High School Science Education in Atlantic Canada In Historical Perspective

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Three Vignettes

The following vignettes are composites of the twenty science educators I interviewed as part of the research for this paper. Their experience in high schools spans the period from 1935 to the present, and all of the Atlantic Provinces of Canada.

Helen Caldwell

Helen Caldwell was a typical, very talented grade 11 urban high school student in 1937. She was untypical, however, of her age group. Most had abandoned school before reaching grade 11. But Helen enjoyed school and planned to go on to university. Her grade 10 biology teacher had inspired her interest in science. A naturalist, he frequently took his students on field trips and into the lab. Helen believes he may have had a Ph.D. in biology. But Helen's grade 11 science experience turned out to be a disappointment. Unable to take both chemistry and physics, she chose chemistry. Her teacher, however, was disorganized, could not maintain any class discipline and taught strictly out of the book, probably because he had no prior background in chemistry himself. Textbooks in both biology and chemistry were large, weighty tomes. In use for over a decade, these textbooks were not replaced for another thirty years.

Helen did sufficiently well on her junior matriculation exams to earn a scholarship to go to university after grade 11. After completing a B.Sc. with a major in chemistry, she worked for several years in a pharmaceutical company's research laboratory before returning to university to earn a Bachelor of Education degree. In retrospect, she believes this program did a poor job of preparing students for teaching. She suspects that those who taught the foundational courses, such as history and philosophy of education, may themselves have never taught in the school system. On the other hand, the methods courses were taught by busy practicing teachers who offered little more than a series of rules for teaching and personal anecdotes. There was no opportunity in the program to observe teaching in the schools.

Poorly prepared for teaching, and entering a profession that at that time barely paid a living wage, less than half of her graduating class ever taught more than a year in the

school system. Helen, however, enjoyed teaching and adapted well to the classroom. With integrity and good interpersonal skills, Helen, like many well-educated female teachers of her generation, succeeded in working around several less well-educated, and frequently arbitrary, male principals. By the end of her career, when there was more social recognition of the leadership skills of many female educators, Helen was made a school principal and then school board science and math consultant.

In the latter role, during the 1970s and early 80s, Helen worked with math and science teachers at all levels in her district. She helped establish one of the more active district level science fairs in the Atlantic Provinces. She also involved teachers at all levels in sharing teaching ideas and developing curriculum. She led teachers in the organization and conduct of district-wide professional development institutes to improve math and science teaching.

This activity peaked during the latter 1980s, after Helen's retirement. But regrettably, the financial constraints that began in the 1990s led to a sharp decline in all the activity she had been so involved in organizing. There is no longer a science fair in the district where Helen worked. Professional development activity, in the reduced amount of time available for it, now focuses on problems common to all teachers. The specific challenges and opportunities for improving science education are seldom addressed. Helen particularly regrets that the provincial science teachers' association in which she was so active is now a mere shadow of its former self.

John Whitehead

John Whitehead entered grade 11 in a rural school in 1956, at a time when Helen was teaching in a big city high school. The school John attended had three classrooms, with a teacher for each, including one for grades 1 to 4, another for grades 4 to 6 and a third for students in grades 7-12. Out of the 6 students who had completed grade 9, John was the only one left by grade 11. Responsible for teaching all subjects from grades 7-11, John's teacher gave him his textbooks, including books for chemistry and physics, and helped him when she could, although John probably knew more science than she did. There were, of course, no labs and no field trips.

The textbooks were somewhat battered, having been in use for several years. But John was a good reader and very curious. He was fascinated by the many technological examples in the science texts. He was often called upon by his teacher to help the younger students with their science and math.

John elected to take the provincial examinations at the end of grade 11. Success on these would qualify him to enter a four year university undergraduate program, perhaps even earn him a scholarship. To no-one's surprise, John did exceptionally well on his provincial exams in mathematics, physics and chemistry, earning him university admission and a scholarship.

For financial reasons, John was not able to proceed directly to university. His teacher knew of a recently built rural high school that was in need of teachers. It had been able to fill four of its six teaching positions with university graduates – these would be the first university graduates John would ever meet – but still had openings for two more teachers. On his teacher's recommendation, John, now 17 years old, and younger than many of his students, became a grade 7-11 teacher of math and science. He held this position for two years, by which time the school was able to find a fully qualified university graduate.

Having enjoyed his experience as a teacher and having saved every penny he could, John entered university the next year. He first earned Bachelors degrees in science and education and later a Masters degree. A life-long educator, John completed his career in 1998 as a senior official in his province's department of education. There he participated in the first efforts at Atlantic Canada regional collaboration in curriculum development. Because of that initiative, he also participated in the first pan Canadian effort to develop common learning outcomes for science across the country. Reflecting on the regional experience, he feels that the promise of regional collaboration is yet to be fully realized. In particular, he argues that the Atlantic Provinces Education Foundation should be as active in supporting the implementation of new science courses as it has been in designing them.

Michelle LeBlanc

We now go back again in time to meet Michelle LeBlanc. By 1976, when she entered high school, Michelle was able to benefit from the larger role the provincial government now assumed to ensure equal educational opportunities throughout her province. The high school in her town was as modern and well-equipped as any in the province. All of the teachers in her high school were university graduates. Most taught subjects for which they were academically qualified. Biology, chemistry and physics courses had well-equipped labs.

Talented students like Michelle were channeled into science courses like BSCS Biology, PSSC Physics and Chem Study. These used science textbooks and supporting resources that had been modernized during the late 50s and early 60s in both content and pedagogy by the intervention of the National Science Foundation in the United States. The discontinuance of provincial exams in her province by the early 70s was probably a factor in permitting programs that inevitably sacrificed breadth of course content to depth of treatment of important concepts and skills.

Although these programs are thought by many educators to have been too abstract for most high school students, Michelle loved them. Later, in retrospect, she realized that a couple of her science teachers were no better prepared than many of her fellow students to take full advantage of the inquiry laboratories and challenging questions and problems built into them. The inquiry labs and challenging problems were often replaced by cook-book labs and recipe-type standard problems and solutions. But Michelle was a curious student and avid reader, so she was able to read on her own much of what her teachers omitted. She now feels that this experience was largely responsible for her entry into

science at university and especially for her success at graduate studies in biophysics and her early scientific career in this field.

As a graduate student, Michelle worked as a laboratory teacher and undergraduate tutor in both physics and biology. She so much enjoyed her teaching that she ultimately chose full time teaching, which she could do at the high school level, forsaking a promising career in scientific research. Other experiences that may have led her in this direction included several years during high school and university when she was very active in amateur theatre, a heavy involvement throughout her student days in student government, and an avid participation in team sports. All of these experiences later served her well as a teacher and teacher educator.

By the time Michelle entered teaching in 1986, the NSF-developed programs of the 1960s were gone from the schools. In their place, all students, including the more scientifically and mathematically gifted ones, were now provided with the kind of watered-down university textbooks that have been the mainstay of high school science throughout the last half century. Filled with facts and recipes for solving standard problems and supported by cookbook style labs, these texts, plus a healthy dose of student note taking from teacher-lectures, have always been justified as good preparation for success in first year university science courses. And indeed, they are. Students like Michelle, who had studied using the NSF-developed programs, often experienced difficulty in making the transition to university science programs.

Michelle, however, responded to the recipe-like textbooks that were provided to her students by designing inquiry type labs for them, by creating more engaging and challenging problems that aimed at conceptual understanding, and by involving all her students in science fair projects. She also arranged for her students to work in collaborative groups with shared responsibility for each other's learning. In this way, she became successful in engaging her stronger students in helping the weaker ones. She also found this method could serve to draw on the range of talents to be found among her students.

Michelle quickly gained a reputation as an excellent teacher. One result was her part-time secondment by a nearby university to teach a methods course during the winter to prospective science teachers. She also taught a graduate course each summer for in-service science teachers. This led in time to her present employment as a full time teacher educator and education researcher.

She often regrets no longer having her own high school classroom to test the ideas she and her education students develop. Ideally, she would continue to share her teaching time between the university and the high school. To partially compensate for the loss of her own high school classroom, Michelle works with a team of science teachers on action research projects.

In her current position, Michelle has participated in one of the more promising developments in recent years – the professionalization of teacher education. This

includes a requirement that all entering the Faculty of Education at Michelle's university first have completed their undergraduate degree programs. This requirement permits the Faculty to organize its program in such a way that students can thoroughly integrate theory and practice. In effect, the new program models current educational theory.

For those planning to teach at the high school level in science, entry requirements to the Faculty include an undergraduate major in one of the sciences and a minor in an allied field, usually in mathematics or another science. The pre-service program is now a two year one. This allows time for school practicums during each of the four terms of the program and the setting aside of a full day during each week of courses for school visits. As well, many courses feature classroom action research projects, undertaken by education students collaboratively with in-service teachers.

As in past decades, the content of the education program offered by Michelle's university features attention to child psychology, special education, instructional methods and curriculum. It now also includes a thorough familiarization with the educational use of information communication technologies.

Although Michelle considers the program at her university far from perfect, she also cites her own experience to argue that no past generation of teachers has been as well prepared for teaching as present entrants to the profession. Unfortunately not all education faculties in the Atlantic Provinces have yet met the standards set by Michelle's faculty, but all appear to be headed in that direction.

Michelle has had serious reservations about the recent pan Canadian and Atlantic regional initiatives in science curriculum development. She would have preferred that those responsible would have spent more time in their deliberations, in the process doing a more thorough job of consultation, including educational researchers. If that had been done, perhaps many problems that have emerged could have been avoided. Perhaps, curriculum development would have been better linked with implementation. In any case, she remains optimistic that the current state of knowledge of how children learn science and how education systems can be improved will gradually influence practice, including the practice of curriculum development in Atlantic Canada.

Development of High School Science Education in Atlantic Canada from 1945

As these fictional biographies of Michelle LeBlanc, John Whitehead and Helen Caldwell have illustrated, there have been substantial changes affecting high school science education since the Second World War.

1. Foremost among these changes has been the proportion of the high school age cohort completing high school. Before the 1950s only a minority of students in Atlantic Canada reached the final year of high school, with most of the attrition taking place before grade

11. Today, over 90% of those entering grade 1 reach grade 12 and approximately 80% graduate.

2. With a large rural population throughout Atlantic Canada, the construction of rural high schools in the 1950s and 1960s had a major impact on the extent and quality of science education. Resulting improvements usually included qualified science teachers and science laboratories, previously available only to those students in the major urban centres. These improvements in rural education were associated with an increased role of the provincial government in education funding.

3. Other changes affecting the science education received by Atlantic Canadians during their high school years have been the improved scientific and pedagogical preparation of science teachers and a reduced student to educator ratio. The norm today for a beginning science teacher is a Bachelor of Science degree with a major and a minor in the sciences or mathematics and a two year postgraduate bachelor's degree in education.

From student to educator ratios greater than 30 prior to 1950, today there are approximately 16 to 17 students per educator, a range that was reached throughout the region by 1990. It translates into an average of 22 to 24 students per high school classroom, arguably low enough for most qualified science teachers to safely conduct science laboratory investigations by students.

4. There have also been changes in science curricula and resources to reflect the advances in science over the past century. In the latter 1950s and early 1960s, scientists and psychologists, with National Science Foundation funding, combined to create new high school science curricula with modernized content and age-appropriate pedagogy. These were widely utilized in teaching scientifically gifted students. Although these curricula faded out of use by the early 1980s, they influenced the curricula used by all science students today. Whereas science textbooks used in high schools in the 1950s could be as much as half a century out-of-date scientifically, the content of today's high school textbooks is reasonably current.

5. That brings us to the changes which present the greatest challenge at the present time. Research in science education, especially from the latter 70s to the present, has produced a veritable revolution in knowledge of how science concepts are learned (and mis-learned). Research in the history and philosophy of science has brought greater understanding of the nature of science and the relations between the development of science, technology and society. This knowledge, like the prior advances in science itself, also needs to be reflected in science teaching.

Associated with these developments in knowledge, a new wave of science curriculum reform began in the early 1980s. This was heralded by new policy documents from such organizations as the Science Council of Canada, which in 1984 published *Science for Every Student* as the conclusion to its deliberative study of science education in the country, and by the American Association for the Advancement of Science, through its publication in 1989 of *Science for All Americans* and later documents.

This new vision for science education was articulated for educators in Atlantic Canada by the Atlantic Provinces Education Foundation through its publication in 1998 of the curriculum policy document, *Foundation for the Atlantic Canada Science Curriculum*.

Unfortunately, other changes in this period have presented roadblocks to the successful introduction into teaching practice of the new knowledge of science and pedagogy. A causative factor has been the constraint on educational finances and some of the specific ways financial restraint has been exercised. One of the intermediate consequences has been reduced opportunities for science teachers to engage in science education specific professional development.

While a declining school enrolment permitted provinces to reduce educational expenditures without increasing the student to educator ratio, the same wisdom was not exercised with respect to the professional development services needed to renew teachers' skills and knowledge. In particular, the number of science education consultants and science teacher educators employed in the region has gone down by over half since the 1980s. Much of this decline has been associated with the consolidation of school boards and the replacement of consultants for each subject area by school level consultants. Not surprisingly, these appear to be unsuccessful in addressing the subject-specific professional development needs of teachers.

Newfoundland provides a specific example of the decline in the number of science education consultants and what this means. In the 1980s the provincial science consultant could and did call upon 35 full-time district level consultants to help in the organization and leadership of professional development for high school science teachers. Most of these had a background in science education. By contrast, today the provincial math and science consultant in Newfoundland can turn to only 10 full time district level consultants to assist with science educator professional development. But each of these 10 educators is responsible for several or all subjects in the high school, and only 2 or 3 have science education backgrounds.

One indicative result of this decline in resources for science teacher professional development is the disappearance of a regional organization (Educators of Atlantic Science Teachers) that once brought science education consultants and science teacher educators together in annual conference from all of the Atlantic Provinces. It folded after its mailing list fell from nearly 50 active participants to under a dozen.

The number of science education consultants and science teacher educators in Atlantic Canada appears to be below the critical mass needed to maintain a vibrant culture of science teacher professional development in this region. Either that is the case or a new approach is needed to revitalize science teacher professional development. Without such revitalization, the introduction into teaching practice of recent advances in knowledge in the field of science education will not occur; the current modernized science curriculum in Atlantic Canada will not be implemented.

Some Things Don't Change

Of course, some things don't change, no matter what changes might be made in the organization and conduct of education.

1. In particular, there have always been outstanding science teachers – teachers who have excited their students' interest in science, often by taking them into the lab or out into the field, often by encouraging them to engage in projects and learn science on their own, often simply by organizing and presenting science in a coherent manner. Usually, outstanding science teachers have strong backgrounds in science, but not always. Almost invariably, outstanding teachers take an active, voluntary part in conferences, workshops, summer courses and science teacher organizations, forever trying to improve themselves as science teachers

2. Unfortunately, there have also always been science teachers – whatever their formal qualifications – who have succeeded in spending years in the science classroom without exerting any of the effort required to make science meaningful and engaging to their students, without renewing themselves with fresh ideas and continuing energy for science teaching.

3. Science enrolment in high school also appears to be a constant, although it can shift from one science course to another. Even with changes in the way the timetable is divided and consequently the total number of courses a student can take during the high school years, students elect on average one science course out of each six courses that they take. Biology is the most popular science subject in each of the Atlantic Provinces, with a majority of students enrolling in at least the first high school biology course. Physics is the least favoured, although this varies from 20% of students taking at least a first physics course in Newfoundland to over 40% doing so in New Brunswick.

Further Development of High School Science Education in Atlantic Canada – Four Recommendations

1. Demographic changes present a challenge and an opportunity to improve science education. School enrolments in the region reached a peak in Atlantic Canada about 1970 and have been in steady decline since. Enrolments are projected to continue to decline over the next decade, perhaps by as much as twenty percent. Even in a context of declining provincial resources committed to school level education, it should be possible to increase per student funding, as indeed appears to be happening now. **The increased financial support for each student's learning can include a renewed commitment to teacher professional development. This can be done by encouraging the most exemplary teachers to obtain graduate degrees in education, including doctoral degrees, and creating new jobs for them as professional development leaders, adding to the presently small number of provincial and district level consultants.**

2. Continuing attention is needed to the balance between high school science as preparation for studying science at the tertiary level and high school science as part

of the foundation for life-long learning, making healthy lifestyle decisions, taking environmentally responsible actions, and participating in an informed manner in democratic decision making.

3. The interviews I conducted and my recent review of some of the textbooks currently being used suggest to me that preparation for success in first year university science courses is the over-riding pre-occupation of high school science educators. **University and high school science educators need to take joint action to ensure that poorly considered instructional methods are not self-perpetuating. The cycle can be broken by continuing, preferably joint efforts to apply contemporary knowledge of how students learn science to both university and high school science teaching**.

4. Another major issue requiring continuing attention is the setting of high standards for high school science education and assessing the results. The assessment methods must match the standards. **If high school science teaching is to address more than science content knowledge, as the Atlantic Provinces Education Foundation envisions, then assessment methods must include much more than the objective type items that typify provincial, inter-provincial and international tests in science**.

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