# Thinking about Science: Understanding the Science, Technology, Society and Environment Education of Canada

**Tengyuan Zhang**
Department of Mechanical and Materials Engineering
Western University, London
Ontario, N6A 3K7, Canada.

**Eaton Asher**
Faculty of Science
Western University
London, Ontario, N6A 3K7, Canada.

**Mengmeng Zhang**
Don Wright Faculty of Music Performance
Western University, London, Ontario, N6A 3K7, Canada.

**Jun Yang**
Department of Mechanical and Materials Engineering
Western University, London
Ontario, N6A 3K7, Canada.

**Abstract**

*Based on the Science, Technology, Society (STS) curriculum model, Canada proposed its new Science, Technology, Society, Environment (STSE) curriculum model, emphasizing the interrelationship between science, technology, society and environment. This paper introduces the background of the development of STSE approach, analyses its goals, dimensions, contents and problems during the implementation. Some in-depth critical thinking is also included in the last section of this paper.*

**Keywords:** Canada, STSE Curriculum, Science Education

## Introduction

To understand the current curriculum for education in Canada, one must acknowledge the influence of periods of intense need for innovation. The second World War is widely regarded as one of these great motivators of technological innovation, leading to the development of science and technology education models. Following the conclusion of the war, governments around the world came to recognise the importance of widespread scientific education. Technological advancements were made at a pace and scale which had never previously been observed, and this caused some concern for the future of society, as well the environment. It was clear that scientific developments would play a large role in shaping the future of the modern world.

The government of Canada maintains that education should focus on the relationship among science, technology, society and environment. Thus, based on the previous Science-Technology-Society (STS) curriculum model, the government recently proposed a new curriculum model named the Science-Technology-Society-Environment Approach (the STSE) (Nuray & Morgil, 2010). The STSE is, fundamentally, a "Common Framework of Science Learning Outcomes," and has become the guiding principle for all science education curriculae in each province, promoted all over of the country (E. Pedretti & Nazir, 2011).

**STSE – History and Development**

Canada has always placed a strong emphasis on the education of science and technology. Early in 1966, the federal government of Canada founded the Science Council of Canada, an organization responsible for providing scientific and technical information to both the federal government and the public. In the year of 1984, a report published by this organization, "Science for Every Student: Educating Canadians for Tomorrow's World", outlined their ambitious goal to reform the model used to teach science in all schools across the country. The report emphasized the importance critical thinking, encouraging the use of the scientific method to explore new ideas and information, daily. They asserted that the purpose of science education was to cultivate students' ability to: (1) participate in political and social activities; (2) study, in-depth, science and technology; (3) develop their intellect and morality; making them independent rational individuals prepared for all possible forms of modern work (Erickson, 1985).

The Council of Ministers of Education of Canada introduced the "Common Framework of Science Learning Outcomes, K to 12" (Education, 1997), which is the first framework about science education of Canada. This framework requires that all provinces use the same curriculum for science education, maximizing the utilisation of high-quality education resources across the nation. This framework also marked the implementation of the STSE approach constructed 12 years prior.

**Philosophy the STSE**

The Canadian education community generally believes that learning is best achieved if students apply what they learn to their daily lives (Aikenhead, 1996; E. Pedretti & Nazir, 2011; E. G. Pedretti, Bencze, Hewitt, Romkey, & Jivraj, 2008). The successful implementation of any curriculum relies on "teaching and learning situations (teaching and learning situation occurs when students and teachers with common interests come together for the purpose of developing an authentic product or a service that is an application of their common interest. (Trigwell, Prosser, & Waterhouse, 1999)), which decide if the curriculum and the implementation of curriculum agree with each other. Carl Glickman, an educator and scholar of Canada, pointed out that

> *"…effective teaching is not a set of generic practices, but instead is a set of context-driven decisions about teaching. Effective teachers do not use the same set of practices for every lesson … what effective teachers do is constantly reflect about their work, observe whether students are learning or not, and then adjust their practices accordingly" (Glickman, Gordon & Ross-Gordon, 2001).*

Regardless of the chosen curriculum model, it should reflect the true nature of science. Teaching and learning situations give students the opportunity to explore the problem, solve the problem and then make an informed decision to select the best solution. By developing these skills in this context, students will understand the interconnected nature of science, technology, society and environment. The "Common Framework of Science Learning Outcomes", published by the Council of Ministers of Education (CMEC, 1997), asserts that a successful STSE curriculum should aim to:

1. Encourage the Complexity of Understanding
    - From the understanding of simple, specific concept to complicated, abstract concept;
2. Enable the Construction of Knowledge
    - From a partial understanding of science to a deep, wide understanding of the world;
3. Facilitate Application in Difference Situation
    - Practice of knowledge from a personal, local situation to a social, global situation;
4. The Thinking of Variations and Angle of View
    - Thinking from one or two simple angle of view and variations to more complicated angel of view.
5. The Critical Judgement
    - From a simple "yes or no" to a logical, objective and critical judgement.
6. The Ability of Making Decisions
    - From a decision made with limited knowledge and guidance of teachers to a decision independently made after sufficient research and investigation.

**Goal of the STSE**

The STSE curriculum model is the core of Canada's education, and thus the goal of STSE also reflects the goal of science education in Canada. The Common Framework of Science Learning Outcomes (CMEC, 1997) defines scientific literacy to be

> *"a general understanding of some of the fundamental ideas, principles, and theories of science; some knowledge of the ways in which scientific knowledge is generated, validated, and disseminated; some ability to interpret scientific date and evaluate their validity and reliability; a critical understanding of the aims and goals for science and technology, including their historical roots and the values they embody; an appreciation of the interrelationships among science, technology, society and the environment; and an interest in science and the capacity to update and acquire new scientific knowledge and technological knowledge in the future" (Education, 1997)*.

The framework also defines the expectation of the STSE curriculum in different grades. For example, by the end of grade 3, students are expected to have (a) the ability to conduct research about his/her surrounding situation; (b) the ability to use tools to solve practical problems; (c) the ability to discern the influence which science and technology have on his/her surroundings; (d) the ability to take action to demonstrate their care for the environment, as well as making contribution to a group decision.
By the end of grade 6, students should be able to (a) explain the philosophy behind using science and technology to explore the world; (b) understand the development and significance of science and technology; (c) understand the influence of science and technology on our daily lives, acknowledging both their positive and negative effects on the environment.

By the end of grade 9, successful students are expected to be able to (a) explain the different methods/science/technology that people used when exploring the unknown; (b) explain the relationships among different methods of experimentation; (c) elaborate the "action and reaction" that the need of people, society and environment have on the development of science and technology; (d) analyze social issues related to the use of science and technology and explain the pros and cons of "sustainable development" from different perspectives.
By the end of grade 12, students should be able to (a) describe and explain the different approaches between disciplines, science and technology in terms of objectives, outcomes and standards; (b) analyze the social and technical interconnections of individuals, societies and the environment, as well as evaluate relevant social issues through the application of scientific evaluation.

**The Strategy of Implementing the STSE**

In Canada, several provinces, including Ontario and Alberta, have reformed the curricula implemented in their schools to integrate the STSE curriculum into their science education, to better reflect the recommendations put forth through the "Framework" (Milford, Jagger, Yore, & Anderson, 2010; Nazir, Pedretti, Wallace, Montemurro, & Inwood, 2011). The Atlantic Provinces have also adopted STSE course content, allowing it to be integrated in one of the following five ways:

**Approach 1: Motivation by STSE content.**

In this integrated approach, the introduction of STSE content aims to increase the fun of science courses, so that abstract scientific concepts, principles and social reality or occur in the students' around can be linked with each other, and in turn to motivate students to learn science courses. However, they are not a part of the academic evaluation system.

**Approach 2: Casual Infusion of STSE Content.**

This integration is characterized not by the introduction of social issues that are closely related to science (internal or external to science), but by the availability of the necessary educational equipment, to let students learn and understand the uses of science. Temporarily added short-term (from 30 minutes to two hours) STSE learning content also becomes available in the traditional science course content. Academic evaluation mainly involves purely scientific content, while STSE content is in the subsidiary status, for example, only some memory tasks will be tested.

**Approach 3: Purposeful Infusion of STSE Content.**

This integrated approach is featured by short-term (from 30 minutes to two hours) STSE learning content which is introduced to the traditional science curriculum content topics, to enable students to systematically explore and learn. These STSE contents form a cohesive theme. In the academic evaluation, to a certain extent, students will be evaluated by their understanding these contents of STSE. The relative weights of STSE and scientific content can be 10% for STSE content and 90% for scientific content. Obviously, the above three kinds of reunification in the traditional way of teaching the science curriculum is also frequently used.

**Approach 4: Singular Discipline Through STSE Content.**

The content and sequence of the science are selected and organized per the content of STSE in a great extent. That is, the content of STSE has become the subject of a scientific discipline, and its series of pure science topics are like those shown in the third type. The feature of this integrated approach is that the curriculum policy first specifies the content of the STSE that a science curriculum will contain; then, the corresponding scientific content is selected per the knowledge that the students need to solve these STSE topics. The selected content is usually a scientific discipline. By doing this, STSE science courses such as STSE Biology, STSE Chemistry, and STSE Physics will emerge. In the academic evaluation, the students will be examined for deep understanding of STSE content. The relative weight of the two parts can be like this: the STSE content accounted for 20%, subject content accounted for 80%.

**Approach 5: Science Through STS Content.**

This approach is similar with the former approach in that the STSE content acts as the organizer of the scientific content, appropriate scientific content will be chosen based on the knowledge students need to solve those STSE issues. But the choice of content in Approach 4 is mainly inside a scientific discipline, while the Approach 5 is multi-disciplinary. Its series of purely scientific topics seem to be selected from a variety of traditional science courses, but there are still some scientific and technical contents which are not included in traditional science courses. These contents usually have a very close relationship with our daily life. In the academic evaluation, the same examination will be taken to test students' deep understanding of those STSE contents. The relative weight of the two parts is like this: STSE content accounted for 30%, subject content accounted for 70%.

**Implementation of STSE**

There are two ways to implement the STSE curriculum: one is that the teacher asks questions related to STSE, and then students analyze, do research and evaluate the proposed situation and solve the problems. (E. Pedretti & Bellomo, 2013) This process links the previously disjointed sciences, technologies, societies, and the environment together to help students understand scientific content and concepts more clearly and more firmly; The other way is based on students' learning styles and social issues, reorganizing science courses, to build the relationship of the STSE courses and other disciplines. The social topics chosen in such way and such courses indirectly address the technical aspects and define the concepts that students need to understand. In this approach, building and understanding the core knowledge of science is a meaningful context. During this process, students study and solve social, practical problems. The "Common Framework of Science Learning Outcomes" advocates the following scientific order for science education: scientific inquiry, problem-solving, and decision making.

Specifically, in a science unit of the STSE program, students think about a social topic or an event in their daily lives. For example, why coffee will soon become cool. Such subjects or events create a cognitive need for scientific knowledge. From the above problem, students understand that heat can be transmitted by convection and radiation transmission. With the appropriate scientific knowledge, students then come back to the subject or event to rethink, and they are motivated to know the relevant technology ------ a vessel which can maintain the temperature of coffee. This encourages students to think and explore daily life technical issues. Through the study, students found that polystyrene foam can be used to keep liquid warm for a long time. Then they are faced with the STSE question: should people use mugs surrounded by polystyrene foam or porcelain cups in their lives? This question involves personal health, environment, costs, and the availability of scientific and technical information. When students have a deep understanding of the scientific knowledge of a problem and master the relevant technology, they will start to know the various decision-making options implied in the various social dominant values, and they will gain the ability to make a well-considered decision.

The STSE curriculum, as described above, ensures that the scientific content is organized in a way which is meaningful to each student, instead of being categorized and isolated from each other.

**Critical Thinking about the STSE Curriculum Model**

The widespread use of technology in modern societies has begun to affect school teaching and curriculum. Most notably, the school's science education curriculum has been infiltrated with many modern science and technology. As early as the 1960s, Science, Technology, and Society (STS) curriculum model was proposed. The environmental education is usually seen as another area of specialized learning, and it is also a branch of science education. Science and environmental education are linked with each other because people believe that science and technology can provide the most effective ways for environmental protection and improvement. Thus, it is added to the STS model to expand the technology-centered curriculum, which is the new proposed STSE curriculum. As a new paradigm of science education, the STSE curriculum has been widely promoted in Canada and has also been incorporated into the science education curriculum by many other countries.

The effect of STSE curriculum model has been studies recently by many researchers in Canada. (Barrett & Pedretti, 2006; Hodson, 2009; Hoeg & Bencze, 2014; MacLeod, 2013; Nuray & Morgil, 2010; Waddington & Imbriglio, 2011) Some of them believe that STSE may not be able to achieve the proposed goal of science education. They point out that the purpose of the STSE program is to make science education more relevant to the social and environmental problems caused by the development of science and technology. It emphasizes the development history of science from a socio-historical point of view which does help students to better understand science within their everyday life. However, science and technology exist within a certain historical background with subjectivity. Scholars argued that too much emphasis on the subjective meaning of science education will result in the ignorance of the invisible social, cultural, and political conditions which generate the scientific knowledge. Contemporary science education is formed in a certain ideological context, which plays an important role in the generation, packaging, and transmission of knowledge. The STSE curriculum, which is advocated by the Common Framework of Science Learning Outcomes, focuses on the facts and knowledge of science, but also involves political content. Thus, students may have an incomplete, even distorted understanding of social problems, especially environmental problems. On the contrary, if the content of the social criticism and commentary is added to the STSE curriculum, critical thinking of students can be cultivated while relevant scientific knowledge is taught to students. This is very common in traditional environmental education. (Sammel & Zandvliet, 2003)

For example, the province of British Columbia has a variety of perspectives on environmental science. In 1995, the “Environmental Concepts in the Classroom” was published by the government of BC province. The file pointed out that environmental education is a complex undertaking involving scientific, economic, moral and political factors, and that environmental education gives students an opportunity to understand the role of nature, the formation of environmental values, and ultimately to make reasonable and responsible decision-making. To combine the theory and practice of environmental education, the BC province put forward six principles in the Syllabus of Science ------ direct experience, responsible action, complex system, action results, aesthetic competence and environmental ethics. In British Columbia, environmental education uses two methods to explain complex systems: one is to analyze the complexity of nature and its internal relationship; the other is to study the artificial system, including human-built environment and part of the social structure.

In this way, students can understand the consequence that human’s decision and action will have on the environment. The awareness of such things will help students develop their aesthetic ability of the environment, and ultimately establish students' environmental ethics. Such outline provides very meaningful model for the teaching of environmental concepts. In contrast, the STSE curriculum described in the Canadian National Science Education Program fails to include such comprehensive environmental concepts.

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