

## Pan-Canadian Science Framework: Product and Process

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### SIMPOSIO "Science-Technology-Society Reform in High School Chemistry in Mexico-USA-Canada"

Durante el Quinto Congreso de Química del Continente de América del Norte (*Fifth Chemical Congress of North America*), celebrado en Cancún (Noviembre 11-15 de 1997) se realizó este simposio, en el que se presentaron los siguientes trabajos:

- 1) Henry Heikkinen, University of Northern Colorado, USA: "The Design and Development of ChemCom: A Case Study in Curricular Risk-Taking and Decision-Making"
- 2) J. Dudley Herron, Morehead State University, USA: "Seminaries for Country Parsons"
- 3) Raja Panwar, Alberta Education, Canada: "Pan-Canadian Science Framework: Product and Process"
- 4) Stella Shrum, Alberta Education, Canada: "Designing and Developing Science-Technology-Society (STS) Telecourses, Resources and Assessment Materials for High School Chemistry in Alberta, Canada"
- 5) Sylvia. A. Ware, Education Division, American Chemical Society, USA: "National Science Education Standards, Benchmarks, and Checom"
- 6) Alberto Cárdenas, Leonor Pinelo, Ignacio Rodríguez and Rosalinda Rojano, Colegio de Ciencias y Humanidades, UNAM, México: "New Science-Technology-Society Syllabi for 70,000 Students of CCH in Mexico City"
- 7) Conrad Stanitski, University of Central Arkansas, USA: "ChemCom After More Than a Decade—A Look Backwards and Forward"
- 8) I. Dwaine Eubanks, Clemson University, USA: "Changing Teachers for Changing Curricula"
- 9) B.E. Ruiz Silva, F. Fate, D. Mitchell, M. Estrick, E. Carter, J. Rountree and R. Olvina, Los Angeles City College, USA: "Upward Bound Chemistry at Los Angeles City College: Designing a Curriculum"
- 10) Andoni Garritz, Universidad Nacional Autónoma de México: "STS and Mexican Teaching Standards"<sup>1</sup>
- 11) Adela Castillejos, Universidad Nacional Autónoma de México: "Using ChemCom with Mexican High School Students and in Teachers' Training Activities"

En este número de la revista incluimos tres de ellos (los números 3, 7 y 9), que fueron desarrollados en extenso por los autores para ser publicados en *Educación Química*.

### Abstract

The focus of this article is the Common Framework of Science Learning Outcomes, K-12 developed under the aegis of the Council of Ministers of Education, Canada (CMEC). In February 1995 CMEC adopted the Pan-Canadian Protocol for Collaboration on School Curriculum, which formed the basis for the Pan-Canadian Science Project resulting in the Framework as a deliverable. Science consultants from provincial and territorial ministries of education, together with classroom science teachers working in Canada's two official languages—English and French—were involved in the development of the framework. This paper examines the structures and processes that were needed to operationalize the project as well as resolve issues. These issues, structures and processes will be of particular interest to educators, but also to non-educators who may be involved in future Pan-Canadian projects conceived as part of the Protocol for Collaboration on School Curriculum.

### Introduction

This paper provides a description of the Common Framework of Science Learning Outcomes, K-12, its development and the issues surrounding this first-ever cooperative endeavor among the provinces (with the exception of Quebec) and territories of Canada to create a science framework for science in both official languages. The framework was developed primarily for curriculum developers working within the provincial and territorial ministries of education, providing them a common starting point for the development of curriculum. It is the hope that curriculum developed using the framework as a reference set will result in greater consistency in learning outcomes, and greater harmonization of science curricula across Canada. Other potential benefits include: easing student mobility across Canada, the development of quality teaching and learning resources, and increased collaboration in the area of professional development.

Canada, unlike many other nations, does not have a federal agency responsible for primary and secondary school education. Responsibility for education resides solely within the provinces or territories. Within Canada, the minister of education is supported by a ministry of education in discharging his or her legislative duties at the provincial or territorial level. In 1967 the Council of Ministers of Education Canada (CMEC) was created to provide ministers of education with a mechanism for consultation in matters of

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mutual interest and concern at the primary, secondary and post-secondary levels. The Council comprised of ministers of education from the provinces and territories meets twice a year, and undertakes activities in a spirit of cooperation while still retaining jurisdiction over local educational policies and practices. An example of a recent cooperative activity undertaken at the national level is the School Achievement Indicators Project (SAIP) that measured student achievement in science, mathematics and language arts for 13- and 16-year olds.

In recent years, there have also been a number of regionally-based cooperative projects in school education. For example, the 1993 Western Canadian Protocol for Collaboration in Basic Education (Kindergarten to Grade 12) identified a number of areas of cooperation, that are at various stages of development or implementation. Areas of cooperation include:

- Aboriginal (Native) Education
- Distance Learning and Technology
- English Language Arts for Francophone Program
- English Language Arts for French Immersion
- French Language Arts
- Francais
- Language Arts
- Mathematics (K to 12)
- Mathematics – Computer Assisted Instruction
- Multi-media Chemistry
- Special Education
- Teacher Preparation and Certification

In Canada, provincial responsibility for education was enshrined at the time of confederation in 1867 in recognition of the regional differences, and a belief in the value on developing policies that are responsive to local needs and interests. As Canada moves into the 21st century, Canadians are beginning to recognize they have increasingly common beliefs about education goals and expectations. As well, in an era of rapid social and economic change, Canadians, like others around the world, are contemplating their economic futures and well being in light of world events. This has led many Canadians to question whether the education system is adequately meeting the needs of their young people. Results of the Third International Mathematics and Science Study (TIMSS) indicated that Canada's overall achievement in science is only marginally above average, and these results have strengthened arguments for changing science teaching and learning in Canadian schools. The response of the ministers of education has been to cooperate more actively on matters of mutual interest with a view to achieving common goals that make optimum use of limited resources.

Recent initiatives in reforming science education in Australia, Britain, New Zealand, United States, and Western Europe have resulted in a variety of curriculum documents or frameworks. Governments, regardless of their political stripes, have engaged in large-scale educational reform initiatives, and now Canada too is part of this phenomenon of international dimensions.

Each country is fighting its own demons through reform of the educational system. So much is evident in the origins of many of the innovations. The accounts of more than a third of the innovations we studied explicitly cited their countries economic performance, and the same worry was probably an underlying cause in several more. There is alarm also, in countries which register low or declining scores in international studies of educational achievement or in national surveys (*Black and Atkin, 1996*).

The response of Western industrialized countries to the recent economic crisis has been to reduce social and economic spending. To cope with recent trends such as globalization of capital and production systems, and the flight of jobs to developing countries, governments and business in Canada are betting on a future prosperity based on knowledge intensive, high paying jobs. In the area of science, and mathematics education, the policy directions call for increased practical applications, and higher standards to better prepare students for further study and the knowledge intensive jobs of the future.

In an effort to contain spending on education, provincial and territorial governments are championing the cooperative development of national outcomes for science education, harmonization of curricula and learning resources, and alternative methods of delivering education. The reform agenda is clearly being driven by economic forces, but there are other factors as well. The pooling of resources could lead to a higher quality product –by choosing the best ideas, a product of higher quality could be developed in a cost efficient manner.

This paper describes both the processes used to develop the framework i.e., the product; and provides an assessment of the process and potential impact of the framework on science education.

## PROJECT AS PLANNED

### *Principles of Understanding*

The development work was guided by the following principles of understanding:

- Collaboration: The spirit and intent of the Pan-Canadian Protocol for Collaboration on School Curriculum described earlier will be supported.

- Consensual decision-making: All decisions whether policy or operational will be based on consensus.
- French language development and decision-making: A sufficient and balanced francophone representation at all levels of project management and processes was put in place to ensure the specific needs of the francophone component of the project, and for the simultaneous development of the framework in French.
- Participation: Provinces and territories could choose to participate in the development of any of the deliverables (for example, GLOS or SLOS or IES) without prejudice to future participation.
- Efficiency: To operationalize the project existing structures, research and information technology were used to keep costs affordable and increase efficiency.
- Effectiveness: To develop a quality product, processes and procedures were put in place to draw upon the strengths of participating provinces and territories.
- Communication: Communication, and communication processes and procedures among and within the ministries of education, and partners in education were essential to the ensure success of the project.
- Stakeholder involvement: To maximize stakeholder involvement and consultations, would occur within the context of the participating provinces and territories.

(1995, pages 2 and 3, Draft Proposal for Pan-Canadian Science Project)

### Project Management

To manage the project, a "lead jurisdiction model" was used. This meant that an anglophone lead jurisdiction (British Columbia) and a francophone lead jurisdiction (Manitoba) were responsible for the development of draft documents, and the development and review of questionnaires and responses to drafts leading to the final document. Representatives from provincial ministries of education participating in the project were members of the Project team. To provide policy direction to the Project team and overall project management, a Project Steering Committee comprised of senior education officials was created. A detailed description of the principles of understanding and the roles and responsibilities of the various structures put in place to operationalize the project are described above. (1995, Draft Proposal for Pan-Canadian Science Project)

The processes for the development of the framework were based on making the best use of provincial and territorial resources; the expertise of science teachers and educators; and stakeholder involvement. Though the framework is designed primarily for used by curriculum developers in the

ministries of education, care was taken to seek stakeholder involvement to ensure success of the project. As established consultation mechanisms within each province were utilized, the scope and the processes of consultations varied. Allocation of human and fiscal resources, and the expertise harnessed to support the project varied from province to province. A possible impact of these differences among the provinces, and in particular, the perceived adequacy of consultations, could be on the level of acceptance of the framework by the stakeholders, especially, science teachers and educators. The level of acceptance and support could have a direct impact on the utility of the framework in developing provincial curricula.

In Alberta, for example, the consultations were extensive. Teachers, parents, employers, post-secondary institutions and the scientific community were provided extensive opportunities to read and respond to the various drafts. Over 1800 copies of the draft framework and questionnaires were distributed by mail, and the drafts were posted on an internet website. As well, advice was gathered through an Advisory Committee, regional review sessions, and presentations at education conferences. At key points in the consultations, stakeholders in Alberta received a copy of the issues and concerns raised, and in subsequent meetings, members of the Alberta Project Team took the time to demonstrate how these issues and concerns had been addressed, and to identify those which were unresolved. It was the belief of the Alberta team that tapping into the expertise in the province would make the framework a better document. A high quality document, in turn would make subsequent curriculum development in science more effective and efficient, and contribute to the overall success of the project.

In November 1995, as a first step, in developing a common Pan-Canadian vision for science education, the participating provinces and territories were asked to submit a vision statement. Based on these statements, the Project Team created a vision statement to guide framework development. The vision statement and the introductory sections were reviewed by education partners in the spring of 1996. Later that spring, teachers and Project Team members drafted general and specific learning outcomes. In the fall of 1996, the draft document was reviewed by stakeholders in the participating provinces and territories. Because of the extensive changes made on the basis of the fall 1996 review, a request was made by the Project Team that a second review phase be added in the Spring of 1997. This second review was agreed to by the Steering Committee, and this review provided stakeholders an opportunity to see how their concerns and issues had been accommodated. Comments received from the Spring 1997 review were then used to prepare the final document for sign-off by the provinces in September

1997, followed shortly by the release of the document in October 1997.

To operationalize the project a variety of structures were created by the CMEC (1995, pages 4-6, Draft Proposal for Pan-Canadian Science Project). The roles and responsibilities of the various structures are provided below.

1. Pan-Canadian Science Project Steering Committee (Policy)

This committee, comprised of anglophone and francophone Assistant Deputy Ministers responsible for curriculum, provided policy and project management direction to the Pan-Canadian Science Project Committee. Specifically, their responsibilities included:

- managing communication among all participating provinces and territories, and stakeholders at the national level
- ensuring balanced regional and linguistic representation
- providing conflict resolution
- ensuring sign-off at consensus points
- identifying and providing recommendations to the Advisory Committee of Deputy Ministers of Education (ACDME) and CMEC, as required.

2. Pan-Canadian Science Project Team

This committee, comprised of anglophone and francophone science consultants from provincial and territorial ministries of education, worked collaboratively on the document according to the direction provided by the Project Steering Committee. Specifically, their responsibilities included:

- ensuring communication among all participating provinces and territories, and stakeholders at the national level
- providing deliverables on time
- identifying and resolving issues and conflicts
- identifying policy issues and preparing recommendations for consideration by the Project Steering Committee.

3. ACDME, CMEC Secretariat, Curriculum Directors, and Lead Jurisdictions

The ministers and deputy ministers of education participating in CMEC and the ACDME respectively, were responsible for approving the proposal for the project, receiving progress reports, and approving the Pan-Canadian Framework prior to release.

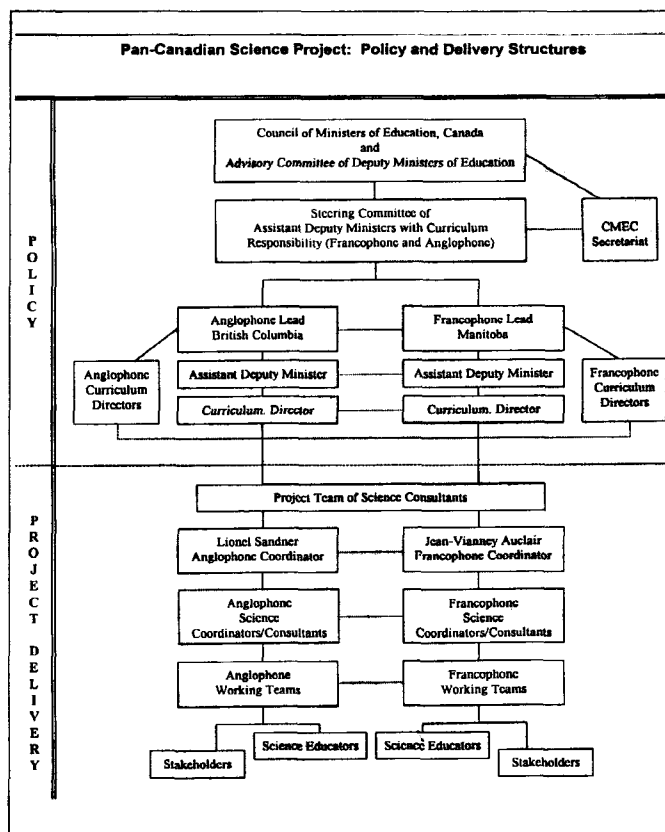
The CMEC Secretariat was largely responsible for preparing reports for CMEC and ACDME as directed by the Project Steering Committee. As well, services such as translation of documents, and preparation of a communication strategy, including press releases were provided by the Secretariat.

The Curriculum Directors from various provincial and territorial ministries of education met on a regular basis to help move the project forward by:

- managing the Pan-Canadian Science Project within their province or territory in keeping with the directions and requirements framed by the Project Steering Committee
- ensuring communication with, and appropriate involvement of stakeholders within their province or territory
- facilitating procedures and mechanisms to ensure completion of tasks on time and within budget allocations
- providing conflict and policy resolutions.

To assist the Project Steering Committee and the Science Project team, the two lead jurisdictions, British Columbia and Manitoba were responsible for:

- providing project coordinators with responsibility for carrying out the logistical details as directed by the Project Steering Committee from initiation to completion of the project
- ensuring communications among participating provinces and territories, CMEC Secretariat and other groups
- providing project support such as arranging meetings (video conferencing, teleconferences, work sessions), word processing, proofing, editing, graphics and desktopping



- ensuring co-development in French, and addressing francophone cultural components and issues

### **CARRYING OUT THE PROJECT: MOVING UP THE LEARNING CURVE**

As noted earlier, the Pan-Canadian Science Project represents a new direction for Canada. To create the framework, new structures and processes were developed. The development of the framework in twenty-three months by provinces and territories with differing views of science education, teaching and learning, and varying levels of expertise and experience, is a major milestone in science education. However, there have been concerns expressed about the number of learning outcomes—some feel there are too many—and are of the opinion the framework is more akin to a curriculum; others feel the framework is not detailed enough to ensure a harmonized science curriculum from province to province. Some have also expressed concerns regarding the short timelines for development and consultations. These concerns and the project in general, are being analyzed by CMEC with a view to create a model for the development of Pan-Canadian learning outcomes for other subject areas.

As a member of the Alberta Project Team, I would offer the following personal assessment.

#### **Project Management and Workplan**

The variety of structures such as the Project Steering Committee, or the CMEC Secretariat, and the Project Team generally worked well. Communication among the project structures was effective for managing the project. This was especially evident in the flexibility demonstrated in revising the project plan timelines and the list of deliverables. A variety of electronic technologies were used to good effect.

The project was designed on the “building block model”, where initial components were developed, and the subsequent pieces were built on the initial “building block.” Starting with the vision statement, the order of subsequent steps were: conceptual design, a set of general learning outcomes (GLOs), a set of specific learning outcomes (SLOs), and illustrative examples (IEs). These building blocks were desirable in that they specified the framework components. As work proceeded it was often necessary to revise a previous building block, or initial component on the basis of the subsequent work done on the blocks that followed. For example, the general learner outcomes were reviewed and revised as the specific learner outcomes were developed. Therefore, work not only proceeded from the general to the specific; it was also recursive, and towards the end of the project both the initial building blocks and the subsequent pieces were fitted together in a seamless manner. Given that the project was the first of its kind, some mistakes were

inevitably made, and unforeseen difficulties were encountered. In general, in the final stages of the project, the work became more efficient and effective. An examination of these difficulties should prove to be instructive to future projects.

Difficulties developed in the following areas:

- **the communication of intents, processes and products**  
At the start of the project the Project Team members were not clear about the purposes the project was to serve, and how the product was to be used. Initially team members were not clear whether the final product was to be a common curriculum or a common framework. This distinction is more than a matter of semantics. In general terms, a curriculum organizes learning outcomes into grade levels, or units of study, and is the first step towards instructional planning. Some curriculum documents include references to learning and teaching resources, teaching strategies, student activities and so on. A framework, on the other hand, includes introductory matter followed by learning outcomes organized by levels, strands and subject area.

A common curriculum proved to be impractical because of the major implications for provincial or territorial implementation. Provinces and territories would have to agree on synchronizing their implementation dates, and for some provinces that had recently revised their curriculum, it would mean the added financial burden of implementing a new program yet again. Clearly such a move would be unpopular with schools, parents and the public.

This lack of consensus created problems within the Project Team in establishing the appropriate focus and formats for development. Additionally, this lack of clarity made it difficult to communicate the project intents and implications to external groups. Unfortunately, the lack of clear answers to basic questions was seen as “evasiveness” by some stakeholders. Considerable effort was required to overcome initial skepticism. At the very least, the CMEC Secretariat could have emulated Alberta’s use of Internet website to keep stakeholders informed about the purpose of the project, and provided key messages by means of information brochures and FAQ (frequently asked questions) responses.

- **the limited number of staff that the lead provinces committed to support the project at the early stages of the project**

With additional staffing, more substantial work could have been done between Project Team meetings, and the efforts of the team at meetings could have focused on improving the work, and on the overall design of the framework. Indeed, whatever was saved on the part of the

lead jurisdictions was probably more than made up for by the extra time and resources put in by participating provinces and jurisdictions. As noted earlier, the contribution level by staff in participating jurisdictions varied from one jurisdiction to another.

- **the tapping of expertise of and insights of the people involved were not used to the best advantage**

Probably the most instructive experience arising from the project was in the effective use of expertise. For example, the teacher-writers were brought in well before matters relating to design and formats had been established, even at the prototype stage. Much of the work done at the first writing session had to be discarded as this work had little relevance to the later stages of work. Perhaps, the most productive use of classroom teachers would have been in short sessions critiquing early work, followed later by more extended sessions of generating and drafting ideas or some specific components of the framework such as the SLOS and the IES.

Officially, the project was set up so that each participating province or territory could bring in a full range of expertise to the project. In practice this did not happen mainly because there was no detailed plan for tapping into such expertise. With the benefit of hindsight, such a plan is essential, given the short timelines for consultations, and ensuring time necessary for dialogue is built into the plan. For example, when different alternatives needed to be generated and assessed cooperatively with the science education community, sufficient advance notice should have been provided so that the time needed could have been created for such an activity. A consequence of this oversight was the feeling among the Canadian science education community that they were not consulted adequately during the process, felt cut-off from the process, and as a consequence feel the framework could have been of better quality.

Additional expertise that could have been brought into the project included learning and development specialists, and scientists and technologists. These specialists could have reviewed the document at key stages of the development. The lead provinces coordinating the project should have included the involvement of these specialists in the project plan.

- **the use of productivity tools**

At the Project Team level, productivity tools for word processing and desktop publishing should have been placed on common platforms. This problem was slowly overcome during the latter phases of the project. However, as a precondition for new projects, efforts must be

made to seek common platforms or platforms that allow for seamless transfer of information. More importantly, a suggestion for shared data bases for writing should have been expedited. This would have required the creation of templates, and the provision of computers to the Project Team. The advantages of this approach include the in-depth exploration of formats, continuous display of changes, and how changes in part of the document affect other components. These displays would have informed the work of teams working in different areas of the framework. Very often a great deal of energy and time was consumed in re-entering data or information into various formats. Providing the framework on a CD-ROM that would allow the user to navigate through the framework and create links and views among the various components would have been the ideal situation. Another missed opportunity was enter learning outcomes, and their attributes into a data base that would permit a variety of linkages among the learning outcomes. These linkages could be made by the four foundations, or by grade and cluster level, and/or by grade clusters. As well, a data base would have permitted a curriculum developer to 'import' the appropriate learning outcomes into their curriculum.

#### FROM VISION TO FOUNDATIONS—THE KEY ELEMENTS OF THE FRAMEWORK

As mentioned earlier, science, mathematics and technology education are particular areas of concern to many countries as they are seen as the major forces driving change in our society (Black and Atkin, 1996). The rationale for the Pan-Canadian Science Project clearly acknowledges Canadians' perceptions of their national deficiencies:

As Canada moves into the twenty-first century, it is essential that all jurisdictions provide students with the necessary knowledge, skills, and attitudes for scientific literacy. Science education contributes to preparing students to be informed citizens, knowledgeable as consumers, productive as workers, and prepared as lifelong learners. (1995, p. 1, Draft Proposal for Pan-Canadian Science Project)

The framework's vision for scientific literacy was clearly influenced by:

- economic considerations

*The emergence of a highly competitive and integrated international economy, rapid technological innovations, and growing knowledge base will continue to have a profound impact on our lives.* (1997, p. 5, Common Framework of Science Learning Outcomes, K to 12)

- the need to prepare future citizens  
*prepare students to critically address science-related societal, economic, ethical and environmental issues. (1997, p. 5, Common Framework of Science Learning Outcomes, K to 12)*
- equity and inclusiveness  
*The framework is guided by the vision that all Canadian students, regardless of gender or cultural background, will have an opportunity to develop scientific literacy. (1997, p.4, Common Framework of Science Learning Outcomes, K to 12)*

The vision for scientific literacy incorporates both the “what”, i.e., the subject matter of science and the “why”, i.e., reasons for learning science. In general, science educators agree science education has a number of goals. These goals include “a selected set of messages about science” (1982, Roberts), or the “why” of science, and the conceptual and procedural knowledge to better understand:

- the processes by which scientific or technological knowledge is created, revised, or tested (Nature of science and Technology)
- the relationships between science and technology in solving problems, i.e., how one affects the other (Relationships between Science and Technology)
- the influence of societal and individual needs and decisions on the direction of scientific and technological endeavors, and in turn the impact of these endeavors on individual lives, social institutions and mores, and the environment. (Social and Environmental Contexts of Science and Technology)

The framework has four major foundations: Science, Technology, Society and the Environment (STSE) that addresses the “why” of science education outlined above. The second major foundation is Skills—including the procedural knowledge necessary to better understand STSE, and the ability to communicate and work collaboratively in teams. The third foundation is Knowledge of science, i.e., science knowledge in life, physical and earth and space sciences that best lend themselves to the telling of “why” of science. The fourth foundation outlines the Attitudes necessary to support the acquisition of three previous foundations.

Each foundation has its general learner outcomes, and specific learner outcomes. The framework is therefore a set of outcomes that are linked by a variety of means. These means include presentation in grade level clusters and use of contextualized examples for the specific learner outcomes, and the use of teaching illustrative examples to show how the linkages can be made. Wherever possible, contextualized examples and illustrative examples make use of Canadian

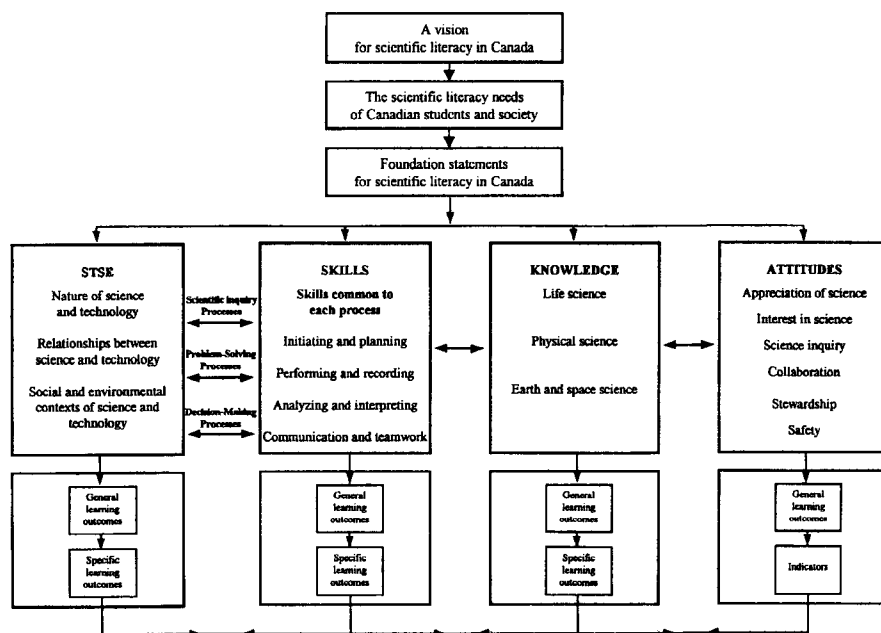
or regional science or technological innovations, and household and personal applications.

### FRAMEWORK STRUCTURE

The *Common Framework of Science Learning Outcomes, K–12*, includes the following components:

- **Introduction:** describes the rationale, purpose, benefits and primary clients of the framework
  - **A vision for scientific literacy in Canada:** a brief statement defining scientific literacy as “an evolving combination of science-related attitudes, skills, and knowledge students need to develop inquiry, problem-solving, and decision-making abilities to become life-long learners.”; and stating the need for diverse learning experiences “...to explore, analyze, evaluate, synthesize, appreciate, and understand interrelationships among, science, technology, society, and the environment that will affect their personal lives, their careers and their future.”
  - **The Scientific literacy needs of Canadian students and society:** identifies the goals of science education. The goals include developing in students:
    1. a critical sense of wonder and curiosity about scientific and technological endeavors
    2. the ability to use science and technology to acquire new knowledge, solve problems to improve quality of life
    3. the ability to critically address science-related societal, economic, ethical, and environmental issues
    4. a foundation to pursue higher levels of study, science-related studies and hobbies
    5. knowledge of science, technology, and environment-related careers
  - **Foundation statements for scientific literacy in Canada:** identifies the four major foundations for scientific literacy for which the learning outcomes were developed. The foundations are:  
*Science, technology, society, and the environment (STSE)*, that includes student understanding of:
    - the nature of science and technology
    - the relationships between science and technology
    - the social and environmental contexts of science and technology
- Skills* required for the following contexts connected to the STSE component of the framework:
- scientific and technological inquiry
  - problem-solving
  - making informed decisions
- Skills are classified into four broad areas:
- Initiating and planning
  - Performing and recording

## CONCEPTUAL MAP FOR THE FRAMEWORK



Analyzing and interpreting  
Communication and teamwork

*Knowledge*, the understanding of concepts and construction of knowledge on the subject matter of science in the following science disciplines:

Life science  
Physical science  
Earth and space science

Unifying concepts are used as a means to create links among the science disciplines. The unifying concepts include:

Constancy and change  
Energy  
Similarity and diversity  
Systems and interactions

*Attitudes* that support responsible acquisition and application of scientific and technological knowledge to the mutual benefit of self and society. Attitudes are classified in six strands that link to STSE and skills, specifically the strands are:

Appreciation of science  
Interest in science  
Scientific inquiry  
Collaboration  
Stewardship  
Safety

Development of the four foundation statements

This section takes into considerations related to student learning and the teaching of science. The concept of emphases (1982, Roberts) are used as a means to facilitate instructional planning that bring together knowledge, skills, STSE, and attitudes. Roberts describes a curriculum emphasis as "a story that tells why the story of science is an important one to study, and these are presented simultaneously." The learning of science, or the what of science, is embedded the purpose of teaching science, or "what school curriculum should emphasize, hence they were named curriculum emphases." These emphases are the nature of science and technology, the relationship between science and technology, and the social and environmental contexts of science and technology. The concept of emphases is especially evident in the illustrative examples that model instruction, where a particular message about the "why" of learning science are woven together with the science subject matter and skills.

This section further describes the for foundation statements in some detail and the elements of growth of student understanding for STSE, and skills.

- **Organization of the framework**

The outcomes have been organized as general learning outcomes (GLOS) for STSE, skills, knowledge, and are set out for the end of grade 3, 6, 9, and 12. GLOS for attitudes are written for a span of grade groupings—K-3, 4-6, 7-9, and



10–12, since attitudes are not acquired in the same way as skills and knowledge. The specific learning outcomes (SLOs) for skills, knowledge and STSE identify what students are expected to know and be able to do for each grade from kindergarten to grade 10. For grades 11 and 12, the SLOs are stated for the end of grade 12.

- **Formats for presenting the learning outcomes**  
the learning outcomes are presented in two formats:
  - by grade groupings (K–3, 4–6, 7–9, 10–12) without reference to a particular grade level
  - by grade; all learning outcomes, including GLOs are presented for each grade level, and SLOs are presented in a cluster. There are four clusters per grade level. For grades 11 and 12 only, the SLOs are in a 11–12 grouping, and the clusters are based on a science discipline. Illustrative examples (IEs) for instruction are provided to show how outcomes for skills, knowledge and attitudes can be delivered by a teacher within a particular STSE emphasis. These IEs begin with an introductory paragraph that places the learning within an STSE context, followed by an exploration section dealing usually with an investigative activity. The development section that follows, formally engages student in their learning. These learnings are applied to new contexts in the application section. The IE concludes with a final section noting the delivered SLOs.
- **General learning outcomes**
- **Learning outcomes presented by grade grouping**
- **Learning outcomes presented by grade**
- **Appendices**
  - Terms and Definitions
  - Trends in science education that informed the development of the Common Framework of Science Learning Outcomes K to 12
  - Bibliography

### THE CHALLENGE OF IMPLEMENTATION

Implementation of the framework is being affected by two important factors. As noted earlier, the first important factor is the participating provinces and territories have their own cycle of curriculum development and implementation. The second factor is each province and territory will determine when and how the framework will be used. For example, Alberta had recently implemented an elementary science curriculum in 1996, and is currently revising the junior high science curriculum, followed by revisions to senior high school general and integrated sciences. This development work in Alberta would have taken place regardless of the Pan-Canadian framework. Similarly, other provinces and territories are beginning curriculum development in

keeping with their curriculum development cycle. The provinces of Ontario and Manitoba were planning to revise their science curriculum prior to the project. With the completion of the framework, these provinces will implement elementary and junior high science programs, followed by senior high science programs. The provinces of Saskatchewan and British Columbia will begin making changes after the year 2000. The Atlantic provinces, comprised of Newfoundland, Nova Scotia, New Brunswick and Prince Edward Island, were working together to revise their K to 12 science curriculum when the project was announced. This work under the aegis of the Atlantic Provinces Education Foundation (APEF) was set aside until the completion of the Pan-Canadian framework. Work has now started again. Initial drafts of the APEF science curriculum indicate efforts are being made to better align APEF curriculum with the Pan-Canadian Framework.

### IMPACT OF FRAMEWORK

#### *Impact on Curriculum Development*

In the process of redevelopment of science curriculum, the provinces and territories are using the framework to guide development work, and identify areas where their programs can be improved. As well, the framework is being used as a source of learning outcomes, and to guide decisions regarding the grade level placement of learning outcomes. Contrary to belief held by some, that the framework would result in identical, or close to identical curriculum across jurisdictions, the framework appears to have only a moderate effect at the topic of study level for a given grade. Currently, the curriculum being developed by the provinces are attempting to blend in the best features of the framework with ideas generated by the development teams, and consequently, there is some commonality in terms of the topic of study. A cursory review of the science frameworks, produced by each state as a follow-up to a national framework in United States, and Australia, reveals varying degrees of commonality.

The greatest impact of the framework will likely be at the design level, in the establishment of the four foundations, and in the K–12 STSE, Skills, and Attitudes sub-frames. It is also hoped that the IEs will result in greater acceptance of adopting curriculum emphases approach as part of the curriculum design.

Other benefits of the framework include: creating a mind set for viewing K to 12 science curriculum in its totality, and thereby ensuring there are no unintended gaps or overlaps in a science curriculum, and that growth in science learning as students move from kindergarten to grade 12 is given greater attention than has been the case in the past. In the future, the development of an elementary science curri-

culum, or senior high curriculum will take place within an explicit framework of a K to 12 curriculum, and greater attention will be paid in ensuring continuity of learning from the early to the latter grade levels.

Though the framework will be a major consideration along with provincial needs and beliefs about curriculum, it is very likely there will be a lesser degree of harmonization than was hoped for. Curricula are highly dependent upon the time and context of their development. Since each province is developing curriculum at a different time and within different contexts, the curriculum developed will be quite different. The greatest degree of comparability will likely be at the grade grouping level i.e., 7 to 9 or 10 to 12.

The only way to achieve commonality at the curriculum level would be to ensure a long-term coordinated effort by provinces to bring their curriculum development cycle into synchronization, and in agreeing to common high school level course structures and graduation requirements—by no means an easy task—For a country as diverse as Canada. At present, regional projects such as the 1993 Western Canadian Protocol for Collaboration in Basic Education (kindergarten to grade 12), described earlier, show greater promise in achieving the degree of commonality expected by most non-educator stakeholders.

### IMPACT ON ASSESSMENT

The framework comes at a time when Canada like other countries has been participating in studies to measure student performance as a means to answering the question: "How well are our schools preparing students for a global economy and for lifelong learning?" Given the recent spate of national (SAIP) and international assessments (TIMSS), and the rise in the number of Canadian provinces that are assessing students at different stages of schooling, some observers have wondered whether the framework's real purpose is to set the stage for nation-wide assessment.

CMEC initiated SAIP in 1989, and a memorandum of agreement to assess 13-year-olds and 16-year-olds was signed in 1991. In 1993, the ministers of education agreed to a SAIP science assessment. The specific questions to be answered were:

- How well do students in Canada do in science?
- Does the achievement of Canadian students in science change over several years?

As science education programs vary a great deal from one province to another, the SAIP Science Assessment Framework and Criteria had to be developed, as the Pan-Canadian Framework did not exist. The assessment framework developed for SAIP included the following areas of a science curriculum:

- knowledge and concepts of science
- nature of science
- relationship of science to technology and societal issues (STS)
- science inquiry skills

The SAIP assessment framework and the Pan-Canadian framework though not identical, do have common features. These areas of commonality include STS (and nature of science), skills, and knowledge. The Pan-Canadian framework which serves a different purpose—that of curriculum development—is more detailed, more comprehensive in scope and includes attitudes in providing an outline of growth in science learning as students move from kindergarten to grade 12.

To measure student achievement over time, the first assessment for science was carried out in April 1996, and the second is planned for April 1999. Given the need to accurately measure achievement over time, it is unlikely that the Pan-Canadian framework will play an important role in shaping the April 1999 SAIP assessment in science. However, if there is another SAIP assessment in science, for example, in 2002, then it is likely that Pan-Canadian framework will play an important role in the development of assessment tools and frameworks.

### IMPACT ON THE DEVELOPMENT OF LEARNING RESOURCES

Ideally, from a curriculum developer's point-of-view, the curriculum should be developed first. The second step should be identification or development of teaching and learning resources such as the textbook and teacher resource manuals, that have a high degree of commonality with the program content and philosophy. In the Canadian context, texts are written by teacher writers and others for commercial publishers. As such the texts often reflect the current state of the science education. When there is a significant shift in program content and philosophy, such as the inclusion of STS, a very significant gap emerges between the curriculum and the resources available in the market place. If curriculum and the resource are not harmonized, the delivered curriculum will very likely be at variance with the framed curriculum. As Roberts (1982) has noted, no matter what the curriculum dictates, it is the textbook that determines the curriculum emphasis. It is therefore, very important for curriculum developers to communicate the changes to the publishing industry, and provide sufficient time for the development of resources that support the content (both the what and why of science) and philosophy of the new program.

Curriculum development in Canada's provinces and territories has not been coordinated in the past. With the variation in the science programs offered by the provinces

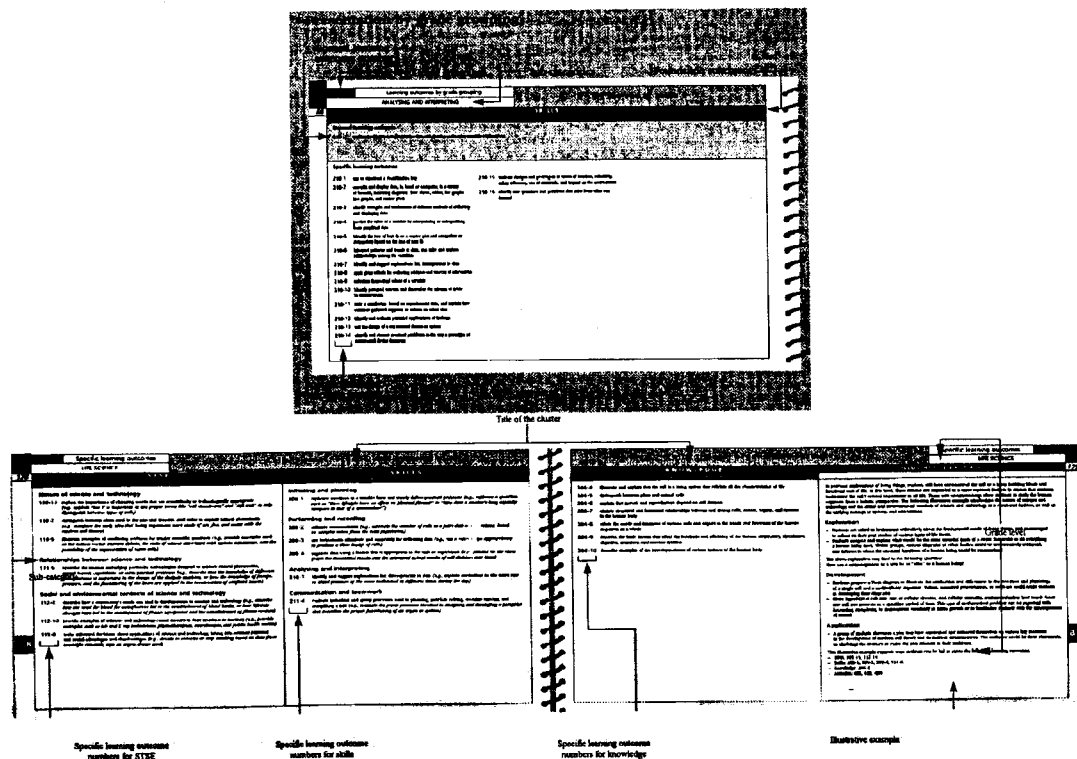
across Canada, there is also tremendous variation in teaching and learning resources. For provinces with smaller student populations finding a textbook that fully supports a program of study is virtually impossible. In some instances in the past, the programs of study have been written to match a particular resource. Another complicating factor is the lack of availability of French language resources that match the program. This lack of availability is due entirely to high costs of developing resources for small populations, and in recouping costs invested by the publisher. If the science curriculum were common, if not identical, across the provinces and territories, then economies of scale would prevail. These economies would allow more education funds to flow directly into the classroom in support of instruction and learning. Since the Pan-Canadian framework is not a common curriculum but rather a common reference document for science curriculum developers in provinces and territories, it is very likely publishers will continue to develop teaching and learning resources to meet the needs of individual provincial and territorial curricula, and thereby negating the economies of scale. There could be some savings for resources for teachers that help them improve science instruction, or provide a richer and in-depth understanding of STS. Such resources are less dependent upon the specifics of a particular science curriculum and their efficacy

lies more in whether the resources embody the program philosophy.

The economies of scale will most likely arise from regional common curriculum initiatives such as the 1993 Western Canadian Protocol For Collaboration in Basic Education (kindergarten to Grade 12) and the Atlantic Provinces Educational Foundation. For example, a new program called Applied Mathematics was created as part of the 1993 Western Canadian Protocol For Collaboration in Basic Education (kindergarten to Grade 12). Since there were no existing text books to support the applied mathematics program, a custom-developed text is being written under contract. Given the larger market because of increased numbers of students taking Applied Mathematics across Western Canadian provinces and territories, the text will be more affordable to schools. More importantly, with a high quality resource, more students than in the past will benefit from the applied mathematics program.

*Impact on Delivery Technologies*

The alternate delivery of education through technology is proliferating at all levels of education, and school science education is no exception. These alternate means, if well integrated with existing proven methods of teaching, have many advantages and are especially powerful when used by



teachers to guide student learning. However, these technologies come at a high price. To ensure Canadian content, and to take advantage of economies of scale, a common science curriculum across Canada would be an ideal situation for government and the publishers. Partnerships between government and business can result in the development of high quality products. Ideally, if the cost of development of a common product can be shared among various governments and business, then the product can be made available to schools at an affordable price, and thereby ensuring more educational dollars can flow directly into the classroom. In the Western provinces the Distance Learning and Technology project is such an example where provinces are cooperating on delivery technologies.

At present, it is difficult to predict whether there will be a common curriculum in Canada, and the reasons for this have been addressed in the preceding section. However, it is more likely that there will be greater agreement in areas such as instructional design and other design templates that for example bring together the various components knowledge, skills and attitudes within an STSE and Canadian contexts. Much of this is already taking place within resources development, and such standardization in the near future will eventually take place in delivery technologies as well.

As provincial governments or business partnerships make technologies more available to schools, greater attention will have to be paid to implementation. Learning how to teach effectively with technologies will take time and planning. Teachers will need to be engaged both in the production, and the use of delivery technologies. As well, teachers will need to define their needs for successful integration of these technologies.

### Conclusion

At this time, the Directors of Curriculum at the provincial and territorial ministries of education are determining interest in participating in further activities arising from the release of the Common Framework of Science Learning Outcomes K to 12. There is a desire to capitalize on the momentum generated by the project, especially now that the framework is being well received across Canada. The framework is the first step represents in a series towards implementation. Making science interesting and relevant to the lives of young people requires that additional initiatives be undertaken. Collaborative efforts on resolving common issues in science education could include areas such as a common program of studies for non-science students, teacher support materials that deal with aboriginal and multicultural perspectives and sustainability and environmental issues, and the integration of sciences with other subjects. The objects of collaboration are only limited by imagination, and the desire to collabora-

te. Perhaps the lasting legacy of the project will be the value of bringing together the various provincial and territorial ministries of education to resolve common issues in science education, and in the increased desire to work collaboratively on improving the quality of science education. Perhaps, only now is Canada taking the steps to complete the agenda for science education that was set out in the 1984 Science Council of Canada's Report 36 Science for Every Student. ■

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quien seguramente las compartirá con los padres de Reg.