projects in *Computer Science 30*. The skills developed and the opportunity for learning that collaborative programming provides outweigh the challenges of organizing group work in a classroom setting. For example, in a split *Computer Science 20* and *Computer Science 30* classroom, there is an opportunity to leverage the skills of the *Computer Science 30* students in a coaching scenario to accelerate learning for the *Computer Science 20* students.

Code Elegance

Elegant code needs to be simple and easy to understand. Saint-Exupery said, "*Perfection is achieved, not when there is nothing more to add, but when there is nothing left to take away*." Developing an algorithm which simplifies code often makes the code more efficient. Writing elegant code involves carefully analyzing the problem and creating an algorithm with a balance between a minimal amount of code and the code being readable and reusable.

Core Principles and Techniques

Core Principles and Techniques are meant to be discussed and implemented throughout the course. Problem solving is at the very core of computer science. The ability to thoroughly understand the nature of a problem and develop a series of instructions that solves the problem is a fundamental programming skill. In addition, as students code programs throughout the course, they must be expected to abide to coding conventions in order to write code that is well organized and easy to understand.

Object-Oriented Programming (OOP)

Object-oriented programming is a design paradigm built on four major principles: encapsulation, abstraction, inheritance and polymorphism. Gaining experience in organizing information into objects that can interact with one another is one of the major new concepts to be introduced in *Computer Science 30*.

Capstone Coding Project

The capstone coding project is a multifaceted assignment that serves as a culminating experience for students in *Computer Science 30*. The preference is for the project to be student-directed. The project should encapsulate the entire development process from conceptualization to delivery of a working product. The scale of the project should reflect the amount of time allocated to it. While students may incorporate project management techniques to manage the project, learning project management is not an outcome of *Computer Science 30*.

Conventions Regarding Code Used in this Document

Although an attempt was made to use the most common/generic operators and syntax throughout this document, operators and syntax vary amongst programming languages. For example, the ‘is not equal to’ relational operator in some languages is symbolized as != while other languages use the <> symbol.

Outcomes at a Glance

Core Principles and Techniques
CS30-CP1 Implement effective coding practices throughout *Computer Science 30*.
CS30-CP2 Engage in collaborative programming practices.

Fundamentals of Programming
CS30-FP1 Investigate types of data structures and the advantages of organizing data in different ways.
CS30-FP2 Create programs that utilize external files.
CS30-FP3 Use libraries to simplify solutions to programming problems.
CS30-FP4 Explore the concepts and principles of object-oriented programming.

Core Concepts
CS30-CC1 Explore recursion and investigate sorting algorithms.
CS30-CC2 Explore number systems and character encoding used in computing.

Capstone Coding Project
CS30-CAP1 Create a large-scale computer program to demonstrate proficiency in procedural or object-oriented programming.
CS30-CAP2 Reflect on and document the process of creating a large-scale computer program.

Legend

CS30-CP1a	
CS30	Course name
CP	Unit of study
1	Outcome number
a	Indicator

Outcomes and Indicators

Core Principles and Techniques	
All outcomes contribute to the development of all K-12 science goals.	
Outcomes	**Indicators**
CS30-CP1 Implement effective coding practices throughout *Computer Science 30*.	a. Discuss the rationale for learning and using different programming languages. b. Contrast the syntax of the language used in *Computer Science 20* with the language used in *Computer Science 30*, as needed. c. Compare the coding conventions of the language used in *Computer Science 20* with the language used in *Computer Science 30*, as needed. d. Refactor existing code to increase elegance. e. Critique third-party code (e.g., student, teacher or textbook programs) and make suggestions for improvement. f. Use interactive debugging techniques involving breakpoints and watch windows. g. Access search engines, forums and question and answer sites independently to find solutions to coding problems.
CS30-CP2 Engage in collaborative programming practices.	a. Explore collaborative programming practices and models. b. Collaborate with others to plan a solution to a problem. c. Develop procedural or object-oriented programs collaboratively. d. Explore version control using shared folders or versioning software. e. Develop and follow a common standard of programming style to integrate code from multiple programmers. f. Reflect on the advantages and challenges encountered when working in collaborative contexts to solve programming problems. g. Interact with experts who work in collaborative programming environments.

Fundamentals of Programming	
All outcomes contribute to the development of all K-12 science goals.	
Outcomes	**Indicators**
CS30-FP1 Investigate types of data structures and the advantages of organizing data in different ways.	a. Provide examples of the types of problems that can be solved using two-dimensional arrays, mutable (dynamic) arrays and associative arrays (e.g., hash tables or dictionaries). b. Develop a program that utilizes a two-dimensional array. c. Solve a problem utilizing a mutable array (e.g., list or ArrayList). d. Explore the use of associative arrays (e.g., hash tables or dictionaries) to store a dataset. e. Discuss the advantages of using different data structures to solve problems.
CS30-FP2 Create programs that utilize external files.	a. Identify the types of problems (e.g., high score list, cookie, preferences or output file) that can be solved by utilizing external data. b. Load content from a local or remote file into a program. c. Parse the data from an external file to remove extraneous information, if necessary. d. Save the state of a program by creating or modifying a file. e. Discuss the importance of saving data into an external file.
CS30-FP3 Use libraries to simplify solutions to programming problems	a. Explain the advantages of using libraries (packages) in programs b. Create a program that imports a package or classes within a package. c. Identify the functionality of a library from the documentation or application programming interface (API). d. Write a program that utilizes an application programming interface (API) (e.g., social networking, weather data, user authentication, photo sharing and geolocation data).
CS30-FP4 Explore the concepts and principles of object-oriented programming.	a. Investigate object-oriented programming concepts including classes, objects, attributes and methods. b. Discuss how a class can be understood as a programmer-defined data type. c. Design and implement a class, and create a program that utilizes instances of this class. d. Apply the principle of encapsulation through the creation and use of user-defined objects. e. Create a constructor and use it to instantiate an object. f. Compare object-oriented and procedural programming paradigms.

Core Concepts	
All outcomes contribute to the development of all K-12 science goals.	
Outcomes	**Indicators**
CS30-CC1 Explore recursion and investigate sorting algorithms.	a. Distinguish between iterative and recursive problem-solving techniques and demonstrate how to accomplish a specific task using both approaches. b. Create recursive functions and use them in programs to solve problems such as calculating factorials, evaluating exponents, designing fractal images or calculating the Fibonacci sequence. c. Discuss the processes (e.g., the stack, stack frames and maximum recursion depth) involved in evaluating recursive functions. d. Identify the advantages and disadvantages of using recursive approaches to problem solving. e. Provide examples of situations where sorting is used to solve problems. f. Discuss the importance of efficiency in sorting algorithms. g. Analyze the execution of insertion, selection and quicksort algorithms using visualizations. h. Illustrate the implementation of a sorting algorithm (e.g., selection, insertion and quicksort) using pseudocode. i. Create a program to sort data in an array using one or more sorting algorithms (e.g., selection, insertion and quicksort).
CS30-CC2 Explore number systems and character encoding used in computing.	a. Discuss how all digital data is stored numerically and how the data type dictates the interpretation of the number. b. Discuss the rationale for using various number systems. c. Convert between binary (base 2), decimal (base 10) and hexadecimal (base 16) number systems. d. Analyze the implications (e.g., rounding error) for precision when storing a floating point value as a binary number. e. Discuss how colour values are represented digitally, including RGB and hexadecimal. f. Discuss how character encoding systems such as ASCII and Unicode represent text.

Capstone Coding Concepts	
All outcomes contribute to the development of all K-12 science goals.	
Outcomes	**Indicators**
CS30-CAP1 Create a large-scale computer program to demonstrate proficiency in procedural or object-oriented programming.	a. Choose a project that is of an appropriate scale and complexity based on the skills and abilities of team members. b. Identify required features and desired features of the project. c. Incorporate programming concepts and principles such as data structures, external files, libraries and/or object-oriented programming as required. d. Develop elegant code and refine through multiple iterations. e. Integrate code from multiple team members as required. f. Conduct beta testing with peers and/or external participants. g. Incorporate feedback from peers and/or external participants as required. h. Revise the scale and complexity of the project according to skill level, available resources and available time. i. Confirm that the project incorporates all required features.
CS30-CAP2 Document and reflect on the process of creating a large-scale computer program.	a. Create a project proposal that includes the basic premise, required features, desired features and project team (e.g., individual, pairs or larger group). b. Develop and revise project documents such as team member tasks, change logs, milestone timeline and/or user manuals. c. Report on beta testing with peers and/or external participants. d. Discuss the importance of developing technical supports such as user manuals and training materials. e. Identify how specific programming challenges were resolved. f. Discuss the challenges and benefits of working with others to develop a large-scale computer program. g. Examine connections between the capstone coding project and related careers. h. Present completed capstone project to peers and/or external participants.

Assessment and Evaluation of Student Learning

Assessment and evaluation require thoughtful planning and implementation to support the learning process and to inform teaching. All assessment and evaluation of student achievement must be based on the outcomes in the provincial curriculum.

Assessment involves the systematic collection of information about student learning with respect to:

- achievement of provincial curriculum outcomes;
- effectiveness of teaching strategies employed; and,
- student self-reflection on learning.

Evaluation compares assessment information against criteria based on curriculum outcomes for the purpose of communicating to students, teachers, parents/caregivers and others about student progress and to make informed decisions about the teaching and learning process.

There are three interrelated purposes of assessment. Each type of assessment, systematically implemented, contributes to an overall picture of an individual student's achievement.

Assessment for learning involves the use of information about student progress to support and improve student learning, inform instructional practices, and:

- is teacher-driven for student, teacher and parent use;
- occurs throughout the teaching and learning process, using a variety of tools; and,
- engages teachers in providing differentiated instruction, feedback to students to enhance their learning and information to parents in support of learning.

Assessment as learning actively involves student reflection on learning, monitoring of her/his own progress, and:

- supports students in critically analyzing learning related to curricular outcomes;
- is student-driven with teacher guidance; and,
- occurs throughout the learning process.

Assessment of learning involves teachers' use of evidence of student learning to make judgements about student achievement and:

- provides opportunity to report evidence of achievement related to curricular outcomes;
- occurs at the end of a learning cycle, using a variety of tools; and,
- provides the foundation for discussions on placement or promotion.

Glossary

Abstraction is the process of identifying general principles in order that one solution can solve multiple problems.

An **algorithm** is a series of systematic instructions to solve a problem.

An **Application Programming Interface (API)** is a set of subroutine definitions, protocols and tools for building application software.

An **associative array** is an abstract data type composed of a collection of key-value pairs such that each possible key appears at most once.

The **assignment** operator assigns a value to a variable.

An **attribute**, in object-oriented programming, is a named property of a class that described the range of values that property may hold

A **breakpoint** is a specific statement in a problem at which program execution can be halted for debugging purposes.

Classes are used in object-oriented programming as templates to create objects, provide initial values for state and implement behaviour.

Computational thinking is the thought process involved in describing a problem and its solutions so that an information-processing agent can carry out the solution. The defining characteristics of computational thinking are decomposition, pattern recognition, data representation, abstraction and algorithms.

A **constructor**, in object-oriented programming, a special type of subroutine called to create an object.

Cultural perspectives is the learning context that reflects a humanistic perspective which views teaching and learning as cultural transmission and acquisition.

Decomposition is breaking a complex problem into simpler parts.

Elegance means that code is correct, simple, efficient and readable.

Encapsulate means to restrict access to an object's internal properties.

Iteration means the repetition of a process, typically associated with loops.

Methods, in object-oriented programming, are procedures associated with a message and an object.

A **mutable array** has the ability to change in size (number of elements) while the program is running.

Object-oriented programming (OOP) is a programming paradigm that is based on objects, which may contain data, in the form of fields, often known as attributes; and code, in the form of procedures, often known as methods.

Objects, in object-oriented programming, refer to a particular instance of a class where the object can be a combination of variables, functions and data structures.

Pattern recognition is learning to identify and use similarities to simplify, shorten and apply similar solutions.

Procedural programming is a programming paradigm that is based on calling procedures, routines, subroutines or functions.

Pseudocode is a notational system in which ideas can be expressed informally during algorithm development.

Recursion is the process by which a function calls itself.

Code **refactoring** is the process of restructuring existing computer code to improve its readability and reduce its complexity without changing its external behavior.

Scientific inquiry is the learning context that reflects an emphasis on understanding the natural and constructed world using systematic empirical processes that lead to the formation of theories that explain observed events and that facilitate prediction.

Scientific literacy is an evolving combination of the knowledge of nature, skills, processes and attitudes students need to develop inquiry, problem-solving and decision-making abilities to become lifelong learners and to maintain a sense of wonder about and responsibility towards the natural and constructed world.

STSE, which stands for science, technology, society and the environment, is the foundation of scientific literacy that is concerned with understanding the scope and character of science, its connections to technology and the social context in which it is developed.

STSE decision making is the learning context that reflects the need to engage citizens in thinking about human and world issues through a scientific lens in order to inform and empower decision making by individuals, communities and society.

The **syntax** of a language is the set of rules that describes the form of a valid program.

Technological problem solving is the learning context that reflects an emphasis on designing and building to solve practical human problems.

A **variable** is a storage location for data in a computer program.

A **visual programming language** lets users create programs by manipulating program elements graphically rather than by specifying them textually.

A **watch window** displays variable values while the program is debugged using breakpoints.

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Suggested Reading

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Feedback Form

The Ministry of Education welcomes your response to this curriculum and invites you to complete and return this feedback form.

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