# Crowding the Curriculum? Changes to grade 9 and 10 science in British Columbia, 1920 - 2014

by

Cangjie Sun
B.Sc., Nanjing University of Information Science & Technology, 2010
M.Sc., University of Victoria, 2012

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# Supervisory Committee

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# Abstract

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In recent years, educators and academics have argued that science curricula have become increasingly crowded, rendering it almost impossible for teachers to address the multitude of learning outcomes mandated in any given document (e.g., Fortner, 2001; Hacker, 1997). Unfortunately, an analysis of the research literature has failed to substantiate this claim with empirical evidence. The purpose of this study was to examine changes of British Columbia's Science 9 and 10 curricula between 1920 and 2014 to determine if curriculum expansion – as an important indicator of an overcrowded curriculum- has happened over time. Additionally, this study investigated the relationship between science curriculum changes and societal and educational values and priorities. The research questions guiding this study were: 1) Have the Science 9 and 10 curricula in British Columbia (BC) expanded over time? That is, has the scope, size and depth of science material to be addressed increased over time? 2) If so, what accounts for this increase over time? 3) If not, what accounts for the claims in the literature that science curricula are increasingly crowded? This study used content analysis to examine, in detail, grade 9 and 10 science curriculum guides issued by BC's government between 1920 to 2014. Content under examination included program goals and rationale; instructional suggestions; topics; subject matter goals and learning outcomes. Supplementary historical documents (government directives, circulars, newspapers, memos, secondary sources) were also examined in order to situate curricula in appropriate social contexts. Results showed that the only constant attribute of the investigated BC grade 9 and 10 science curricula is change, which is characterized by expansion and continuous reconfiguration of content, persistent attempts to respond to social and educational needs, and constant oscillations between student-centered and subject-centered teaching approaches. This study also illustrates that the crowding of the science curriculum has as much to do with changing educational theories and ideologies as with scientific developments. This study is important in that it fills a significant gap in the research literature. It is the first to address the questions of how and why science curricula have expanded and become more complex over time. Finally, this study is timely in that British Columbia's government has proposed sweeping changes to current curricula with a broad goal of better preparing learners for demands of the 21st century (BC Ministry of Education [BCMOE], 2012). More specifically, BC's government has proposed to replace the vast number of curricular learning outcomes with fewer more broadly conceived competencies that would enable learners to probe more deeply into areas of personal interest (BCMOE, 2013). This study provides evidence that such a move would reverse a longstanding trend in the opposite direction.

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# Chapter 1: Introduction

## Rationale and purpose for research

In recent years, educators and academics have argued that science curricula everywhere have become increasingly crowded, rendering it almost impossible for teachers to address the multitude of learning outcomes mandated in any given document (e.g., Fortner, 2001; Hacker, 1997). Researchers who made the above claim also used similar terms such as "overcrowd" and "overload" in an interchangeable way. By definition, they all suggest an excessive load or amount that exceeds the capacity. Accordingly, crowding/overcrowding/overloading in the curriculum all suggest a curriculum that is excessive in relation to our capacity to implement it; in other words, the curriculum has reduced manageability. Thus, those terms would be used interchangeably hereafter. An analysis of the research literature has failed to substantiate the claim of an overcrowded curriculum with empirical evidence. The current literature tends to have preconceived notions that science curriculum is overloaded, thus stating it as a proven fact. Chris (2002) undertook a study with small focus groups of teachers and investigated how they would prefer to integrate global climate change (GCC) into the science courses for 14-16 year old students in schools in part of Southern Region of England. He claimed that "there was general agreement that the science curriculum [was] already crowded with little scope for extending enquiries outside the topics already prescribed" (Chris, 2002, p1196). However, he did not provide any evidence where this general agreement came from, and just accepted and presented it as a fact. Czerniak (1999) conducted a study on curriculum integration in which connections were proposed to be made between science and math. He argued that potential obstacles to enacting the interdisciplinary curriculum were related to the capacity of the curriculum. Teachers felt that there was no room or time for this integration in an already overcrowded curriculum. However, it was not clear from the study that why teachers thought the science and math curriculum were too crowded. Turner (2008) argued that there was frequent criticism that science curricula everywhere were crowded with too much content. The excessive amount of potential outcomes tended to intimidate and discourage teachers. Similarly, no ground upon which this claim was made can be identified in his study. Yalvac (2007) investigated the interdependence of Science, Technology, and Society (STS) in achieving scientific literacy for all. In his paper, he noted that "it is [teachers'] concern that an over-crowded science curriculum can be an obstacle to successfully implementing an STS education" (Yalvac, 2007, p334). Unfortunately, he did not present any evidence that supported those teachers' claims. Hacker (1997) argued that many teachers experienced the issue with an overloaded curriculum and it may influence their choice of teaching and learning strategies. In particular, teachers found there was not enough time to implement practical work such as experimentation. Therefore, they tended to choose traditional informational instructional strategy. However, he failed to justify the above claims with further evidence.

As can be seen from the above, much of what we know about crowding in the science curriculum comes from teachers' experiences that the science curriculum was overcrowded thus not manageable. However, the current literature accepted teachers' claims as facts without substantiating the ground upon which those claims were made. It is thus crucial to have an investigation into factors that contribute to their experiences/claims of an overcrowded science curriculum. The National Council for Curriculum and Assessment in Ireland identified three broad and inter-related dimensions of curriculum overload that may contribute to the overcrowding experience the teachers had: 1) the existence of subject hierarchy may give priorities to literacy and numeracy. Language and Mathematics may be accorded a majority of the instructional time, and science may have to compete with other subjects for the remaining teaching time. Thus, science teachers may feel that they did not have enough time to address the prescribed materials. 2) the lack of time/support for teacher planning may result in incompetency in navigating the content and methods of the curriculum, and thus tend to overwhelm teachers. Furthermore, the teachers were expected to draw up a range of school policies, subject plans, and standardized tests and they had to put in more time and effort to adjusting to changing and expanding roles, responsibilities and expectations. 3) the curriculum guide itself expands in multiple aspects such as width and depth of content, assessment, guidelines for teachers, and program goals. Correspondingly, teachers' workload is increased due to more time and effort put into preparation and instruction (National Council for Curriculum and Assessment (NCAA), 2010). The scope of this study focuses on substantiating the third dimension, i.e. the expansion of curriculum guides' implications on curriculum overload. Further studies on the first two dimensions that are related to the development and implementation stages of the curriculum will serve as good supplementary studies.

In particularly, the purpose of this study was to examine the changes to British Columbia's Science 9 and 10 curricula through a content analysis of the curriculum guides to determine if the curricula have expanded over time. The jurisdiction of British

Columbia was chosen as the province has been at the forefront of public school reform in Canada (Tomkins, 1986). The area of science was singled out for its high sensitivity to educational movements, to scientific development, and to economic and political policy adjustment. Additionally, general educational objectives are broadly embodied in the process of natural science studies, making science curriculum an excellent candidate to represent the course of study in the public school. Furthermore, grade 9 and 10 sciences mark the transitional stage between elementary science and high school science for academic-bounded students, and are the last two years of science program for vocational-bounded students, thus being selected as the grade levels under investigation.

More importantly, this study is timely in that British Columbia's government has proposed sweeping changes to current curricula with a broad goal of better preparing learners for demands of the 21$^{st}$ century (BC Ministry of Education [BCMOE], 2012). More specifically, BC's government has proposed to replace the vast number of prescribed learning outcomes with fewer more broadly conceived competencies that would enable learners to probe more deeply into areas of personal interest (BCMOE, 2013). This study was to provide insight in the connections between the new BC curriculum of 2014 and the past curricula.

**Research questions**

A curriculum that constantly expands in scope, depth and width is a good indicator of the crowding in the curriculum. Thus the research questions guiding this study were: 1) Have the Science 9 and 10 curricula in British Columbia (BC) expanded over time? That is, has the scope, size and depth of science material to be addressed increased over time? 2) If so, what accounts for this increase over time? 3) Can we find antecedents to proposed revisions of the BC 2014 curriculum in the past curricula?

**Method and Data Sources**

This study used content analysis to examine, in detail, grade 9 and 10 science curriculum guides issued by BC's government between 1920 and 2014. Content analysis is a technique used in examining artifacts of social communication such as written documents and transcriptions of recorded verbal communications. In content analysis, thematic patterns are identified, and explanations of the inferences of those patterns are presented. The sampling of content and units of analysis in this study are at multiple levels from words, phrases, and sentences to ideological stance, subject matter, and similar elements relevant to the context. More specifically, the curriculum guides are analyzed in the following aspects including language use at words and sentences level; topics; learning outcomes; assessment strategies; program goals and rationale; and instructional suggestions where applicable. Additionally, content analysis can analyze the data in detail as well as reveal trends and patterns over long periods of time (Berg & Lune, 2004). For example, McBroom (1992) did a study on conditions and opportunities for women in the clergy between 1984 and 1987 in the United States. He used content analysis and examined data during individual years as well as over the span of all years under study. He concluded that women's situation in the clergy deteriorated rather than improved over the four years. Adopting content analysis in a similar way, this study analyzes curriculum guides of each individual year between 1920 and 2014, and organizes findings and data that emerge during the year-to-year analysis in a systematic way. Furthermore, supplementary historical documents (government directives, circulars, newspapers, memos, secondary sources) are also examined in order to situate curricula in appropriate social contexts.

**Summary of work**

Chapter 2 is the literature review on the history of education and curriculum change in the United States and Canada. It is crucial to have the educational contexts of different time in that the curricular changes are responsive to reforms in prevalent educational ideologies and pedagogies. Chapter 3 to Chapter 5 includes content analysis of the available BC grade 9 and 10 science curriculum guides from 1920 to 2014. Chapter 3 is from 1920 to 1936, and chapter 4 is from 1937 to 1969 while chapter 5 is from 1970 onwards. Each chapter consists of summaries and analyses of each year's science 9 and 10 curriculum guides in a chronological order. The summary included, where applicable, a description of the general structure of the curriculum, curriculum goals, prescribed learning outcomes, student assessment and subject matter, among others. The summary of each year's curriculum guide is followed by an analysis of the changes being made to that year's curriculum compared to that of the previous year. Additionally, synthetic analyses are presented after year 1936, 1969, and 1983. The timeline breaks at those years match the natural breaks marked by major reforms in education such as the progressivism in the 1930s, the implementation of Bruner-type learning in the 1960s and the revival of progressive pedagogical concepts in the 1980s. The synthetic analyses identify important trends of curriculum changes in terms of expansions, revisions, and shifting philosophical and pedagogical paradigms. The year to year summary and analysis provide a continuum of curriculum changes over the time span from 1920 to 2014, while the synthetic analyses offer insights into significant long-term trends, meaningful variability and oscillations, as well as extremities of this continuum. Chapter 6 summarizes main findings from the study and discussed further implications of the findings. In particular, the connections between the new BC curriculum of 2014 and the curricula of the past are examined, shedding light on the pattern of a spiral development of the secondary science curriculum.

# Chapter 2: Literature review on the history of North American education

The persistent problem of what should be taught in school and what rules should be applied to school teaching have perplexed educators and philosophers for centuries. During the late nineteenth century when North American society started to transform from a rural, agricultural community to an industrial nation, various educational interest groups struggled for control of administration, the curriculum, and the philosophy of schools. A growing economy led western nations to preoccupation with producing functional citizens in the new era. Yet, there has always been a lag between educational thought and its actual embodiment in the curriculum, and on quite a few occasions, what was discussed in the academic world never got passed down to schools or was barely incarnated in the curriculum with a full acknowledgement of its original intention. For example, the American report the *Cardinal Principles of Secondary Education*, issued in 1918, criticized the school's failure in recognizing human differences, in isolating academic subjects aiming for the entrance of college from life and its inertia to change (Reece, 2005). The report was one of the most cited reports in the early twentieth century. Nevertheless, complaints about classrooms being student unfriendly and favoring academics continued into the 1940s. Therefore, juxtaposing curriculum theories, pedagogical paradigms and educational ideologies with actual school curriculum might shed light on the extent to which theories were translated into classroom practices. This juxtaposition could also inform us of the evolution of curriculum and provide insights into future curriculum design and planning. A majority of educational changes originated from the United States, and served as the model for reforms taking place in Canada.

Major Canadian curricula and administrative revisions all reflected an American influence (Wilson, Stamp, & Audet, 1970). Therefore, the following review on the history of public education focuses on ideas from the United States and how those ideas were represented by Canadian practices.

Mental discipline as the dominant curriculum theory in the second half of $19^{th}$ century in America, alleged that certain subjects could be used to enhance mind powers such as memory, will, reasoning and imagination, and proper ways of teaching those subjects would strengthen the mind and develop mind powers further (Franklin, 2008). The metaphor that mind is like a muscle which could be exercised to strengthen was adopted by numerous mental disciplinarians and later passed down to teachers who embraced it as a justification for verbatim recitation, strict doctrines and rigorous discipline. The intellectual training of mental discipline theory was seen in Canadian education systems. Elementary school courses in New Brunswick emphasized both development of all faculties of mind and the acquisition of knowledge useful in ordinary vocations and in the discharge of daily duties (Lawr & Gidney, 1973). While at the same time, the mental discipline theory suffered serious flaws associated with its lack of connection with practices in the real world. Skeptics of mental disciplines questioned that if mental discipline theory was right about the human mind working in the same way as a muscle, then why was learning restricted to a few subjects prescribed but not exercised on a variety of fields (Urban & Wagoner, 2000)? By the 1890s, the mental discipline rationale collapsed in the US and schooling was restructured in response to a changing social order which invoked a new round of debates over what knowledge would best serve the new society (Kliebard, 1995).

It is expected that what society values eventually would be taught to the young generation, though the response of school curriculum, more often than not, tends to lag the transformation of society. Across a wide spectrum of competencies ranging from practical skills such as sewing and book keeping to academic endeavors characterized by theory learning and critical thinking, different educational interest groups emerging at the turn of the century competed to find a place for what they deemed valuable for children and society in the school curriculum. The early 20$^{th}$century served as the battleground between practical driven education and academic driven education for numerous educators and philosophers and was the most productive era in terms of the development of educational ideologies, curriculum theories, and the administrative and pedagogical reforms in schools (Ravitch, 2000).

The appointment of the American National Education Association's Committee of Ten in 1892 marked a national effort in reconciling different entrance requirements of colleges with secondary school courses of study, and thus provided impetus for redefining the task of secondary schooling. Charles W. Eliot, an American academic who served as the president of Harvard for 40 years, and had been engaged in reforming American higher education, took the role of the chairman of the Committee of Ten. He was also the leader of the *humanist* interest group which held positive viewpoints towards human capabilities. Humanism bore more flexibility than those of mental disciplinarians and aimed to develop reasoning ability and moral character. Furthermore, Eliot noted that Americans tended to underestimate what pupils were capable of doing and actual individual differences were not as evident as previously presumed (Reese, 2005). The Committee of Ten insisted on uniformity between curricula of college bound students and vocational bound students, which evoked sharp criticism from a second interest group – *developmentalists* who held an opposing opinion.

The pivotal figure of the *developmentalist* interest group was G. Stanley Hall, a pioneering American psychologist and educator. His research focus had been on early childhood development and evolutionary theory. The recommendations from the Committee of Ten were perceived by Stanley Hall as mischief due to their failure in attuning themselves sufficiently to the expanding school population the variations of which rendered the uniform curricula unworkable. *Developmentalistis*' planning of courses of study for different segments of the school population won out over the notion of a liberal education for all. By the 1920s, a majority of America's public schools offered a differentiated curricula to accommodate diversified social roles students would play in their later adulthood, as opposed to the previous common curriculum where shared values, particular those related to morality of society were taught to all students. The education advocated by *developmentalists* was child-centered by nature and assumed that the natural sequence of development in the pupils was the determining factor on what should be taught in schools (Urban & Wagoner, 2000).

Canadian developments followed closely behind those of the U.S.. As Canada became more industrialized at the beginning of twentieth century, there were increasing demands for practical training in schools. In response to this need of preparing people for occupations appropriate to the new economy, manual training courses and technical courses were added to the traditional curriculum. Ontario started to develop its first technical school in the year 1911 (Lawr & Gidney, 1973). Vocational education entered secondary schooling in most provinces of Canada by the mid-1920s (Tomkins, 1986).

Half of the vocational students throughout Canada were enrolled in Ontario. Programs implemented in Canada were slightly different from American high schools where academic stream (university bound) and vocational stream (work bound) students took different electives but had the same core-subject classes together. Ontario schools maintained different curricula and administrative systems between academic and vocational cases. Putman and Weir suggested in their survey that besides a liberal general course for all, the program of study should offer more options in such different directions as immediate industrial and commercial vocation or a technical high school (Putman & Weir, 1925). Vocational education failed to prevail in certain provinces as each province’s interests were so diverse that the standardization of the program was difficult to be established. For instance, agricultural provinces found no need for technical education, thus they focused more on cultural and academic subjects.

The third interest group, *social efficiency educators*, shared the philosophy of establishing teaching methods based on scientific observations of child behaviors in classroom advocated by *develomentalists*, but they took it one step further with the employment of scientific management of education focusing on standardization and efficiency in the curriculum rather than discovering the developmental stage of a child (Calahan, 1962). Departing from *developmentalists*’ focus on child psychology, social efficiency educators’ emphasis was on maintaining a waste-free curriculum. The idea of efficiency also permeated Canadian education, particularly in terms of administrative structure changes. Supervisory system consisting of inspectors of public schools and municipality was developed to oversee the accountability of the teacher, the school board, and the curriculum (Johnson, 1964).

The fourth interest group, *social meliorists*, saw the schools as forces for creating a new social order by promoting social equalities and justice. Sharing a similar view as John Dewey, advocates of social meliorism such as Lester Frank Ward saw the impetus for social progress in schools (Ward, 1916). Ward was the most vocal and published social meliorist. He was a botanist and geologist and worked for the U.S. government. Traces of implementations of meliorism in education were seen in Canada's education policies in the 1920s, when moral education surfaced in the school with an emphasis on building character and citizenship and promoting national improvement and race-betterment. The Putman and Weir Survey in British Columbia argued that the moral purpose of the curriculum was as significant as its function of reinforcing mental power. A high moral purpose would enable one of average mental ability to make as profitable life as one of high mental power but short of character (Putman & Weir, 1925). The revised program of studies at junior and high schools included objectives of character development and citizenship in the curriculum. The reform shifted the emphasis of individual development, while still important, to the construction of state and society through shaping each student into a person with social responsibility (Tomkins, 1983). Educational changes after World War I were largely associated with industrialism, urbanization and development in democracy. New moral and social issues demanded more people to be trained as intelligent citizens in a democratic society, and required society to extend education to as many as possible (Wilson, Stamp, & Audet, 1970).

The four scopes of what should be valued in the public education and how those values should be infused in the curricula competed and reconciled with one another in the early twentieth century, and no single interest group was able to gain complete superiority over others. Furthermore, ideas and practices that originated from the above noted interest groups in the US always permeated Canadian education system in a timely manner. Several significant investigations of Canadian education such as the Putman-Weir Survey in the early twentieth century brought Canadian curriculum in line with its American counterpart (Lawr & Gidney, 1973).

Then entered the towering figure of American education, John Dewey, who developed his own stance on curriculum matters through synthesizing and reinterpreting the aforementioned ideas from various educational interest groups. John Dewey was an American philosopher and psychologist as well as an educational reformer. His advocacy of democracy had immense influences on progressivism. Dewey's laboratory school experimented on different curricula aiming to discover students' mental powers and interests and harmonize them with a "miniature society" designed to educate children into effective social membership by "providing him with the instruments of effective self-direction" (Urban & Wagoner, 2000). Dewey's philosophy differed to that of *social meliorists* and *developmentalists* in that there was no enforcement in fitting children to social arrangements and conditions nor obsession with efficiency in curriculum. On the other hand, the miniature cooperative social environment was a congenial setting designed to initiate children's mental development. Through familiarizing themselves with structure, materials and operations of the larger community, it was hoped that children would be able to obtain control of their own powers. The three Rs, Dewey believed, can only be taught most effectively when associated with basic occupations that shaped people's social life. Also, Dewey actively sought a solution to fill the gap between native experience of children and the systematic and abstracted knowledge of adult consciousness. The task of the laboratory school was to seek matters and materials within children's life and interests that contribute to a mastery of abstract subject matter represented by organized bodies of knowledge. For example, cooking, Dewey claimed, "is a natural avenue of approach to simple but fundamental chemical facts and principles, and to a study of the plants which furnish articles of food" (Mathew & Edwards, 2007, p. 27). Dewey was trying to construct a continuum of experience with one end being the child's immediate and chaotic experience and the other end being logically organized experience of adult world. The program of study would lead through the whole journey between the two defining points. Having one of the biggest influences on American schooling in 20th century, Dewey's ideas were nevertheless questioned by later scholars such as Bruner (1963) who claimed that the intrinsic structure of an academic discipline itself has the power of being attractive to children and a course of study following the same pattern of intellectual development can be applied to both mature scholars and children.

By the 1930s, curriculum development in America reached its peak, and to a large extent, was characterized by a blending of the afore-mentioned clear-cut ideologies into a composite reform movement. Curriculum reform became a preoccupation at both national and local levels, and school districts had engaged in experimenting with innovative curriculum plans featuring a departure from the traditional humanistic curriculum in terms of both subject matter and pedagogical methods. In Oklahoma, the curricula were designed to meet the needs and interests of the children, marked by a shift from traditional subjects to such areas of living as home economics, personal finance, health education, safe driving, etc. In Denver, special attention was paid to personal adjustment to changes in the new social, political and economic environment (Ravitch, 2000). On a larger scale, social efficiency educators fought for a ground where they trimmed or replaced the traditional subjects to introduce subjects more directly relevant to life, epitomized by the development of vocational education. Essentialism emerged as an ally to social efficiency educators in the sense that they advocated that only core subjects that can be justified on the grounds of essentiality should be taught in school and they should be taught in an organized and systematic way (Angus & Mirel, 1995). Essentialists criticized the lack of rigorousness in the present child-centered curriculum advocated by Dewey and others, and the loosening of standards due to the subordination to immediate needs, personal experience and children initiative. The child-centered origins of *developmentalists*' curriculum were developed by Dewey and adherents in the effort to value the child's freedom while at the same time align the curriculum containing a larger social interest with a child's true nature. The first step, as Dewey's philosophy suggested, was to find the disciplines of knowledge associated with basic human activities and ordinary life experience. The second step was to lead the learners on a progressive course eventually approaching the processes of the intellectual development of mature scholars. The chaotic educational reforms of the 1930s were labelled as "progressivism or progressive education", a loosely defined term to designate something other than traditional practice which had been universally criticized as ignoring the needs and interests of children, lacking social function and justice (Mathew & Edwards, 2007).

Canada caught the "wind" of educational change in a timely manner with ideas and practices from "progressive education" starting to permeate the Canadian curriculum, particularly in western Canada. Canadian representatives of progressive education such as Hubert Newland from Alberta, sought to infuse John Dewey's ideas into classroom practice. In 1936, British Columbia's curriculum instructions were developed by the new Minister of Education George Weir who was a public figure in British Columbia and a professor of Education at the University of British Columbia. The new curricula were designed to include more comprehensive descriptions of philosophy and objectives for each subject. It was proposed that the curriculum should be organized into units, also labeled as "large comprehensive topics", which were built around a central core of thought and fundamental principles. Audio-visual aids were massively employed in the new curriculum to make materials "meaningful" to the child and de-emphasize the textbook-centered teaching. In 1937, Vancouver established the Department of Visual Education (Johnson, 1964). Ontario's progressive reform on curriculum was geared towards a more enlightening curriculum that allotted more time for elementary science and fine and practical arts. The revised Ontario curriculum in the late 1930s incorporated three core progressivism principles including active learning, individualized instruction and relationship between the school and society. For example, the relatively new domain for education – health study involved active learning through activities in which students explore various healthy habits. Art and music encouraged children to express their own ideas. Social studies, as the most "social *meliorist*" element of the curriculum, assisted children in understanding the social world in which they live (Christou, 2012).

During World War II, certain subjects were restructured to include more immediate practical value so as to contribute to warfare. Aeronautics was stressed in the physics curriculum, while war aims were emphasized in social studies. Industrial arts embarked on military needs and home economics and management were directed towards adjusting to war time life (Kliebard, 1995). Nevertheless, the territory of North America had never been the center of battle nor involved in a severe national crisis during World War II. As a result, not much attention was given to school's function in wartime. On the other hand, what was referred to as "life adjustment education" was proposed by the United States Office of Education (USOE), in the hope of preparing a bigger proportion of the school population for functional adulthood in the postwar era. At a conference held in Washington in 1945, a report from the USOE indicated that vocational school prepared 20 percent of its youth within the community for desirable skilled occupations while high school contributed to 20 percent of children's enrollment in college. The remaining 60 percent of the country's youth were not receiving the proper education for them to adjust their life to the new social order (Urban & Wagoner, 2000). Therefore, the new life adjustment education, aiming to prepare children for such real life activities as tools of communication, effectiveness as consumers, social relationships, and competence in improved family living, entered the curriculum as a supplement for college preparation education and vocational education.

However, life adjustment education was never fully implemented in practice and bore the same criticism as what Dewey's progressive education was once accused of: a lack of rigor and an undermining intellectual development. Academicians argued that democratic education advocated by proponents of life adjustment education where only a small segment of the school population was channeled into the academic stream and others followed a "soft" curriculum was in fact antidemocratic. Its premise wrongfully assumed a majority of students' incapability for intellectual training (Reece, 2005). The counterattack from the intellectual community never ceased and was brought to a peak by the country's shock of the successful launching of the Soviet Union's first man-made satellite, *Sputnik*, in 1957. National security, social development, and economic prosperity were immediately linked to efforts to bring school activities in accordance with the frontiers of scholarly endeavor. The American Congress passed the National Defense Education Act (NDEA) in 1958, the main body of which advocated major revisions in math, science and foreign languages curricula, with special attention being paid to "hardening" the curriculum and identifying talented students. Following the educational activities facilitated by NDEA, a series of curriculum reform movements took place in the late 1950s and were carried on into the 1960s. At the frontier of the reform, was the Harvard Psychologist Jerome Bruner, who argued that pupils of any age should be trained to think like professionals and to understand the intrinsic structures of academic disciplines (Bruner, 1963). The advocated inquiry and discovery learning that prevailed in 1960s and 1970s bore several similar ideas to progressive education in terms of the emphasis on child and learning processes; yet, it significantly differed from progressivism in such notions as the recognition of intrinsic attraction of academic disciplines, intellectual leadership of the few talented and gifted students and children's competencies. The discovery approach held the view that children were able to understand the natural structure of bodies of knowledge which was organized from the accumulated practices and ideas of adult scholars.

Similar to the States, Canada also saw a great amount of efforts put into educational reform initiated by Cold War imperatives. Reports from Alberta's Cameron Royal Commission and the Chant Commission in British Columbia all stressed the dependence of national security and standards of living on science education (Tomkins, 1986). Soon after World War II, Canadian critics of progressive education in public schools, most of whom were university professors, started to publish articles in newspapers and magazines condemning the declining academic standards in progressive curriculum and the fact that high school graduates were losing jobs because of poor mastery of the three Rs (Von Heyking, 2006). After 1950, mass secondary education was in great demand to address the diverse educational and economic needs during the post-war period. Curriculum reforms nation-wide were vocational oriented. Nevertheless, traditional academic subjects with their function in providing basic skills and knowledge still dominated the curriculum. In the sixties, the rapid economic growth demanded schools to produce more professional and technical manpower while at the same time promote democracy and social justice. Attempts on striking a balance between the two demands resulted in a major expansion of school education and rapidly changing emphasis of the curriculum in this decade (Lawr & Gidney, 1973). From the mid-1950s to the early 1960s, a short period of subject-centered curriculum reform against progressivism again prevailed in Canada. The Chant report in British Columbia defined the relative significance of each subject, and proposed more emphasis on effective intellectual development. This short-lasting reform was soon replaced by the so called "Neo-Progressive Revival" in the late 1960s, epitomized by Hall Dennis Report calling for broad reforms in Ontario public education. This report shifted subject-centered and vocational-oriented curricula to a progressive child-centered curriculum. The scope of the Hall Dennis Report had initially been on regulating elementary schooling and was extended to secondary level soon after. It recommended individual learning and flexibility in curriculum. The individualization of learning pave the way for the subsequent adoption of the credit system in Ontario's high schools, which superseded grade structured programs with individualized timetables and programs. By 1970, students in elementary and junior high school in Canada were all learning science. Earth and space science entered the general science curriculum in late 1970s. Experimental approaches as those suggested by Bruner and adherents, were adopted and accompanied by an expansion of laboratories. More profound changes occurred at the senior high school level in chemistry, physics and biology with a heavy influence from American ideas.

While educational reform goaded by the launching of *sputnik* was characterised as a response to America's increasing competitiveness in national defense and science and technology in general, the "excellence" movement embarked upon by the Reagan administration in 1983 through the report, *A Nation at Risk*, was initiated in an effort to re-establish and secure the US as the leader in the new world economy (Urban & Wagoner, 2000). The role of school was closely linked to economic prosperity by political authorities and the public, and more rigorous standards were introduced to restore high quality academic performance. The reform of education systems in North American and European countries in response to the reconstruction of global economies was felt by Canada, and the nation responded quickly with academic debates and governmental reports such as *Prosperity Through Competitiveness* (Canada, Prosperity Secretariat, 1991). The interest in centralizing the school as a means of individual and social betterment, whose roots were well watered by numerous educators over the 20$^{th}$ century, continued in the waning decades of the century, and was carried into the 21$^{st}$ century. From Goals 2000 signed by President Bill Clinton in 1994 to the federal No

Child Left Behind Act in 2002, standards-based education reform was epitomized by standardized national tests aiming to produce overall high academic achievement for the growth of national economies (Rudalevig, 2003) .

The above literature review presented the changing educational context of the past century in the opposite direction to the traditional education focusing on indoctrination and memorization in 19th century. Ideologies from various educational interest groups and philosophers were seen to be interwoven and were integrated in the later curriculum at different levels and dimensions.

# Chapter 3: Content analysis and synthetic analysis of curriculum guides from 1920 to 1936

A chronological content analysis was conducted. The first paragraph of each year's content analysis normally includes a summary of the key features of each year's curriculum and the following paragraphs consist of an analysis that identifies the change the curriculum has gone through in a particular year (mostly in comparison to the curriculum of the previous year). If one year's curriculum stayed the same as, or is no great difference to, that of the previous year, the summary part and analysis part would be combined into one. Analysis of science 9 precedes that of science 10. Additionally, three synthetic analyses were presented after the content analysis of the year 1936, 1969, and 1983 which marked three critical turning points in curriculum development. Each synthesis encapsulated major paradigms that characterized the science curriculum guides during the period of time stratified by the three critical years, i.e. 1921-1936, 1937-1969 and 1970 onwards.

## 3.1 Content analysis from 1920 to 1936

British Columbia experienced a period of prosperity after WWI. The Panama Canal realized its full potential in the 1920s, and traditional export such as lumber as well as new exports like Okanagan apples and prairie grain were transported through the canal to Britain and continental Europe. A comprehensive development plan for Greater Vancouver was in preparation. Vancouver led British Columbia in economic growth, and its residents' wages increased by 12 percent between 1922 and 1928. As economy boosted, concern over the welfare of children, particularly with regard to schooling also grew. Years children stayed in school for were longer and by the 1920s a majority of children tended to complete full term of elementary schooling with regular attendance. British Columbia was a national leader in school reforms and development. It was the first province in Canada to offer provincial correspondence education aiming at elementary children living in isolated areas. In 1929, the correspondence education at secondary level was implemented. The school assumed additional social responsibilities by including occupational training in the curriculum. The occupational training, curriculum standardization and differentiation by grades all contributed to the expansion of the school (Barman, 2007).

Additionally, the province continued to encourage people to engage in agriculture, with the intent of ameliorating the unemployment situation by channeling returned soldiers towards land. Several land settlement schemes such as Sumas reclamation project and southern Okanagan land project were initiated to open new areas to farming. In accordance with the province's emphasis on agriculture, the secondary science curriculum of 1920s incorporated the scope of agriculture which played an equally important role as traditional sciences, i.e., physics and chemistry. Electrical appliances started to permeate Canadian family and by 1930s seven out of ten Canadian homes were electrified. The secondary science curriculum first introduced topics of electricity in 1924, and the home electricity was stressed in 1936's curriculum.

Just when people thought the prosperity would continue, the crash of the stock market in 1929 triggered the Great Depression which was a long time coming due to the postwar inflation. People sought for solution in schooling (Lemisko & Clausen, 2006).

Following is a chronological analysis of grade 9 and 10 science curricula since 1920 that accorded with the above social and economic backdrop of British Columbia closely.

**1920**

**Science 9 program**

The "Preliminary Course, Junior Grade Science" (equivalent to grade 9) in the curriculum was optional in 1920 and pupils had the choice of taking general science or physics and chemistry (physics and chemistry was the name of one science course while general science was its counterpart). The general science section prescribed in the curriculum introduced the name of the textbook (*Elements of General Science* by Caldwell & Eikenberry) as well as the accompanying laboratory manual. Students were responsible for performing "the suggested experiments and keep careful notes" (1920, p17). The physics and chemistry section in the curriculum introduced the name of the textbook (*Exercises in Practical Physics for Schools of Science* by Gregory & Simmons) with a list of chapters of the book that were to be omitted when teaching.

The grade 9 science curriculum in 1920 was in its very primitive form without the introduction of the general goals of the curriculum, the syllabus, the suggestions on lesson delivery, prescribed learning outcomes, and assessment methods that were considered important components of later curricula. The curriculum only gave the titles of the textbooks used in class, which suggested a textbook dependent course of study. Consequently, the textbooks became the curriculum to a large extent and provided the scopes of the science program. The general science textbook included 31 chapters of content that can be organized under five general topics: The air, water and its uses, work and energy, the Earth's crust, life upon Earth (Table 3). Out of the 31 chapters, teachers had the choice of selecting any twenty chapters to be covered in class. Thus it was unlikely that all the five topics would be taught to their full capacity in grade 9 general science program. The selected chapters of the Physics and Chemistry textbook could be categorized into five topics as well: Matter and its property, air pressure, measurement of heat, properties of air and water, and action of acids on metals and carbonates (Table 3). Theories and facts under each topic were mostly illustrated by diagrams of experiments conducted by earlier educators and scholars. For example, the section 65 of Chapter 6 in the textbook of General Science, included a diagram of a carbon dioxide generator in which one bottle with a stopper contained pieces of marble and hydrochloric acid and it was connected with a glass of water through a bent tube that penetrated the rubber stopper. The diagram also showed air bubbles (carbon dioxide bubbles) coming out of the tube in the glass of water. The accompanying text presented such facts about carbon dioxide as it could be produced by putting hydrochloric acid on marble, carbon dioxide was clear and colorless, and it could be used to extinguish fire.

**Science 10 program**

The “Advanced Course, Junior Grade Science” (equivalent to grade 10) in the curriculum consists of Botany (mandatory) and one or two of Agriculture, Chemistry, and Physics. The curricula of Botany and Agriculture had simple syllabi which listed points of knowledge (not in any apparent logic order) that would be learnt in the courses (Table 4). The Botany curriculum also had a brief discussion of students’ expected achievements such as recognizing well-marked families of flowering plants. Furthermore, the curriculum stated that “care should be taken not to make this course too formal by too much dependence on the text-book, [and] the ordinary nature-study method should prevail" (BCDOE, 1920, p19). The physics and chemistry components of the grade 10 curriculum looked similar to those of grade 9, in which chapters of the textbooks that should be covered in class were listed. A total of five topics were respectively prescribed for chemistry and physics (Table 4). Furthermore, the curriculum explicitly states that "[experiments] in the accompanying Laboratory Manual covering the above [chapters of the textbooks] should be performed" (BCDOE, 1920, p20).

Some key components of curricula made their appearances in the Grade 10 science curriculum (i.e. Botany which was the dominant subject in 1920) such as suggestions on students' achievement and lesson delivery. Unlike the grade 9 science curriculum which used the phrase "suggested experiments" without explicitly stating what the suggested experiments were about, the grade 10 curriculum specifically stated that the experiments that covered the knowledge of the lecture part should be performed. Also, there was a degree of flexibility in the curriculum as it explicitly stated that the course should not be dependent on the text-book but should be more nature study oriented.

### 1921

#### Science 9 program

The grade 9 science curriculum in 1921 stayed exactly the same as that of 1920.

#### Science 10 program

The grade 10 curriculum still consisted of Botany (mandatory), Agriculture, Chemistry and Physics (students choose one out of the above three subjects). The botany curriculum in 1921 had grouped the content into six categories rather than a random list of content as in the curriculum of 1920. More details on what students were supposed to learn were stated under each category. In addition, four recommended reference books were also listed at the end. More chapters of the textbook and more detailed elaborations on specific sections of each chapter were included in the chemistry curriculum. The physics curriculum required that the exercises in the Laboratory Manual relating to selected chapters in the textbook should be performed by pupils.

The botany curriculum in 1921 definitely had an ampler and better structured syllabus than that of 1920, with the content classified in a systematic way and more specifics included in the desired learning outcomes. Although there was no such section labelled as “Prescribed Learning Outcomes (PLOs)” or “Achievement indicators” in the curriculum, suggestions on what students should learn and achieve were provided. The primitive forms of PLOs can be seen in the 1921 curriculum. Furthermore, in addition to textbooks, reference books were also recommended indicating an expansion in the scope of scientific reading for students.

Another subtle but very important change in the physics curriculum of 1921 compared to that of 1920 was the change in some rhetoric of the curriculum. For example, in 1920, the curriculum stated that “[experiments] in the accompanying Laboratory Manual covering the above [chapters of the textbooks] should be performed”. However, in 1921, the curriculum used the phrase “related to” in replace of the word “covering”: “[experiments] in the Laboratory Manual related to the above [chapters of the textbooks] should be performed”.  “Covering” indicated a constraint on the scope of experiments (i.e. only experiments that were on the same topics with the textbook would be performed by students) while “related to”indicated more choices of experiments (i.e. not only the experiments that are on the same topics with the textbook but also the ones that are deemed relevant to the textbook by teachers). A change from “covering” to “related to” potentially expanded the curriculum and introduced more flexibility for teachers.

**1923**

**Science 9 program**

The numeric grade level made its first appearance in 1923 (i.e. Grade IX and Grade X). The grade 9 science in 1923 was still optional but only consisted of general science with physics and chemistry being taken out of the curriculum. The description of general science in the curriculum was exactly the same as that of 1921.

It can be seen that, in the year 1923, the options of physics and chemistry were excluded from grade 9 science curriculum with only general science left. The topics prescribed by general science textbooks covered more diverse areas than those of physics and chemistry. Subject-matter with regard to Earth’s crust and life on Earth were options in general science but not in physics and chemistry. Additionally, topics within general science were organized in a more interdisciplinary manner while physics and chemistry tended to define topics in a discrete manner. For example, knowledge pertaining to three states of matter (physical science) and transpiration (biology) were both included within the topic of water and its uses in general science textbook. This may be interpreted as an early initiative in making a shift to a more integrated science program that preceded the progressive reform on the horizon when Putman and Weir survey was disclosed two years later.

**Science 10 program**

The grade 10 science curriculum consisted of Botany, Agriculture, Chemistry and Physics (students choose one or two out of the four subjects). The agriculture curriculum added livestock study in the curriculum. The botany curriculum placed the emphasis on ”comprehension of principles rather than mastery of detail, and upon observation rather than book knowledge (BCDOE, 1923, p28)”. Furthermore, the emphasis of the content of the botany curriculum shifted from the identification of plant families to the understanding of biological processes of plant such as growth, nutrition, and reproduction and the exploration of flora through field trips to natural habitats. The study of plants of economic value to British Columbia such as weeds and medicinal plants, made its first appearance in the curriculum. One more section of the textbook was added to the chemistry curriculum. Three more topics for experiments were added to the physics curriculum.

The Botany curriculum started to address practical issues by emphasizing observations over book learning, and including introductions of economic plants in British Columbia. This can also be seen from the selection of a practical oriented reference book - *Practical Botany* by Bergen and Caldwell. It was in accordance with the economic development of the province in 1920s. The chemistry curriculum included one more section on the law of multiple proportions that elaborated unification of elements in more than a single proportion. Three more exercises No. 36, 37 and 39 in the Laboratory Manual were added to the physics curriculum. As mentioned above, the several topics that were added to the physics and chemistry curricula indicated a gradual expansion of the curriculum in terms of subject-matter.

**1924**

**Science 9 program**

The grade 9 science curriculum stayed the same as that of 1923 with 3 books of reference added. No apparent change was made to the curriculum except for the inclusion of books of reference.

**Science 10 program**

The grade 10 science curriculum consisted of Botany, Agriculture, Chemistry and Physics (students choose one or two out of the four subjects). The Botany, Agriculture and Chemistry curriculum stayed the same as that of 1923. The Physics curriculum listed the topics covered by the course and the corresponding selected book chapters. More textbook chapters were included in the curriculum. Furthermore, the experiments in the Laboratory Manual that should be performed by the students themselves were explicitly stated in the curriculum. A general list of apparatus required for experiments was also included at the end.

While the curricula of Botany, Agriculture, and Chemistry were not different to those of the previous year, the curriculum of physics had substantially developed in terms of the appearance of a sequence of topics (i.e. measurement, mechanics of solids, mechanics of fluids, heat, light and electricity and magnetism) compared to just a list of textbook chapter numbers in 1923. Unlike the flexibility found in the curriculum of 1923, where teachers can decide which experiment should be conducted by pupils, the 1924 curriculum was more rigid, with required experiments explicitly listed.

**1927**

**Science 9 program**

In 1927, grade 9 science went through a major expansion and consisted of general science which was categorized into 10 headings (split in two parts, i.e. General Science 3 and General Science 4). Each heading characterized one topic (e.g. Work and energy, Electricity, and reproduction in plants and animals, etc.) and was further delineated into subheadings of different themes within the topic (e.g. magnetism and electric current under the heading Electricity). A huge list of about 60 books of reference was included at the end.

The grade 9 curriculum experienced a major development in 1927 from the previous curriculum consisting of only books of references. Topics related to basic earth science, physics, and biology were three major themes in the curriculum. These topics were designed to foster citizenship. For example, the learning of plants was directed to address plants' relation to human welfare and the recognition of internal combustion engines' economic and social importance was introduced. Interestingly, there was no topic related to chemistry in the grade 9 curriculum in 1927.

**Science 10 program**

The grade 10 science curriculum consisted of Botany, Agriculture, Chemistry and Physics (students choose one or two out of the four subjects). The Botany, Agriculture and Physics curricula stayed the same as those of 1924 while more chapters of textbooks that should be taught were included in the chemistry curriculum.

One obvious change in the curriculum compared to that of the 1924 was the inclusion of more content in the chemistry curriculum. In addition, the notion of "omitting questions requiring numerical calculation (1924, p9)" in 1924's curriculum was eliminated. The chemistry curriculum expanded a small amount in terms of the amount of covered materials and the new requirement of numerical calculations.

**1928**

Grade 9 and 10 curriculum stayed the same as that of 1927 with minor revisions to the language use.

**1929**

The grade 9 curriculum stayed the same as the previous year.

**Science 10 program**

The Botany, Agriculture, and Physics curriculum stayed the same as the previous year while the Chemistry curriculum continued expanding with two more textbook chapters and five more experiments added to the curriculum.

Similar to year 1927, the Chemistry curriculum was on the path of gradual expansion. The two added upper-level chapters were adapted from the prescribed textbook (i.e. Practical Chemistry by Conant) and were accompanied by more experiments, indicating an emphasis on the chemistry part in the science curriculum. The gradual expansion of secondary chemistry curriculum in early twentieth century was in line with the expansion of manufacturing industry boosted by WWI which was carried over into postwar era. Manufacturing sectors such as iron and steel industry involved a variety of chemical reactions on a large scale, calling for workers and technicians equipped with extensive chemistry knowledge (Chemical Institute of Canada, 1969). Additionally, the development of high school chemistry was likely to be led by that of university chemistry instruction. The chemistry department of Canadian universities continued to grow with the appointment as instructors of specialists in various branches of chemistry; the construction of chemistry buildings; and chemistry's growing role in a variety of disciplines, science, medicine, nursing, agriculture, and home economics among others. For example, The University of British Columbia (UBC) hired one more staff, R.H. Clark (M.A. , Toronto; Ph.D., Leipzig) in its chemistry department to teach organic chemistry a year after the university was opened in 1915. A fine building where chemistry department was based was completed in 1925 after its delay during wartime (Graham, 1950). The increasing chemistry instruction at university inevitably also prompted the advancement of high school chemistry which aimed to better educate young people with basics in chemistry.

**1930**

Grade 9 curriculum stayed the same as that laid out in the junior high school Programme of Studies in 1927. A new high school Programme of Studies came out to accommodate the "reorganization of the school system in conformity with the recommendations of the British Columbia School Survey Commission and in line with the methods followed in the most efficient educational systems in Europe and North America". The new change in the curriculum was designed to reflect the development of educational thought during the past ten years and the developing socio-economic conditions of British Columbia. The new curriculum addressed the importance of recognizing individual differences by offering a liberal range of free electives adapted to individual student's needs.

**Science 10 program**

Grade 10 science curriculum consisted of Chemistry I and Physics I (students choose one from the two subjects) which were the same curricula as those of 1929.

Biology and Agriculture were alternatives for students who did not choose Chemistry or Physics. The Agriculture curriculum stayed the same as that of the previous year. The Biology curriculum directed the study of living forms from "elementary nature-study to more scientific observation, classification, and experimentation" ( BCDOE, 1930, p77). Four learning themes (Table 18) were outlined in the curriculum with page references of various books given.

The grade 10 science curriculum was reorganized with Botany taken out, and chemistry and physics labelled as I. Agriculture was not included in the grade 10 science curriculum but served as an alternative for grade 10 science. The subject of Biology was prescribed in the curriculum for the first time, also as an alternative for grade 10 science. The four themes outlined were organized in a progressive way to initiate a learning process from descriptive study to experimental study: 1) Descriptive study of selected living forms under the guidance of teachers. 2) Observations of the above selected topics. 3) Experimental study or growth of the selected living forms. 4) Identification of economic importance to man. Agriculture and botany were gradually phased out of the curriculum when biology came in. Biology was a more comprehensive discipline characterized by the study of living forms and its curriculum was designed to be observational and experimental.

**1932**

**Science 9 program**

The 1932 programme was a reconfiguration of 1927's programme into six categories of topics related to chemistry, physics and biology. The titles of the topics were presented in the form of scientific questions, with titles of sub-topics characterizing the main topics listed under each question. In addition, the general science curriculum stated that it aimed in cultivating appreciation of the nature and developing understanding of the scientific principles that governed the environment within the range of pupils' experience and interests. It also instructed teachers to decide the degree of treatment with a consideration of pupil's interests and abilities.

The most obvious feature of the 1932 programme was the emphasis on applying scientific principles in understanding and solving real world problems. A majority of the problems were directed to making connections between scientific facts and real life experiences and applications. For example, instead of randomly enumerating all the subjects (e.g. Magnetism, electric current) under the title "Electricity" as in 1927's programme, the question - "How does man use electrical energy?" replaced the title "Electricity". Under this question, multiple subject-matter were listed in a logic order, in particular, subject-matter related to the application in real life such as the "application of electricity in every-day life" permeated the curriculum.

**Grade 10 curriculum stays the same as that of the previous year.**

**1933**

The grade 9 curriculum was the same as the previous one.

**Science 10 program**

The chemistry, biology and agriculture curriculum stayed the same as that of 1930. The only change in the physics curriculum was a replacement of the old textbook (i.e. High School Physics by Merchant & Chant) by the new textbook (New Practical Physics by Black and Davis).

**1936**

**Science 9 program**

Sections on “Introduction”, “Instructions on science reading”, “Textbook and Reference books”, “Experiments guide” and “Objectives” were laid out to address the philosophical and pedagogical aspects of the curriculum. In essence, the program was designed to assist the child in his growth and self-realization, in adjusting to his environment, and possibly modifying the environment. The curriculum was designed to supply a graduated and systematized course of experiences to bring about the desired learning necessary for intelligent living in later life that was not achieved in ordinary life due to either lacking or so casual. The content was categorized into 10 units. Within each unit, the timeline of unit, statement of unit, aims, and references were laid out first. Then they were followed by tables of “Subject-matter”, “Approaches and Methods”, and “Activities and Notes” which were developed and reconfigured from the problem based learning structure in 1932’s curriculum.

The curriculum in 1936 expanded tremendously with the introduction of “unit” system. Different subjects were organized in “units”, which represented “large comprehensive topics” and were built around “central thought or fundamental principle” (1936,p1). In addition, the programme in 1936 further developed the pedagogical aspect of the curriculum, i.e. providing guidance on teaching and learning. Though the statements on the objectives and testing of the curriculum were still at a junior level, they were the antecedents of the goal of the curriculum and assessment methods, which were considered key components of the contemporary curriculum.

The grade 10 curriculum was the same as the previous year.

## 3.2 Synthetic analysis from 1921 to 1936

### 3.2.1 Curriculum change in terms of expansion

Curriculum expansion accompanied curriculum change with fewer exceptions. Three ways leading to the expansion of the science curriculum were identified in the analysis from 1921 to 1936: 1) the inclusion of more subject-matter; 2) the employment of rhetorical strategy (the way the curriculum was rephrased); 3) the requirement of more difficult subject-matter and higher level of skills.

A common change was the inclusion of more subject-matter in the curriculum. Both grade 9 and 10 curriculum had gone through the process of more content being included with less content being taken out: more chapters of the prescribed textbook were included in the chemistry section of 1921's grade 10 curriculum; in 1923's curriculum, the section of Botany introduced a new topic on economic plants of British Columbia, while more chapters of the textbook continued to be added to the chemistry section. Additionally, three more experiments expected to be performed by pupils were added to physics. In 1924, grade 10 physics included four more chapters in the physics curriculum and explicitly prescribed 20 mandatory experiments to be conducted by students. A booming of the grade 9 science curriculum in 1927 was characterized by a unification of multiple science disciplines (i.e. earth science, physics, and biology). Furthermore, major concepts and core content under each topic in the statement form had replaced the mere list of titles of textbook chapters in the previous curriculum; in 1929, grade 10 chemistry continued introducing more content through adding more required book chapters. in 1930, botany was taken out of the curriculum when biology first comes in as an elective.

Biology, of which botany was a just branch, entailed a more comprehensive study of living forms including both animals and plants. Problem based learning was incorporated in the 1932 grade 9 science curriculum, assuming the form of a core scientific question followed by a list of subject-matter contributing to the understanding of the question. Some subject-matter was inherited from the 1927 curriculum while a great amount of new subject-matter, such as wireless communication, cell differentiation, application of electricity in daily life, were also introduced. The grade 9 science curriculum experienced the biggest expansion in 1936 when the "units" system was introduced. Topics related to biology, chemistry, environmental science, earth science and physics were categorized in 10 units.

A change of language use, even at sentence level, may imply an extension in the content prescribed. For example, the programme in 1920 required pupils to perform experiments *covering* the topics in the selected chapters of the assigned textbook; however, in the programme of 1921, the word *covering* was changed to *relating to*. *Relating to* indicated that more experiments may be performed by pupils should the teachers find relevance between the experiment and the topic in the textbook; whereas *covering* demanded only experiments that were on the same topics as the topics prescribed by textbook should be performed by students.

Another way that the workload increased for the curriculum was in terms of demanding higher level of skills from the students and infusing more difficult subject-matter. Before 1924, questions related to numerical calculations in grade 10 chemistry were excluded from the curriculum; however, in 1927, those questions were not omitted any more, which implied, a higher level of ability related to the application of numerical computation in chemistry were to be achieved. In the grade 9 science curriculum of 1927, reproduction of single-celled organisms was to be learnt, under the topic “reproduction”; however, in 1932, cell differentiation in multi-cellular organism, was required to be taught.

### 3.2.2 Curriculum change in terms of revisions and improvements

Descriptions of subject-matter and content were also constantly under development. In 1927, one subject-matter was characterized as “sources and transformation”. In 1932, it was unfolded into two subject-matters, i.e. “the sun as the source of energy” and “transformation of energy”. The subject-matter is more specific so that there is no misunderstanding or ambiguity when it came to teaching and learning.

Furthermore, the curriculum was constantly reorganized and reframed to place emphasis on different styles of learning and teaching. For example, some of 1927’s topically outlined core content was reframed into problem driven structure in 1932: the former core content in the statement form - “Electricity”, was transformed into the question form-“How does man use electrical energy”. The subject-matter “magnetism” and “Electric currents” under the topic “Electricity” were transferred to the topic “How does man use electrical energy” without any change.

### 3.2.3 Oscillating patterns in the science curriculum

Oscillations between practical and theoretical learning, and between rigidity and flexibility of the curriculum, were constantly found in the curriculum.

Practical issues always played a very important part in the early 1920s' science curricula. For example, the botany section of 1923's grade 10 curriculum introduced economic plants in British Columbia; However, in 1936, the curriculum explicitly stated, "a child's system of meanings becomes more and more independent of immediate concrete objects as he matures. The ability to work in the imagination and build up systems of ideas is essential in education. To limit the curriculum to that which has immediate practical application is to overlook the truth." As a result, emphasis was placed on fundamental facts related to chemistry, biology and physics rather than real life application of knowledge in this year's curriculum.

Furthermore, the curriculum underwent constant alternation between a rigid structure and a high degree of flexibility, and sometimes a mixture of both: the physics section in 1924's curriculum prescribed a list of experiments that needed to be performed by students whereas 1923's curriculum left the decisions to teachers. In 1936, the subject-matter of each unit was outlined in great detail aiming to provide more instructions on what to teach within each subject-matter but teachers still had the freedom to select the subject-matter they prefer to teach on a functional basis.

### 3.2.4 Reflection on Progressive Education

What the curricula of the late 1920s and 1930s had reflected were universally consistent with the progressive education movement at that time. For example, the child-centered and social reconstructionist approaches advocated by the "progressive education", which prevailed in western Canada after 1920, were first infused in the new junior high school programme of 1927. The 1927 programme offered "constants," courses which were required of all students and “variables” courses as electives for individual choice. Furthermore, the science 9 curriculum of 1927 touched on topics such as the economic and social importance of internal combustion engines, which developed pupil’s knowledge contributing to social reconstruction.

Later in 1930, a new high school Programme of Studies came out and aimed to accommodate the “reorganization of the school system in conformity with the recommendations of the British Columbia School Survey Commission and in line with the methods followed in the most efficient educational systems in Europe and North America” (1930, p1). Dewey’s ideas of learning through active inquiry entered 1932’s grade 9 science curriculum. Major concepts previously expressed in the statement form are transformed into the form of scientific questions, e.g. “how does water work for me”, “what is the source of energy”, “how does man use electrical energy”.

In 1936, British Columbia’s curriculum instructions were developed under the new Minister of Education George Weir, and involved more comprehensive descriptions of philosophy and objectives for each subject. The curriculum was organized into units, also labeled as “large comprehensive topics”, which were built around central core of thought and fundamental principle. Each unit consisted of a selection of subject-matter and experiences chosen to “stimulate the growth of the child and to assist him in fitting into his environment” (1936).

# Chapter 4: Content analysis and synthetic analysis of curriculum guides from 1937 to 1969

The outbreak of WWII ended the economic hardship of the 1930s. Ship and aircraft construction stimulated manufacturing, and employment rate arose after nearly one decade of recession. After the war, Canada entered the period of prosperity characterized by tremendous economic expansion and the cold war state as an ally of United States competing with Soviet Union for superiority in economy, politics and military. Both WWII and the cold war exerted great influences on BC secondary science curricula.

## 4.1 Content analysis from 1937 to 1969

**1937**

Grade 9 curriculum is the same as that of the previous year.

**Science 10 program**

Grade 10 science of 1937 was renamed as “General Science IV”. The curriculum introduced a variety of sections including *the objective of general science IV, suggestions on testing*, and *recommendations on science reading*. Furthermore, in accordance with the introduction of “units” system in grade 9 science, the core content of the grade 10 science was categorized into six units. Each unit characterized an integrated or interdisciplinary topic relating to physics, biology, chemistry, climate science, and environmental science. Under each topic described within the unit, subjects or themes that were important in understanding the topic were listed. Furthermore, each subject or theme was followed by lists of key points of knowledge, books of reference and recommended activities for pupils.

The topic of each unit was designed in such a skilful way that the general science curriculum in 1937 became a real amalgam of multiple science disciplines. For example, the fourth unit was "water plays an essential part in many chemical and physical phenomena, and is essential to life". The themes and subjects under this unit included understanding of the hydrosphere, chemical properties of water, physical properties of water, water's importance for humans, water as habitat for different forms of life. It can be seen that climate science, chemistry, physics, environmental science as well as biology were all addressed under this unit through the exploration of various themes and subjects. Several new topics relating to earth science, climate science and man's exercises over plant entered the science 10 curriculum of this year. The aggregation of multiple science subjects was stressed in the objective of the 1937 programme:

> *Present course is not confined to any one particular field, but cuts across the subject-matter content of several sciences. This has been accomplished by fusing them into one course, "General Science", rather than by fashioning a mosaic of the several sciences* (BCDOE, 1937).

**1938**

**Science 9 program**

Compared to the grade 9 curriculum of 1936 which had ten units, the curriculum of 1938 was reduced to six units. The structure of the curriculum was similar to that of grade 10 curriculum in 1937, and can be illustrated in the following streamline: unit (a comprehensive topic related to physics, biology and chemistry) -> key subjects or themes within the unit -> activities and discussions.

Interestingly, the structure did not follow the problem based learning structure of 1936's grade 9 science curriculum. In a way, this year's curriculum shrank compared to that of 1936 in terms of the amount of knowledge prescribed, the descriptions of subject-matter as well as instructions on teaching approaches and methods; however, the capacity of the curriculum may stay the same, as the seemingly reduced units were mostly the result of reorganization and reconfiguration of the previous ten units, and still contained most topics. For example, Unit III of 1936 included topics of improving the quality of the plants and animals, and Unit IV introduced topics of protection of forests, agriculture and fisheries. All those materials were found in Unit I of 1938's curriculum which was labelled as reproduction. Furthermore, core topics that required more than 4 weeks of instructions all remained such as Earth's crust, work and energy, chemical changes and reactions, reproduction of plants and animals, among others. Units of introduction on scientific method and measurement were taken out; however those topics were allotted a small amount of time (i.e. one or two weeks compared to five weeks normally assigned to a unit) and may be integrated with other topics.

The grade 10 curriculum stayed the same as the previous curriculum.

**1939**

The grade 9 and grade 10 curriculum both stayed the same as the previous ones.

**1941**

The grade 9 curriculum was the same as the previous one.

**Science 10 program**

The curriculum of 1941 was developed from that of 1937 with the recently introduced unit of climate science taken out. Furthermore, some of the old subjects and themes of units of 1937 were incorporated in the current curriculum with some degree of reorganization in structure, while others were replaced by new subjects and themes. For example, subjects on inanimate and animate bodies of matter were taken out while applying electron theory in explaining valence was infused. In addition, at the end of each unit, a huge list of recommended films was developed from a short list of motion pictures and film slides in 1937's curriculum.

A noticeable change from 1937's programme to 1941's programme was the massive expansion in the use of visual aids, particularly educational films. For a certain unit, as many as 30 recommended films were attached. Film making companies such as Garrison Film Distributors, Inc., in New York made those silent and sound films to provide visual aids for materials learnt from textbooks and enrichment topics. A variety of topics had their accompanying films such as molecular theory of matter, magnetic effects of electricity, story of a can of salmon, among others. This extensive employment of films explained the fact that more time was allotted to each unit and was likely related to the development of film industry since late 1930s. Furthermore, chemistry gained more shares in the curriculum thanks to the space left when climate science was taken out. There was a trend of more complicated theories and concepts overriding fundamental facts. For instance, the chemistry unit of 1937 stated that valence helped us to write chemical formulas but the unit did not explore further the mechanism of valence. The chemistry unit of 1941 required students to use electron theory to explain valence and the behaviour of molecules in water solutions.

**1942**

**Science 9 program**

The 1942 programme maintained the same structure as the 1939 programme; however, the units were completely redefined so were the accompanying subjects and themes. Unit II of the 1939 programme was stated as "when we know the laws governing the combination of substances we are better prepared to transform the raw materials of the earth's crust into more useful substances" (BCDOE, 1939). Its counterpart of 1942 was labelled as "man is able to utilize more completely the materials of the earth's crust when he understands the conditions under which they were formed" (BCDOE, 1942). While the Unit II of 1939 placed emphasis on the chemical procedures man used in transforming earth's crust the Unit II of 1942 focused on understanding natural forces that had effected vast changes in the earth's crust. Furthermore, in conformity with 1941's grade 10 programme where visual aids such as films took up a great amount of space, considerable educational films relevant to the prescribed topics were recommended in the grade 9 curriculum as well.

The redesign of units was "application to real life" oriented. In contrast to 1939's curriculum where emphasis was placed upon understanding facts of subjects, the 1942 curriculum sought to find links between the subjects in the curriculum and their applications. For example, units were constructed around mastery of plants, utilization of materials of the earth's crust, propagation and control of useful and harmful plants and animals through scientific study and application of scientific principles to housing construction, among others.

Grade 10 curriculum is the same as the previous one.

1945, 1946, 1948

No change is made in the grade 9 and 10 curriculum.

**1951**

The grade 9 and grade 10 science curricula were compiled in the same programme in 1951, and respectively labelled science 10 and science 20. Generally speaking, the new programme emphasized solving problems by using the scientific method, i.e. scientific observation and inquiry, as well as experimental method. In addition, the "Evaluation and Testing" section was included as part of the guidance on assessment for teachers.

**Science 9 program**

Topics of units related to earth science, biology, chemistry and physics built on those of 1942 but underwent major reconstruction and reorganization. The property of elements and compounds was organized into its own unit in 1951 while previously it was embedded in the unit relating to the composition of Earth's crust. The topic of house construction was transferred to grade 10 science and two biology units were merged into one. Topics of climate science which were taken out of 1941's grade 10 curriculum re-entered the current grade 9 curriculum.   The previous unit of "application of scientific principles to housing instruction" was eliminated and was replaced by the study of energy and electricity. The structure of each unit was redesigned and configured into "major concept" "core ideas", "references", "core content", and "Activities".

There were topics being taken out of the curriculum and other topics coming into the curriculum. The climate science unit was passed down to grade 9 science from grade 10 science with an enriched content and emphasis on weather forecasting. In addition, visual aids mostly films for basic topics and enrichment corresponding to each unit were listed in the appendix.

**Science 10 program**

Grade 10 science was structured in the same way as grade 9 science. Life science, energy usage in the industrial society, conservation of resources, which had not been touched on in the grade 10 curriculum of 1941, all had their shares of the units. Furthermore, a detailed list of equipment and supplies suggested for the course was provided in the appendix.

A booming period of economic development characterized by transportation in 1950s in British Columbia was reflected in the grade 10 curriculum. The last grade 10 curriculum in 1941 only touched on simple mechanical machines while the current curriculum placed an emphasis on both external and internal combustion engines used in transportation.

**1956 and 1959**

Both the grade 9 and 10 science curricula of 1956 inherited most part of 1951's curricula with minor revisions and inclusions of more subject-matter. For example, in 1951, the curriculum stated "ninety-eight elements [in periodic table] have been investigated, and about ninety-two of these occur in nature" (BCDOE, 1951 ); however, in 1956, the "ninety-eight elements" was updated to "more than 100 elements". Apparently, over the past five years, more elements had been discovered by scientists, and the curriculum makers tried to keep up with the science community through timely modification to the curriculum accordingly. In addition, in the second unit of grade 9 curriculum, the subject-matter, "source of energy" was added.

The programme in1959 was the same as that of 1956.

**1963**

A set of alternative units for physics content in the 1959 general science curriculum came out in 1963. The alternative units were experiment driven, and were designed to assist students in exploring basic physical principles through hands-on experimentation, teacher demonstrations and analysis of their observations. It should be noted that teachers did not have to substitute the alternative units for the present ones if they had little background in science studies. On the other hand, competent teachers might want to use the alternative units, and their experience with these alternative units would provide inputs on the revision of the new curriculum (BCDOE, 1963).

**Science 9 program**

For grade 9 science, “Mechanics”, “Heat” and “Space Science” were provided as respective alternatives to the present units on “Matter”, “Energy” and “Meteorology”. Under each alternative unit, the main topics were listed at the beginning. Core ideas within each topic were investigated through selected experiments, with diagrams of the set up and detailed instructions on experiment steps, followed by extended discussions and questions on the topic. The equipment for all the experiments was listed at the end of each unit. There were about 20 prescribed experiments in Mechanics and Heat units while about 8 experiments were included in Space Science unit.

The most pronounced difference between the alternative units and the present units was that the core idea of the former put emphasis on exploring the scientific principles through hands-on experiments while the core idea of the latter focused on learning specific facts written in statement form. An approach similar to the procedure of scientific inquiry in academic world was proposed:

"[pupils are required to come up with a] statement of the problem faced, the apparatus required, the methods used, the observations made, the calculations arising from the observations and, finally, a conclusion".

In essence, it was very experimental and overhauled the traditional teacher-lecturing model of junior secondary science classes. Additionally, the unit of space science as an alternative to that of meteorology was likely associated with the beginning of the Space Age in late 1950s, when Russia launched it's first satellite - Sputnik. Canada followed development in America, which had been vigorously engaged in space research to make a quick response to the Russian superpower. In November 1958, Canada launched its first sounding rocket, and four months later, the National Aeronautics and Space Administration (NASA) approved Canada's proposal of building a satellite for the study of the ionosphere and agreed to launch it on its rocket. In September 1962, Canada's first satellite "Alouette" was launched into space in California, and made Canada the third country, only after Russia and America to design and build its own satellite.

**Science 10 program**

Two alternative units – "Wave Motion and Sound" and "Electricity and Atomic Structure" were designed to be substitutes to the present units on physics – "Home Construction" and "Power and Transportation". Similar to the alternative units in grade 9, the two new units were built up around scientific experiments. All the topics included were explored through relevant hands-on experiments or teacher demonstration.

"Home Construction" and "Transportation" which were related to the application of physical science in human society were replaced by basics in physics. Subject-matter such as wave motions, electro-magnetic field, and atomic physics, among others, were explored. The alternative units drew upon the understanding of fundamental theories rather than making connections between real life practice and scientific cognition. This was in accordance with one of Chant's recommendations that covering too wide a range of topics tended to compromise the accuracy and thoroughness of scientific study. Thus, topics were selected to promote a systematic and comprehensive course of study of basics within each discipline. Additionally, one of the objectives of schools that Chant believed we should achieve was to help pupils become familiar with that which was great and valuable in science. Reflecting on this notion, it appeared to be a natural outcome that the focus of the science learning shifted to theories and fundamentals which characterized the essential component of each subject area (Report of the Royal Commission on education, 1960).

**1964**

**Science 9 program**

A new unit in chemistry came out as another alternative to existing unit I, "Matter" (The unit, "Mechanics" that was released in 1963 was also an alternative unit to the existing unit 1). Similar to the alternative units of physics released last year, the new chemistry unit employed an experimental approach, and aimed to help students explore the basic chemical principles and laws by conducting and analyzing purposefully designed experiments.

The new unit in chemistry emphasized “learning from practice” as opposed to a list of subject matter in the statement form in the current unit. As the class was experiment oriented, students were required to attempt a scientific method of study, which indicated that answers were not provided beforehand and the students were required to undertake a journey from stating scientific problems to coming up with final conclusions, through observations and data analysis. For instance, in the learning of elements and compounds, the new unit included one experiment where students were required to heat carbon and mercuric oxide and observe which one broke down. The one that broke down would be a compound and the other one would be an element. The properties of the element and the compound would then be elicited from the students, who had taken observations of different chemical reactions of element and compound under heat. All the core ideas in the new chemistry unit were derived from experiments, which introduced a scientific and exploratory learning style to the science class.

**1967**

**Science 9 program**

The three alternative units in physics (i.e. “Mechanics”, “Heat”, “Space Science”) coming out in 1963 and the chemistry alternative unit (“Matter and its structure”) in 1964 officially replaced the units in 1959’s curriculum guides; however, those alternative units went through major revisions from their original form to become the new units. Inheriting the experimental approach employed by the previous alternative units, the new units included more specific instructions for teachers and enriched topics in addition to core material, and underwent a reorganization and development of the previous subject matter.

Core experiments to be handled by all students and experiments for enrichment for more able students were specified in the curriculum, as opposed to the previous alternative units in which all material were given the same attention. A "notes to the teacher" section was always provided at the end of each experiment to make explicit statement of expected learning outcome or to remind teachers of the drawback from the simplicity of the experiment, or to instruct teachers to perform further experiment for enrichment.

The guiding principles underlying the present revision were that "science is largely experimental and the teaching of science should be based on observation and experiment", and "a good science lesson is an enquiry, an investigation" (BCDOE, 1967).

A distinct feature of the revised curriculum was that it gave substantial specifics on facts to be drawn from the experiment, and how to lead the class to explore the material and tips on enriched material that allowed more competent teachers to go deeper on the subject. This was best illustrated by the physics component in the curriculum. For example, at the beginning of the unit "Mechanics", a list of concepts that were supposed to be taught to the class was provided along with instructions on if the concept should be treated quantitatively, such as acting and reacting forces in Newton's Third Law of Motion, or qualitatively as required in the studying of inertia. Similar to the previous alternative units, a series of experiments to be conducted by students or demonstrated by teachers were the core material all the learning and teaching centered around. However, more instructions on ways of approaching the experiment and the recommended learning outcomes, indicated a more strictly prescribed guidance of teachers. For instance, the "Mechanics" unit in 1963 included Galileo's acceleration experiment to show Newton's first law of motion. A brief introduction of the setup of the experiment as well as a few suggestions on observations were presented but with no further instructions on how to analyze the experiment, and teachers were required to let students "deduce and state Newton's first law of motion" based on the limited information provided above. As a result, teachers' own understanding of the experiment and their preferred ways of approaching the underlying physical laws would be the determinant factor of students' success in deriving Newton's first law of motion. On the other hand, the "Mechanics" unit in 1967 gave detailed guidance on factors to be considered in the experiment (e.g. the speed of the ball as it moves up and down the slope, the forces exerted on the ball at different places along the rail) which assisted teachers in leading students to attain purposive observations. Five essential points contributing to the understanding of the experiment, hence the first law of motion, were also provided to teachers to initiate discussions in the class. Furthermore, the ability of organizing collected data was considered crucial in scientific enquires, thus was emphasized by the new curriculum as an important step in analyzing the prescribed experiments.

Additionally, the chemistry unit went through a major expansion both in the scope and the level of difficulty of the content. The two-page introduction on the recognition of basic types of matter in the previous unit was replaced by a thirty-page section on "chemical reactions and their equations". The chemistry component was established as another important scope of the general science curriculum in addition to physics.

Furthermore, space science was assigned one unit in the revised curriculum guides, which was not surprising as Canada had been trying to gain a better place in the competition of exploring the outer space. The alternative unit on space science in 1964 adopted the same experimental approach as other units on physics or chemistry, and observations of astronomical objects (e.g. moon, sun, stars) were encouraged with the use of telescope and cameras. Interestingly, the revised space science unit in 1967 abandoned the experimental approach and was designed to be “descriptive in nature”. This was the only unit in grade 9 science curriculum that did not employ an experimental approach, likely due to the limited experiments that could be performed with regard to astronomy in a school environment. A broader scope of each topic was explored in the new unit through descriptions, such as the principle of the satellite orbits, which was not thoroughly examined as a result of the lack of proper experiment.

**Science 10 program**

Similar to the change in grade 9 curriculum, the two alternative units – “Electricity” and “Wave motion” coming out in 1963 replaced the previous units with major revisions in content. The structure of the curriculum was also consistent with that of grade 9 curriculum: experiment purpose, experiment instructions, notes to teacher. Again, it can be seen from the above that the grade 10 curriculum also assumed an experimental approach. Serving as the basis for further study at the Grades 11 and 12, grade 10 science was designed to treat the subject at greater depth than grade 9. Therefore, unlike grade 9 in which all the material to be taught was prescribed in the curriculum, a list of books with further information, particularly material for enrichment on selected experiments, was provided for teachers’ reference.

Additionally, the chemistry unit was completely redesigned to address fundamentals in chemistry such as chemical reactions and equations as well as properties of electrolytes, as opposed to the previous unit in 1959 (which stayed in the curriculum until the present year), in which the application of chemical compounds in the home and in industry was the core content. Not surprisingly, the unit also underwent a major expansion, from the previous 2-page unit to a 54-page unit.

The earth science unit that was replaced by space science unit in grade 9 curriculum entered the grade 10 curriculum and drew upon sub-crustal features of the earth. Being subject to the lack of proper experiments that can be conducted in a school environment, as the space science unit once encountered, the earth science unit introduced most topics such as internal constituency of the earth and earthquakes in a descriptive form with the exception of one experiment demonstrating the theory of Isostasy.

It can be seen that the curriculum was constantly refined to provide students with better learning experience. The chemistry unit reinforced the experimental approach by recommending a “discovery” approach, which represented a more marked change from traditional methods of presentation. Furthermore, the curriculum constantly reminded teachers the processes of theories being developed based on observations by eminent scientists; for example, the curriculum specifically mentioned that the discovery of ionic dissociation underwent an arduous journey from Faraday’s numerous experimental observations to Arrhenius’s final quantitative measurement of the electrical conductivity’s dependence on concentrations of solutions. This implied that teachers, it was hoped, could lead the class to go down a similar path which previous scientists once followed.

The discovery approach adopted by the curriculum in 1967 clearly exemplified the student implementation of Bruner-type education in the new curriculum. Jerome

Bruner, as one of the most prestigious education reformers since John Dewey, saw students as young scientists. Therefore, the curricula promoted by Bruner sought the coherence in the representation of subject matter in adolescent world and the mature scholar world. The "discovery learning" of the disciplines were put forward by Bruner and his fellow reformers, based on the assumption that each discipline "had an inherent structure that could be the basis of teaching their most seminal ideas and ways of thinking" (Tomkins, 1986).

Furthermore, a few experiments were redesigned to better illustrate the underlying physics. For example, in the previous unit on "Electricity", the connection between magnetism and electric current was explored through an experiment where a compass needle was used to show the direction of the electric-generated magnetic field at certain point. This experiment was improved in the new curriculum, with the introducing of iron filing on a card encased in the electric wire, which would align with the lines of generated magnetic field, to show the pattern of the entire magnetic field not only the orientation of the magnetic force at a particular point.

**1969**

**Science 9 program**

The predominant approach used by the 1969 curriculum was still an experimental approach, the same as that of the curriculum of 1967, but the traditional lecture-type of teaching was given more attention as a supplement to the experimental approach. It was not hoped that students could reproduce scientific history, therefore, much information was still needed to be passed on by teachers. The lecture text book (also referred to as the "science reader" in the curriculum) by Forester, *Reading about Science* 2, was prescribed for teachers' and students' references to relevant material for each unit. The reading of selected monographs from the book, combined with post-lab discussions, would assist students in organizing their investigations on experiments. Additionally, a labtext, *Developing Science concepts in the laboratory* by Rasmussen and Schmid, was prescribed for instructions on experiments. Therefore, unlike the curriculum guide in 1967 in which almost all the information on the experiment was included, 1969's curriculum guide did not give detailed descriptions on the experiments, particularly not on the experiment set-up, and teachers were instructed to refer to the labtext for further information on the experiments. Consequently, the curriculum guide in 1969 was down to 186 pages from the 231 pages in 1967.

The scope of the five units in the curriculum stayed the same as those of 1967. Each unit was preceded by a list of the main objectives which were to be obtained through the succeeding experiments, monographs from the reader and discussions on experiments.

While the topics investigated within each unit were similar to that of 1967, the experiments were constantly under revision and development for better learning experience. For example, in the physics unit – Force and Energy, an experiment was designed to demonstrate the acceleration being in the same direction of the net forcing. In 1967's curriculum, a long rubber band was used to drag a block of wood on the floor; however, the force exerted by the rubber band and the frictional force were not measured by any force gauge, and therefore the students couldn't have a direct visual understanding of the direction of the net force. If there was no way for them to see which force (elastic force or the frictional force) was bigger, students may not be able to relate acceleration to the direction of the net force. In 1969's curriculum, the rubber band was replaced by two weights attached to the opposite ends of the wooden block. By increasing the weight on one side to the point of accelerating the motion of the block, students were able to see that the side with more weights on is in the same direction of the acceleration.

It can also be seen that fine adjustment on the language, such as a slight change from the word "relating to" to the word "covering" in 1921's curriculum which indicated an expansion in the content, can foreshadow a far-reaching curricula change. In the 1967 curriculum, it stated that "the lecture-type lesson should not be entirely taboo"; however, in 1969 curriculum, it was revised as "the lecture-type lesson should be used when necessary". The statement in 1967 implied that the lecture-type of teaching is discouraged to the extent that it was inhibited most of the time. In fact, in 1967, it was suggested all teaching should be done in laboratories. On the other hand, the necessity of the lecture-type lesson was recognized in 1969 curriculum by more extensive use of text books such as Science Reader.

Also, the curriculum guides specifically addressed the possible concern from teachers about too much material to be covered in the time available by stating:

"There is undoubtedly too much material to be covered by any one group of student. This is a resource course from which teachers must select and organize their own course."

It can be seen from the above that teachers have certain degree of freedom in adapting the material to meet students' needs.

A few other interesting notes on the change of 1969's curriculum were that the space science unit introduced an element of discovery by providing students with data, which can be used to test their predictions. The biology unit, to some extent, demanded more time in the curriculum: in 1967, it was suggested that different experiments could be assigned to different teams, and the results would be pooled for the use of the whole class; however, in 1969, students had to conduct all the experiments prescribed in the curriculum. For example, in 1967, each group of students could choose to test food substances for the presence of one of the following three matters: Carbohydrates, Fats and Proteins. In 1969, every group was required to test more food substances for the presence of all of the above three matters. As a result, it demanded more time being allotted to this unit and more instructional work from teachers as well as more practice for students.

Even though the sheer volume of the curriculum of 1969 was less than those of 1967, the extensive use of the supplementary labtext and monographs from the textbooks indicated that more introductory and explanatory work had to be done by teachers to inform students to come up with their scientific questions and analyze their observations critically.

## 4.2 Synthetic analysis from 1937 to 1969

### 4.2.1 Curriculum change in terms of expansion

The science curriculum after 1936 continued to expand in terms of inclusion of more subject matter, development on instructions on teaching and learning as well as requirement on higher level skills. In 1937, 10 years after grade 9 science became a mosaic of several sciences, grade 10 science was unified into general science. The unification of grade 10 science had a more cross-subject feature than that of grade 9 science in 1936. Each unit of 1936's science curriculum still represented only one area of science; however, several units of 1937's curriculum could be highly interdisciplinary. The integrated way of science learning was in essence a child-centered approach that enhanced student learning by facilitating better overall comprehension of global interdependencies, synthesis of knowledge beyond individual discipline and a better attitude toward oneself as a learner. Furthermore, climate science and meteorology first came into the secondary science curriculum through a unit comprising atmosphere's role in climatic and weather conditions in this year. In 1941, the subject-matter of the curriculum had not increased by much; however, a large number of films were recommended leading to more time being allotted to each unit. Interestingly, the reform in secondary science curriculum went through a "dry period" from year 1943 to 1948, when grade 9 and 10 science curriculum stayed the same as those of 1942. It was after this period that the frequency of curriculum revisions became less, and major revisions of curriculum normally happened once every decade since 1950s. Part of the reason may be attributable to the fact that it took longer time and more effort to conduct comprehensive actions with input from voices of different parties to initiate a curriculum responsive to a transforming society with increasing complexities. Also, the curriculum became more comprehensive and tended to accommodate concurrent social and educational demands for a longer period of time. In year 1951, the grade 9 and 10 science curriculum underwent another major reorganization and reconstruction. Climate science was passed down to grade 9 curriculum from previous grade 10 curriculum in 1941. There were topics being taken out of the curriculum and other topics coming into the curriculum. An ample selection of activities corresponding to each core content of the unit was offered in replace of visual aids (i.e. educational films) that prevailed in the previous curriculum.

The junior secondary science curricula continued to grow after 1960 in terms of the amount of materials covered and the level of sophistication where topics were treated. The remarkable expansion of the chemistry units in 1967 can be seen through a dramatic increase in the space allotted to chemistry component in the curriculum. The chemistry unit in grade 9 science program was increased by 28 pages while it was a 52-page surge for grade 10. More challenging topics demanding analytic skills or mathematical mastery, such as chemical reactions and equations, required more effort being put into teaching and learning to achieve the desired goals in the allotted time. In 1969, the biology unit demanded students to do all the prescribed experiments, as opposed to breaking the class into groups, each conducting one experiment, and pooling the results for the use of the whole class in 1967. Additionally, it was in 1969 that the designers of science curricula first asserted that, with their recognition of the consecutively growing science curricula, too much material had been prescribed in the curriculum, and teachers needed to adapt the resource in conformity with their teaching competences and students' capabilities.

Improving the design of subject-matter for better learning experience, and providing more instructional suggestions for goal-oriented teaching, all contributed to a more functional science programme, aiming to keep pace with learning needs, scientific development and new goals of society.

In 1967, the grade 9 science specified the concepts and ideas that were to be treated quantitatively or qualitatively, which gave the teacher a knowledge of desired level of mathematical skills for each subject-matter. Furthermore, experiments included more instructions on what to observe, to encourage purposeful observations, instead of leaving it open to students who may not possess the yet-to-be learnt insight into what to focus on when observing experiments. Additionally, a “notes to the teacher” section was added to provide expected learning outcomes of each experiment as well as information on supplementary and complementary materials for extension and enrichment. Several experiments in grade 10 science were redesigned, mostly with the purpose of fixing defects in the previous version or illustrating ideas and principles in a more rigorous way. In 1969, the teacher was encouraged to use textbook and labtext, as was not the case in 1967, for acquiring comprehensive information around the conducted experiments. The inter-connections among different subject-matter and the logical order in which the material should be organized, were emphasized by 1970’s science 10 programme. Grouping experiments illustrating similar concepts into subcategories and sequencing academic subject-matter based on each discipline’s inherent structure presented science learning in a coherent manner.

### 4.2.2 Discovery approach and student-centered approach

The Bruner-type education, particularly with respect to discovery approach, started to permeate the science curricula in 1960s, as a result of the fact that the United States, being shocked from the launch of the Russian satellite Sputnik, feared a falling behind in producing scientists and preparing young people for excellence in scientific subjects (Newton, 1988). The focus shifted from the experiential learning, an essential approach of progressive education intending to associate education to children’s daily activities, to understanding the knowledge and subject matter within disciplines.

Additionally, the intrinsic attraction of academic disciplines, as Bruner pointed out, de-emphasized the need to relate subject matter to children's daily experience in order to attract their interests.

The discovery approach made its debut in BC science 9 and 10 curricula in 1963, when two alternative units for physics content of grade 9 and 10 science curricula assumed a subject-centered paradigm, in which a series of experiments either demonstrated by teachers or conducted by students directed the course of study. Later in 1967, the entire curriculum guide, to a great extent, became a sequence of experiments with an emphasis on skills and processes of science.

Bruner believed that the intellectual activities at the frontier of scientific research and the public school should be held in a coherent way. With a similar stance, presenting subject-matter based on the inherent structures of academic disciplines was adhered to by the curriculum: the students were guided to undertake the same processes leading to scientific discoveries once experienced by prominent scientists. For example, in 1967, grade 10 science introduced several experiments similar to those conducted by Faraday which contributed to the discovery of Faraday's law of electrolysis.

### 4.2.3 Curriculum response to social change

In addition to the changes driven by new educational ideologies and pedagogies, reforms of junior secondary science, as opposed to other subject areas, were more subject to scientific and technological development and other social changes.

During postwar prosperity, British Columbia received such economic encouragement as railway building, mining and smelting, pipeline construction and a series of other major projects. Correspondingly, grade 9 science of 1942 introduced two units of topics on utilizing materials of the earth's crust such as using sandstone and minerals as building materials, and extracting coal and petroleum as important sources of energy and other industrial products. The fourth unit of grade 9 science of 1951 aimed to provide the students with a comprehensive knowledge related to mining industry and introduced topics of mineral deposits, ore-body, and metallurgy, among others. In fact, throughout the units in grade 9 and 10 science of 1951, man's controls and uses of his environment had been emphasized. Several issues directly relevant to people's life were included with regard to the use of salt in cooking and cleaning as well as chemical compounds in cosmetics. The fifth unit of grade 10 science summarized methods for protecting and making wise use of the earth's natural resources. Forest industries, fishing, mining, and agriculture were all identified as industries that extensively used our natural resources for improving our standards of living. In turn, the curriculum also recognized the problem of conservation posed by the progress of civilization.

The science curriculum of 1937 introduced a unit relating to weather and climate and it included the definition of weather (the condition of the atmosphere from day to day with respect to temperature, air-pressure, humidity, precipitation, clouds, and wind), the local and planetary winds and the high and low pressure systems. In particular, it stressed the fact that weather forecasting was important in navigation, aviation, and agriculture. Weather prediction had been mostly subjective and based on empirical rules until early 20th century. Since the 1920s, weather forecasting, particularly numerical weather forecasting had been developing. Lewis Richardson attempted the first numerical weather forecasting by hand in 1922 when he made a six hour forecast for the state of the atmosphere over two points in central Europe; however, his prediction was proved to be incorrect by two orders of magnitude due to problematic initial conditions in his analysis. The first successful numerical prediction was not achieved until 1950 when the ENIAC digital computer was used to solve the barotropic vorticity equation over a single layer of the atmosphere by a team of American scientists led by meteorologist Jule Charney and applied mathematician John von Neumann.

Another example was the introducing of the unit on power development and its application to transportation in the programme of 1951. This was likely to be a response to the major expansion in highway investments in BC started in the 1950s. The massive road-building during 1950s and 1960s brought productivity boosts to more vehicle intensive sectors (Gillen, 2012). Energy and transportation had assumed major roles in the society, the understanding and further development of which immediately become one of the educational objectives in the science curriculum.

The introducing of *Space Science* unit in 1963 was a sign of Canada's endeavor in the development of space science, goaded by the *post-sputnik* space technology competition between America and Russia. Also, it was timely in that Canada launched satellite *Alouette* the previous year, and became the third country to design and build its own satellite. Additionally, Canada's investment in the nuclear industry, such as developing nuclear power reactors that were later used to generate low cost electricity during 1960s, contributed to the presence of *radioactivity* unit, though serving as enrichment, in science 10 program in 1967. The unit focused on basic theories and concepts in nuclear physics such as radioactive decay, and nuclear fission and fusion, but had not introduced much about the application of nuclear power, possibly as a result of the fact that nuclear industry was still in its very primitive form.

# Chapter 5: Analysis of curriculum guides from 1970 onwards

## 5.1 Content analysis from 1970 to 1983

**1970**

**Science 10 program**

A few new features in the grade 10 curriculum guide this year were added including the introducing of *Syllabus* which consisted of a brief introduction of topics covered for each unit, *Results of Investigation* as an aid to teachers, and *Skills* prescribing skills to be learned and practiced by the students, which was likely the precursor of the *Prescribed Learning Outcome* in the contemporary curriculum. It should be noted that under the *Skills* section, only practical experimental skills were required such as using a microscope, connecting a series circuit, and drawing histograms, to name a few; understanding of theories and concepts were not prescribed in this section.

There was one more unit in this year's science 10 curriculum compared to those of 1967's curriculum due to the fact that the previous unit II – Electricity, Magnetism and Radioactivity was broken into two units, i.e. Electricity and Magnetism as unit II and Radioactivity as unit VI in the present curriculum. However, unit VI was now designed as enrichment rather than mandatory core materials.

Even though the present curriculum still employed the experimental approach, it emphasized understanding core ideas in each subject field rather than being a sequence of experiments presenting somewhat discrete and unsystematic topics, as commonly seen in previous curricula. The *Syllabus* for each unit effectively grouped experiments of similar topics together. For example, the previous unit II listed18 experiments, each of which was designed to illustrate certain aspect of electricity or magnetism (Table 1); however, it can be seen that the list was not organized in a logic order. Experiment II-1, II-2, and II-14 to II-17 were all demonstrations or hands-on experiments for the illustration of electricity but they were kept apart by topics on magnets and electromagnetism from II-3 to II-13. This long list of experiments without classification also tended to obscure the interconnection among the multiple topics exhibited through the experiments. Experiment 11, and experiments 15 were designed to show the *Edison effect*, based on which the incandescent light bulb was developed. II-17 was employed to show the mechanism of a fluorescent lamp, which later replaced incandescent light due to its efficiency in saving electricity. Combining them into one category would help students develop a systematic understanding of the development from the incandescent light bulb to the fluorescent lamp.

On the other hand, 1969's curriculum reorganized the experiments in a more logic order and grouped the experiments according to their themes (Table 2): electricity (including statics and current electricity) -> magnetism -> the interaction between electricity and magnetism (electromagnetism and generation of current).

It can also be seen that four experiments, II-7, II-15, II-16, and I-17 (underlined in Table 1) from 1967's curriculum were taken out and two new experiments, II-6 and II-7 (underlined in Table 2) entered the curriculum in 1970 (the other experiments in both years illustrate similar concepts). In particular, the topic on *Series and parallel circuits* in 1970's curriculum was a further investigation of the experiment on *Voltage and the* *intensity of current* which remained the same as that of 1967, and included a considerable amount of mathematical calculations in it.

Furthermore, the earth science unit touched on climate science by a review of lithosphere, hydrosphere, and atmosphere; however the emphasis of the investigations was on the geological aspect rather than the climatic aspect. A final notion on this year's curriculum was that it mentioned evaluation but never gave detailed instructions on how to carry out the assessment and what to be assessed.

**Table 1 List of experiments in BC grade 10 science curriculum of 1967. Experiments underlined were taken out later in 1970's curriculum.**

| Experiment No. | Main topic of the experiment |
|---|---|
| II-1 | Static electricity |
| II-2 | Current electricity |
| II-3 | Property of magnet |
| II-4 | Effect of electricity interacting with magnetism |
| II-5 | Magnetic field associated with a solenoid |
| II-6 | Characteristics of current-carrying solenoid electromagnet |
| II-7 | <u>Interaction between two electromagnetic fields</u> |
| II-8 & II-9 | Interaction between a current-carrying wire and a permanent magnet |
| II-10 | Operation of an electric motor |
| II-11 | Make galvanometer and electric motor |

| | |
|---|---|
| II-12 | Generating electric current by moving the magnetic field |
| II-13 | Demonstration of en electric generator |
| II-14 | Voltage and the intensity of current |
| II-15 | Electric charges flowing in a vacuum |
| II-16 | Vacuum tube diode |
| II-17 | Hydrogen gas discharge tube |
| II-18 | Radioactivity |

**Table 2 List of experiments in BC grade 10 science curriculum of 1970. Experiments underlined were content added in the curriculum compared to the curriculum in 1967.**

| Category of experiments | Experiment No. | Main topic of the experiment |
|---|---|---|
| Electrostatics | II-1, II-2 | Static electrical charges |
| Current electricity | II-3 | Steady flow of electrons |
| | II-4 | Measuring current in electrical circuits |
| | II-5 | Relationship between current and voltage |
| | II-6 | Series and parallel circuits |
| | II-7 | Household circuits |

| | | |
|---|---|---|
| Magnets | II-8 & II-9 & II-10 | Properties of magnet |
| Electromagnetism | II-11 & II-12 | Magnetic effects of electric current, and current-carrying solenoid |
| | II-13 | Galvanometer, interaction between a current-carrying coil and a permanent magnet |
| | II-14 | Generating electric current by moving the magnetic field. |

**1972**

**Science 10 program**

Two alternative units – *Mixtures in Chemistry and Environmental Science* - came out in 1972 as a supplement to the 1970 science 10 programme. In particular, these two units served as alternatives for students for whom science 10 may be a terminal science course, and might possibly be used to replace two of the previous units on chemistry and physics.

The chemistry unit reduced the mathematics and deduction part to a minimal level, and contained mostly observation and organization. The environmental science unit was a pre-biology course unit and gave the teacher more say in deciding the level of sophistication it should be treated with.

**1980**

**Science 9 program**

Except for the two alternative units of grade 10 science in 1972, no new junior secondary science curricula came out until 1980 when an update of the Science 9 curriculum guide in 1969 was released attempting to provide teachers with more assistance.

The grade 9 curriculum in 1980 also served as a transitional curriculum guide when the new curriculum of 1983 was in progress. The purpose of the guide was to help students gain a systematic understanding of the physical world and acquire scientific skills through investigations and observations during scientific processes. A series of learning standards, labeled as *learning outcomes,* were outlined and the meeting of which led to the realization of program goals and purposes. Four units, i.e. Physics, Space Science, Chemistry, and Biology were prescribed and can be sequenced to accommodate local needs.

**1983**

**Science 9 and 10**

The previous laboratory-centered curriculum was overhauled by 1983's student-centered program accommodating individual preferences with an emphasis on the understanding of skills, processes, and knowledge of science while at the same time developing scientific attitudes and critical thinking abilities. The scope of knowledge of grade 9 and 10 science was consistent, with topics under each scope being different or same topics being treated at different level of sophistication between the two grades. The curriculum makers considered junior secondary science to mark a transition from the concrete practices widely employed in early school years to the abstract and professional learning processes of adulthood. Consequently, the science program should be designed to support students to find information and ascertain facts through creative and critical thinking, a process also known as investigative learning, as well as process skills, with the incorporation of concrete supporting experiences.

The curriculum guide was organized into four major parts, with the *Curriculum Goals* as the core component, and the other three components, i.e. *Organizers*, *Integrated Teaching, and Resources for planning*, designed to achieve the intents of the curriculum identified by *Curriculum Goals*. The bridge linking the other parts of the curriculum to the *Curriculum Goals* was the *Learning Outcomes*, which prescribed desired learning results contributing to the achievement of the *Curriculum Goals* in the following four aspects: the attitudes to be developed, the skills to be practiced, the knowledge to be understood and the thinking ability to be achieved. The listed *Learning Outcomes* were designated as either essential or optional. The essential learning outcomes applied to all the students while the optional learning outcomes were selected by teachers based on their locale.

Furthermore, this curriculum de-emphasized the learning of science through the individual disciplines of biology, chemistry, physics, earth science and space science as had been the case in almost all previous science curricula. Instead, it adopted an integrated teaching approach on the outlined six scopes or what was defined as *organizers*: Astronomy and Space Science; Changes in Matter; Changes in the

Environment; Ecology and Resource Management; Energy and Life Functions. Suggestions on integration were given at the end of each organizer, listing possible connections that could be made to other organizers within each grade in terms of topics and learning outcomes. For example, the content of photosynthesis process prescribed under the *Life Functions* organizer of grade 10 science was suggested to be taught jointly with the section on simple reactions prescribed under *Changes in Matter* organizer; and the topic on nuclear waste disposal in the *Energy* organizer was recommended to be integrated with the pollution control section in *Ecology and Resource Management* section.

More importantly, several yearly plan models each reorganizing topics from the six organizers into one or more themes, were provided in the curriculum to assist teachers in developing individual units and lessons to cover a year's science program in an integrated fashion. The prescribed topics and learning outcomes from the six organizers were examined conjunctively to form one or more integrated themes which would bring together the learning outcomes across six organizers in a logical manner. For example, one overview model characterized the topics in grade 9 science into two themes: *The Human Body: Maintenance and Care; and Changing Ideas About the Universe.* The first theme incorporated a selection of topics and learning outcomes from the *Changes in Matter* organizer *(*e.g., *topic:* nutritional components of food, *learning outcome:* develop a curiosity about the composition of matter*), the Ecology and Resource Management organizer (*e.g., *topic:* food sources, *learning outcome:* describe the local biome*), the Energy* and *Life Functions organizer (*e.g., *topic*: conservation of energy in agriculture, *learning outcome*: demonstrate an understanding of the law of conservation of energy*)*. It can be seen that food, which sustained the human body, were investigated in various aspects under multiple perspectives, and in a sequence that integrated the learning outcomes. The second theme also incorporated a variety of topics and learning outcomes across the six organizers. The combination of both themes included almost all topics and learning outcomes prescribed under the six organizers, which were presented in a logical and integrated fashion.

A more comprehensive investigation of the old topics in the new curriculum was often marked by the *Learning Outcomes* section's attempt to assist students in mastering the skills, processes and knowledge part of the topic while at the same time developing scientific attitudes and critical thinking abilities. One example was the investigation of the earth's interior, which in 1970's curriculum was taught in a descriptive form with an emphasis on the understanding of facts and theories about earth's interior. In the curriculum in 1983, not only did pupils have to acquire the same level of knowledge about the earth's interior, they were also required to develop higher level of thinking abilities by deducing the nature of the interior of the earth with seismic data, and learn to appreciate the study of earthquake prediction in relation to possible benefits to society. Activities such as conducting a field trip to a local seismograph station to collect data, designing models to simulate P and S waves, and researching why scientists study the interior of the earth, were suggested to assist teachers in planning how they will teach towards the aforementioned learning outcomes.

## 5.2 Synthetic analysis from 1970 to 1983.

### 5.2.1 Curriculum change in terms of expansion

In 1970, the previous unit - *Electricity, magnetism and Radioactivity* – was split into two separate units – *Electricity and magnetism*, and *Radioactivity*, with both units covering more subject matter. Additionally, mathematical skills which were not necessary for most enquiries in the previous curriculum were now required in several investigations. Revisiting the student-centered approach, 1983’s programme replaced the description of subject-matter with a series of learning outcomes addressing multiple facets of science education including attitudes, skills and processes, and knowledge and thinking abilities, the meeting of which would lead to the achievement of curriculum goals. A wide variety of activities – group work, field trip, experiments, multi-media presentation, research project, to name a few- were suggested to be used in conjunction with the infusing of factual information prescribed by textbooks, to fulfill curricula requirements at different dimensions and levels. Being investigative in nature, the program went beyond the factual learning and attempts to draw upon higher thinking abilities and scientific attitudes, thus necessitating teaching and learning in greater scope and depth.

### 5.2.2 Curriculum response to social change

In 1983, when nuclear power was more extensively used in the country, the energy organizer infused various activities such as conducting class debate on the pros and cons of nuclear power plants, and viewing films on nuclear energy, as a way to raise awareness of the multi-faceted social and industrial outcomes of this new source of energy. Additionally, the grade 9 science of 1983 introduced a separate unit of energy, and included topics of renewable and non-renewable sources of energy. It was in accordance with the energy-intensive situation of the province. The development of BC Hydro and Power Authority, generally known as BC Hydro, was an indicator of the province's increasing demand for energy. BC Hydro built six large hydro-electric generating projects between 1960 and 1980. The possibility of geothermal power production at Meager Creek, north of Pemberton was also investigated by BC Hydro; however their testing showed that large-scale production of electricity was unfeasible due to the fact that the underground rock wasn't permeable enough. In fact, the National Energy Program was created in 1980 by the federal government in response to the energy crisis that commenced a year earlier. Its goals included increasing Canadian ownership of the oil industry, achieving oil self-sufficiency and gaining a greater share of energy revenues (Helliwell, MacGregor, & Plourde, 1983).

The early 1980s was another period of elevated tension because it was the start of back to basics movement. It was intriguing that 1983's curriculum still identified itself as child-centered oriented, and promoted integrated teaching approach which was an instructional means normally found in a child-centered learning setting.

## 5.3 Science curriculum after 1990s

The grade 9 and 10 science curricula after 1996 were organized in the way to offer a systematically progressive secondary science program; namely they shared a common program rationale, followed the same pedagogies and philosophy of science teaching, and categorized topics into the same scopes (e.g. Life science, Physical science, Earth and space science). As it is the philosophical and pedagogical aspect that we are focusing on rather than a comparative analysis of a massive amount of specific topics, it suits our purpose better to deal with grade 9 and 10 science curriculum together from here onwards to avoid repetitions and redundancy.

**1996**

**Science 9 and 10 program**

The 1996 curriculum emphasized the application of science, which was characterized as a framework within which all science should be taught. It argued that the learning of applications of science would lead to an understanding of the development of science and social context in which science occurred. Furthermore, in the hope of preparing students for further education and adult lives, the curriculum aimed to present how knowledge, skills, processes and thinking of science were used in everyday life and workplace. To achieve this goal, the curriculum assumed an activity-based program in which a variety of hands-on activities and field trips were included.

The curricula for science 9 and 10 were both structured in terms of three curriculum organizers - Life Science, Physical Science and Earth and Space Science -, repackaging and reconstructing the former six organizers in 1983. The curriculum for each grade began with a one - page description of the Applications of Science framework. It was followed by four columns of information for each of the organizers respectively describing prescribed learning outcome statements, suggested instructional strategies for achieving the outcomes, suggested assessment strategies, and recommended learning resources.

The curriculum of 1996 differed from that of 1983 with regard to the predominant activity-based pedagogical approach, comprehensive assessment strategies and promoted gender and social equity.

Grade 9 and 10 science revisited and consolidated concepts from previous grades, emphasizing the knowledge, skills, processes, and thinking abilities, more importantly, the essence of each discipline. The learning of grade 9 and 10 science, it was hoped, could be the base from which the student develops their own interests and makes informative choices for the senior science courses. The primary approach adopted by the curriculum was activity-based learning stressing "doing" science. Most concepts and theories were backed up by such hands-on activities as building models of various physical and biological systems, computer simulation, data collection, conducting experiments, and role-playing, among others. In "doing" science, the curriculum makers intended to help students build an understanding of science and technological applications and increase their awareness of practices of science in daily life to explore science-related careers. Furthermore, unlike 1983's curriculum in which the integrated teaching approach was heavily implemented to make connections between different topics, 1996's curriculum did not include a strictly prescribed integration scheme, but encouraged teachers to integrate learning outcomes from the various organizers wherever they saw an opportunity.

While there were only general assessment strategies provided in evaluating student performance in 1983's curriculum, 1996's curriculum employed a variety of ways to gather information about student performance in specific activities. The detailed assessment strategies aimed to evaluate the extent to which the learning outcomes were met so as to ensure the accountability of the curriculum.

Furthermore, the gender and social biases were recognized by the curriculum and a section aiming to promote gender and social equity was included in the introduction. It claimed that culture and gender biases in science classes were identified by research and a few strategies were to be infused in the curriculum to eliminate these biases such as exploring both practices of science and human elements (e.g., social and moral implications of science), relating science to everyday life in ways that appeal to all students in school, employing electronic means which were accessible across different genders, social classes and geography, and creating opportunities designed specifically for girls to help them develop their own interests.

While teachers still had to follow the strictly prescribed learning outcomes, the curriculum of this year granted teachers more authority in deciding their teaching methods and desired ways of integrating cross-discipline subject matter.

**2006**

**Science 9 and 10 program**

The science 9 curriculum implemented in 2007 and the science 10 curriculum implemented in 2008 incorporated their 1996 counterpart and underwent tremendous development in terms of assessment strategies of student achievement for prescribed learning outcomes. The curriculum consisted of four organizers: Processes of Science, Life Sciences, Physical Sciences, and Earth and Space Science. Each organizer was delineated into three main sections: Prescribed Learning Outcomes, Student Achievement Indicators, Classroom Assessment Model. Prescribed learning outcomes defined the required attitudes, thinking, skills, and knowledge for students after the completion of the program. Student achievement indicators included a sequence of descriptions of what students should be able to do to meet the expectations in the corresponding prescribed learning outcomes. The Classroom Assessment Model outlined a series of assessment strategies providing specific suggestions on assessing students' work such as looking for evidence students depict a valid result, and evaluating the extent to which they identify potential contributing factors. Furthermore, suggested scoring rubric for students' work such as lab report and poster was set out at the end.

The organizer "Processes of Science" superseded the previous organizer "Application of Science" which put great emphasis on hands-on activities. While "doing science" was still addressed in the current organizer, "learning science" through thinking and analyzing skills such as using graphics and formulae to convey information were also stressed.

The curriculum in 2006 demanded strict attention to meeting all prescribed learning outcomes through various assessment strategies, potentially increasing the workload of teachers and indicating an expansion in the curriculum. In 1996, the curriculum stated that the prescribed learning outcomes should be stated and expressed in observable terms but in 2006 the curriculum revised the rhetoric, and stated that the prescribed learning outcomes should be expressed in observable terms as well as measurable terms, emphasizing the measurability of learning outcomes. It was a change initiated by the height of the accountability era. Assessment processes were introduced through the incorporation of the achievement indicator section. Besides, 1996's curriculum provided the outcome statement only to help teachers plan their lessons based on their professional judgment. On the other hand, 2006's curriculum clearly stated that "[s]chools have the responsibility to ensure that all prescribed learning outcomes in this curriculum are met" (p27, science 9 2006).

If it was not clear in the previous curriculum what activities should be used to achieve one particular learning outcome, what students were able to do to show their achievement of the learning outcome and what processes and strategies would be employed to assess students' work, it is all clear now in the current curriculum. The prescribed learning outcome, student achievement indicators, and the assessment strategies were closely linked to each other to ensure that every single prescribed learning outcome would be met. For example, one prescribed learning outcome under the organizer Life Science was to explain the process of cell division. One of the corresponding suggested achievement indicators was that students were able to describe cancer as abnormal cell division. The assessment strategies suggested the teacher to have students write a "What is Cancer" booklet and assess the booklets on the extent to which students include information about how cancer relates to cell division, identify potential contributing factors to cancer, and incorporate terminology such as benign, malignant, and metastasis.

**2013/2014**

**Transforming BC's Curriculum**

The BC Education Plan was released in October, 2011. This was followed by large-scale reform. The new curriculum that is still under development is produced with the aid of a series of consultations with provincial educational advisory groups, provincial and regional conferences, and inquiries into best practices in BC on transforming education to address the needs of all learners more effectively. A recommendation emerging from the above process was that “the Province needs a more flexible curriculum that prescribes less and enables more, for both teachers and students.” (BCMOE, 2013, p2).

So far, several components of the K to 9 curriculum including curriculum organizers, big ideas and learning standards are drafted and other components such as core competencies and assessment strategies. For grade 9 science, the curriculum organizers are organized in a similar way to the previous curriculum and consisted of life, physical and earth sciences. Big ideas are key concepts and thoughts within each organizer. An interesting feature to note is that this component resembled the section Core ideas in the science 9 curriculum of 1951 where major concepts were listed in a similar way. For example, the formation of compounds was characterized as a core/big idea in both curricula. The Learning standards component prescribed the curricular competencies as well as concepts and content students were expected to master. Even though the Learning standards component was allegedly to prescribe fewer but higher order concepts over facts, it is not clear that the curriculum have been trimmed dramatically in that the amount of concepts and topics prescribed (around 18 topics in total, refer to Table 45) is almost the same as the science 9 curriculum of 2006 (around 20 topics, refer to Table 43). Furthermore, the curriculum competencies required students to develop skills in a variety of facets with regard to questioning and predicting, planning and conducting, processing and analyzing data, evaluating and communicating. Additionally, the assessment process which was the major component that crowded out the curriculum of 2006 is still under development. Therefore, it is still too early to say that the curriculum will become less crowded. However, it can be seen that the new curriculum aims to use less prescriptive language when describing topics to be covered to create more space for teachers to innovate and personalize learning. Additionally, the content was greatly updated to align with such current issues in science as microbiome which was a concept not generally recognized until the late 1990s and basics of interactions in the climate system and the carbon cycles the knowledge which are crucial to develop an understanding of the process of climate change.

With the number of prescribed learning outcomes reduced, the next step of the curriculum is to develop cross-curricular competencies in addition to subject-specific competencies. The cross-curricular competencies are defined as “sets of intellectual, personal and social and emotional proficiencies that all students need to develop in order to engage in deep learning and life-long learning” (BCMOE, 2013). Three core competencies, Communication, Thinking and Personal and Social have been identified and are under further development. Students are expected to employ those competencies in all areas of learning in school and in life.

Additionally, rather than emphasizing one dominant type of learning as most previous curricula did, the new curriculum invites multi-faceted ways of learning such as inquiry-based learning which was prevalent in 1960, student-centered learning which prevailed in the curriculum of 1936, integrated and interdisciplinary studies that were greatly emphasized in 1983. Curriculum makers sent a clear signal of introducing a manageable curriculum with more flexibility in order for teachers to innovate and personalize learning and to teach in response to students’ needs and social context.

## Chapter 6: Summary and further implications

The findings from the content analysis of the historical curricula point to the fact that the BC science 9 and 10 curricula have been expanding in content and required skills, depth of subject matter and other pedagogical aspects including instructions for teaching and assessment processes. A review of the history of education in North America revealed that this constant expansion of curricula was one of the outcomes of reforms in educational ideologies and pedagogies led by various educational interest groups and influential educators. Furthermore, supplementary analysis of historical documents and media information indicated that public education was responsive to a variety of social, economic and environmental changes and therefore invited more issues and topics in the already crowded science curricula. Following is a summary of further reflections on the three major findings.

**1) There was a long term trend of curriculum expansion.**

The grade 9 and 10 science curriculum of BC expanded in the following three ways: a) The inclusion of more subject matter and learning activities. b) More detailed guidance on teaching and instructions. c) Requirement of higher level skills and exploration of subject matter at a greater depth. The long term trend of expansion of the curricula was identified by this study, and the fact that the science curriculum has been expanding with occasional stability during certain time span since 1920 suggested the possibility of a crowded grade 9 and 10 science curriculum. It was evident that the science curricula of the second half of 20$^{th}$ century prescribed much more than those of the first half of the century. For example, the curricula after the 1950s generally prescribed 15 to 20 topics while the curricula before 1936 generally covered only 5 to 10 topics. More importantly, unlike the early curricula which focused solely on knowledge acquisition, the curricula that came after gradually incorporated requirements on a variety of competencies such as skills, attitudes, critical thinking abilities, social responsibilities, and interdisciplinarity, among others, rendering the science curriculum less manageable. Furthermore, the curriculum makers themselves admitted in as early as 1969's grade 9 science curriculum that, with their recognition of the consecutively growing science curricula, too much material including but not limited to knowledge, skills, processes of science and attitudes were prescribed in the curriculum, and teachers needed to adapt materials accordingly if needed. This statement made by the curriculum makers themselves further supported my findings.

Another simple and direct way to probe the capacity of the science curricula is to look at the volume of each curriculum in terms of page numbers. The number of pages of each curriculum from 1920 to 2006 for grade 9 and 10 science was plotted (Figure 1, 2). The number of pages gives us a rough idea of the growth of curriculum in terms of sheer volume. For example, before 1936, the grade 9 science curricula generally had just one or two pages, but in 1936, with the introducing of the unit system, the curriculum expanded to 36 pages. This is the first major expansion of science curricula. Since then, the volume of the curriculum fluctuated by a small amount and almost stabilized until 1967 when the page number surged to 231. However, this configuration that turned the curricula into lab manuals where more than 60 experiments were described in details was a case of overdoing out of the obsession with Bruner's discovery approach. If the curricula have been better structured and the detailed descriptions of experiments were moved to a lab textbook as they should be, the curriculum would be around 50 to 100 pages. As we can see from the following years, a total page number of 50 to 100 is the norm for the science curricula after 1960. A reliable conclusion from this analysis on the page numbers of the curricula is that the sheer volume of curricula in the second half of 20th century is much more than those of the first half of the century, indicating an expansion in content in the past century.

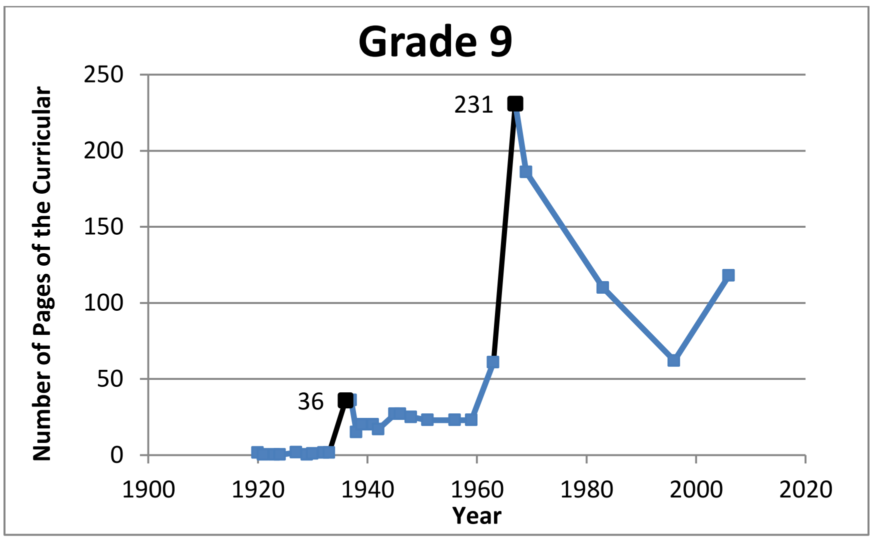


**Figure 1. Number of pages of grade 9 science curriculum guides from 1920 to 2006. The black lines indicate years of major curriculum expansion.**

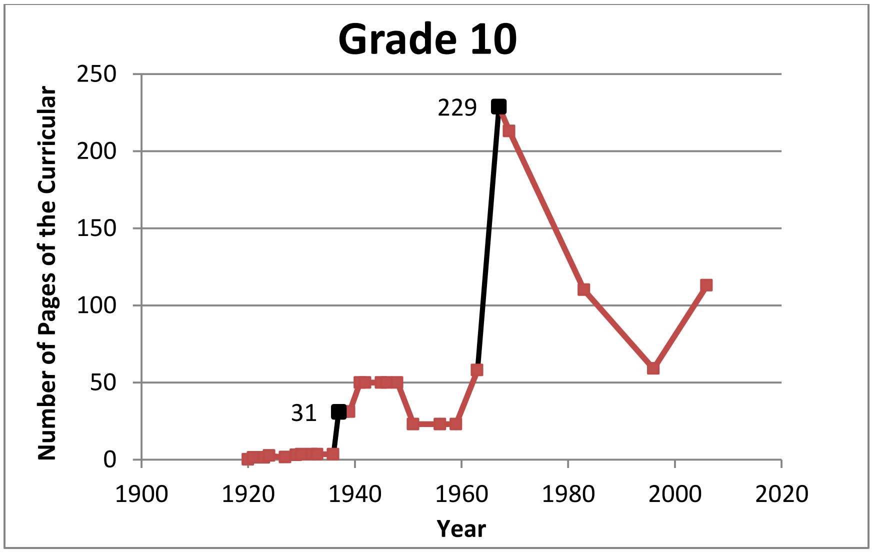


**Figure 2. Number of pages of grade 10 science curriculum guides from 1920 to 2006. The black lines indicate years of major curriculum expansion.**

**2) This expansion was driven by dominant educational ideologies and pedagogies at the time, as well as changing social contexts**

This constant expansion of curricula was one of the outcomes of reforms in educational ideologies and pedagogies led by various educational interest groups and influential educators.

Among all the educational reforms, progressive education in the 1930s and the discovery learning movement in the 1960s led to the biggest changes in the Grade 9 and 10 science curriculum in BC. One of the greatest influences was John Dewey's notion of experiential education that greatly expanded the science curricula in the late 1920s to 1930s. The idea and philosophy of progressive education was extensively infused in the curriculum, which was based on the essential argument that interest of the child was the foundation of learning and would lead to active learning. Furthermore, Dewey believed that students should learn the facts and laws of scientific subject matter through familiarity with everyday social applications. Following this principle, a great number of such subject matter falling within the scope of valuable life experience as the use of facilities that utilize electricity, heat, and light were included. Also, the curriculum makers intended to choose subject-matter and experiences that were conducive to assisting children in fitting into society and acquiring capacity for readjustment should his/her environment change. As a result, the science curriculum included such topics as "man using electrical energy to satisfy human needs", "man improving the quality of the plants and animals which he needs by learning to control some of the biological factors in his environment", "man making advances in the field of chemistry towards supplying his needs by learning the laws of chemical reaction", among others. The massive implementation of Bruner's discovery learning approach during the 1960s and 70s, which emphasized learning through problem solving in doing science, turned the science curriculum guide into a voluminous laboratory manual which included a sequence of more than 60 experiments.

Furthermore, supplementary analysis of historical documents and media information together with the content analysis of the curricula indicated that public education was responsive to a variety of social, economic and environmental changes and therefore invited more issues and topics in the already crowded science curricula. For instance, BC's increasing prosperity after World War II stimulated the expansion in vehicle ownership and started the modern age of the highway. Then a unit on the power development and its application to automobiles and other modern transportation was incorporated into the science 10 curriculum in 1951. Also, the boost in science and technology provoked constant updates and amendment of scientific studies at the secondary level. The goal of the science education in 1960s, fueled by the Space Race between the North America and the Soviet Union, was to gain supremacy in spaceflight capability which was seen necessary for national security. The unit of space science subsequently made its debut in the curriculum of 1963, and has been holding an important place in the science curriculum ever since. As the causes and impacts of climate change and global warming are more understood, many governments around the world including Canada are beginning to take steps to address it. Developing policies and actions on climate change is on the government agenda, as well as educating the young generation of the science relevant to climate change. The new 2014 BC Grade 9 science curriculum incorporated content of the carbon cycle; forms of carbon; the interactions between the lithosphere, atmosphere, biosphere, and hydrosphere. The knowledge of the above paves the way for a more thorough investigation of climate change in later grades and in university.  The knowledge of carbon cycles and forms of carbon are conducive to the understanding of the source and sink of carbon dioxide which is the most important anthropogenic greenhouse gas. The understanding of interactions among various components of the Earth contributes to the learning of the concept of the climate system which replaced the deficient prevalent view of climate in the current secondary science curricula –the average state of atmosphere being the climate. Climate modelling which is the essential tool we use to investigate climate change issues is based on a quantitative description of different components within the earth system and their interactions.

**3) The new curricula of 2014 shared a number of ideas with past curricula**

The proposed (2013/2014) curriculum is designed to facilitate: inquiry based learning, personalizing instruction, critical thinking skills, cross-curricula/interdisciplinary competencies, all of which can find their antecedents in curricula of the past.

Three years, i.e. 1936, 1967, 1983 were identified as the critical temporal points at which the science curriculum underwent considerable revisions and major expansions. Additionally, curricula of those critical years and other years bore ideas that resemble those of the new BC transformative curriculum.

**Personalized learning**

The curricula of 1936 stated that instruction should be adjusted within the course of study to fit to the needs of the individual. Although the science curriculum was outlined in considerable detail, the teacher had the freedom to make his or her own choice in selecting appropriate subject-matter most relevant to students' interests and appreciations, and to the formation of attitudes and ideals. This differentiation of instruction is in accordance with the central philosophy of the new curriculum of 2013, namely that instruction should be personalized and made more relevant to learners. Additionally, the curriculum stated that materials are only meaningful to a child when they help him to solve problems that are real to him or her. This bore the same idea as one of the guidelines for the development of cross-curricula competencies of the 2013 curricula which stressed that the competencies should be clearly related to real-world problems.

**Critical thinking skills**

Critical thinking skills were stressed by the secondary science curriculum in as early as 1936 when the students were required to apply the learnt ideas in solving real problems. The curricula of 1983 also required students to develop higher levels of thinking abilities, for example, by deducing the nature of the interior of the earth with seismic data. The new curricula of 2013/2014 transcended the idea of critical thinking skills and put forward creative thinking competency. New ideas and concepts are encouraged to solve existing and emerging real world problems. In fact, the critical thinking skill has been a favourite theme in the goals of science curricula since educators realized it is the thinking not the factual information that can lead to an intellectual disciplined process.

**Cross-curricular and interdisciplinary competencies**

Integrated teaching approaches were extensively used in 1983's curricula to facilitate interdisciplinary and cross-curricular learning, which is also emphasized by the new 2013/2014 curricula.

The new curriculum aims to support teachers in organizing learning outcomes in integrated or thematic units, a teaching method that was extensively used in 1983's curricula. The science curriculum in 1983 was designed to facilitate interdisciplinary and cross-curricula learning. The six curriculum organizers, i.e. Astronomy and Space Science; Changes in Matter; Changes in the Environment; Ecology and Resource Management; Energy and Life Functions, each characterizing a specific subject area, were taught in one or two thematic units with an integrated manner. For example, they could be reorganized into two themes: The Human Body: Maintenance and Care; and Changing Ideas About the Universe. The first theme incorporates a selection of topics and learning outcomes from the Changes in Matter organizer (e.g., topic: nutritional components of food, learning outcome: develop a curiosity about the composition of matter), the Ecology and Resource Management organizer (e.g., topic: food sources, learning outcome: describe the local biome), the Energy and Life Functions organizer (e.g., conservation of energy in agriculture, learning outcome: demonstrate an understanding of the law of conservation of energy). It can be seen that food, which sustains the human body, can be investigated in various aspects under multiple perspectives, and in a sequence that integrates the learning outcomes. The second theme also incorporates a variety of topics and learning outcomes across the six organizers. The combination of both themes includes almost all topics and learning outcomes prescribed under the six organizers, which are presented in a logical and integrated fashion.

The curriculum of 1936 also stressed the training of reading and writing through special subjects such as general science. The oral or written summary of subject-matter learnt in a science class should be exacted in a high standard as would be in an English class. The emphasis on the importance of effective communication and presentation of ideas and concepts is consistent with some of the prescriptions in the Communication Competency of the 2013 curricula in which students are required to interpret and present information effectively. The section of Cross-Curricular Competency of the new curricula is still under development, but will undoubtedly benefit a lot from the ideas of 1983's curricula.

**Inquiry based learning**

Inquiry-based approaches supported by the new science curriculum of 2013/2014 intend to facilitate a comprehensive inquiry process including questioning and predicting, planning and conducting, processing and analyzing data and information, evaluating and communicating. In the history of BC science curriculum, the inquiry-based approach was infused in the curricula of 1967.

In 1967, the discovery approach advocated the scientific inquiry based learning through hands-on experiments. For example, when studying electrolytes, the students are not given a set of previously identified solutions. They are required to recognize the existence of a set of solutions, such as hydrogen chloride and hydrogen acetate, having certain properties in common, from their own observations and experimentation, and summarize those properties after they identified them. They will only be informed of the class of the solutions, i.e. acid afterwards; and then the same for a separate set of solutions which belong to base family.

**Will the new BC science curriculum become less crowded?**

The recently released first draft of science 9 curriculum pointed to a future curriculum of smaller size which may consist of just a couple of pages like it was in early $20^{th}$ century. The curriculum makers intend to reduce the amount of prescribed subject-matter while allowing more flexibility in the curriculum for teachers to personalize instruction and to facilitate a variety of competencies. The page numbers of the curriculum guides are likely to be cut down to just a few pages (Figure 3, 4). Does it mean the science curriculum will become more manageable? Considering the fact that a great number of ideas of the new curriculum are developed from those of the past curriculum which, from this study has been already shown to have a tendency of crowding, it is not safe to draw the conclusion that the new curriculum will be a less crowded one. A more appropriate question to ask here is that if the new curriculum can prepare and equip the students with the necessary skills to adjust to the fast transformations of our information society.

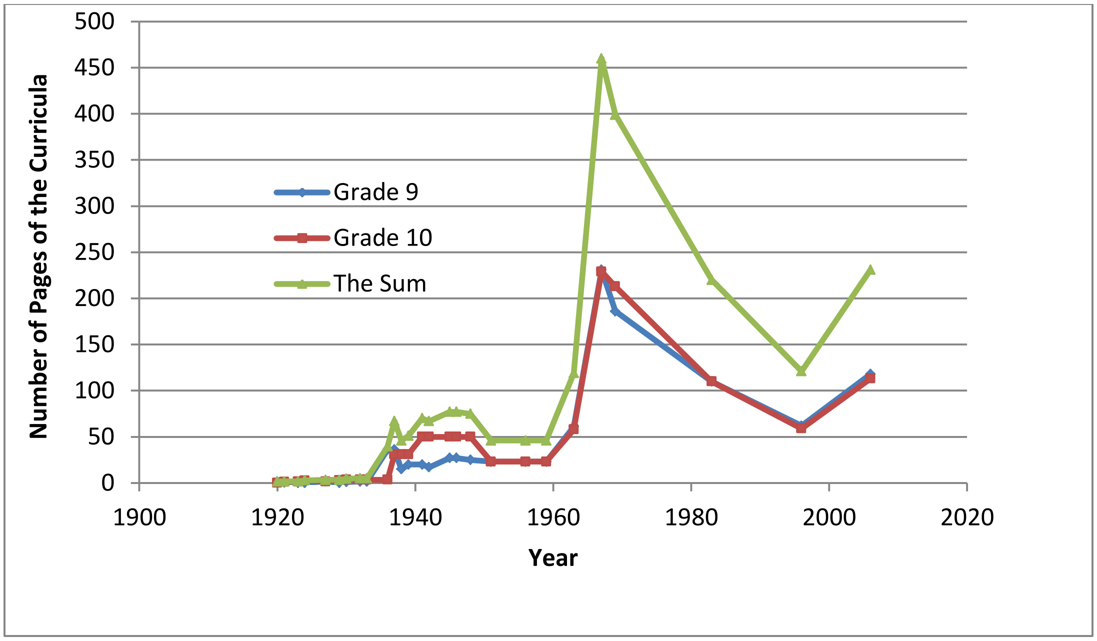


**Figure 3. Page number of grade 9 and 10 science curriculum guides and their sum over the period of time 1920 to 2006.**

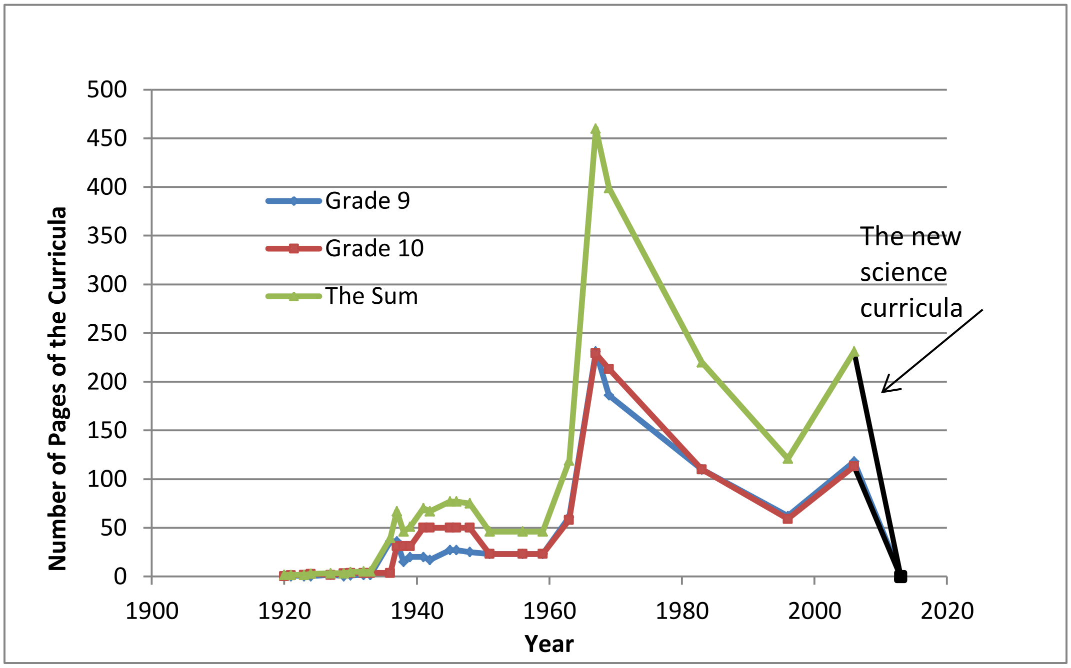


**Figure 4. Projected page number of grade 9 and 10 science curriculum guides in year 2014.**

### A revival of child-centered learning?

The pendulum of the BC science curriculum has been swinging between one focusing on addressing the child's needs and interests and one emphasizing the learning of prescribed subject-matter (Figure 5). The goal of the curriculum after 1950 became fairly responsive to all kinds of such competing demands as personal development, mastery of subject matter and social construction. Furthermore, both child-centered and student-centered pedagogy were always interwoven in the curriculum aiming to strike a balance between each other. Therefore, what is presented in Figure 5 is debatable and serves as the basis for further discussions on the practices of the two types of pedagogy in science education.

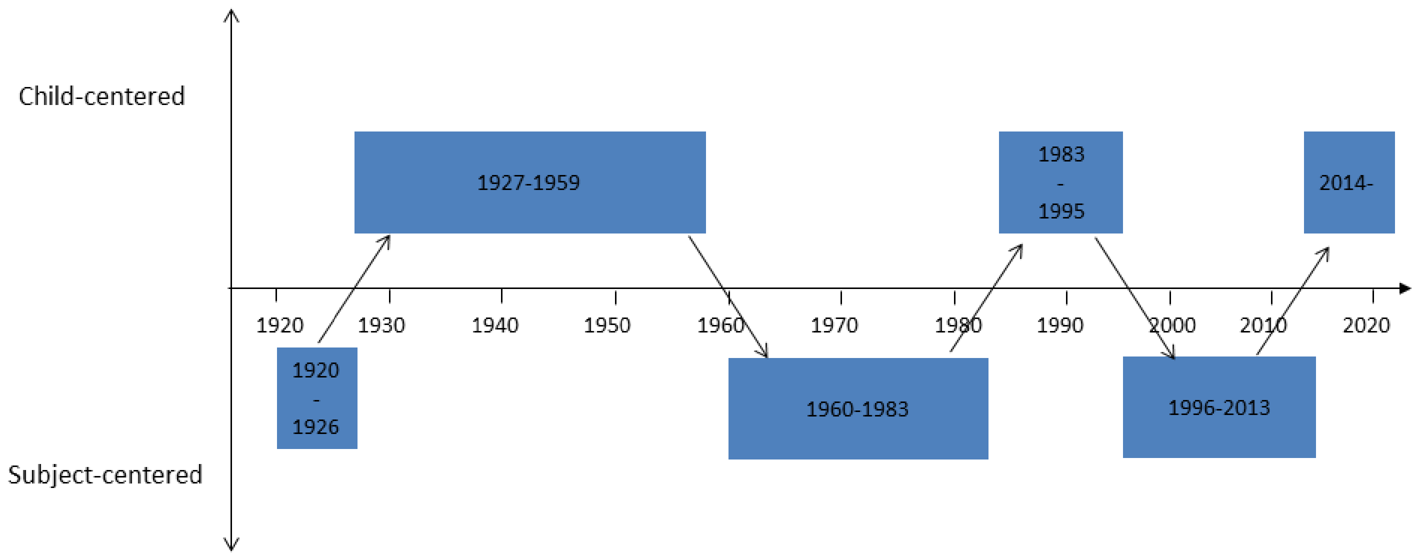


**Figure 5. Timeline of oscillations between child-centered and subject-centered curricula from 1920 to 2014. Years in the blue boxes above the temporal axis have more of a child-centered curriculum while years below the temporal axis have a dominant subject-centered curriculum.**

During the 1920s, the science curriculum guide was in its very primitive form and generally just provided a list of chapters and experiments from prescribed textbooks that needed to be taught in class. Emphasis was placed on the learning of subject-matter, mastery of knowledge and comprehension of principles. The facet of individual interests and differences was not considered in the curriculum of the early to mid-1920s.

The first critical turning point of public education in BC was during late 1920s and 1930s when the philosophy of progressive education, particularly the idea of child-centered learning, was infused in the science curricula. The goal of the programme of 1927 was to draw upon facilitating experimental direction of pupils' interests, inviting more flexibility in curriculum organization and administration, and providing career guidance through individual diagnosis. The curriculum of 1936 emphasized the importance of making provision for individual differences. Teachers were required to focus on the quality of work rather than the quantity of it, and to make informative selections of subject-matter that contribute to the child's interest and appreciations, to their formation of attitudes and ideals.

The second critical reform of science education in BC was driven by the Chant report in 1958 and the prevalence of Bruner's discovery learning pedagogy in the science curricula during 1960s. Among the broad mandate the former imposed, intellectual development within academic disciplines, such as acquiring useful facts and information, as well as instrumental skills, was the primary aim. This period of subject-centered education was a response to the fast-growing economies and the international competition in facilitating scientific literacy in public and fostering talented young scientists. Nevertheless, when selecting materials, the curricula of 1960s also endeavoured to incorporate some experiments relevant to the child's immediate experience in real life.

The laboratory-centered science education lasted for more than a decade before the child-centered approach, which the discovery approach had once replaced, took over again in 1983. The new programme of 1983 was designed to help students understand the physical world, and how humans fit in it. Hands-on activities, group work, field survey, research project, to name a few, were extensively employed by the new program aiming to assist students in directing their own studies on fundamental ideas and concepts of science as well as the application of science which are of personal and practical nature to learners and of importance to society. The fact that the curriculum of 1983 is student-centered is especially interesting as the *back to basics movement* which demanded more rigorous and traditional curriculum prevailed in late 1970s and 1980s in North America (Pines, 1982). However, a child-centered curriculum does not necessarily mean subject-matter learning is deemphasized. In fact, the curriculum of 1983 is the first curriculum that formalized the section labelled as *Prescribed Learning Outcomes*, providing a comprehensive description of the attitudes to be developed, the skills to be practiced, the knowledge to be understood and the thinking ability to be achieved. The way they make the curriculum tailored more towards students' need is that the listed learning outcomes are designated as either essential or optional. The essential learning outcomes apply to all the students while the optional learning outcomes are selected by teachers based on what emphasis is important for their locale and is compatible with their student group and own expertise. The purpose of the curriculum also became very diverse and broad in accommodating such competing demands as personal intellectual training and social construction. The science program in 1983 was labelled child-centered more in the sense of going in the opposite direction to the previous curricula in the 1960s and early 1970s in which disciplines were separated rather than integrated and there was no flexibility for addressing students' interests and needs at all.

The curriculum in 1996 and 2006 focused on enforcing a great amount of prescribed learning outcomes and assessing students' achievement of them. There was little room left for teachers to personalize instruction and to encourage students to develop their own interests. Even though the curricula also stated that students should develop their own interests. Once again, the new curriculum of 2014 proposes to reverse this trend of subject-centered education and bring back a new era of child-centered education. Each oscillation between subject-centered and child-centered education is an attempt to adjust to the new social order. It remains to be seen if child-centered education will be a best fit for our current society.

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# Appendix A – List of Topics

**Table 3  1920 Science 9**

| Sequence / Scope | Science 9 Topics | References |
|---|---|---|
| General science | 1. The air 2. Water and its uses 3. Work and energy 4. The Earth's crust 5. Life upon Earth | Textbook: General Science Caldwell & Elkenberry |
| Physics and chemistry | 1. Matter and its property 2. Air pressure<br>3. Measurement of heat<br>4. Properties of air and water<br>5. Action of acids on metals and carbonates | Textbook: Elementary Physics and Chemistry-Gregory & Simmons, Stages I., II,, and III,. |

**Table 4  1920 science 10**

| Sequence / Scope | Science 10 Topics | References |
|---|---|---|
| Chemistry | 1. Air and its components<br>2. The gas laws<br>3. Some chemical laws and technical terms<br>4. Equations, valency, and nomenclature<br>5. The atomic and molecular theories | Textbook: a text-book for high schools –Cornish |
| Physics | 1. Measurement<br>2. Pressure and buoyancy of Fluids<br>3. Determination of Density<br>4. Wave motion<br>5. Nature and Source of Heat | Textbook: Merchant & Chant's High School Physics |
| Botany | 1. Seeds and germination 2. Leaves<br>3. Transpiration and photosynthesis<br>4. Root forms and growth<br>5. Plants and habitat<br>6. Idea of family, genus, and species | Refer to the curriculum |
| Agriculture | 1. Soil study<br>2. Plant and seed studies<br>3. Vegetable gardening<br>4. Fruit-growing<br>5. Poultry<br>6. Insect study<br>7. Bee-keeping | Refer to the curriculum |

**Table 5  1921 science 9**

| Sequence / Scope | Science 9 — Topics | References |
|---|---|---|
| General science | 1. The air<br>2. Water and its uses<br>3. Work and energy<br>4. The earth's crust<br>5. Life upon the earth | Textbook: GENERAL SCIENCE Caldwell & Elkenberry |
| Physics and chemistry | 1. Matter and its property<br>2. Air pressure<br>3. Measurement of heat<br>4. Properties of air and water<br>5. Action of acids on metals and carbonates | Textbook: ELEMENTARY PYSICS AND CHEMISTRY-Gregory & Simmons, Stages I., II,, and III,. |

**Table 6 1921 science 10**

| Sequence / Scope | Science 10 — Topics | References |
|---|---|---|
| Chemistry | 1. Air and its components<br>2. The gas laws and some chemical laws<br>3. Equations, valency, and nomenclature<br>4. The atomic and molecular theories<br>5. Common salt and its products<br>6. Carbon | Textbook: a text-book for high schools – Cornish |
| Physics | 1. Measurement<br>2. Pressure and buoyancy of Fluids<br>3. Determination of Density<br>4. Wave motion<br>5. Nature and Source of Heat | Textbook: Merchant & Chant's High School Physics |
| Botany | 1. Study of a mature seed-plant: Habitat, root, stem, leaf, flower, frutis.<br>2. Similar study of at least five plants belonging to each of the following families: Liliaceae, Ranuneulaceae, Crucifera, Coniferae, Gramineae, Saxifragaceae, Violaceae, Ericaceae, etc.<br>3. Comparison of the plants studied and grouping according to structure and according to habitat<br>4. Topical summary of data collected<br>5. Growth of the seed and of the root and stem<br>6. Simple experiments to illustrate osmosis, photosynthesis, and transpiration. | Refer to the curriculum |
| Agriculture | 1. Soil study<br>2. Plant and seed studies<br>3. Vegetable gardening<br>4. Fruit-growing<br>5. Poultry<br>6. Insect study<br>7. Bee-keeping | Refer to the curriculum |

**Table 7 1923 science 9**

| Sequence / Scope | Science 9 — Topics | References |
| --- | --- | --- |
| General science | 1. The air<br>2. Water and its uses<br>3. Work and energy<br>4. The earth's crust<br>5. Life upon the earth | Textbook: GENERAL SCIENCE Caldwell & Elkenberry |

**Table 8 1923 science 10**

| Sequence / Scope | Science 10 — Topics | References |
| --- | --- | --- |
| Chemistry | 1. Air and its components<br>2. The gas laws and some chemical laws<br>3. Equations, valency, and nomenclature<br>4. The atomic and molecular theories<br>5. Common salt and its products<br>6. Carbon | Textbook: a text-book for high schools – Cornish |
| Physics | 1. Measurement<br>2. Pressure and buoyancy of Fluids<br>3. Determination of Density<br>4. Wave motion<br>5. Nature and Source of Heat | Textbook: Merchant & Chant's High School Physics |
| Botany | 1. Growth<br>2. Nutrition<br>3. Reproduction<br>4. Classification of Plants<br>5. Plant associations<br>6. Economic Plants of British Columbia | Refer to the curriculum |
| Agriculture | 1. Soil study<br>2. Plant and seed studies<br>3. Vegetable gardening<br>4. Poultry<br>5. Live Stock<br>6. Insect study<br>7. Bee-keeping<br>8. Fruit-growing | Refer to the curriculum |

**Table 9 1924 science 9**

| Sequence / Scope | Science 9 — Topics | References |
|---|---|---|
| General science | 1. The air<br>2. Water and its uses<br>3. Work and energy<br>4. The earth's crust<br>5. Life upon the earth | Textbook: General Science Caldwell & Elkenberry |

**Table 10 1924 science 10**

| Sequence / Scope | Science 10 — Topics | References |
|---|---|---|
| Chemistry | 1. Air and its components<br>2. The gas laws and some chemical laws<br>3. Equations, valency, and nomenclature<br>4. The atomic and molecular theories<br>5. Common salt and its products<br>6. Carbon | Textbook: a text-book for high schools – Cornish |
| Physics | 1. Measurement<br>2. Mechanics of Solids<br>3. Mechanics of Fluids<br>4. Heat<br>5. Light<br>6. Electricity and Magnetism | Textbook: Merchant & Chant's High School Physics |
| Botany | 1. Growth<br>2. Nutrition<br>3. Reproduction<br>4. Classification of Plants<br>5. Plant associations<br>6. Economic Plants of British Columbia | Refer to the curriculum |
| Agriculture | 1. Soil study<br>2. Plant and seed studies<br>3. Vegetable gardening<br>4. Poultry<br>5. Live Stock<br>6. Insect study<br>7. Bee-keeping<br>8. Fruit-growing | Refer to the curriculum |

**Table 11 1927 science 9**

| Sequence / Scope | Science 9 — Topics | References |
| --- | --- | --- |
| General science | 1. The Earth in Relation to other Heavenly Bodies<br>2. Heat and the Earth's Crust<br>3. Work and Energy<br>4. Interior Combustion Engines<br>5. Electricity<br>6. Life upon the Earth<br>7. Essential Functions of Living Things<br>8. Reproduction in Plants and Animals<br>9. Improvement of Species<br>10. Control of the Body | Refer to the curriculum |

**Table 12  1927 science 10**

| Sequence / Scope | Science 10<br>Topics | References |
|---|---|---|
| Chemistry | 1. Elements and compounds<br>2. Gases and their properties and measurement<br>3. Water and its composition<br>4. Carbon dioxide<br>5. The theory of atoms and molecules<br>6. Symbols, formulas, and equations<br>7. Chemical calculations | Textbook: Practical Chemistry - Black & Connat's |
| Physics | 1. Measurement<br>2. Mechanics of Solids<br>3. Mechanics of Fluids<br>4. Heat<br>5. Light<br>6. Electricity and Magnetism | Textbook: Merchant & Chant's High School Physics |
| Botany | 1. Growth<br>2. Nutrition<br>3. Reproduction<br>4. Classification of Plants<br>5. Plant associations<br>6. Economic Plants of British Columbia | Refer to the curriculum |
| Agriculture | 1. Soil study<br>2. Plant and seed studies<br>3. Vegetable gardening<br>4. Poultry<br>5. Live Stock<br>6. Insect study<br>7. Bee-keeping<br>8. Fruit-growing | Refer to the curriculum |

**Table 13  1928 science 9**

| Sequence / Scope | Science 9 — Topics | References |
|---|---|---|
| General science | 1. The Earth in Relation to other Heavenly Bodies<br>2. Heat and the Earth's Crust<br>3. Work and Energy<br>4. Interior Combustion Engines<br>5. Electricity<br>6. Life upon the Earth<br>7. Essential Functions of Living Things<br>8. Reproduction in Plants and Animals<br>9. Improvement of Species<br>10. Control of the Body | Refer to the curriculum |

**Table 14 1928 science 10**

| Sequence / Scope | Science 10 Topics | References |
|---|---|---|
| Chemistry | 1. Elements and compounds<br>2. Gases and their properties and measurement<br>3. Water and its composition<br>4. Carbon dioxide<br>5. The theory of atoms and molecules<br>6. Symbols, formulas, and equations<br>7. Chemical calculations | Textbook: Practical Chemistry - Black & Connat's |
| Physics | 1. Measurement<br>2. Mechanics of Solids<br>3. Mechanics of Fluids<br>4. Heat<br>5. Light<br>6. Electricity and Magnetism | Textbook: Merchant & Chant's High School Physics |
| Botany | 1. Growth<br>2. Nutrition<br>3. Reproduction<br>4. Classification of Plants<br>5. Plant associations<br>6. Economic Plants of British Columbia | Refer to the curriculum |
| Agriculture | 1. Soil study<br>2. Plant and seed studies<br>3. Vegetable gardening<br>4. Poultry<br>5. Live Stock<br>6. Insect study<br>7. Bee-keeping<br>8. Fruit-growing | Refer to the curriculum |

**Table 15 1929 science 9**

| Sequence / Scope | Science 9 | References |
|---|---|---|
| | Topics | |
| General science | 1. The Earth in Relation to other Heavenly Bodies<br>2. Heat and the Earth's Crust<br>3. Work and Energy<br>4. Interior Combustion Engines<br>5. Electricity<br>6. Life upon the Earth<br>7. Essential Functions of Living Things<br>8. Reproduction in Plants and Animals<br>9. Improvement of Species<br>10. Control of the Body | Refer to the curriculum |

**Table 16  1929 science 10**

| Sequence / Scope | Science 10<br>Topics | References |
|---|---|---|
| Chemistry | 1. Elements and compounds<br>2. Gases and their properties and measurement<br>3. Water and its composition<br>4. Carbon dioxide<br>5. The theory of atoms and molecules<br>6. Symbols, formulas, and equations<br>7. Chemical calculations<br>8. Solutions | Textbook: Practical Chemistry - Black & Connat's |
| Physics | 1. Measurement<br>2. Mechanics of Solids<br>3. Mechanics of Fluids<br>4. Heat<br>5. Light<br>6. Electricity and Magnetism | Textbook: Merchant & Chant's High School Physics |
| Botany | 1. Growth<br>2. Nutrition<br>3. Reproduction<br>4. Classification of Plants<br>5. Plant associations<br>6. Economic Plants of British Columbia | Refer to the curriculum |
| Agriculture | 1. Soil study<br>2. Plant and seed studies<br>3. Vegetable gardening<br>4. Poultry<br>5. Live Stock<br>6. Insect study<br>7. Bee-keeping<br>8. Fruit-growing | Refer to the curriculum |

**Table 17 1930 science 9**

| Sequence / Scope | Science 9 — Topics | References |
|---|---|---|
| General science | 1. The Earth in Relation to other Heavenly Bodies<br>2. Heat and the Earth's Crust<br>3. Work and Energy<br>4. Interior Combustion Engines<br>5. Electricity<br>6. Life upon the Earth<br>7. Essential Functions of Living Things<br>8. Reproduction in Plants and Animals<br>9. Improvement of Species<br>10. Control of the Body | Refer to the curriculum |

**Table 18 1930 science 10**

| Sequence / Scope | Science 10 — Topics | References |
|---|---|---|
| Chemistry | 1. Elements and compounds<br>2. Gases and their properties and measurement<br>3. Water and its composition<br>4. Carbon dioxide<br>5. The theory of atoms and molecules<br>6. Symbols, formulas, and equations<br>7. Chemical calculations<br>8. Solutions | Textbook: Practical Chemistry - Black & Connat's |
| Physics | 1. Measurement<br>2. Mechanics of Solids<br>3. Mechanics of Fluids<br>4. Heat<br>5. Light<br>6. Electricity and Magnetism | Textbook: Merchant & Chant's High School Physics |
| Biology | 1. The study of individual forms<br>2. Systematic topical review of recorded observations<br>3. Experimental study of growth<br>4. Animals and plants that are of economic importance to man | Refer to the curriculum |
| Agriculture | 1. Soil study<br>2. Plant and seed studies<br>3. Vegetable gardening<br>4. Poultry<br>5. Live Stock<br>6. Insect study<br>7. Bee-keeping<br>8. Fruit-growing | Refer to the curriculum |

**Table 19  1932 science 9**

| Sequence / Scope | Science 9 — Topics | | References |
|---|---|---|---|
| General science | Problem 1 | In what ways does man make use of the properties of the air?<br>- Air pressure<br>- Wave motions of the air | Refer to the curriculum |
| | Problem 2 | How does water work for man?<br>- Phase change of water<br>- Water as a solvent and hydraulic presses | |
| | Problem 3 | What is the source of energy?<br>- Light and heat<br>- External and internal combustion engines | |
| | Problem 4 | How does man use electrical energy?<br>- Electricity and Magnetism<br>- Application of electricity in everyday life | |
| | Problem 5 | How do we work?<br>- Metabolism of living matter<br>- Use of simple machines | |
| | Problem 6 | What living processes are common to all forms of life?<br>- Cell differentiation<br>- Reproduction in plants and animals, and inheritance | |

**Table 20  1932 science 10**

| Sequence / Scope | Science 10 — Topics | References |
|---|---|---|
| Chemistry | 1. Elements and compounds<br>2. Gases and their properties and measurement<br>3. Water and its composition<br>4. Carbon dioxide<br>5. The theory of atoms and molecules<br>6. Symbols, formulas, and equations<br>7. Chemical calculations<br>8. Solutions | Textbook: Practical Chemistry - Black & Connat's |
| Physics | 1. Measurement<br>2. Mechanics of Solids<br>3. Mechanics of Fluids<br>4. Heat<br>5. Light<br>6. Electricity and Magnetism | Textbook: Merchant & Chant's High School Physics |
| Biology | 1. The study of individual forms<br>2. Systematic topical review of recorded observations<br>3. Experimental study of growth<br>4. Animals and plants that are of economic importance to man | Refer to the curriculum |
| Agriculture | 1. Soil study<br>2. Plant and seed studies<br>3. Vegetable gardening<br>4. Poultry<br>5. Live Stock<br>6. Insect study<br>7. Bee-keeping<br>8. Fruit-growing | Refer to the curriculum |

**Table 21  1933 science 9**

| Sequence / Scope | Science 9 | | References |
|---|---|---|---|
| | Topics | | |
| General science | Problem 1 | In what ways does man make use of the properties of the air?<br>- Air pressure<br>- Wave motions of the air | Refer to the curriculum |
| | Problem 2 | How does water work for man?<br>- Phase change of water<br>- Water as a solvent and hydraulic presses | |
| | Problem 3 | What is the source of energy?<br>- Light and heat<br>- External and internal combustion engines | |
| | Problem 4 | How does man use electrical energy?<br>- Electricity and Magnetism<br>- Application of electricity in everyday life | |
| | Problem 5 | How do we work?<br>- Metabolism of living matter<br>- Use of simple machines | |
| | Problem 6 | What living processes are common to all forms of life?<br>- Cell differentiation<br>- Reproduction in plants and animals, and inheritance | |

**Table 22  1933 science 10**

| Sequence / Scope | Science 10 — Topics | References |
|---|---|---|
| Chemistry | 1. Elements and compounds<br>2. Gases and their properties and measurement<br>3. Water and its composition<br>4. Carbon dioxide<br>5. The theory of atoms and molecules<br>6. Symbols, formulas, and equations<br>7. Chemical calculations<br>8. Solutions | Textbook: Practical Chemistry - Black & Connat’s |
| Physics | 1. Measurement<br>2. Mechanics<br>3. Fluids<br>4. Heat<br>5. Magnetism and Electricity<br>6. Light | Textbook: Merchant & Chant’s High School Physics |
| Biology | 1. The study of individual forms<br>2. Systematic topical review of recorded observations<br>3. Experimental study of growth<br>4. Animals and plants that are of economic importance to man | Refer to the curriculum |
| Agriculture | 1. Soil study<br>2. Plant and seed studies<br>3. Vegetable gardening<br>4. Poultry<br>5. Live Stock<br>6. Insect study<br>7. Bee-keeping<br>8. Fruit-growing | Refer to the curriculum |

**Table 23  1936 science 9**

| Sequence / Scope | Science 9 — Topics | | References |
|---|---|---|---|
| General science | Unit I | Man organizing his discoveries: Scientific Method | Refer to the curriculum |
| | Unit II | Man's need of measurement: measurement of length, area, volumes, gravity, density, temperature, heat and time. | |
| | Unit III | Man's control of the biological factors | |
| | | Reproduction of plants and animals | |
| | Unit IV | The balance of nature | |
| | | Plant progressions | |
| | Unit V | Elements and compounds | |
| | | Laws of chemical reaction | |
| | Unit VI | Matter and forces | |
| | | Motion | |
| | | Work and energy | |
| | Unit VII | Electrical energy | |
| | | Sound | |
| | Unit VIII | Earth's crust | |
| | Unit IX | Minerals and Mining | |
| | Unit X | Science applied through inventions | |

**Table 24 1936 science 10**

| Sequence / Scope | Science 10 — Topics | References |
|---|---|---|
| Chemistry | 1. Elements and compounds<br>2. Gases and their properties and measurement<br>3. Water and its composition<br>4. Carbon dioxide<br>5. The theory of atoms and molecules<br>6. Symbols, formulas, and equations<br>7. Chemical calculations<br>8. Solutions | Textbook: Practical Chemistry - Black & Connat's |
| Physics | 1. Measurement<br>2. Mechanics of Solids<br>3. Mechanics of Fluids<br>4. Heat<br>5. Light<br>6. Electricity and Magnetism | Textbook: Merchant & Chant's High School Physics |
| Biology | 1. The study of individual forms<br>2. Systematic topical review of recorded observations<br>3. Experimental study of growth<br>4. Animals and plants that are of economic importance to man | Refer to the curriculum |
| Agriculture | 1. Soil study<br>2. Plant and seed studies<br>3. Vegetable gardening<br>4. Poultry<br>5. Live Stock<br>6. Insect study<br>7. Bee-keeping<br>8. Fruit-growing | Refer to the curriculum |

**Table 25  1937 science 9**

| Sequence / Scope | Science 9 | | References |
|---|---|---|---|
| | Topics | | |
| General science | Unit I | Man organizing his discoveries: Scientific Method | Refer to the curriculum |
| | Unit II | Man’s need of measurement: measurement of length, area, volumes, gravity, density, temperature, heat and time. | |
| | Unit III | Man’s control of the biological factors | |
| | | Reproduction of plants and animals | |
| | Unit IV | The balance of nature | |
| | | Plant progressions | |
| | Unit V | Elements and compounds | |
| | | Laws of chemical reaction | |
| | Unit VI | Matter and forces | |
| | | Motion | |
| | | Work and energy | |
| | Unit VII | Electrical energy | |
| | | Sound | |
| | Unit VIII | Earth’s crust | |
| | Unit IX | Minerals and Mining | |
| | Unit X | Science applied through inventions | |

**Table 26  1937 science 10**

| Sequence / Scope | Science 10 — Topics | | References |
|---|---|---|---|
| General science | Unit I | Composition of matter | Refer to the curriculum |
| | | Chemical and physical changes of matter | |
| | Unit II | Forms of energy | |
| | | Simple machines | |
| | | The use of electrical and magnetic energy | |
| | Unit III | The atmosphere, the weather and the climate | |
| | Unit IV | Physical property of water | |
| | | Chemical property of water | |
| | | Water as habitat | |
| | Unit V | Origin of the earth | |
| | | The surface of the earth | |
| | | Metallic substances of great use to man | |
| | Unit VI | The control that man exercises over plant-life | |
| | | Man obtaining best returns from animals | |
| | | Work and energy | |

**Table 27 1938 science 9**

| Sequence / Scope | Science 9 | | References |
|---|---|---|---|
| | Topics | | |
| General science | Unit I | Reproduction of plants and animals | Refer to the curriculum |
| | | Improvement of plants and animals by man | |
| | Unit II | Raw materials of the Earth's crust | |
| | | Control of chemical change | |
| | Unit III | Work and energy | |
| | | Simple machines | |
| | Unit IV | Electrical energy | |
| | | Control and measurement of electric current | |
| | | Transformation of electrical energy to light and heat | |
| | Unit V | Sound as one means of communication and expression | |
| | Unit VI | Sources and properties of light | |

**Table 28 1938 science 10**

| Sequence / Scope | Science 10 | | References |
|---|---|---|---|
| | Topics | | |
| General science | Unit I | Composition of matter | Refer to the curriculum |
| | | Chemical and physical changes of matter | |
| | Unit II | Forms of energy | |
| | | Simple machines | |
| | | The use of electrical and magnetic energy | |
| | Unit III | The atmosphere, the weather and the climate | |
| | Unit IV | Physical property of water | |
| | | Chemical property of water | |
| | | Water as habitat | |
| | Unit V | Origin of the earth | |
| | | The surface of the earth | |
| | | Metallic substances of great use to man | |
| | Unit VI | The control that man exercises over plant-life | |
| | | Man obtaining best returns from animals | |
| | | Work and energy | |

**Table 29  1941 science 9**

| Sequence / Scope | Science 9 — Topics | | References |
|---|---|---|---|
| General science | Unit I | Reproduction of plants and animals | Refer to the curriculum |
| | | Improvement of plants and animals by man | |
| | Unit II | Raw materials of the Earth's crust | |
| | | Control of chemical change | |
| | Unit III | Work and energy | |
| | | Simple machines | |
| | Unit IV | Electrical energy | |
| | | Control and measurement of electric current | |
| | | Transformation of electrical energy to light and heat | |
| | Unit V | Sound as one means of communication and expression | |
| | Unit VI | Sources and properties of light | |

**Table 30 1941 science 10**

| Sequence / Scope | Science 10 — Topics | | References |
|---|---|---|---|
| General science | Unit I | Composition of matter | Refer to the curriculum |
| | | Chemical and physical changes of matter | |
| | Unit II | Forms of energy | |
| | | Simple machines | |
| | | The use of electrical and magnetic energy | |
| | Unit III | Physical property of water | |
| | | Chemical property of water | |
| | | Water as habitat | |
| | Unit IV | Minerals of the earth's crust | |
| | | Metallic substances of great use to man | |
| | | Extraction of metals from their ores and refining processes | |
| | Unit V | The control that man exercises over plant-life | |
| | | Man obtaining best returns from animals | |
| | | Work and energy | |

**Table 31  1942 science 9**

| Sequence / Scope | Science 9 — Topics | | References |
|---|---|---|---|
| General science | Unit I | Plants and plant products that serve man in many ways | Refer to the curriculum |
| | | Knowledge of functions of different parts of plants and growth habits of plants | |
| | | Nutrients from vegetables and fruits | |
| | Unit II | Origin of the earth | |
| | | Recognition of minerals and rocks | |
| | | Soil conservation | |
| | Unit III | Composition of earth's crust | |
| | | Raw materials of industry from the earth's crust | |
| | Unit IV | Application of scientific principles to housing construction: air and light condition of the home, labour-saving devices, and water supply. | |
| | Unit V | Control of plants, animals and some species of fungi and bacteria. | |

**Table 32 1942 science 10**

| Sequence / Scope | Science 10 — Topics | | References |
|---|---|---|---|
| General science | Unit I | Composition of matter | Refer to the curriculum |
| | | Chemical and physical changes of matter | |
| | Unit II | Forms of energy | |
| | | Simple machines | |
| | | The use of electrical and magnetic energy | |
| | Unit III | Physical property of water | |
| | | Chemical property of water | |
| | | Water as habitat | |
| | Unit IV | Minerals of the earth's crust | |
| | | Metallic substances of great use to man | |
| | | Extraction of metals from their ores and refining processes | |
| | Unit V | The control that man exercises over plant-life | |
| | | Man obtaining best returns from animals | |
| | | Work and energy | |

**Table 33 1951 science 9**

| Sequence / Scope | Science 9 — Topics | References |
|---|---|---|
| Matter – Unit I | Properties of element | Refer to the curriculum |
| | Properties of Compound | |
| | Characteristic atoms of element | |
| Energy – Unit II | Forms of energy and work | Refer to the curriculum |
| | Magnetism | |
| | Static and current electricity | |
| | Sound energy | |
| Meteorology – Unit III | Weather: changes in the atmosphere | Refer to the curriculum |
| | Movement of great masses of air and front | |
| | Weather forecasting | |
| Materials from the Earth's Crust – Unit IV | Minerals, rocks and ores | Refer to the curriculum |
| | Method of Mining and processes of metallurgy | |
| | Coal and petroleum and their products | |
| Life Processes – Unit V | Green plants | Refer to the curriculum |
| | Food supply and structures and life processes to utilize the energy contained in food | |

**Table 34  1951 science 10**

| Sequence / Scope | Science 10 — Topics | References |
|---|---|---|
| Matter – Unit II | Conductors of electricity | Refer to the curriculum |
| | Acids, bases and salts | |
| | Chemical formulas and equations | |
| Energy – Unit III & Unit IV | Home construction | Refer to the curriculum |
| | Use of electricity and light | |
| | Simple machines | |
| | Power for transportation | |
| | Automobile and water and air transportation | |
| Conservation of Resources – Unit V | Increased use of natural resources | Refer to the curriculum |
| | Conservation in basic industries | |
| | Use of formerly wasted natural resources and materials | |
| Life Processes – Unit I | Reproduction of organisms | |
| | Revolution of plants and animals | |
| | Cell structure | |

**Table 35  1967 science 9**

| Sequence / Scope | Science 9 — Topics | References |
|---|---|---|
| Chemistry- Unit I | A study of atoms | Refer to the curriculum |
| | Valence and the Periodic Table | |
| | Chemical reactions and equations | |
| Physics - Unit II & Unit IV | Effects of forces | |
| | Motions | |
| | Measurement of forces and pressure | |
| | Work and energy | |
| | Introduction to temperature and heat | |
| | Temperature and changes of phase | |
| | Measurement of temperature and heat | |
| | Transfer of heat energy | |
| Biology – Unit III | Energy storage and transformation | |
| | Energy requirement and usage of organisms | |
| | Energy in food chains | |
| Space science – Unit V | The solar system | |
| | Galaxies and stars | |

**Table 36 1967 science 10**

| Sequence / Scope | Science 10<br>Topics | References |
|---|---|---|
| Biology – Unit 1 | Reproduction and heredity: cell structure , mitosis in plant and animal cells, regeneration, seeds and how they grow, heredity and environment , etc. | Refer to the curriculum |
| Physics – Unit II & IV | Properties of electric current and electric charge | Refer to the curriculum |
| | Relationships between magnetism and electricity | |
| | The electrical nature of matter | |
| | Radioactivity | |
| | Characteristics of water waves | |
| | The nature and behaviour of waves | |
| | Sound waves | |
| Chemistry-Unit III | Chemical reactions and their equations | Refer to the curriculum |
| | Some physical properties of the chemical elements | |
| | The electrical conductivity of aqueous solutions | |
| | Chemical properties of electrolytes | |
| Earth Science – Unit V | Earthquakes and the earth's interior | Refer to the curriculum |
| | Rocks and minerals that originate underground | |
| | Geology in engineering | |
| | Field trips | |

**Table 37 1969 science 9**

| Sequence / Scope | Science 9 — Topics | References |
|---|---|---|
| Chemistry- Unit I | A study of atoms | Refer to the curriculum |
| | Valence and the Periodic Table | |
| | Chemical reactions and equations | |
| Physics - Unit II & Unit IV | Effects of forces | |
| | Motions | |
| | Measurement of forces and pressure | |
| | Work and energy | |
| | Introduction to temperature and heat | |
| | Temperature and changes of phase | |
| | Measurement of temperature and heat | |
| | Transfer of heat energy | |
| Biology – Unit III | Energy storage and transformation | |
| | Energy requirement and usage of organisms | |
| | Energy in food chains | |
| Space science – Unit V | The solar system | |
| | Galaxies and stars | |

**Table 38 1970 science 10**

| Sequence / Scope | Science 10 — Topics | References |
|---|---|---|
| Biology – Unit 1 | Reproduction and heredity: cell structure , mitosis in plant and animal cells, reproduction, the study of inheritance, etc. | Refer to the curriculum |
| Physics – Unit II & IV & VI | Properties of electric current and electric charge | Refer to the curriculum |
| | Relationships between magnetism and electricity | |
| | The electrical nature of matter | |
| | Characteristics of water waves | |
| | The nature and behaviour of waves | |
| | Sound waves | |
| | Radioactivity | |
| Chemistry-Unit III | Chemical reactions and their equations | Refer to the curriculum |
| | Some physical properties of the chemical elements | |
| | The electrical conductivity of aqueous solutions | |
| | Chemical properties of electrolytes | |
| Earth Science – Unit V | Exterior features of the earth: lithosphere, hydrosphere, atmosphere | Refer to the curriculum |
| | Earthquakes and the earth's interior | |
| | Rocks and minerals that originate underground | |
| | Orogeny and Geology in engineering | |
| | Field trips | |

**Table 39 1983 science 9**

| Sequence / Scope | Science 9 — Topics | References |
|---|---|---|
| Astronomy and space science | Solar system | Refer to the curriculum |
| | Stars and galaxies | |
| Changes in matter | Reactions and symbols | |
| | Rate of reaction | |
| | Household chemical | |
| Changes in the environment | Folding and faulting | |
| | Igneous intrusion and extrusion | |
| | Plate tectonic theory | |
| | Earthquakes and volcanoes | |
| | Fossil fuels | |
| Ecology and resource management | Local biome | |
| | Soil and nutrients in the soil | |
| Energy | Heat measurement and phase change | |
| | Renewable and non-renewable sources of energy | |
| | Law of conservation of energy and energy transformation | |
| | Simple machines | |
| Life functions | Nutrients in foods and how they are utilized by the body | |
| | Processing and storing of foods and the use of supplements and additives | |
| | Human body functions with respect to the skeletal, muscular, digestive, respiratory, circulatory, and excretory systems | |

**Table 40 1983 science 10**

| Sequence / Scope | Science 10 — Topics | References |
|---|---|---|
| Astronomy and space science | Space technology | Refer to the curriculum |
| | Space travel | |
| Changes in matter | Chemical formulas, Reactions and symbols | |
| | Periodic Table, Rate of reaction | |
| | Simple Reactions, chemical | |
| | Ionic compounds | |
| | Industrial processes | |
| Changes in the environment | Radioactive dating | |
| | Seismology and the interior of the Earth | |
| | Prospecting and exploration geology | |
| Ecology and resource management | Population growth | |
| | Resources, pollution and control | |
| Energy | Electricity and magnetism | |
| | Home energy use | |
| | Household circuitry | |
| | Nuclear | |
| Life functions | Simple cellular processes | |
| | Reproduction, inheritance of characteristics, eugenics | |
| | Disease identification and treatment | |

**Table 41  1996 science 9**

| Scope \ Sequence | Science 9 Topics | References |
|---|---|---|
| Life science | organs and organ systems | Refer to the curriculum |
| | Interrelation of body systems | |
| | Current and emerging biomedical technologies | |
| | Influence of hormones, environmental chemicals, and common drugs on body systems | |
| | Diet and lifestyle's importance in helping maintain a healthy body | |
| | Different ways that raw materials necessary for human life are utilized | |
| | Effects of some disease-causing agents and their diseases on body systems | |
| Physical science | Properties of elements and compounds | |
| | Physical and chemical changes | |
| | Law of Conservation of Mass | |
| | Effects of various factors on the rate of chemical reactions | |
| | Heat | |
| | Law of conservation of energy | |
| | Relationships between force, motion, and mass | |
| | Evaluation of the efficiency of various mechanical systems | |
| Earth and space science | Organization of the solar system | |
| | Remote sensing techniques | |
| | Comparison of distances of objects in space | |
| | Stars | |
| | Astronomical discoveries and current understanding of the universe | |
| Applications of science (the framework through which students learn about the above three content organizer) | Safety in particular procedures and experiments | |
| | Identification of advantages of controlled experiments, patterns of change, sources of error in measurement techniques, and interactions between the various parts in a system | |
| | Use of data and evaluation of different models | |
| | Socioscientific issues | |
| | Application of scientific principles in technology | |

**Table 42 1996 science 10**

| Sequence / Scope | Science 10 — Topics | References |
|---|---|---|
| Life science | Organelles' function within the cell | Refer to the curriculum |
| | Cell structures, functions and developmental stages | |
| | Influence of viruses and bacteria on cell functioning | |
| | Asexual and sexual reproduction | |
| | Genetic code and assembly of different proteins | |
| | Principles governing the inheritance of traits | |
| | Mutations and current and emerging biomedical, genetic, and reproductive technologies | |
| Physical science | Structure of matter | |
| | Subatomic particles (electrons, protons, neutrons) | |
| | Bonding of constituent parts | |
| | Chemical formulae and equations | |
| | Electricity and magnetism | |
| | Distribution and safety considerations of electricity from its generated source to its use within the home and reducing energy waste | |
| | Radioactivity | |
| Earth and space science | Techniques used to learn about the earth | |
| | Major factors responsible for earthquakes, volcanic eruptions, mountain building, and formation of ocean ridges | |
| | Theory of plate tectonics | |
| | Impacts of volcanoes and earthquakes on the environment | |
| Applications of science (the framework through which students learn about the above three content organizers: Life science, physical science, and Earth and Space science) | Safety in particular procedures and experiments | |
| | Limitations of techniques and instruments to the accuracy and reliability of an investigation | |
| | Appropriate methods of presenting information | |
| | Interactions between scientific developments and the beliefs and values of society | |
| | Analysis of data and conclusions that may be subject to bias | |

**Table 43 2006 science 9**

| Sequence / Scope | Science 9 — Topics | References |
|---|---|---|
| Life science | Process of cell division | Refer to the curriculum |
| | Relating the processes of cell division and emerging reproductive technologies to embryonic development | |
| | Comparison of sexual and asexual reproduction | |
| Physical science | Modern atomic theory | |
| | Periodic table | |
| | Chemical symbols of elements and formulae of ionic compounds | |
| | Changes in properties of matter | |
| | Static electrical charges | |
| | Electric current | |
| | Series and parallel circuits | |
| | Electrical energy | |
| Earth and space science | Understanding of universe and solar system | |
| | Traditional perspectives of a range of Aboriginal peoples in BC on the relationship between the Earth and celestial bodies | |
| | Astronomical phenomena with reference to the Earth/moon system | |
| | Implications of space travel | |
| Processes of science (skills and processes of science will mostly be developed as part of work related to the other curriculum organizers) | Safe procedures | |
| | Performance of experiments and interpretation of information using scientific method | |
| | Scientific literacy | |
| | Ethical, responsible and cooperative behavior | |
| | Use of technologies specific to investigative procedures and research | |

**Table 44  2006 science 10**

| Sequence / Scope | Science 10 — Topics | References |
|---|---|---|
| Life science | Interaction of abiotic and biotic factors within an ecosystem | Refer to the curriculum |
| | Potential impacts of bioaccumulation | |
| | Ways in which natural populations are altered or kept in equilibrium | |
| Physical science | Atoms, ions, and molecules | |
| | Acids, bases, and slats | |
| | Organic and inorganic compounds | |
| | Conservation of mass and rate of reaction | |
| | Radioactivity and modern atomic theory | |
| | Relationship of displacement and time interval to velocity for objects in uniform motion | |
| | Relationship between velocity, time interval, and acceleration | |
| Earth and space science | Plate tectonics | |
| | Characteristics and sources of thermal energy | |
| | Effects of thermal energy within the atmosphere | |
| | Possible causes of climate change and its impact on natural systems | |
| Processes of science (skills and processes of science will mostly be developed as part of work related to the other curriculum organizers) | Safe procedures | |
| | Performance of experiments and interpretation of information using scientific method | |
| | Scientific literacy | |
| | Ethical, responsible and cooperative behavior | |
| | Use of technologies specific to investigative procedures and research | |

**Table 45  2014 science 9**

| Sequence / Scope | Science 9 — Topics | References |
|---|---|---|
| Micro-organisms | Viruses and bacteria | Refer to the curriculum |
| | Microbiomes | |
| | Immune system | |
| | Vaccination | |
| | antibiotics | |
| Elements | Element properties as organized in the periodic table | |
| Four fundamental forces | Gravitation | |
| | Electromagnetism | |
| | Weak nuclear force | |
| | Strong nuclear force | |
| Quantum theory | Types of radiation | |
| | Wave-particle duality of photons | |
| | Energy transmission (quanta) | |
| Four interacting spheres of Earth | The carbon cycle | |
| | Forms of carbon | |
| | The nitrogen cycle | |
| | Hazardous chemicals | |
| | The interactions between the lithosphere, atmosphere, biosphere, and hydrosphere | |